The Hybrid Panel-Truss Element: Developing a Novel Finite Element for the Nonlinear Analysis of Reinforced Concrete Beams and Shells

by

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Abstract

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This research thesis presents a finite element for the nonlinear analysis of reinforced concrete beams and shells. The Hybrid Panel-Truss (HyPT) element overcomes the computational limitations that exist when working with current analysis paradigms implemented in commercial software. Instead of explicit shape functions, the element utilizes the combined actions of simpler subcomponents to capture the coupled axial, flexural and shear deformations associated with reinforced concrete structures. The finite element formulation itself is robust as only one element is required through the depth of a member, and efficient since the global degrees of freedom necessary in a structural analysis model are reduced. The predictive accuracy of the HyPT element was verified using the American Concrete Institute database of shear critical reinforced concrete beam tests. In addition, the element was used to successfully model the experimental component of this research - the first documented pure torsion tests on reinforced concrete shells.

Acknowledgements

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A special acknowledgment goes to Professor Michael P. Collins, whose lectures on the combined actions of shear and torsion in reinforced concrete were crucial in helping me formulate the finite element presented in this thesis. His advice and suggestions throughout the experimental program were also invaluable. I will fondly carry his saying - "To find the answer, you must know the answer" - with me throughout my career.

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I would also like to thank all of my graduate student peers in the Civil Engineering Department for making this a wonderful environment to work in. I would like to especially acknowledge the following individuals: Jeff Salmon, for the countless coffees and company during the long days in the lab; Allan Kuan, for the hours spent discussing all research-related topics; Giorgio Proestos, for the time spent training me to use the Shell Element Tester (SET) and for being an inspiring academic.

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Chapter 1

Introduction

The following chapter will present an overview of the research program presented in this thesis. The growth of nonlinear finite element analysis in structural engineering is first presented in the context of the parallel technological development in computing. This discussion is followed by the justification for this specific research, which is primarily motivated by the need to overcome certain challenges associated with modern finite element modelling paradigms when applied to the analysis of complex three dimensional reinforced concrete structures.

This is followed by an outline of the specific experimental and numerical objectives that were defined at the outset of the project, and how these are presented in the thesis document structure. A summary of key research documents and existing research literature is also included for readers that wish to delve into the main influences for the finite elements presented in this thesis.

1.1 Background and Research Motivation

Over the last 40 years, two factors have contributed to major advancements in the fields of reinforced concrete design and analysis. First, the exponential increase in computational power has allowed for structural engineering problems with geometric complexity and material nonlinearity to be efficiently handled by computer-based solution procedures. The ubiquitous presence of nonlinear finite element analysis (NLFEA) in all aspects of structural analysis work is a testament to the success of this approach. Second, the 1986 publication of Modified Compression Field Theory (MCFT) has introduced a general and rational solution to the complex shear problem in reinforced concrete [1]. In 1996, this theory was further developed into a design procedure [2], which has subsequently become the basis for the shear provisions in the Canadian reinforced concrete design code [3, 4] and numerous other codes worldwide.

The predictive accuracy of the MCFT can be coupled with the speed of computer-based analysis - examples of this are the VecTor2 [5, 6] and Response-2000 [7] software packages developed at the University of Toronto. For a member level analysis, VecTor2 functions by representing a reinforced concrete structure as a mesh of triangular or rectangular membrane elements based on the MCFT formulation [8]. For a sectional analysis, Response-2000 functions by representing a reinforced concrete cross-section as the summation of several discrete slices through the thickness [9]. Figure 1.1 depicts the growth in the computing power of commercially available Intel^{TM} processors [10] in the context of a sectional analysis of a complex pretensioned highway girder with Response-2000.

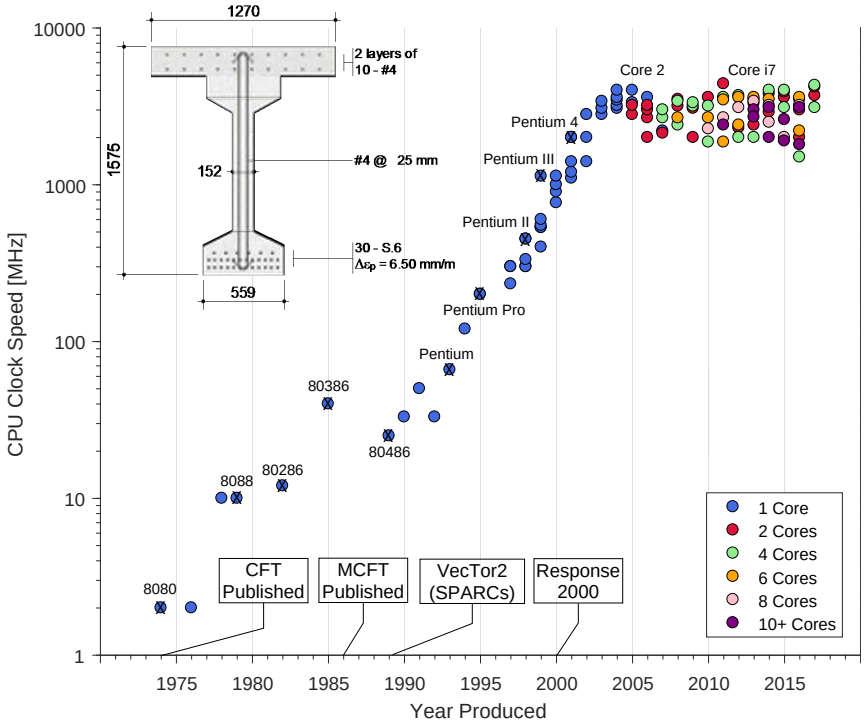


Figure 1.1: *The Growth of Processing Power in the Context of a Sectional Analysis*

The dramatic improvement in computer processors has made it possible to solve reinforced concrete sectional analysis problems that were previously unwieldy; a task that would take several hours two decades ago can now be completed in mere seconds. Yet a detailed non-linear analysis of a whole structure, as opposed to a cross-section, is in many ways still considered a challenging task. While cross-sectional and single member analyses can tell us much about specific sub-components of a structure, there are also complex effects (e.g. torsion) that can result from three-dimensional loading, complex geometry, or general global behaviour that will not necessarily be captured by a local analysis. It is therefore more desirable to model as much of a structure as realistically as possible - the trade-off is that adding modelling complexity leads to a more computationally demanding analysis. Depending on the geometry, models with thousands of elements and degrees of freedom (DOFs) could be necessary to represent the complete structure. While rigorous academic software (i.e. The VecTor Suite) can be extended to the macro-level analysis of structures, the execution time often becomes excessive at such large scales. Figure 1.1 underscores the fact that relying on increasing processor speeds is also not a viable long-term strategy for large-scale structural analysis. The growth of single processor speeds has essentially plateaued, and in the last decade emphasis has instead been placed on the development of multi-core processors. While this development helps speed up certain computational tasks, not all structural analysis algorithms and solution methods can currently be run in parallel to take advantage of multiple cores.

The main computational demand associated with NLFEA comes from simultaneously solving a large system of equations, which represents the relationship between the forces and displacements at DOFs (i.e. the stiffness method). When formulated as a finite element problem this relationship falls under two distinct paradigms - either using many low-powered elements, or using few high-powered elements to represent the structure. The term *power* refers to the number of DOFs and the complexity of the underlying shape functions defining the element. The highly non-linear nature of reinforced concrete has typically precluded the use of the later approach; it is difficult to develop a high-powered general element based on shape functions that can accurately cover large volumes and still capture phenomenon such as localized cracking, yielding, and shear failure. Therefore, successful reinforced concrete analysis programs such as VecTor2 have adopted the first approach by using numerous low-powered elements instead [11]. These elements are based on simple linear shape functions, and can be used to approximate a highly nonlinear strain field when distributed in a sufficiently fine mesh. Yet this means that the analysis results can be highly sensitive to modelling parameters, and relying on a large quantity of elements to represent a structure becomes exponentially more computationally expensive as the size of the structure being modelled increases. Therefore, a novel finite element paradigm is necessary, one that is both simply formulated and robust with respect to the number of elements - resulting in a finite element analysis that is less reliant on computational capacity, but still able to accurately capture the nonlinear behaviour of reinforced concrete.

1.2 Research Objectives and Overview

This thesis will present the mathematical formulation of the Hybrid Panel-Truss (HyPT) element, which has been created in an attempt to deal with the analysis time and model complexity challenges arising from current reinforced concrete NLFEA paradigms. The overall research program can be subdivided into the following set of objectives:

1. To consolidate the work done to date on the two-dimensional version of the element, and to expand the derivation to include a rigorous membrane formulation based on the MCFT.
2. To validate the two-dimensional element against a series of experimental results.
3. To construct two shell specimens, with and without shear reinforcement, and to load them under pure torsion with a displacement-controlled loading protocol.
4. To derive and validate the three-dimensional version of the element against the torsion experiments.

The **first objective** is to present an updated derivation of the two-dimensional Hybrid Panel-Truss (2d-HyPT) element, which is intended for the full-member analysis of reinforced concrete beams and columns. The element is derived with a specific focus on the ability to predict shear failure, therefore expanding the derivation to include a shear panel based on an MCFT formulation is a significant improvement to previous approaches.

The **second objective** is to determine the speed and accuracy of the 2d-HyPT element when utilized in the analysis of reinforced concrete structures. The derivation of the single element stiffness matrix is accompanied by an extensive member-level validation study against a database of shear critical reinforced concrete beams, followed by a large-scale structure validation exercise against two previously tested frames.

The **third objective** is to design, construct and carry-out a testing program for two reinforced concrete shells under pure torsion, with the goal of determining the influence of T-head shear reinforcement on the ultimate strength and ductility of the specimens. The testing procedures and the data for these experiments are meticulously presented as they represent the first tests of this nature. These results are also integral to the derivation of the three-dimensional version of the HyPT element - there were certain assumptions regarding the out-of-plane strains that were inherent in the 2d-HyPT formulation and could only be clarified with experimental data.

The **fourth objective** is to extend the 2d-HyPT element formulation for use in three dimensions. The 3d-HyPT element is based on many of the same principles as its two dimensional counterpart, but takes added steps to account for additional connectivity and out-of-plane effects in the element. The experimental data from the two torsion shell tests is also built into certain assumptions included in the model.

1.3 Literature Review

The proposed element is unique in that it combines the computational simplicity of a low-powered element with the ability to capture complex deformation patterns typical of a high-powered element. With both the 2d and 3d-HyPT formulations, only one element is necessary through the thickness of a member, thereby significantly reducing the number of global DOFs present in a problem. The element uses a multi-component approach where the axial, flexure and shear deformations inherent in reinforced concrete are captured by specific internal components. The relative deformations of one-dimensional axial trusses, that each connect two nodes, are used to represent axial and flexural deformations; two-dimensional shear panels, that each connect the four nodes of a face, are used to represent shear deformations. These deformation patterns can be defined through simple translational DOFs, while more complex effects are explicitly accounted for in the resulting deformation patterns associated with the element. In contrast, more complex finite elements attempt to account for things like rotational deformations through explicit DOFs and require numerical integration schemes to solve, which will add an additional computational demand to the analysis. The following section briefly reviews some of the standard approaches for modelling shell elements, and then introduces some of the previous research dealing with multi-component models and how these ideas have influenced the derivation of the HyPT element.

1.3.1 Elasticity-Based Finite Element Models for Shells

Standard shell elements are formulated based on either the Kirchoff plate bending or the Mindlin theory, which are appropriate for modelling thin or thick shells respectively. Thin shells are a special case, where the finite element formulation is simplified by neglecting out-of-plane effects. On the other hand, the thick shell formulation takes a more generalized form and can be applied to all cases, and is therefore a more complex finite element to derive [12]. The following section will focus on the strengths and weaknesses of standard shell finite elements that have been derived from three-dimensional elasticity.

Degenerated Shells

A discussion of various shell modelling techniques is presented by Figueiras and Owen [13], where the most practical approach is using what are called degenerated elements. These elements are developed from the equations of three-dimensional elasticity, which are implemented in the form of isoparametric elements that use independent displacement and rotational DOFs. Essentially a generalized three-dimensional solid element is collapsed to a shell element, which relies on the deformation of fewer nodes. Figure 1.2 shows the degeneration of a 20-noded and 60-DOF solid element into a 8-noded and 40-DOF shell element [14]. In this example, each node has three translational and two rotational DOFs.

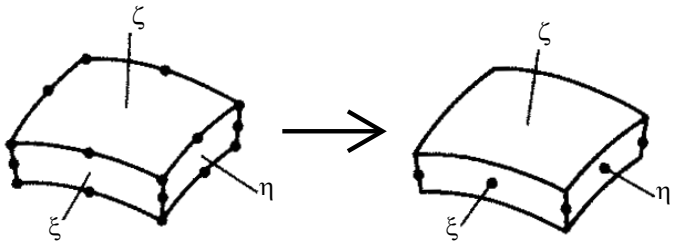


Figure 1.2: *Degeneration of Three-Dimensional Solid Element (Adapted from Cook et. al. [14])*

The Heterosis Shell Element

The Heterosis shell is a type of degenerated element that has been shown to perform well when implemented with a rotating crack model for the analysis of both thin and thick reinforced concrete shells [15, 16]. The element is a 9-noded quadratic element with a total of 42 DOFs, where the three translational DOFs of the central node are removed. Yet while this element is considered a good compromise between the less complex Serendipity and more complex Lagrange quadratic elements [17], it still suffers from some of the same drawbacks. The Heterosis element relies on complex numerical integration to determine the stiffness matrix of the element while minimizing spurious deformation modes - the reduced numerical integration scheme used is a 3x3 Gaussian grid for the bending and membrane energy, and a 2x2 Gaussian grid for the out-of-plane shear energy [13]. This particular reduced integration scheme is used to achieve optimal computational performance while removing what are known as "zero-energy" deformation modes, which are mathematical artifacts that are in reality physically impossible as they occur in the element without changes to the the internal energy. For example, if the number of integration points is reduced in an attempt to speed up the calculation process, the finite element formulation becomes more prone to these unrealistic deformations. Figure 1.3 illustrates a spurious deformation mode that would exist if the stiffness of a two-dimensional element was being calculated with just one integration point at the center. The dotted line shows a hypothetical deformation in the element, which a numerical integration based on the central point would suggest requires no change to the internal energy, as represented by the constant vertical and horizontal strains measured at the point (i.e. no change in length of the red lines).

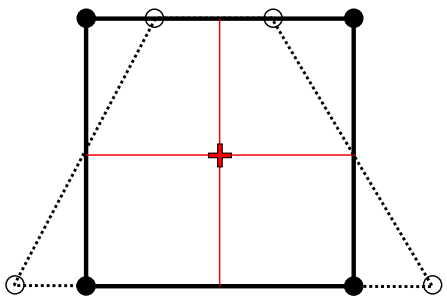
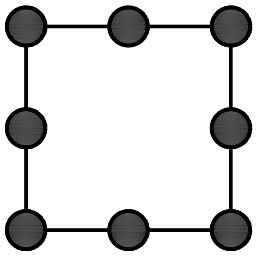
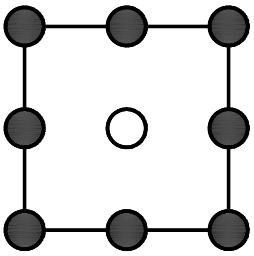
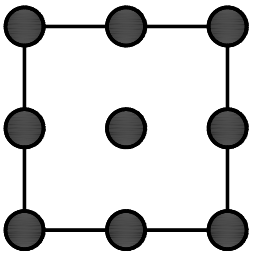


Figure 1.3: *Spurious Deformation Mode with A Single Integration Point*

Even with a complex integration scheme, the Heterosis element still has one spurious deformation mode, while the Serendipity and Lagrange elements have two and four respectively [13]. Although the severity of certain modes is somewhat reduced as they would not be communicable in a mesh of elements. There also exist other methods that attempt to control the "zero-energy" modes in simpler reduced integration schemes, such as one-point quadrature [18]. Yet such methods become exceedingly difficult to apply to reinforced concrete, where a high degree of nonlinearity often means that sampling only one point is not enough to characterize the complex strain field.

To summarize, while the Heterosis element is both mathematically rigorous and proven to work for the analysis of thin and thick reinforced concrete shells, its reliance on a complicated integration scheme results in a large computational demand - at each iteration, and for each element, several numerical integrations must be performed to determine the element stiffness matrix. It is also difficult to improve on this formulation, since reducing the number of integration points to improve the speed will lead to either spurious deformation modes, or an incorrect representation of the nonlinearity in reinforced concrete. For reference, information on the three degenerated shell models mentioned in this section is presented in Figure 1.4, which is taken from the work by Trevor Hrynyk [16].

	SERENDIPITY	HETEROSIS	LAGRANGE
			
u, v, w shape functions	Serendipity	Serendipity	Lagrange
θ_1, θ_2 shape functions	Serendipity	Lagrange	Lagrange
integration scheme	bending: 2 x 2 – Gauss shear: 2 x 2 – Gauss	bending: 3 x 3 – Gauss shear: 2 x 2 – Gauss	bending: 3 x 3 – Gauss shear: 2 x 2 – Gauss
number of spurious zero-energy modes	bending: 1* [1]membrane: 1*	bending: 0 [1]membrane: 1*	bending: 1 [1]membrane: 2+1*
constraint index	1	3	4

[1] from Figueiras and Owen (1984)

* not communicable in a mesh of two or more elements

● - u, v, w, θ_1, θ_2 degrees of freedom considered

○ - θ_1, θ_2 degrees of freedom considered

Figure 1.4: *Summary of Degenerated Shell Elements (Hrynyk [16, p. 164], Adapted from Hughes[17])*

1.3.2 Multi-Component Models

The HyPT element takes a different approach to the modelling of reinforced concrete, relying on the aggregate action of simpler subcomponents, instead of using element-level shape functions derived from three-dimensional elasticity. The stiffness matrices of the various components are calculated by relating the nodal displacements of the element to a combination of flexural, axial, and shear deformations. The truss bar subcomponents that carry axial and flexural deformations are calculated based on a fiber-model approach, while the shear panel subcomponents are calculated using an in-plane MCFT analysis.

The idea to represent the complex interactions in reinforced concrete by summing the contributions of several more simple subcomponents is not a new concept - the HyPT element draws inspiration from some notable multi-component examples that are presented in this section.

Multi-Layer Model

The stacked membrane, or multi-layer model, is a generalized sectional method where a shell is assumed to be made up of several in-plane membrane elements (Figure 1.5). Variations in stiffness through the thickness of the shell are explicitly accounted for as unique stress-strain relationships are calculated for each membrane. The force resultants (N_x, N_y, N_{xy}) and moment resultants (M_x, M_y, M_{xy}) can then be summed across the whole shell to determine the overall sectional behaviour. The analytical process is improved since a two-dimensional membrane is a relatively simple problem to solve, although the downside is that out-of-plane shear effects are neglected. The idea of using multiple in-plane membranes to represent global behaviour is reflected in the derivation of the shear panel subcomponent for the 3d-HyPT element.

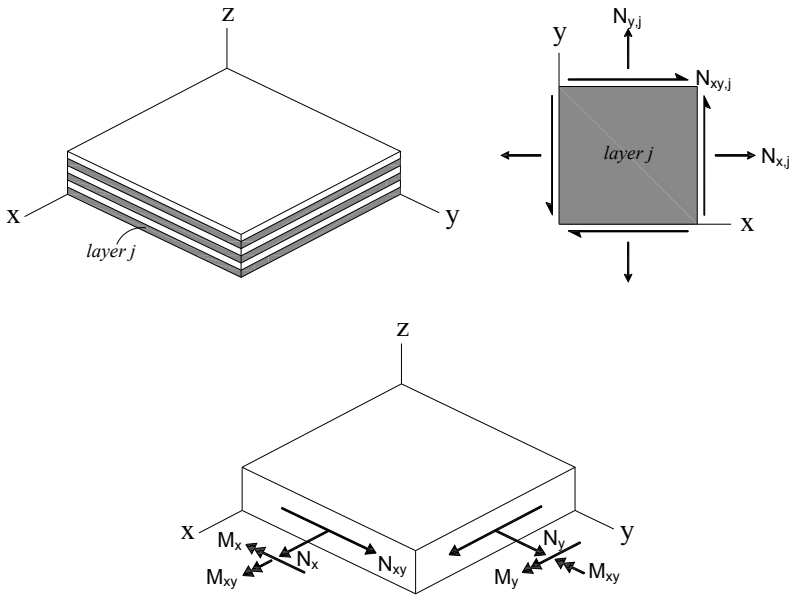


Figure 1.5: *Multi-Layered Model and Sectional Forces (Hrynyk [16, p. 8], Adapted from Collins [19]*

Space Truss Model

The internal load-carrying mechanism in a cracked reinforced concrete member subjected to torsion can be described with the three-dimensional Space Truss model. After cracking, a reinforced concrete beam is idealized as a truss with longitudinal chords, diagonal concrete struts, and transverse steel ties [20]. In the horizontal direction, each chord consists of the passive and active longitudinal steel area and any concrete that is in compression. While in the vertical direction, the concrete forms a diagonal compressive strut held together by the stirrups. Looking at the section, the compression in the strut is balanced by a tension in the chords and a shear flow along the perimeter, while at the corner the vertical component is carried by a tension in the stirrups and an additional force in the chord [21].

If the geometry of the space truss is known, the force resultants in each of these components can be calculated from statics. Moments and axial forces can be resolved into chord forces, while shears and torsions will result in diagonal compressions that can be resolved into shear flows along the faces of the section and additional chord forces [20]. Figure 1.6 is taken from the work by Collins and Mitchell, which shows how an applied torsion is carried through the different components in a cracked reinforced concrete section. The idea of resolving the sectional resultants into longitudinal and vertical force demands that are carried by different components is also used in the formulation of the HyPT element.

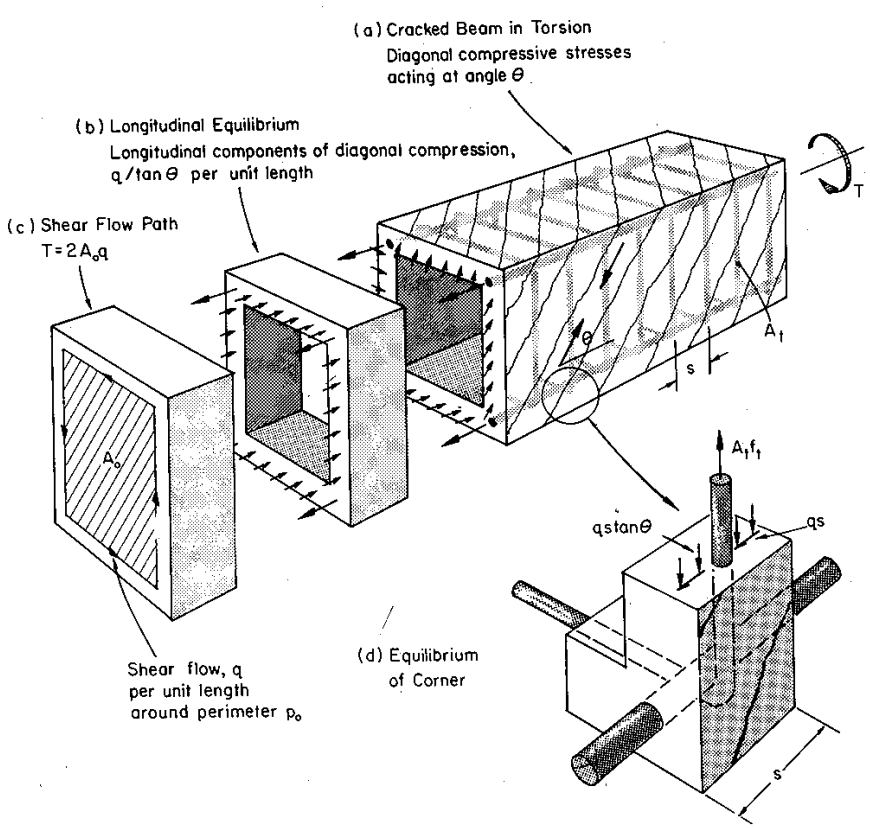


Figure 1.6: *Space Truss Model and Force Equilibrium (Collins and Mitchell [21])*

Stringer Panel Model

The Stringer Panel model is similar to the Space Truss model since it distributes the different internal forces in a reinforced concrete member to specific components. For example, the four stringers transfer normal forces, and border a flat plate that can only transfer shear forces [22]. The top and bottom stringers are analogous to the top and bottom chords defined in the Space Truss model. A schematic of the element is shown in Figure 1.7.

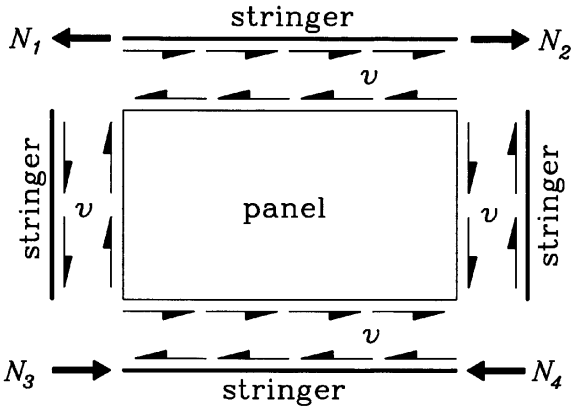


Figure 1.7: *Stringer Panel Element Schematic (Blaauwendraad [22])*

An important feature of the Stringer Panel model is that it was specifically formulated as a finite element, and is hence closely related to the research objectives of this thesis. By contrast, the Space Truss model is an excellent general design tool, but it is not directly applicable to a finite element procedure. The Stringer Panel elements are assembled to construct a two dimensional member, such as the cantilever beam that is shown in Figure 1.8. Once the element mesh is defined, the structure is subjected to external loads. The global behaviour is then determined based on the relationship between the load and displacement defined by the sum of all the individual element stiffnesses and connections between DOFs. There are many similarities between the Stringer Panel and the HyPT formulation, although the 2d-HyPT element accounts for reinforced concrete nonlinearity through the constitutive relationships of the MCFT, and improves the robustness of the analysis by requiring only one element through the thickness of the member.

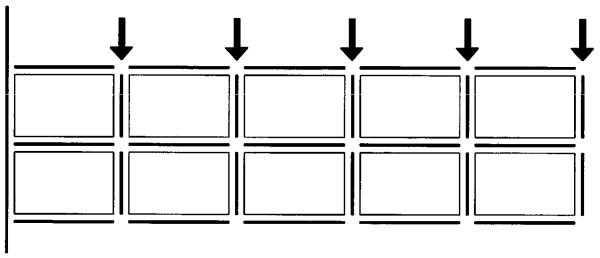


Figure 1.8: *Cantilever Constructed from Stringer Panel Elements (Blaauwendraad [22])*

1.3.3 Previous Work Related to the 2d-HyPT Element

There exists some specific research on the derivation and implementation of the 2d-HyPT element, which has until this thesis remained unnamed. Several students at the University of Toronto, supervised by Professor Bentz, have over recent years worked with the element, to varying degrees, as implemented in the analysis program Augustus-II. There has yet to be an official peer-reviewed publication related to the development of the element.

For those interested in reading about further applications and case studies using the 2d-HyPT element the following thesis documents could be useful: Yeung (2008, [23]), Cheung (2012, [24]), Zaeem (2013, [25]), Yap (2016, [26]). But note that the current thesis presents the most up-to-date derivation of the element, and consolidates all of the previous derivations while simultaneously improving the element formulation significantly. To avoid confusion, the derivation work in these previous theses should be considered superseded by the work presented herein.

1.4 Thesis Organization

The main body of this thesis is organized into seven main chapters, plus an appendix for additional information. Each of these chapters accomplishes the following:

- Chapter 1: Provides an introduction to the topic of finite element analysis in the context of reinforced concrete shells. Outlines the high-level focus and organization of the thesis.
- Chapter 2: Presents a mathematical derivation of the stiffness terms for the various subcomponents in the two-dimensional Hybrid Panel Truss (2d-HyPT) element. Presents the results of an extensive validation study against a database of shear critical beams and two experimental frames.
- Chapter 3: Describes the experimental program. Focuses on the material properties, construction procedures, instrumentation types, and experimental loading protocol for both shell specimens.
- Chapter 4: Presents the relevant data from the two pure torsion shell experiments, and explains how the instrumentation data streams were processed and manipulated.
- Chapter 5: Discusses the results of the shell tests and draws conclusions that will be implemented when deriving the finite element for the analysis of shell structures.
- Chapter 6: Extends the mathematical derivation of the 2d-HyPT into three dimensions for the use in the analysis of complex structures. Presents the implementation of the 3d-HyPT element in an original computer program and compares the analysis results to the experimental data.
- Chapter 7: Summarizes the main contributions of this research and recommends future research tasks.

Chapter 2

A Finite Element for the Analysis of Reinforced Concrete Beams: Derivation and Verification

The following chapter will present the numerical derivation and verification of a finite element for the nonlinear structural analysis of reinforced concrete beams subjected to in-plane loading. The finite element will be referred to as the Hybrid Panel-Truss (2d-HyPT) element - the prefix is meant to distinguish it from the three-dimensional implementation of the element used for the analysis of reinforced concrete shells, which is derived in Chapter 6 of this thesis. If no prefix is used, a reference to the two-dimensional implementation is to be assumed.

The derivation is divided into sections corresponding to the individual components that make up the complete stiffness matrix for a single element. The verification study is then meant to test the element's ability to accurately predict the failure loads for a database of reinforced concrete beam tests, along with two large-scale frames tested at the University of Toronto. In this thesis, the HyPT element is used to construct finite element models of the verified specimens and experiments reported in the ACI shear critical beam databases, for beams with and without shear reinforcement [27, 28].

2.1 Description of 2d-HyPT Element

The Hybrid Panel-Truss (HyPT) element is a two-dimensional rectangular element with a total of four nodes and eight degrees of freedom (DOFs) - two orthogonal translational DOFs per node oriented in the plane of the member (Figure 2.1).

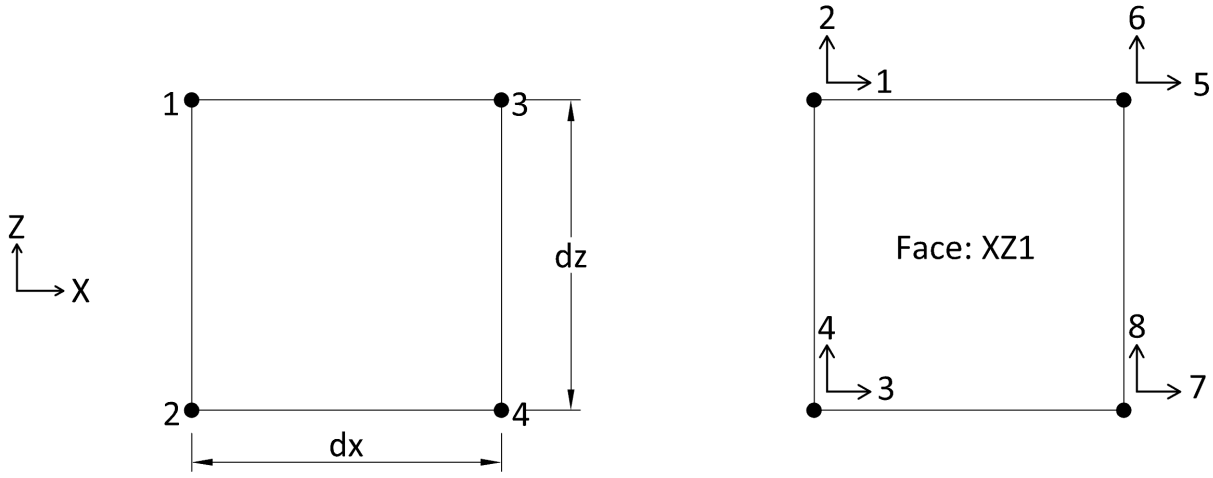


Figure 2.1: *HyPT Element Numbering Convention: Nodes (Left) & DOFs (Right)*

A reinforced concrete beam or column member can be represented with several individual elements placed in series along the longitudinal axis (defined by the direction of the flexural reinforcement). The unconventional node numbering shown in Figure 2.1 reflects the fact that elements are always linked through both nodes on either their left or right face, reminiscent of the plane-sections concept used to describe flexure. Loading and restraint conditions are only applied at the nodes. Figure 2.2 shows a schematic of a simply-supported beam with a double point load, represented by nine elements over the total span.

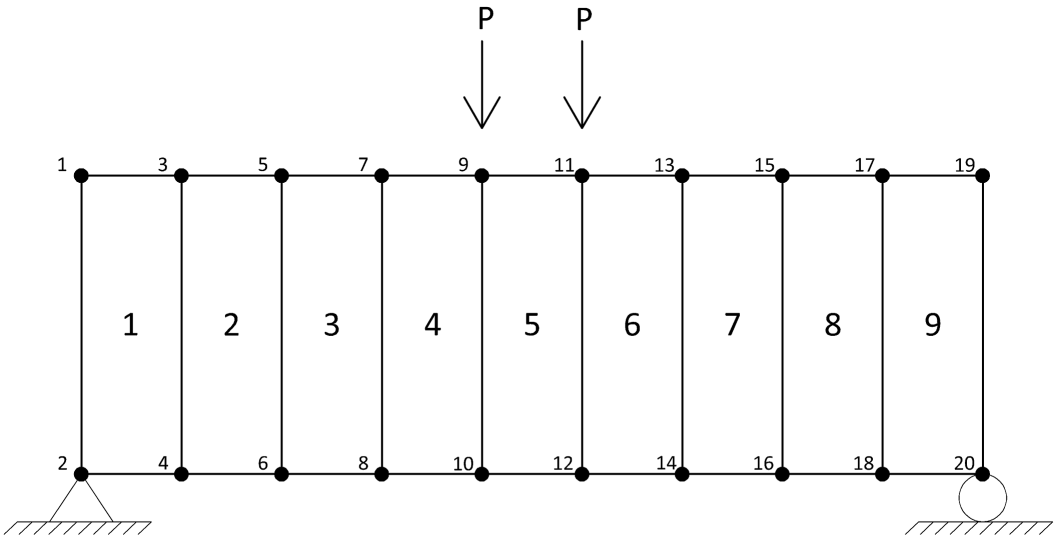


Figure 2.2: *Beam Modelled with HyPT Elements Placed in Series*

The full height of the member is represented by only one element - the material properties of the cross-section (the plane into the page) are used to define the stiffness of the individual elements (Figure 2.3) spaced along the length. The cross-sectional dimensions (d_y & d_z) are set by the structural geometry, while the length/size of the element (d_x) is set by the user.

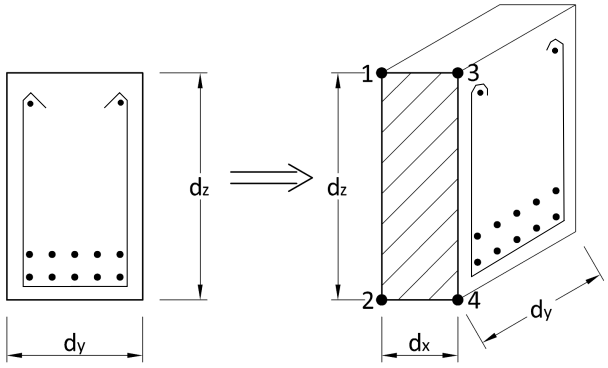


Figure 2.3: *Element Stiffness Defined by Cross-Section*

The efficiency of the HyPT element, with respect to the number of DOFs needed, is due to the unique combination of three separate subcomponents that together are able to represent the internal actions inherent in reinforced concrete: flexure/axial, shear, and post-cracking shear-flexure interaction. The HyPT element can be idealized as a two-dimensional panel that provides shear stiffness, linking two vertical and horizontal one-dimensional truss bars that provide flexural and axial stiffness (Figure 2.4). Similar multi-component models have been proposed in the past, an early example being the Space Truss model developed in the context of torsion design [20], or the Stringer Panel developed in the context of finite element analysis [22]. More details on these models can be found in the literature review section, but as a summary both models idealize reinforced concrete as a system composed of truss and panel elements.

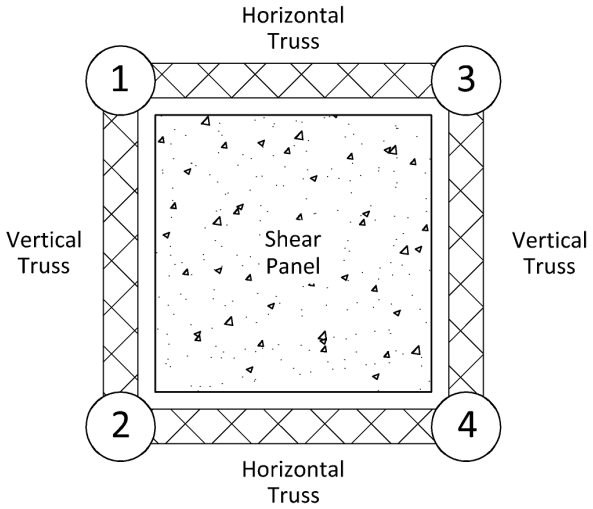


Figure 2.4: *Visualization of HyPT Element Subcomponents*

2.2 Flexural & Axial Truss Stiffness Terms

The flexural and axial stiffness of the HyPT element is defined by a series of one-dimensional truss bars, which can only carry axial force, linking two adjacent nodes. The top and bottom truss bars connect nodes 1-3 and 2-4 respectively, and the left and right truss bars connect nodes 1-2 and 3-4 respectively.

2.2.1 Deformation Patterns

The combined action of the horizontal truss bars is used to represent complex deformation patterns. For example, Figure 2.5 illustrates how axial compression and tension in the element can be represented by the uniform shortening or lengthening of the top and bottom truss bars.

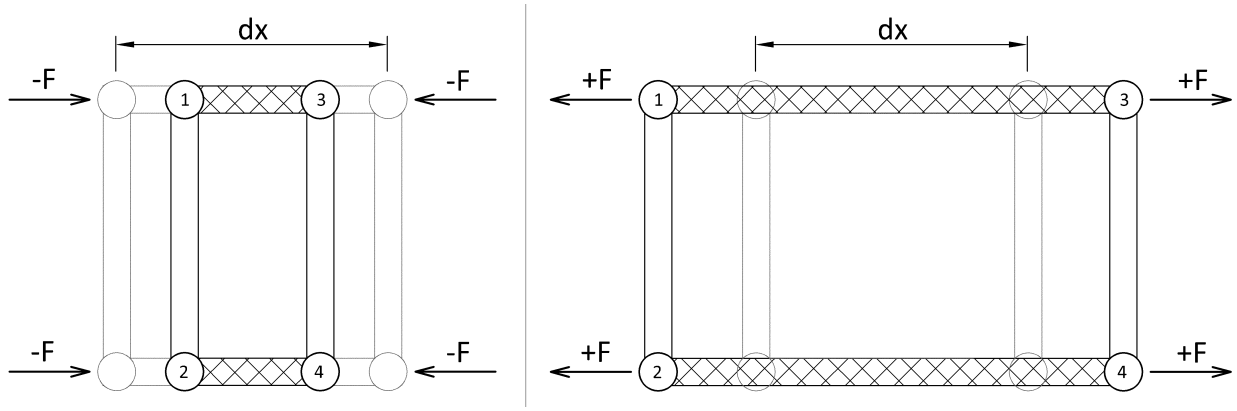


Figure 2.5: *A Representation of Axial Compression (Left) and Tension (Right) in the Element*

Flexural deformations are represented by the relative deformation of the horizontal truss bars, while retaining rotational equilibrium in the element. For example, positive flexure is seen as the relative contraction of the top truss bar and elongation of the bottom truss bar, and reverse for negative flexure (Figure 2.6).

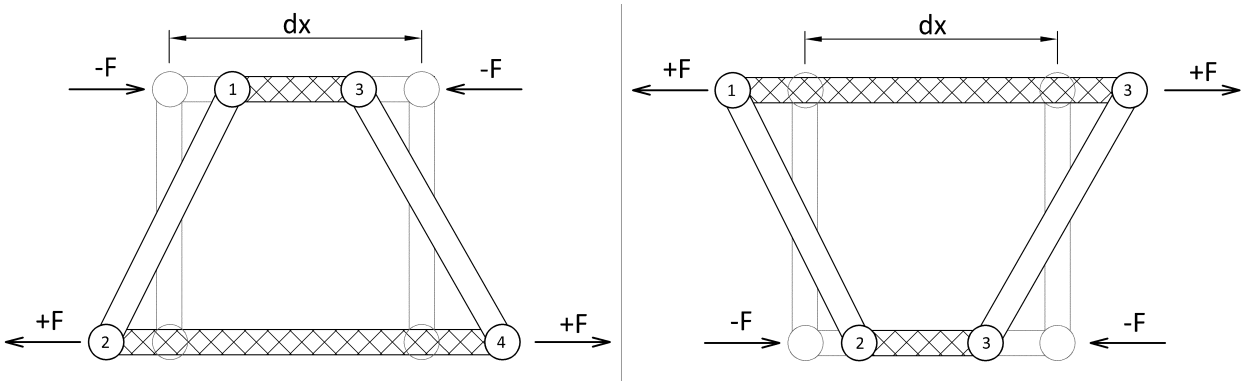


Figure 2.6: *A Representation of Positive (Left) and Negative (Right) Flexure in the Element*

2.2.2 Truss Bar Stiffness Matrix - Diagonal Terms

A stiffness matrix is used to relate the axial and flexural deformation patterns described in the previous section to the applied forces on the four nodes of the HyPT element. The deformation of a generic truss bar is show in Figure 2.7, which can also be expressed in matrix form (Equation 2.1).

$$\begin{bmatrix} K_{bar} & -K_{bar} \\ -K_{bar} & K_{bar} \end{bmatrix} \begin{Bmatrix} u_1 \\ u_2 \end{Bmatrix} = \begin{Bmatrix} F_1 \\ F_2 \end{Bmatrix} \quad \text{where: } K_{bar} = \frac{EA}{L} \tag{2.1}$$

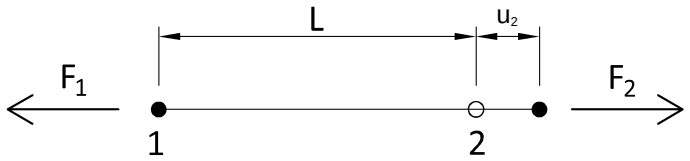
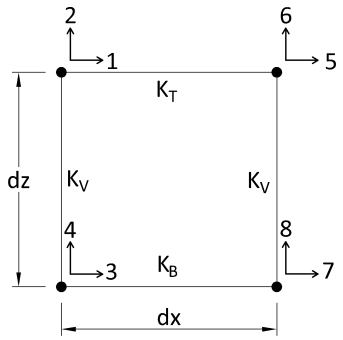


Figure 2.7: *Generic Truss Bar*

This concept, when applied to all four truss bars in the HyPT element, results in the linear system represented by Equation 2.2. The location of individual stiffness terms is determined based on which DOFs are being linked by that particular truss bar - the DOFs and truss bar notations are reiterated in Figure 2.8.

$$\begin{bmatrix} K_T & 0 & 0 & 0 & -K_T & 0 & 0 & 0 \\ 0 & K_{V,L} & 0 & -K_V & 0 & 0 & 0 & 0 \\ 0 & 0 & K_B & 0 & 0 & 0 & -K_B & 0 \\ 0 & -K_V & 0 & K_V & 0 & 0 & 0 & 0 \\ -K_T & 0 & 0 & 0 & K_T & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & K_V & 0 & -K_V \\ 0 & 0 & -K_B & 0 & 0 & 0 & K_B & 0 \\ 0 & 0 & 0 & 0 & 0 & -K_V & 0 & K_V \end{bmatrix} \begin{Bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \\ u_5 \\ u_6 \\ u_7 \\ u_8 \end{Bmatrix} = \begin{Bmatrix} F_1 \\ F_2 \\ F_3 \\ F_4 \\ F_5 \\ F_6 \\ F_7 \\ F_8 \end{Bmatrix} \tag{2.2}$$



where:

K_T = Top Truss Bar Stiffness

K_B = Bottom Truss Bar Stiffness

K_V = Left or Right Truss Bar Stiffness

Figure 2.8: *Element DOFs and Connecting Truss Bars*

2.2.3 Truss Bar Stiffness Matrix - Off-Diagonal Terms

The formulation of the stiffness matrix presented in the previous section implies that the top and bottom faces of the element behave independently. For example, if a unit displacement is applied at DOF #1, only the top truss bar will develop force while the bottom truss bar is unaffected as shown in Figure 2.9.

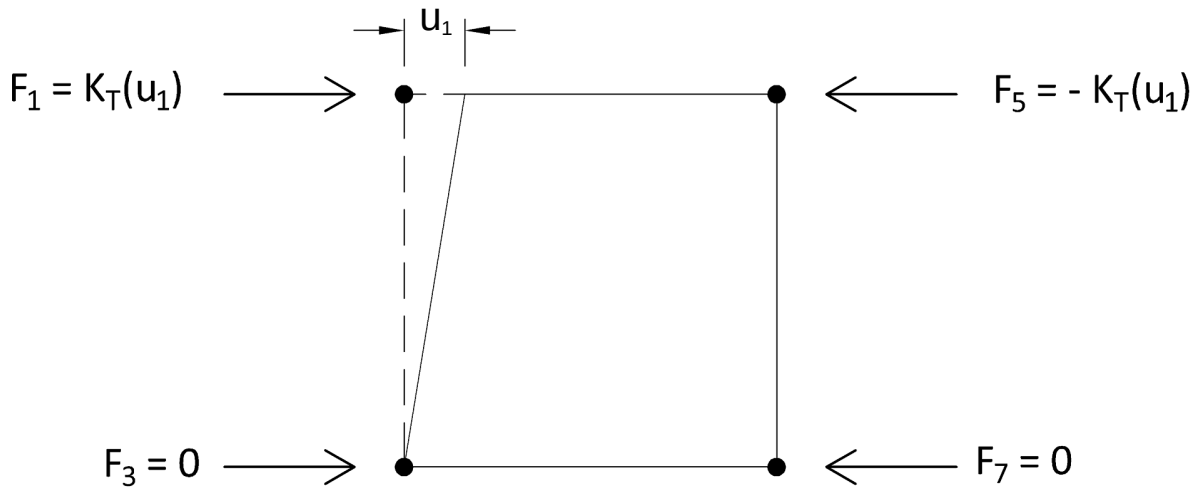


Figure 2.9: *Forces Developed in a Non-Linked Truss System*

Yet this is not a realistic scenario, as the bottom of the element is inherently linked to the top through the material (steel reinforcement bars and concrete) found over the depth of the section. Looking at it from the perspective of plane-sections, pushing on the top node of the element will result in a linearly varying strain over the whole section, which must result in some force transferred to the bottom node as well (Figure 2.10). Off-diagonal terms are required in the stiffness matrix to reflect this relationship, thereby linking the top and bottom truss bars on both the left and right side of the element.

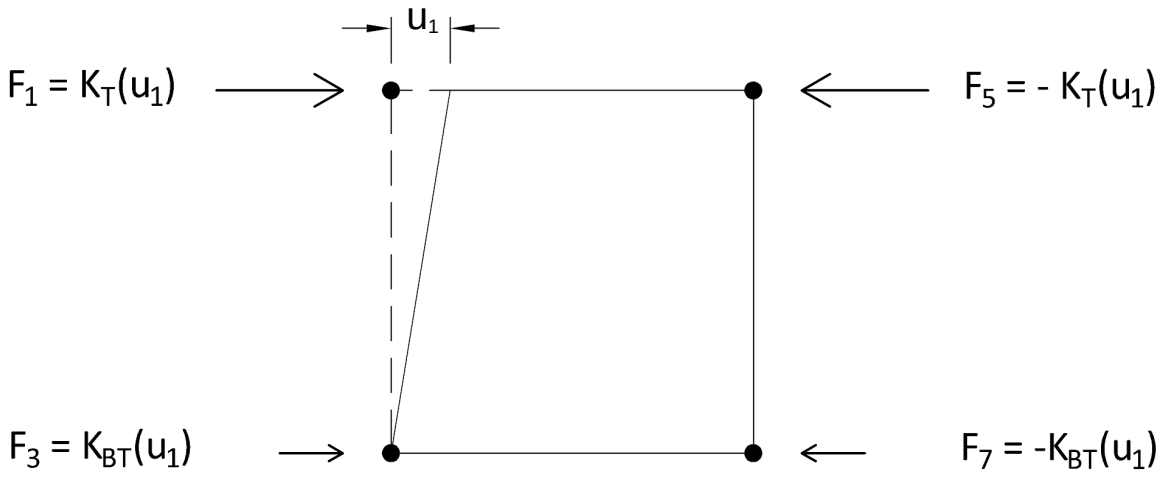


Figure 2.10: *Forces Developed in a Linked Truss System*

This concept can be further explained by examining the force equilibrium on the face of a homogeneous and linear elastic block with a unit displacement applied at the corner. A linear strain results in a triangular stress block, which can be transformed to equivalent forces at the nodes by maintaining rotational equilibrium in the system. These resultants are the F_1 and F_3 forces as shown in Figure 2.10 and 2.11.

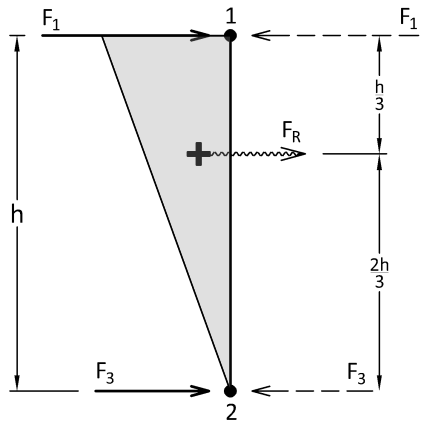


Figure 2.11: *Equivalent Nodal Forces Due to a Triangular Stress Block*

Equation 2.3 shows the relationship between the top and bottom truss bars (where $K_{BT} = K_{TB}$), as represented by a unit displacement on the left side of the element (Figure 2.10). The rest of the off-diagonal terms can be derived through the same exercise, simply applying a unit displacement on the right face.

$$\begin{bmatrix} K_T & K_{TB} \\ K_{BT} & K_B \\ -K_T & -K_{TB} \\ -K_{BT} & -K_B \end{bmatrix} \begin{Bmatrix} u_1 \\ u_3 \end{Bmatrix} = \begin{Bmatrix} F_1 \\ F_3 \\ F_5 \\ F_7 \end{Bmatrix} \tag{2.3}$$

Combining the diagonal and off-diagonal truss terms leads to system of equations represented by Equation 2.4. Note that the off-diagonal terms only exist for the horizontal truss bars, the vertical truss bars are not linked in the same manner (the reasoning behind this will be explained in the following section).

$$\begin{bmatrix} K_T & 0 & K_{TB} & 0 & -K_T & 0 & -K_{TB} & 0 \\ 0 & K_V & 0 & -K_V & 0 & 0 & 0 & 0 \\ K_{BT} & 0 & K_B & 0 & -K_{BT} & 0 & -K_B & 0 \\ 0 & -K_V & 0 & K_V & 0 & 0 & 0 & 0 \\ -K_T & 0 & -K_{TB} & 0 & K_T & 0 & K_{TB} & 0 \\ 0 & 0 & 0 & 0 & 0 & K_V & 0 & -K_V \\ -K_{BT} & 0 & -K_B & 0 & K_{BT} & 0 & K_B & 0 \\ 0 & 0 & 0 & 0 & 0 & -K_V & 0 & K_V \end{bmatrix} \begin{Bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \\ u_5 \\ u_6 \\ u_7 \\ u_8 \end{Bmatrix} = \begin{Bmatrix} F_1 \\ F_2 \\ F_3 \\ F_4 \\ F_5 \\ F_6 \\ F_7 \\ F_8 \end{Bmatrix} \tag{2.4}$$

2.2.4 Truss Bar Stiffness Terms - Calculations

Vertical Truss Bars

The two vertical truss bars provide stiffness in the transverse direction, which is only required for numerical stability. Since the HyPT element is formulated to span the whole height of the section, it does not explicitly rely on the vertical trusses to capture axial or flexural deformations, and assumes that clamping stresses are negligible. Therefore, to simplify these vertical truss terms a constant stiffness is assigned to the them based on the gross area of concrete, element height, and uncracked concrete elastic modulus. This calculation is expressed in Equation 2.5 and Figure 2.12.

$$K_v = \frac{E_c \left(d_x d_y\right)}{2 d_z} \tag{2.5}$$

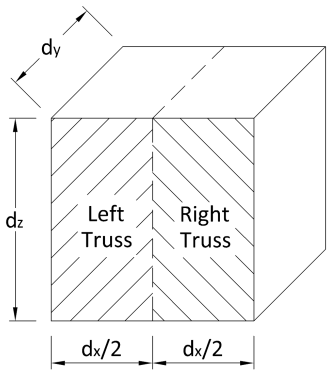


Figure 2.12: *Vertical Trusses Based on the Gross Cross-Section*

Horizontal Truss Bars

Axial and flexural deformations are represented by the elongation and contraction of the top and bottom truss bars. The stiffness terms of these components must therefore be calculated in a way that captures the nonlinear behaviour of reinforced concrete in both tension and compression. The goal is to relate an increasing strain state (based on the relative displacement of the four nodes of the element) to a degradation of the truss bar stiffness as both the steel and concrete reach their nonlinear ranges.

The HyPT element uses a "fiber model" model approach, whereby the section is divided into discrete components (concrete and steel layers), to calculate the separate stiffness terms. The procedure is as follows:

1. Find linear strain over height of section (based on nodal displacements)
2. Find axial force resultants in discrete components (secant stiffness method)
3. Increment strain at DOF of interest (stiffness method approach)
4. Calculate sectional forces due to strain increment
5. Transform to equivalent nodal forces (moment equilibrium)
6. Calculate stiffness terms

Step 1.

Based on the displacement of the four nodes (Figure 2.13) the strain in the horizontal trusses can be calculated through Equations 2.6. Assuming that plane-sections remain plane, the strain will vary linearly from the top to the bottom of the section. Displacements are taken as positive to the right and negative to the left, and compressive strains are negative and tensile strains are positive.

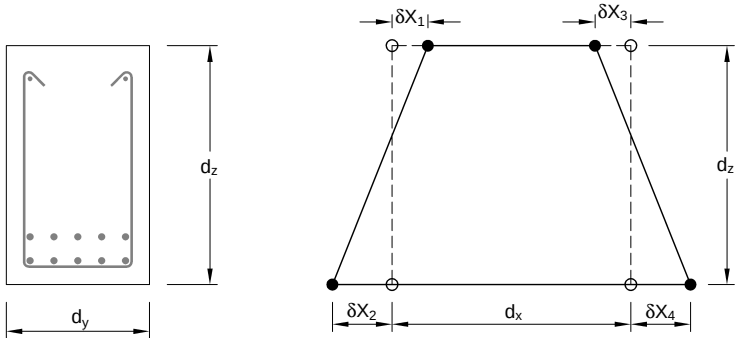


Figure 2.13: *Nodal Displacements to Calculate Horizontal Truss Strains*

$$\mathcal{E}_{top} = \frac{\delta X_3 - \delta X_3}{d_x}$$
$$\mathcal{E}_{bot} = \frac{\delta X_4 - \delta X_2}{d_x} \tag{2.6}$$

Step 2.

The internal forces in the cross-section can be found by integrating and summing the resulting stresses over the whole depth (Figure 2.14). The concrete stress is a continuous function over the depth (d), while the steel stress is expressed at discrete points ($d_{s,i}$) (Equation 2.7).

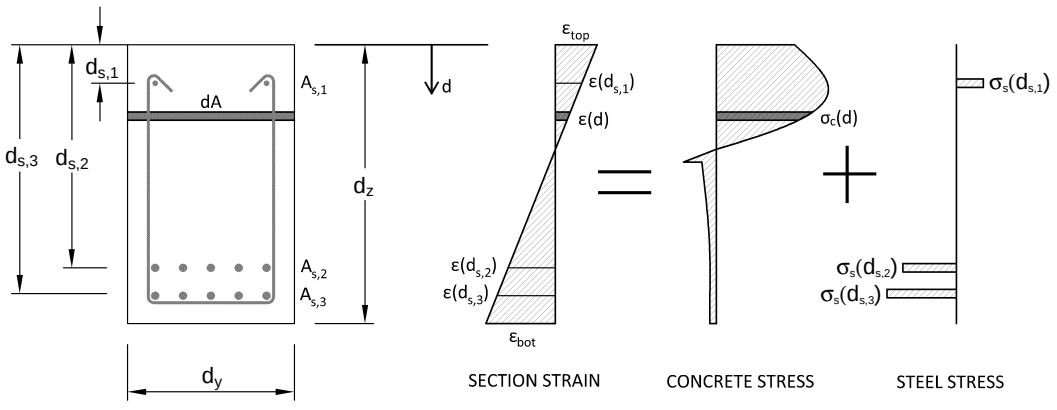


Figure 2.14: *Resulting Sectional Concrete and Steel Stresses*

$$F_c = \int_0^{d_z} \sigma_c(d) \cdot dA$$
$$F_s = \sum_{i=1}^{\#Layers} \sigma_s(d_{s,i}) \cdot A_{s,i} \tag{2.7}$$

The concrete expression can be simplified if the total force is expressed as the contribution from discrete slices, with a constant strain (Figure 2.15) and corresponding stress calculated at the center of the slice ($d_{c,i}$). The number of slices needed to accurately represent the integral depends on the degree of nonlinearity in the concrete function, although from experience using 10-20 layers results in a reasonable approximation. For a rectangular cross-section with a constant width, the integral can be reduced to Equation 2.8.

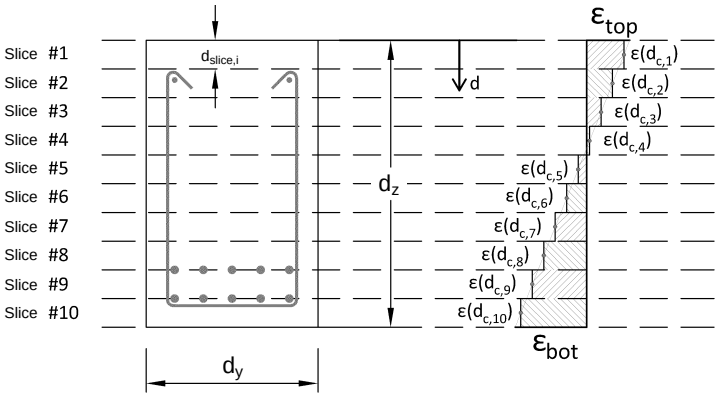


Figure 2.15: *Concrete Section Expressed as Discrete Slices*

$$F_c = d_y \cdot \sum_{i=1}^{\#Slices} \sigma_c(d_{c,i}) \cdot d_{slice,i} \tag{2.8}$$

To account for the concrete and steel material nonlinearity, the strains are mapped to their corresponding points on the material stress/strain curve (Figure 2.16). The forces can then be calculated in terms of the secant stiffness (Equation 2.9). Using the modular ratio (n) the steel stiffness is expressed in terms of the concrete stiffness in the corresponding slice (subtracting the area of concrete displaced by the steel).

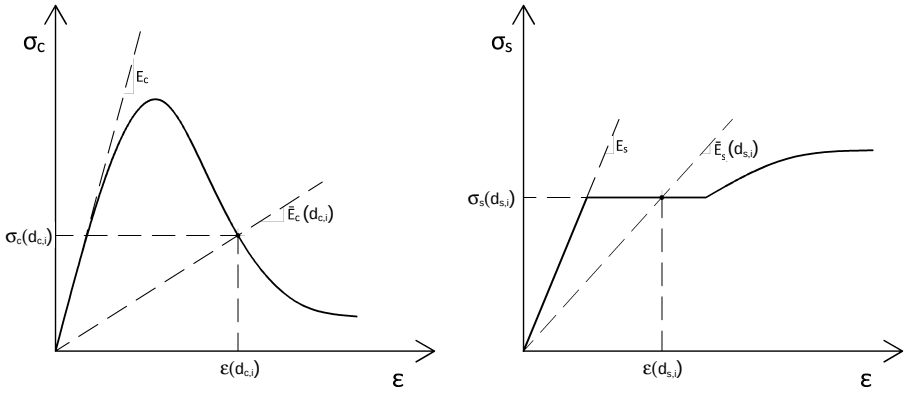


Figure 2.16: *Concrete (Left) and Steel (Right) Secant Stiffness Formulation*

$$\begin{aligned} F_c &= d_y \cdot \sum_{i=1}^{\#Slices} \bar{E}_c(d_{c,i}) \cdot \varepsilon(d_{c,i}) \cdot d_{slice,i} \\ F_s &= \sum_{i=1}^{\#Layers} \bar{E}_c(d_{s,i}) \cdot (n_i - 1) \cdot \varepsilon(d_{s,i}) \cdot A_{s,i} \end{aligned} \tag{2.9}$$

Step 3.

Recall the definition of stiffness (force per unit displacement) as it applies to the stiffness method. Where $K_{i,j}$ is the term that corresponds to the force at DOF j resulting from a unit displacement at DOF i, while keeping all other displacements at zero (Equation 2.10).

$$K_{i,j} = \frac{F_j}{\Delta_i} \tag{2.10}$$

For example, the truss stiffness matrix for the left face of the HyPT element is expressed in Equation 2.11.

$$\begin{bmatrix} K_{1,1} & K_{1,3} \\ K_{3,1} & K_{3,3} \end{bmatrix} \begin{Bmatrix} \Delta_1 \\ \Delta_3 \end{Bmatrix} = \begin{bmatrix} K_T & K_{TB} \\ K_{BT} & K_B \end{bmatrix} \begin{Bmatrix} \Delta_T \\ \Delta_B \end{Bmatrix} = \begin{Bmatrix} F_T \\ F_B \end{Bmatrix} \tag{2.11}$$

where:

$\Delta_T = \mathcal{E}_{top} \cdot d_x$

$\Delta_B = \mathcal{E}_{bot} \cdot d_x$

Using the stiffness method definition, the individual terms can be derived by applying an infinitesimal strain to the existing strain condition ($d\epsilon_{top}$ in Figure 2.17). Calculating $K_{1,1}$ and $K_{1,3}$ requires an increment in DOF 1 (top), while calculating $K_{3,3}$ and $K_{3,1}$ requires an increment in DOF 3 (bottom) (Equation 2.12).

$$\begin{aligned} K_{1,1} &= \frac{dF_T}{d\Delta_T} = \frac{dF_T}{d\mathcal{E}_{top} \cdot d_x} \\ K_{1,3} &= \frac{dF_B}{d\Delta_T} = \frac{dF_B}{d\mathcal{E}_{top} \cdot d_x} \\ K_{3,3} &= \frac{dF_B}{d\Delta_B} = \frac{dF_B}{d\mathcal{E}_{bot} \cdot d_x} \\ K_{3,1} &= \frac{dF_T}{d\Delta_B} = \frac{dF_T}{d\mathcal{E}_{bot} \cdot d_x} \end{aligned} \tag{2.12}$$

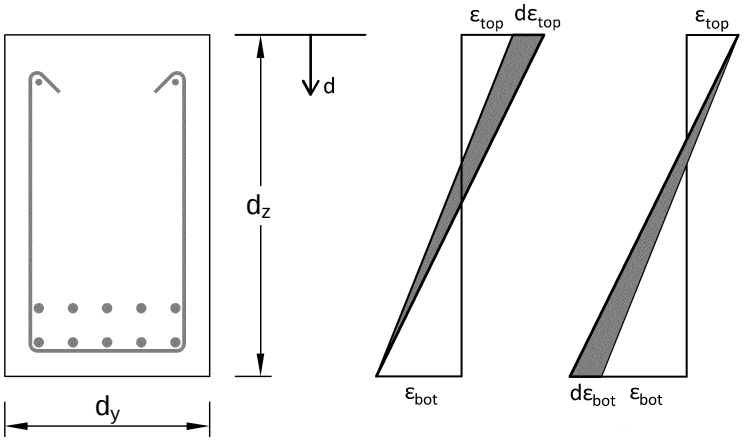


Figure 2.17: *Incrementing Top (Left) or Bottom (Right) Truss Strain*

Step 4.

Applying the same rationale used to explain the off-diagonal terms (Section 2.2.3) means that a unit displacement (or infinitesimal strain) that is applied at either the top or bottom truss must result in a linearly decreasing strain increment - shown in Equation 2.13, where d is measured from the top of the section.

$$\begin{aligned} \varepsilon(d) &= \frac{d_z - d}{d_z} \cdot d\mathcal{E}_{top} \\ \varepsilon(d) &= \frac{d}{d_z} \cdot d\mathcal{E}_{bot} \end{aligned} \tag{2.13}$$

The incremental force contribution from the various cross-sectional layers is then found by substituting the appropriate incremented strain expression into the material force summation, which results in Equation 2.14 and 2.15. The strain term based on the nodal coordinates is replaced by the incremented strain expression, since only the additional force contribution is of interest when calculating the stiffness term. For example, when calculating the $K_{1,1}$ term a strain increment is applied to the top truss - the concrete slices closer to the top of the section would have a larger incremented strain and force contribution than the slices closer to the bottom. This leads to the intuitive result that the top slices contribute more to the stiffness of the top truss than the bottom truss.

$$d\mathcal{E}_{top} \rightarrow \begin{cases} dF_c = \dfrac{d_y \cdot d\mathcal{E}_{top}}{d_z} \cdot \displaystyle\sum_{i=1}^{\#Slices} (d_z - d_{c,i}) \cdot \bar{E}_c(d_{c,i}) \cdot d_{slice,i} \\ dF_s = \quad \dfrac{d\mathcal{E}_{top}}{d_z} \quad \cdot \displaystyle\sum_{i=1}^{\#Layers} (d_z - d_{s,i}) \cdot \bar{E}_c(d_{s,i}) \cdot (n_i - 1) \cdot A_{s,i} \end{cases} \tag{2.14}$$

$$d\mathcal{E}_{bot} \rightarrow \begin{cases} dF_c = \dfrac{d_y \cdot d\mathcal{E}_{bot}}{d_z} \cdot \displaystyle\sum_{i=1}^{\#Slices} (d_{c,i}) \cdot \bar{E}_c(d_{c,i}) \cdot d_{slice,i} \\ dF_s = \quad \dfrac{d\mathcal{E}_{bot}}{d_z} \quad \cdot \displaystyle\sum_{i=1}^{\#Layers} (d_{s,i}) \cdot \bar{E}_c(d_{s,i}) \cdot (n_i - 1) \cdot A_{s,i} \end{cases} \tag{2.15}$$

Step 5.

The incremental sectional forces are now transformed to equivalent nodal forces by solving moment equilibrium across the section. The top or bottom nodal forces are calculated as the sum of the concrete and steel moment contributions about the bottom or top truss respectively, divided by the lever arm (Equation 2.16).

.

$$\begin{aligned} dF_T &= \frac{dM_{c,bot} + dM_{s,bot}}{d_z} \\ dF_B &= \frac{dM_{c,top} + dM_{s,top}}{d_z} \end{aligned} \tag{2.16}$$

Equations 2.17 and 2.18 show the incremental moment equations resulting from a top or bottom strain increment respectively. The first term in the subscript refers to the material type, and the second term refers to the moment axis.

$$d\mathcal{E}_{top} \rightarrow \begin{cases} dM_{c,bot} = \dfrac{d_y \cdot d\mathcal{E}_{top}}{d_z} \cdot \sum_{i=1}^{\#Slices} (d_z - d_{c,i})^2 \cdot \bar{E}_c(d_{c,i}) \cdot d_{slice,i} \\ dM_{c,top} = \dfrac{d_y \cdot d\mathcal{E}_{top}}{d_z} \cdot \sum_{i=1}^{\#Slices} (d_z - d_{c,i})(d_{c,i}) \cdot \bar{E}_c(d_{c,i}) \cdot d_{slice,i} \\ dM_{s,bot} = \dfrac{d\mathcal{E}_{top}}{d_z} \cdot \sum_{i=1}^{\#Layers} (d_z - d_{s,i})^2 \cdot \bar{E}_c(d_{s,i}) \cdot (n_i - 1) \cdot A_{s,i} \\ dM_{s,bot} = \dfrac{d\mathcal{E}_{top}}{d_z} \cdot \sum_{i=1}^{\#Layers} (d_z - d_{s,i})(d_{s,i}) \cdot \bar{E}_c(d_{s,i}) \cdot (n_i - 1) \cdot A_{s,i} \end{cases} \tag{2.17}$$

$$d\mathcal{E}_{bot} \rightarrow \begin{cases} dM_{c,bot} = \dfrac{d_y \cdot d\mathcal{E}_{bot}}{d_z} \cdot \sum_{i=1}^{\#Slices} (d_{c,i})(d_z - d_{c,i}) \cdot \bar{E}_c(d_{c,i}) \cdot d_{slice,i} \\ dM_{c,top} = \dfrac{d_y \cdot d\mathcal{E}_{bot}}{d_z} \cdot \sum_{i=1}^{\#Slices} (d_{c,i})^2 \cdot \bar{E}_c(d_{c,i}) \cdot d_{slice,i} \\ dM_{s,bot} = \dfrac{d\mathcal{E}_{bot}}{d_z} \cdot \sum_{i=1}^{\#Layers} (d_{s,i})(d_z - d_{s,i}) \cdot \bar{E}_c(d_{s,i}) \cdot (n_i - 1) \cdot A_{s,i} \\ dM_{s,bot} = \dfrac{d\mathcal{E}_{bot}}{d_z} \cdot \sum_{i=1}^{\#Layers} (d_{s,i})^2 \cdot \bar{E}_c(d_{s,i}) \cdot (n_i - 1) \cdot A_{s,i} \end{cases} \tag{2.18}$$

Step 6.

The separate stiffness terms can now be calculated as previously shown (Equation 2.12), by dividing the transformed nodal force by either $d\mathcal{E}_{top} \cdot d_x$ or $d\mathcal{E}_{bot} \cdot d_x$. Note that the stiffness matrix is symmetric across the diagonal (e.g. $K_{1,3} = K_{3,1}$ etc.).

2.3 Shear Panel Stiffness Terms

Shear stiffness of the HyPT element is provided by a two-dimensional panel at the center of the element, which connects all four nodes. The shear stresses and strains are related by the secant shear stiffness ($\bar{G}$) as shown in Equation 2.19 and Figure 2.18, where the secant shear stiffness term can be calculated from an MCFT analysis of the panel [1, 11]. The following section will explain how the shear stiffness is represented in the HyPT element formulation.

$$\tau_{xz} = \tau_{zx} = \bar{G} \cdot \gamma_{xz} \tag{2.19}$$

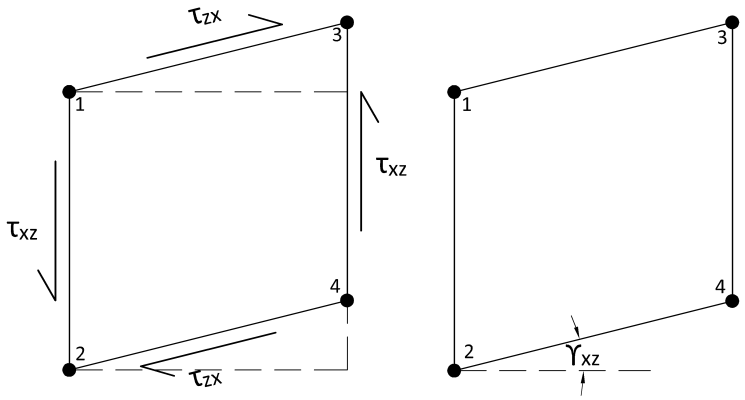


Figure 2.18: *Shear Stresses (Left) Related to Shear Deformations (Right)*

2.3.1 Deformation Patterns

Shear strain is a measure of angular deviation, which cannot be explicitly captured by the system of one-dimensional truss bars that are used for flexural and axial deformations. Therefore, the shear panel is necessary to represent the deformation patterns shown in Figure 2.19. While positive and negative shear are arbitrary definitions with respect to the shear stiffness, for the derivation of the stiffness matrix the sign convention shown below will be used.

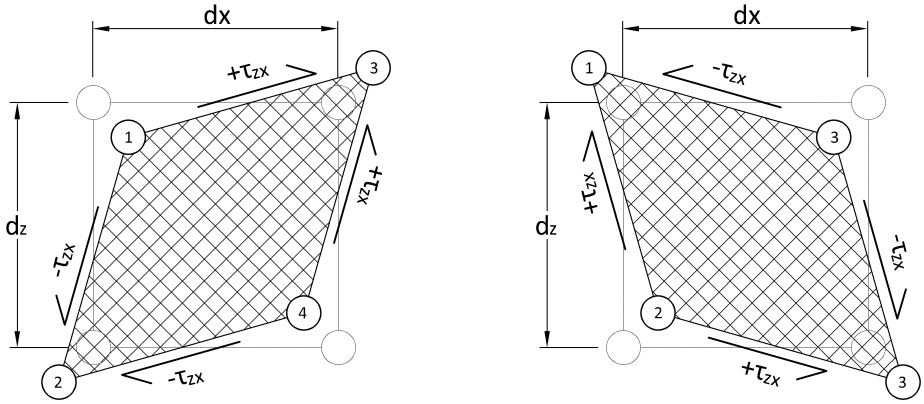


Figure 2.19: *A Representation of Positive (Left) and Negative (Right) Shear Stresses in the Element*

2.3.2 Expressing Nodal Forces in Term of Applied Shear Stress

The shear stress acting on a plane is assumed to be distributed equally between adjacent nodes (i.e. $\mathcal{T}_{xz}$ is constant in Figure 2.20). The resulting nodal forces are expressed in Equation 2.20.

$$\begin{aligned} F'_x &= \frac{1}{2}\tau_{xz} \cdot A_{face} = \frac{1}{2}\bar{G}\gamma_{xz} \cdot d_y d_x \\ F'_z &= \frac{1}{2}\tau_{xz} \cdot A_{face} = \frac{1}{2}\bar{G}\gamma_{xz} \cdot d_y d_z \end{aligned} \tag{2.20}$$

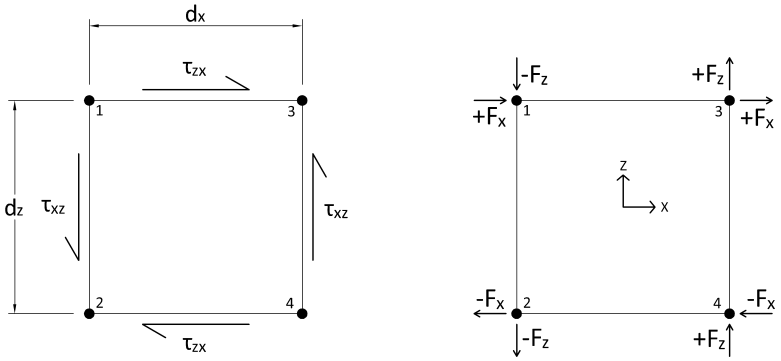


Figure 2.20: *Positive Shear Stress (Left) and Resulting Nodal Forces (Right)*

The forces calculated in Equation 2.20 do not reflect the fact that the effective shear zone in a reinforced concrete section does not span the whole height. A more accurate representation of the panel stresses is shown in Figure 2.21, where the effective shear zone is defined by the location of the resultant tension and compression axial forces in the section. The forces in the effective zone must still be consistent with the location of the nodes, and must be tranformed to equivalent nodal forces. This is done by modifying Equation 2.20 while keeping rotational and force equilibrium, which leads to Equation 2.21.

$$\begin{aligned} F_x &= F'_x \cdot \frac{d_v}{d_z} \\ F_z &= F'_z \cdot \frac{d_v}{d_z} \end{aligned} \tag{2.21}$$

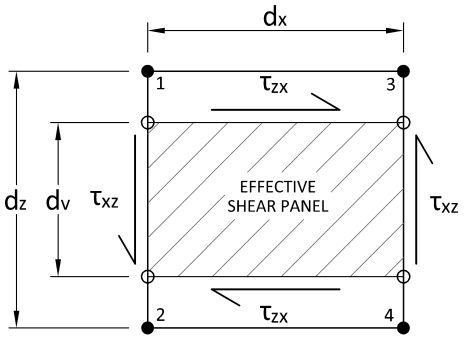


Figure 2.21: *Shear Stresses Acting on the Effective Shear Panel*

2.3.3 Expressing Shear Strain in Terms of Nodal Displacements

Shear strains in the panel are only a component of the total potential deformation, therefore it is necessary to find an expression to extract the shear strain from an arbitrary deformation pattern. This is done by visualizing the relative vertical displacement of the right side of the element (Figure 2.22) as being composed of three different types of displacements: rigid body, curvature and shear. This relationship is expressed in Equation 2.22, where the sign convention is based on the axis defined in Figure 2.20 (i.e. up & right = +).

$$\underbrace{\frac{\Delta z_3 + \Delta z_4}{2}}_{\text{Avg. Right}} - \underbrace{\frac{\Delta z_1 + \Delta z_2}{2}}_{\text{Avg. Left}} = \underbrace{\theta_L \cdot d_x}_{\text{Rigid Body}} + \underbrace{\phi d_x \cdot \frac{d_x}{2}}_{\text{Curvature}} + \underbrace{\gamma_{xz} \cdot d_x}_{\text{Shear}} \tag{2.22}$$

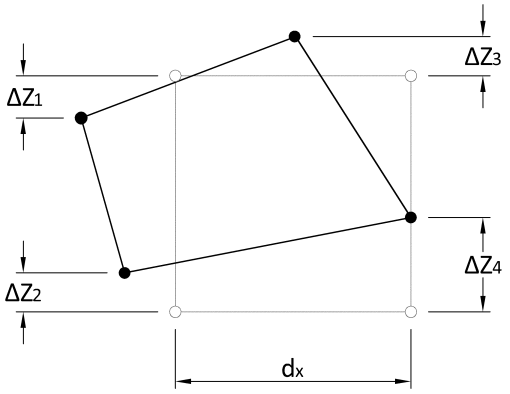


Figure 2.22: *Arbitrary Deformation Pattern - Relative Vertical Displacements*

Rigid body displacement is defined as a rotation of the panel. Assuming that the left corner is fixed, as shown in Figure 2.23, the relative vertical displacement of the right side is expressed by Equation 2.23.

$$\frac{\Delta z_3 + \Delta z_4}{2} = \theta_L \cdot d_x \tag{2.23}$$

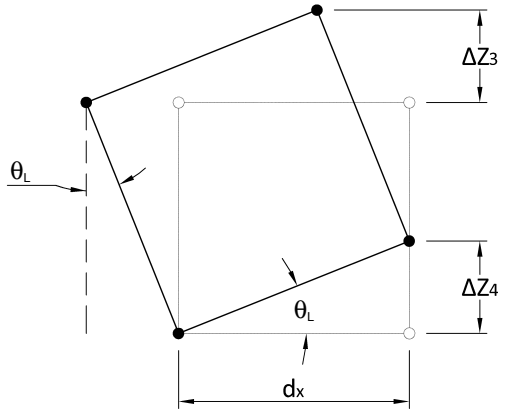


Figure 2.23: *Vertical Displacement of the Right Side due to Rigid Body Displacement*

The rotation of the left or right side is expressed in Equation 2.24 (counter-clockwise rotation is positive).

$$\theta_L = \frac{\Delta x_2 - \Delta x_1}{d_z}$$
$$\theta_R = \frac{\Delta x_4 - \Delta x_2}{d_z} \tag{2.24}$$

Curvature displacement is determined by fixing the left face, then assuming that only the right face displaces (Figure 2.24). By formulation, the curvature is constant over the length of a HyPT element so applying the Moment Area Theorem #2 results in 2.25.

$$\frac{\Delta z_3 + \Delta z_4}{2} = \phi d_x \cdot \frac{d_x}{2} \tag{2.25}$$

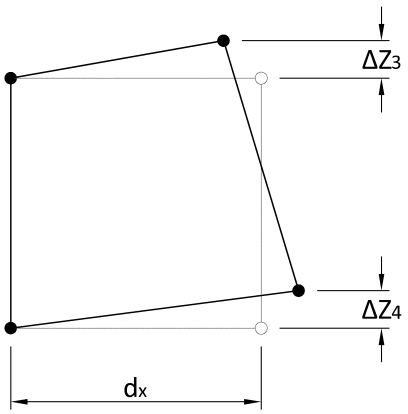


Figure 2.24: *Vertical Displacement of the Right Side due to Curvature Displacement*

Moment Area Theorem #1 states that the change in rotation between two points is equal to the area under the curvature diagram, which for a constant curvature region leads to Equation 2.26.

$$\phi d_x = \theta_R - \theta_L \tag{2.26}$$

Substitute Equation 2.24 into 2.26 and rearranging to solve for the curvature results in Equation 2.27).

$$\phi = \frac{(\Delta x_4 - \Delta x_3) - (\Delta x_2 - \Delta x_1)}{d_z d_x} \tag{2.27}$$

Shear displacement is determined by fixing the left face and assuming that the right face displaces due to shear (small angle assumption). The relative displacement is shown in Figure 2.25 and expressed by Equation 2.28.

$$\frac{\Delta z_3 + \Delta z_4}{2} = \gamma_{xz} d_x \tag{2.28}$$

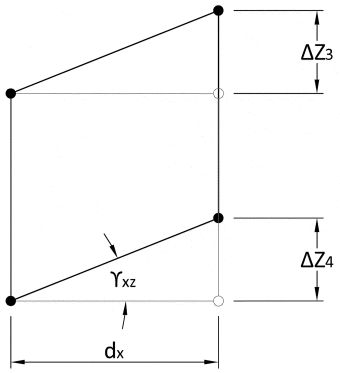


Figure 2.25: *Vertical Displacement of the Right Side due to Shear Strain.*

The final result is shown in Equation 2.29, where the shear strain can be expressed in terms of nodal displacements. The expression is found by substituting Equation 2.24, 2.27 & 2.28 into Equation 2.22 and solving for the shear term.

$$\gamma_{xz} = \frac{\Delta x_1}{2d_z} - \frac{\Delta z_1}{2d_x} - \frac{\Delta x_2}{2d_z} - \frac{\Delta z_2}{2d_x} + \frac{\Delta x_3}{2d_z} + \frac{\Delta z_3}{2d_x} - \frac{\Delta x_4}{2d_z} + \frac{\Delta z_4}{2d_x} \tag{2.29}$$

2.3.4 Shear Panel Stiffness Matrix

Substituting the shear strain expression (Equation 2.29) into the expressions for the nodal forces (Equation 2.20) results in the stiffness matrix and system of linear equations represented by Equation 2.30.

$$\frac{\bar{G}d_y d_v}{4d_z} \cdot \begin{bmatrix} \frac{d_x}{d_z} & -\frac{d_x}{d_x} & -\frac{d_x}{d_z} & -\frac{d_x}{d_x} & \frac{d_x}{d_z} & \frac{d_x}{d_x} & -\frac{d_x}{d_z} & \frac{d_x}{d_x} \\ -\frac{d_z}{d_z} & \frac{d_z}{d_x} & \frac{d_z}{d_z} & \frac{d_z}{d_x} & -\frac{d_z}{d_z} & -\frac{d_z}{d_x} & \frac{d_z}{d_z} & -\frac{d_z}{d_x} \\ -\frac{d_x}{d_z} & \frac{d_x}{d_x} & \frac{d_x}{d_z} & \frac{d_x}{d_x} & -\frac{d_x}{d_z} & -\frac{d_x}{d_x} & \frac{d_x}{d_z} & -\frac{d_x}{d_x} \\ -\frac{d_z}{d_z} & \frac{d_z}{d_x} & \frac{d_z}{d_z} & \frac{d_z}{d_x} & -\frac{d_z}{d_z} & -\frac{d_z}{d_x} & \frac{d_z}{d_z} & -\frac{d_z}{d_x} \\ \frac{d_x}{d_z} & -\frac{d_x}{d_x} & -\frac{d_x}{d_z} & -\frac{d_x}{d_x} & \frac{d_x}{d_z} & \frac{d_x}{d_x} & -\frac{d_x}{d_z} & \frac{d_x}{d_x} \\ \frac{d_z}{d_z} & -\frac{d_z}{d_x} & -\frac{d_z}{d_z} & -\frac{d_z}{d_x} & \frac{d_z}{d_z} & \frac{d_z}{d_x} & -\frac{d_z}{d_z} & \frac{d_z}{d_x} \\ -\frac{d_x}{d_z} & \frac{d_x}{d_x} & \frac{d_x}{d_z} & \frac{d_x}{d_x} & -\frac{d_x}{d_z} & -\frac{d_x}{d_x} & \frac{d_x}{d_z} & -\frac{d_x}{d_x} \\ \frac{d_z}{d_z} & -\frac{d_z}{d_x} & -\frac{d_z}{d_z} & -\frac{d_z}{d_x} & \frac{d_z}{d_z} & \frac{d_z}{d_x} & -\frac{d_z}{d_z} & \frac{d_z}{d_x} \end{bmatrix} \begin{Bmatrix} \Delta x_1 \\ \Delta z_1 \\ \Delta x_2 \\ \Delta z_2 \\ \Delta x_3 \\ \Delta z_3 \\ \Delta x_4 \\ \Delta z_4 \end{Bmatrix} = \begin{Bmatrix} F_{x1} \\ F_{z1} \\ F_{x2} \\ F_{z2} \\ F_{x3} \\ F_{z3} \\ F_{x4} \\ F_{z4} \end{Bmatrix} \tag{2.30}$$

The secant shear stiffness must be determined at each iteration through an MCFT analysis, following the same principles outlined in the membrane element formulations published by Professor Vecchio [11]. The HyPT shear panel follows a displacement-based procedure, where the input strains to the MCFT (ϵ_x & γ_{xz}) are based on the nodal displacements of the element from the previous iteration, while the transverse/clamping stress (σ_z) is assumed to be 0. The outputs from this calculation are: σ_x, τ_{xz}, and ϵ_z.

2.4 Post-Cracking Interaction Terms

When the concrete cracks in shear, additional tensile forces must be transferred into the longitudinal bars to satisfy equilibrium [4]. Additional terms must be added to the HyPT element stiffness matrix to reflect the additional forces that exist at the nodes post-cracking. The structural mechanics underlying these terms is explained in the following section.

2.4.1 Uncracked Concrete

Uncracked reinforced concrete can be treated as an isotropic material, where the force equilibrium for a pure shear element is shown in Figure 2.26. The horizontal component of the principal compression and tension balance perfectly at the section, while the vertical resultant is equal to the applied shear

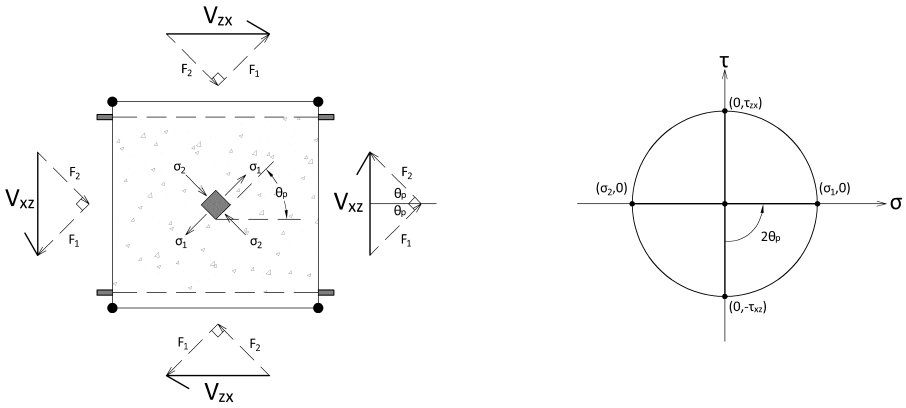


Figure 2.26: *Force Equilibrium (Left) and Stress State (Right) for Shear in Uncracked Reinforced Concrete*

2.4.2 Cracked Concrete

When concrete cracks the tensile capacity is significantly reduced, but due to tension stiffening the average principal tensile stress in the concrete does not go to zero (MCFT formulation [1]). The horizontal components of the compression and tension forces no longer balance, therefore an additional axial force (F_x) is necessary to balance the internal force polygon as shown in Figure 2.27. The F_1 force corresponds to the post-cracking tensile capacity in the concrete.

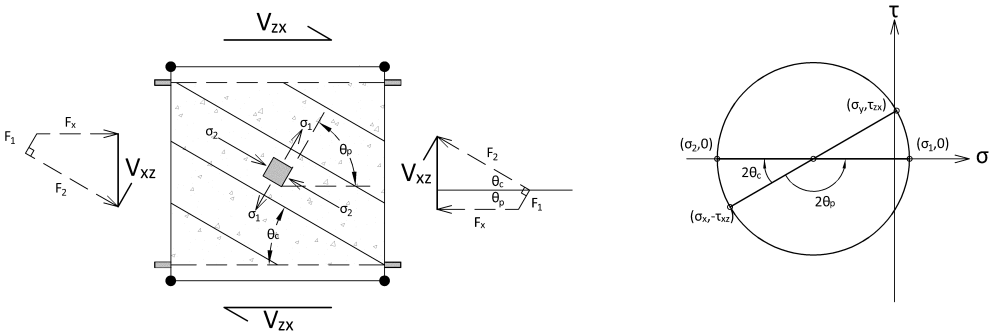


Figure 2.27: *Force Equilibrium (Left) and Stress State (Right) for Shear in Cracked Reinforced Concrete*

For the purpose of this derivation, a conservative assumption is made that there is no post-cracking tensile capacity (CFT formulation [21]). The simplified force polygon and stress state are shown in Figure 2.28.

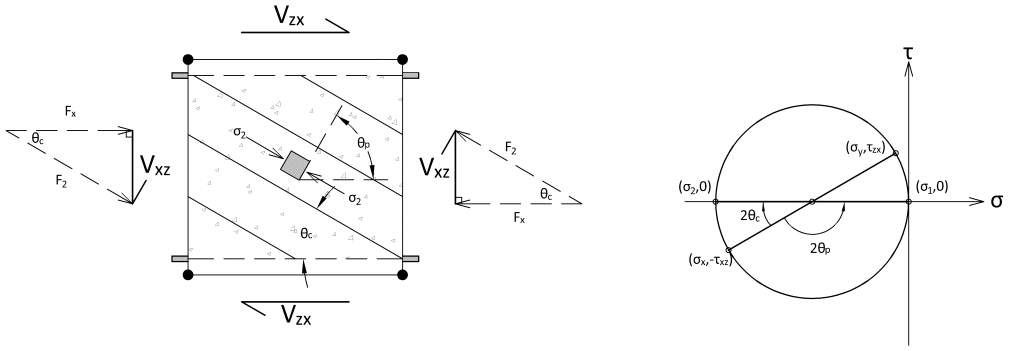


Figure 2.28: *Simplified Force (Left) and Stress State (Right) for Shear in Cracked Reinforced Concrete*

2.4.3 Post-Cracking Chord Forces

The axial force required to balance the horizontal component of the compression struts is carried as an additional tensile force (F'_h) in the longitudinal reinforcement. The net axial force on the section is zero, therefore the sum of the additional tension in the reinforcement must be equal to the horizontal component of the compression struts as shown in Figure 2.29. The load is assumed to be evenly distributed between the top and bottom chords, because the tension is uniform over the section.

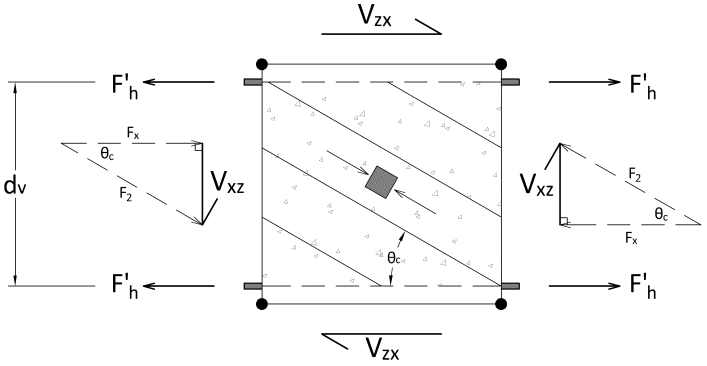


Figure 2.29: *Additional Horizontal Force Carried in the Section Chords*

Assuming a uniformly applied shear stress over the effective depth, the horizontal component of the strut can be expressed by Equation 2.31.

$$F_x = \tau_{xz} d_v d_y \cdot \cot(\theta_c) \tag{2.31}$$

Substituting Equation 2.19 for the shear stress and distributing the force equally to the top and bottom chord results in Equation 2.32.

$$F'_h = \frac{F_x}{2} = \frac{\bar{G}\gamma_{xz} d_v d_y}{2} \cdot \cot(\theta_c) \tag{2.32}$$

Transforming the forces on the longitudinal bars to the nodal coordinates, similar to the procedure discussed in the derivation of the truss bar stiffness terms (Section 2.2.4), results in Equation 2.33.

$$F_h = F'_h \cdot \frac{d_v}{d_z} = \frac{\bar{G}\gamma_{xz} d_v^2 d_y}{2d_z} \cdot \cot(\theta_c) \tag{2.33}$$

2.4.4 Post-Cracking Interaction Stiffness Matrix

Regardless of the sign of the shear that causes cracking, the direction of the resulting additional forces on the nodes is always tensile, as shown in Figure 2.30.

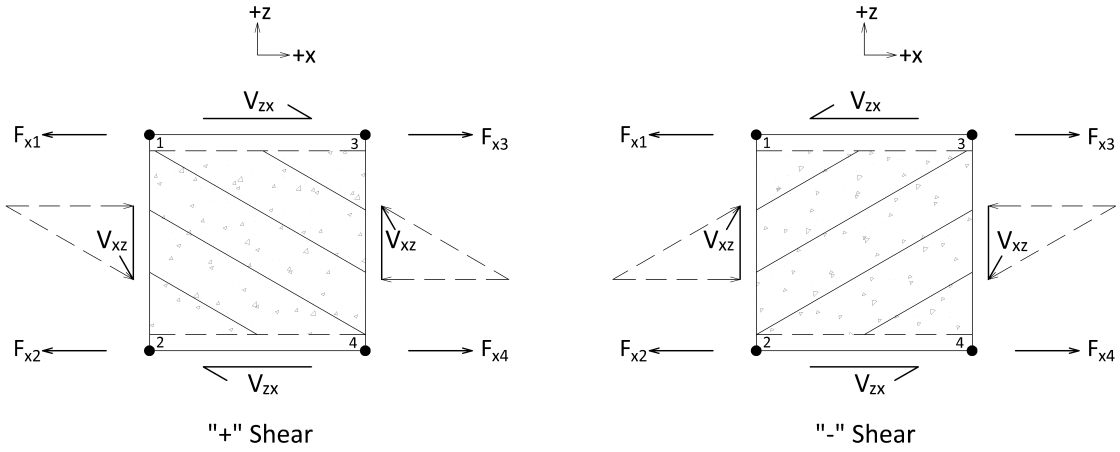


Figure 2.30: *Post-Cracking Forces Independent of the Applied Shear Direction*

Substituting the shear strain expression (Equation 2.29) into the additional horizontal force expression (Equation 2.33) results in the system of equations shown in Equation 2.34. Note that the top sign is for positive shear strains, while the bottom sign is for negative shear strains. The unidirectionality of the post-cracking forces leads to the non-symmetry of the matrix, which is not typical for a traditional finite element formulation.

$$\begin{bmatrix} \mp a & \pm b & \pm a & \pm b & \mp a & \mp b & \pm a & \mp b \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \mp a & \pm b & \pm a & \pm b & \mp a & \mp b & \pm a & \mp b \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \pm a & \mp b & \mp a & \mp b & \pm a & \pm b & \mp a & \pm b \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \pm a & \mp b & \mp a & \mp b & \pm a & \pm b & \mp a & \pm b \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \begin{Bmatrix} \Delta x_1 \\ \Delta z_1 \\ \Delta x_2 \\ \Delta z_2 \\ \Delta x_3 \\ \Delta z_3 \\ \Delta x_4 \\ \Delta z_4 \end{Bmatrix} = \begin{Bmatrix} F_{x1} \\ 0 \\ F_{x2} \\ 0 \\ F_{x3} \\ 0 \\ F_{x4} \\ 0 \end{Bmatrix} \tag{2.34}$$

The constants (a & b) are represented by Equations 2.35, where the secant shear stiffness is the only unknown variable, and is found in the same way discussed in Section 2.3.4.

$$a = \frac{\bar{G} d_v^2 d_y}{4 d_z^2} \cdot \cot(\theta_c)$$
$$b = \frac{\bar{G} d_v^2 d_y}{4 d_z d_x} \cdot \cot(\theta_c) \tag{2.35}$$

The axial forces that are developed in the z-direction in a cracked element are not of interest, hence the 0-terms in Equation 2.34. These terms could be derived with same procedure just described, looking at the top and bottom instead of the left and right faces. But these terms can be neglected since the HyPT element effectively neglects clamping stresses and assumes a large and constant stiffness in the vertical truss bars; modifying the corresponding vertical stiffness terms would have a negligible impact. Recall that the calculation of the secant shear stiffness is also based on the conservative assumption of zero clamping stress.

2.5 Element Verification

An extensive verification study was performed to determine the accuracy of the 2d-HyPT element in the context of predicting the load-deformation response of reinforced concrete structures. The 2d-HyPT element was implemented in the analysis program Augustus-II, which was used for the member level analysis of slender shear critical beams published in the ACI-DAfStb Databases [27, 28], followed by the large-scale analysis of reinforced concrete frames previously tested at the University of Toronto [29, 30].

2.5.1 Methodology

Reinforced concrete cross-sections are defined with Response-2000 [7], and then referenced in a specially formatted global structural geometry text file. This serves as the input file for the Augustus-II program, which formulates the global stiffness matrix (based on the HyPT element formulation) and then solves the linear system of equations. The process is summarized in Figure 2.31, and a detailed description of this methodology can be found in Section 4.3 of the thesis written by Zaeem [25].

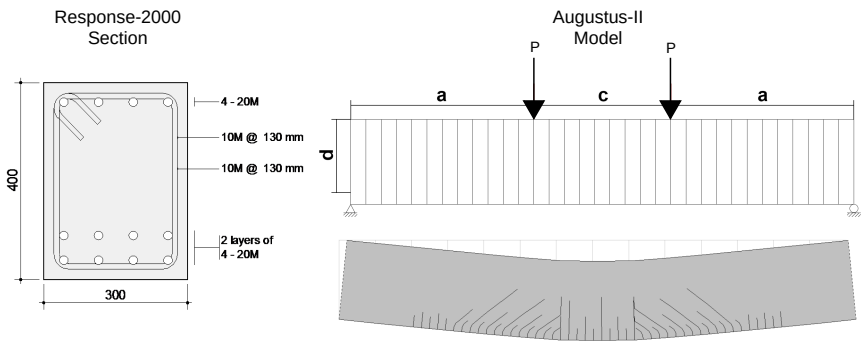


Figure 2.31: *HyPT Element Implementated with Response-2000 (Left) and Augustus-II (Right)*

2.5.2 Shear Critical Beam Database Analysis

An Augustus-II analysis was run for each of the reinforced concrete beams found in the ACI database for shear critical tests - the predicted failure load from this analysis was then compared to the recorded experimental failure load (Exp./Pred.). A ratio greater than 1.0 implied that the analysis was conservative and under-predicted the actual failure load, which in theory is a desirable outcome from a design perspective since the safety of the structure is guaranteed. Conservative results are especially important in shear critical cases, since the failure mechanism of such structures is brittle and occurs without much warning. Shear failure is also difficult to capture accurately, therefore the ability of the HyPT element to consistently and conservatively estimate the failure of the database beams is a significant achievement. The databases are summarized in Appendix A.

Full Dataset

The database results are divided between beams with [28] and without [27] stirrups, presented in Figures 2.32 & 2.33 respectively. The results were further subdivided into point or uniformly loaded rectangular beams, and point-loaded T-beams. To determine whether there is any significant relationship between the predictive capabilities of the element and geometric properties of the beams being tested, each figure shows the same data plotted against four different parameters. For beams without stirrups (Figure 2.32) the trend indicated that predictions improve for deeper cross-sections (top left), more lightly reinforced cross-sections (bottom left), and more slender beams (top right). The dataset for beams with stirrups (Figure 2.33) is much smaller, and hence these trends are not as easily determined.

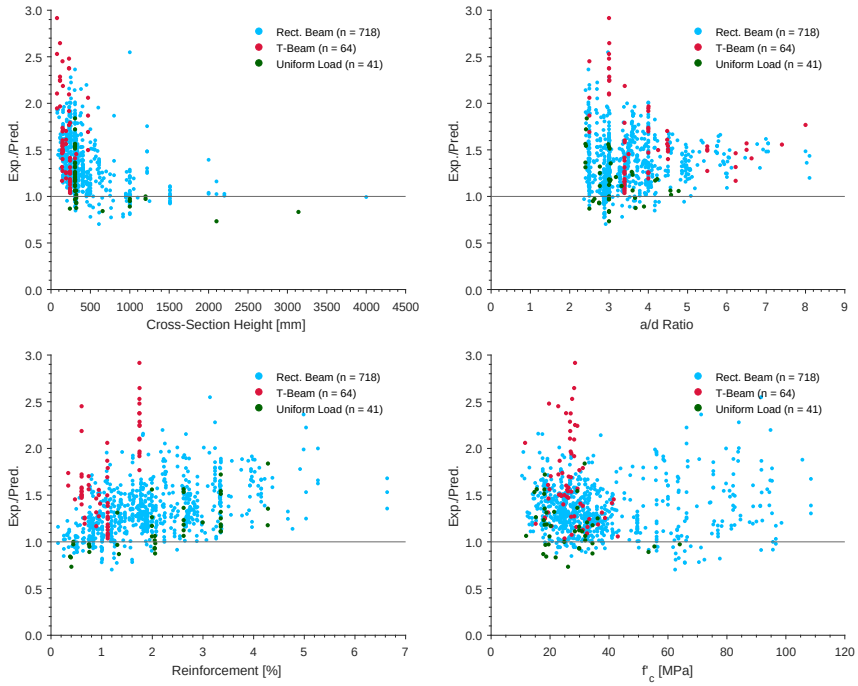


Figure 2.32: *Full Dataset Analysis Results - Shear Critical Beams (No Stirrups)*

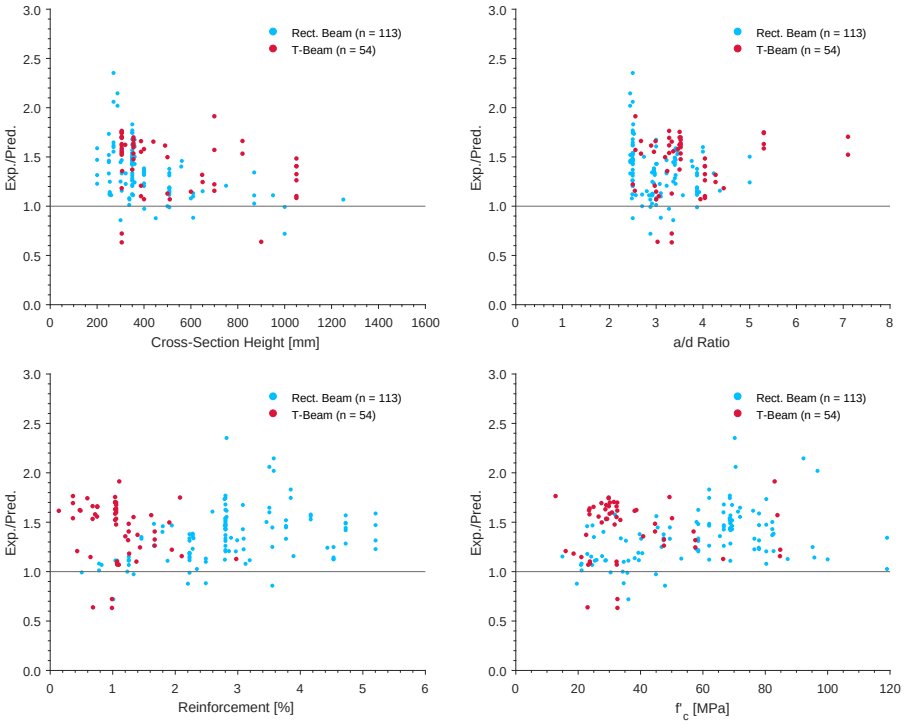


Figure 2.33: *Full Dataset Analysis Results - Shear Critical Beams (Stirrups)*

Table 2.1 presents the statistics of the full database analysis performed in Augustus-II compared to the American (ACI), European (EC) and Canadian (CSA) design codes. The code results are taken from a previous study [31] using the 2013 version of the database, which has since been updated leading to a different number of beams examined in the current study.

The Augustus-II results are represented with a normal curve that has the properties listed in the table. The 5^{th} percentile value indicates the Exp./Pred. ratio under which 5% of the total tests fall (a value close to 1.0 is desirable). The Augustus-II analysis is shown to provide good results - the averages fall within the ranges of the codes, with an improved coefficient of variation. The rectangular beams with both point and distributed loads are much better represented than the T-beams.

Table 2.1: Database Summary

Type[*]	*No Stirrups*				*Stirrups*			
	n	μ	*COV*	5^{th} %	n	μ	*COV*	5^{th} %
ACI 318-11	784	1.42	38.3 %	-	170	1.52	22.3 %	-
EC-2	784	1.10	27.9 %	-	170	1.44	17.9 %	-
CSA A23.3-14	784	1.22	22.3 %	-	170	1.29	29.8 %	-
Augustus-II	823	1.30	15.8 %	0.96	167	1.37	19.5 %	0.93
Rect. Beam	718	1.30	15.2 %	0.97	113	1.33	16.6 %	0.96
T-Beam	64	1.51	16.5%	1.10	54	1.53	26.1 %	0.87
Uniform Load	41	1.09	15.0%	0.82	0	-	-	-

[*] Code analyses based on the 2013 version of databases [31]

Reduced Datasets

Due to the small quantity of T-beams and distributed load tests there was less certainty regarding their statistical representation. Also, a number of rectangular beams listed in the database were deemed unrealistic from a constructibility standpoint - excessively reinforced or with a small cross-sectional height. Therefore, to show how Augustus-II performed in analyzing more realistic beams that are also more statistically significant (i.e. larger number of entries), an analysis of certain database subsets is presented next.

Figure 2.34 shows a histogram of the analysis results for point-loaded rectangular beams with and without stirrups, where the level of flexural tension reinforcement falls below the balanced level as specified by the Canadian Code (Clause 13.4 in [3]). Figure 2.35 shows the CDF of these results, compared to that of a normal curve with the values listed on the figure. The average and coefficient of variation for this subset are improved, while good agreement with the normal curve are shown for the lower half of the results.

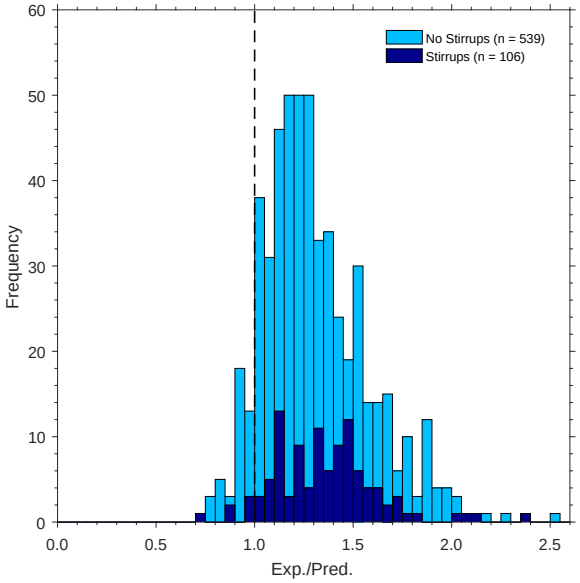


Figure 2.34: *Analysis Distribution of Under-Reinforced ($\rho \leq \rho_{bal}$) Shear Critical Rectangular Beams*

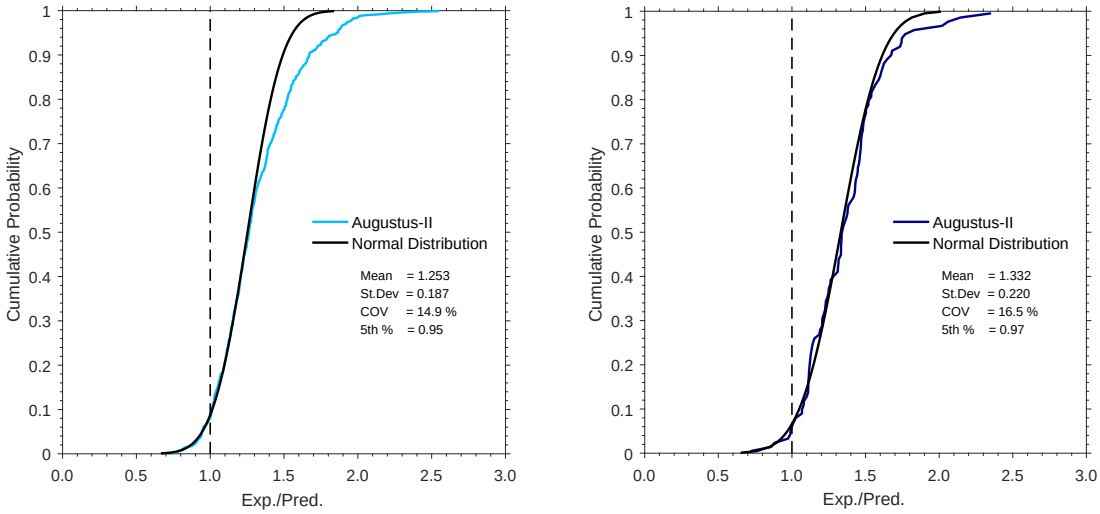


Figure 2.35: *Cumulative Density of Analysis Distribution: No Stirrups (Left), Stirrups (Right)*

Figure 2.36 shows a histogram of the analysis results for point-loaded rectangular beams with and without stirrups, where the previous subset is further filtered so that the height of the rectangular cross-section is greater than 350 mm. The total number of beams is significantly reduced, with only 218 beams without stirrups and 41 beams with stirrups meeting the criteria. Figure 2.37 shows that the average and coefficient of variation for this subset are further improved: averages of 1.199 and 1.173, and COVs of 15.8% and 14.9%, for beams with and without stirrups respectively. Once again the normal curve shows excellent agreement with the lower half of the data, which implies that there is no systematic error in Augustus-II when predicting beams that fall into the lower range.

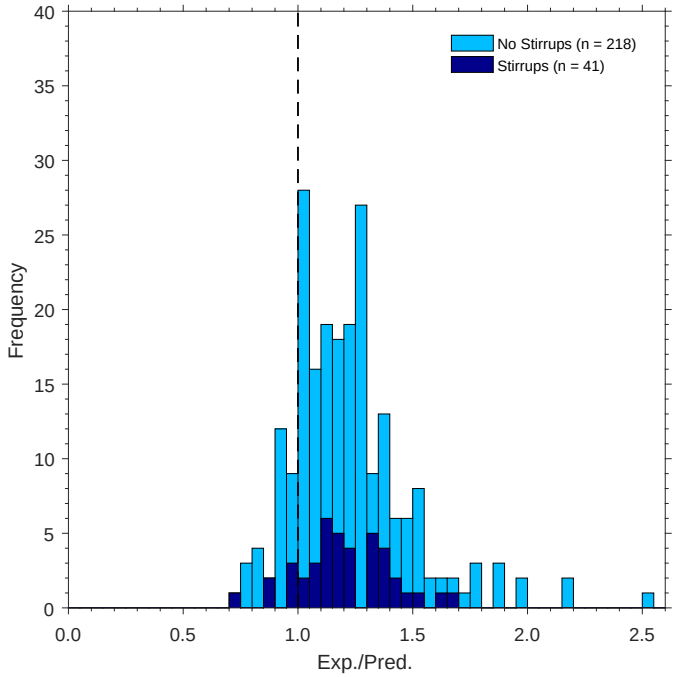


Figure 2.36: *Analysis Distribution of Large ($h \geq 350$ mm) Shear Critical Rectangular Beams*

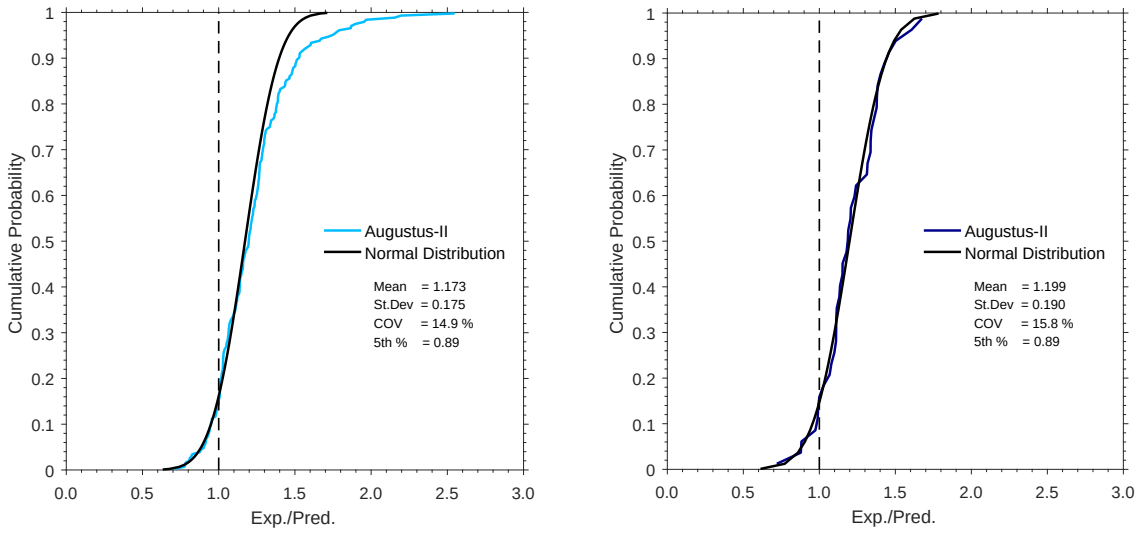


Figure 2.37: *Cumulative Density of Analysis Distribution: No Stirrups (Left), Stirrups (Right)*

2.5.3 Large-Scale Structural Analysis

The Augustus-II framework is not limited to just member-level analysis, it can also be extended to large-scale structures (e.g. frames and coupled shear walls). These models use HyPT elements for the beams and columns, and a mesh of two-dimensional membrane elements, defined in the program Membrane-2000 [32], for the joint regions.

Duong Frame (2006)

Figure 2.38 shows the geometry and structural detailing of a two-storey frame that was tested at the University of Toronto in 2006. These images are taken directly from Duong's doctoral thesis [33, p. 34-35].

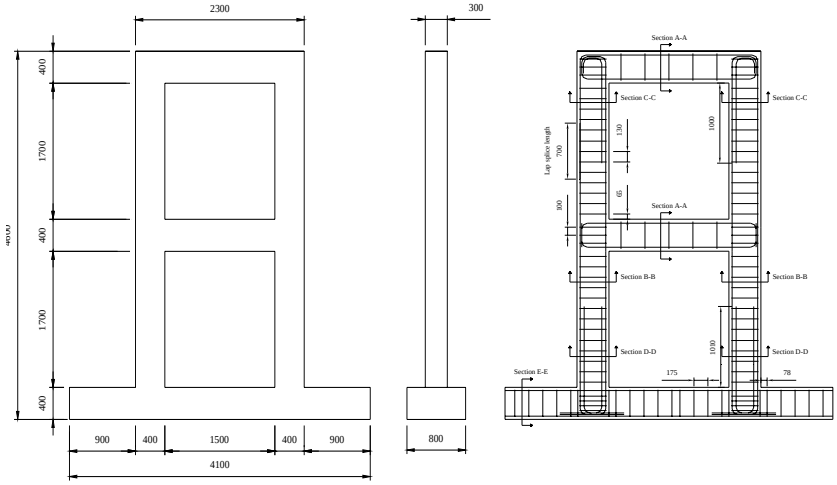


Figure 2.38: *Geometry of Two-Storey Frame Tested at the University of Toronto (Duong, [33, 29])*

Figure 2.39 shows the frame modelled in Augustus-II. The various colours in the left image correspond to the different sections defined in Response-2000 and Membrane-2000. The right image is the post-processed output of the frame just before failure, where the deformed shape and crack pattern is consistent with a load being applied at the top beam and shear failure in the first floor beam about to occur.

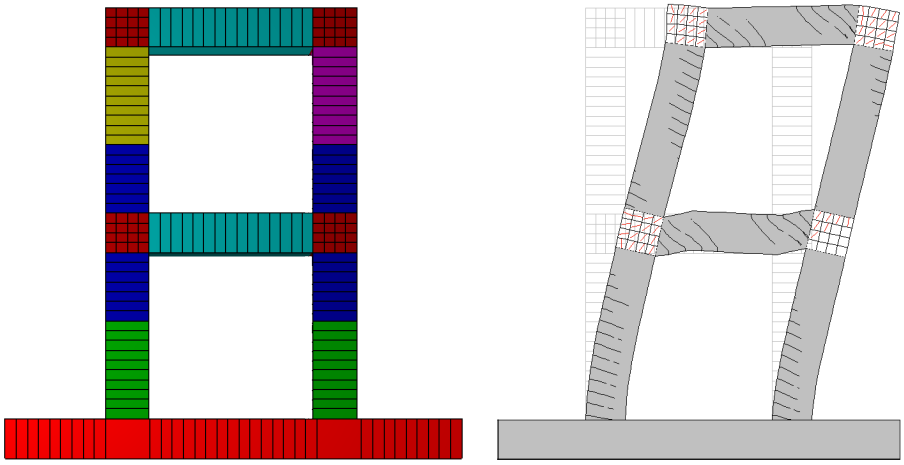


Figure 2.39: *Duong Frame - Model Mesh and Deformed Shape Before Failure*

The full experimental protocol for the Duong Frame was complex, involving reverse cyclic loading and the structural retrofitting of the damaged beam. The HyPT element has not been derived to capture cyclic behaviour, therefore only the initial first forward loading cycle of the test is being compared in Figure 2.40.

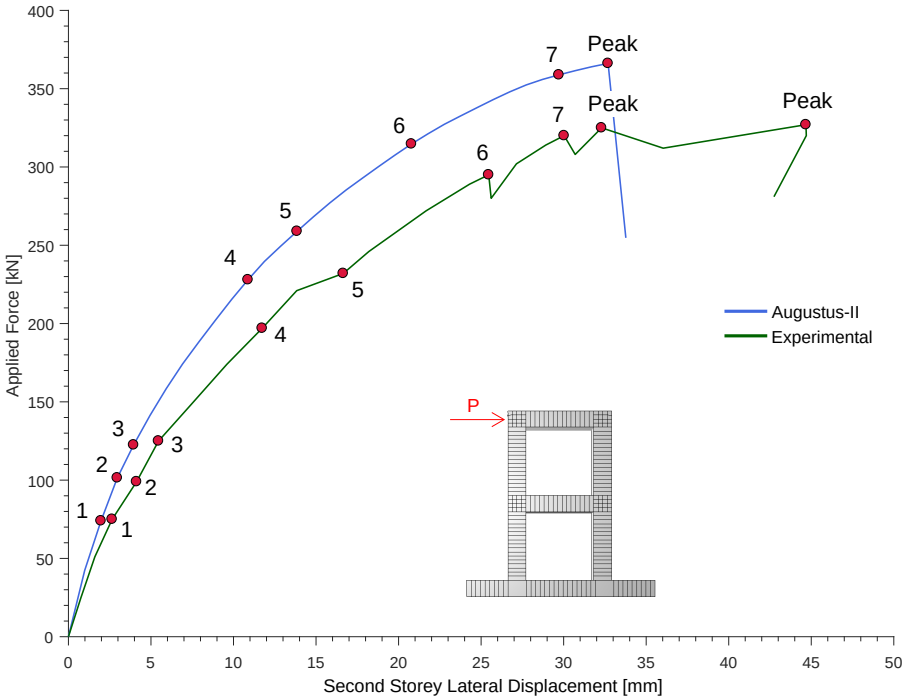


Figure 2.40: *Duong Frame - Pushover Analysis vs. Experimental Results*

The Augustus-II analysis slightly over-predicts the strength and stiffness of the frame and fails suddenly by shear failure in the first storey beam (this is the correct mode of failure), while the actual specimen exhibited significantly more ductility at its peak load. Yet the structural observations (Table 2.2) show good agreement between the experiment and model - the initial peak loading occurs at roughly the same second storey displacement, although the experimental specimen is able to sustain an additional 12 mm of displacement before unloading.

Table 2.2: Important Structural Observations at Load Stages [33, p. 112,132]

Point	*Description*	*Experimental*		*Augustus − II*	
		$P\ [kN]$	$\Delta\ [mm]$	$P\ [kN]$	$\Delta\ [mm]$
1	1^{st} Floor Beam - First Flexural Crack	75	2.65	74	1.98
2	Left Column - First Flexural Crack	99	4.13	101	2.96
3	1^{st} Floor Beam - First Shear Crack	123	5.46	122	3.95
4	2^{nd} Floor Beam - First Shear Crack	197	11.74	228	10.88
5	1^{st} Floor Beam - First Flexural Yield	232	16.65	259	13.85
6	1^{st} Floor Beam - Full Flexural Yield	295	25.46	315	20.79
7	2^{nd} Floor Beam - First Flexural Yield	320	30.03	359	29.72
Peak*	Significant Stiffness/Load Drop	325	32.30	366	32.69

* The frame was unloaded and cycled following this forward loading cycle

Salmon Frame (2017)

A single-storey frame recently tested at the University of Toronto was also modelled in Augustus-II - the mesh and deformed shape are shown in Figure 2.41. This experimental study has yet to be presented in a peer-reviewed publication, therefore the structural geometry and detailing are not shown here.

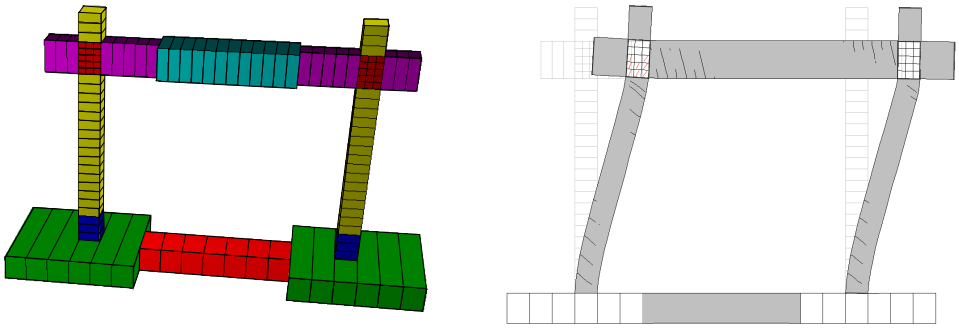


Figure 2.41: *Salmon Frame - Model Mesh and Deformed Shape Before Failure*

The researchers responsible for this test have requested that the detailed experimental hysteresis of the frame also be omitted from the current discussion. This explains why only the Augustus-II results, with important points annotated, are shown in Figure 2.42. Based on this pushover analysis, the peak load was 164 kN and occurred at a lateral displacement of 26 mm. Subsequent failure was initiated by complete yielding of the longitudinal steel at the top of the right column - this observation is reflected in photos of the failed specimen [30]. It is important to note that a direct comparison to the experimental results is not warranted since the cyclic nature of the tests would affect the ductility of the frame, although a backbone curve based on the peaks of the later forward cycles appears to closely match the reported Augustus-II peak value.

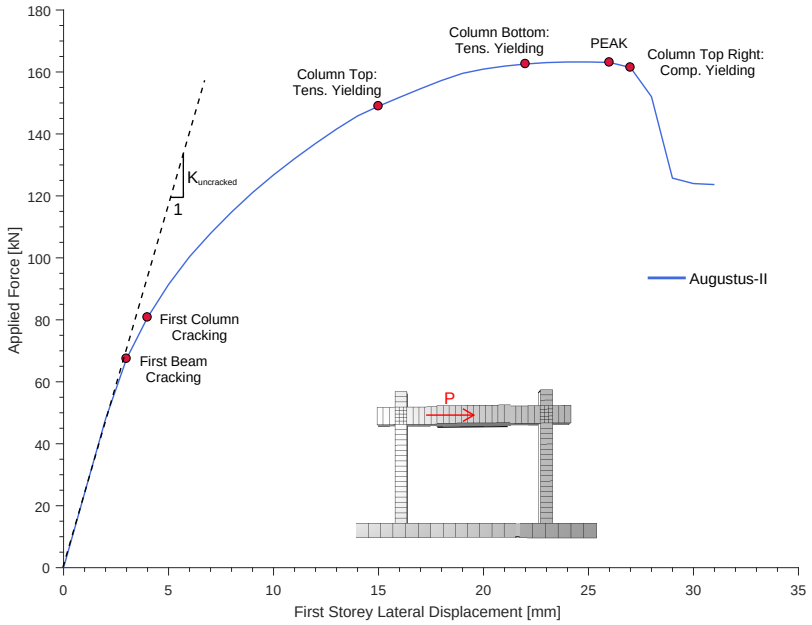


Figure 2.42: *Salmon Frame - Pushover Analysis Results*

Coupled Shear Wall

Augustus-II also has the ability to analyze full-scale structures that would typically be too large to build and test in a laboratory setting, and too cumbersome to analyze in traditional FEM programs. Figure 2.43 shows the mesh and deformed shape of a 10-storey coupled shear wall, where the coupling beams are modelled with HyPT elements and the walls with membrane elements. A detailed discussion of these models and results can be found in the thesis written by Yap [26]. The input nodal displacements for the membrane elements are determined by linear interpolation between the 2d-HyPT nodes at interface locations where the nodes do not coincide.

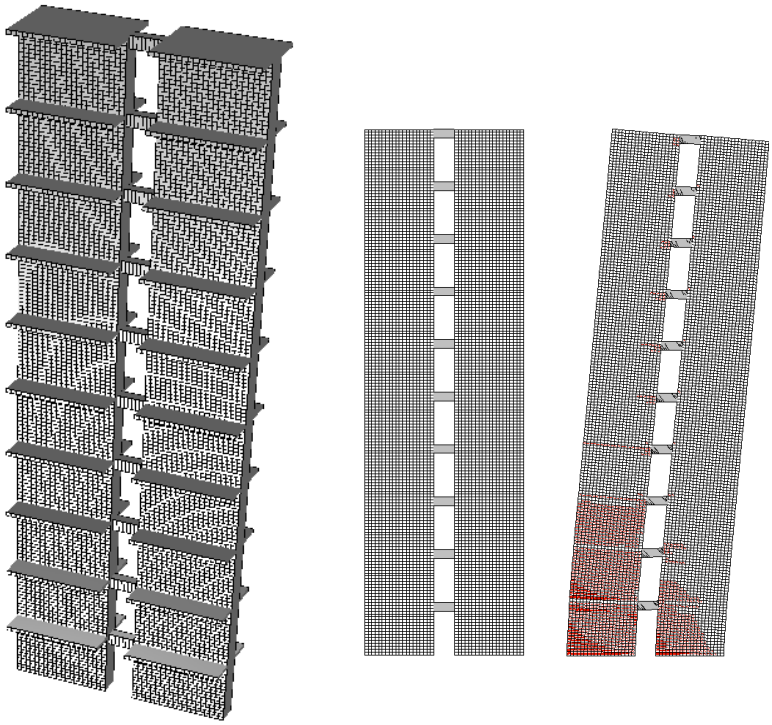


Figure 2.43: *Coupled Shear Wall Modelled with Augustus-II (Yap [26])*

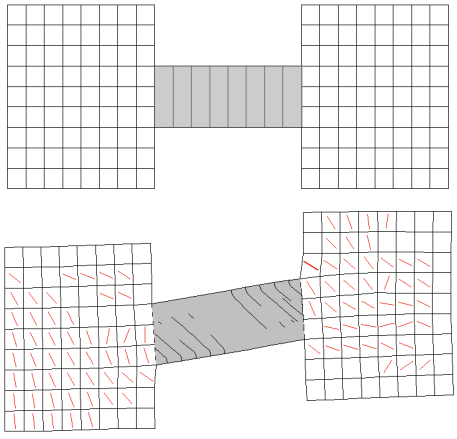


Figure 2.44: *Individual Coupling Beam Model*

2.5.4 Augustus-II Convergence Study

To determine the relative performance of Augustus-II, two beams from the ACI database (#131 (Aster, 1974) & #1356 (Sneed, 2007)) were selected and also analyzed with VecTor2, which is a successful program for the nonlinear finite element analysis of reinforced concrete developed at the University of Toronto [6]. Figure 2.45 shows the VecTor2 finite element meshes for both beams - in contrast to Augustus-II, the mathematical formulation of the elements used in VecTor2 is such that several are required through the thickness of a member to accurately represent the structural mechanics of reinforced concrete.

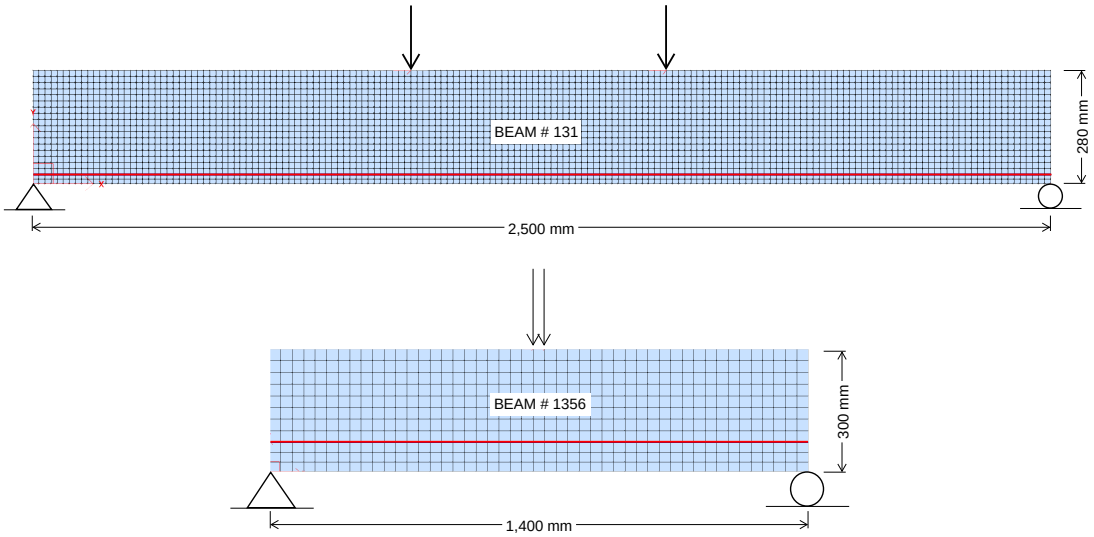


Figure 2.45: *VecTor2 Beam Meshes*

The two programs are assumed to be performing satisfactorily since shear failure occurs in both beams at similar converged Exp./Pred. ratios (∼1.2 for Beam #131, ∼1.5 for Beam #1356). The purpose of this study is determine the number of elements that are needed in each program to achieve convergence (i.e. when the failure load stops changing with the addition of more elements) and how the analysis duration is influenced by the number of elements.

Figure 2.46 shows the results of this convergence analysis for both beams, where the red dot indicates the point at which convergence is achieved for either program. Each beam is represented with two graphs - the graph to the right plots the same data as its neighbour, but the scale of the x-axis is significantly reduced. It is clear that Augustus-II is much more stable with respect to the number of elements - the program requires almost two orders of magnitude fewer elements to fully converge (∼100 vs. ∼5000 elements), and yields reasonable results with only 20 elements. Figure 2.46 shows the relationship between the number of elements and the runtime of the program. The HyPT element is clearly a more computationally efficient element at its convergence point - Augustus-II requires under 20 seconds to complete the analysis of both beam, while VecTor2 ranges from 15-30 minutes. Although more computationally demanding, VecTor2 is still a useful general program that can provide a level of detail not possible with the 2d-HyPT implementation.

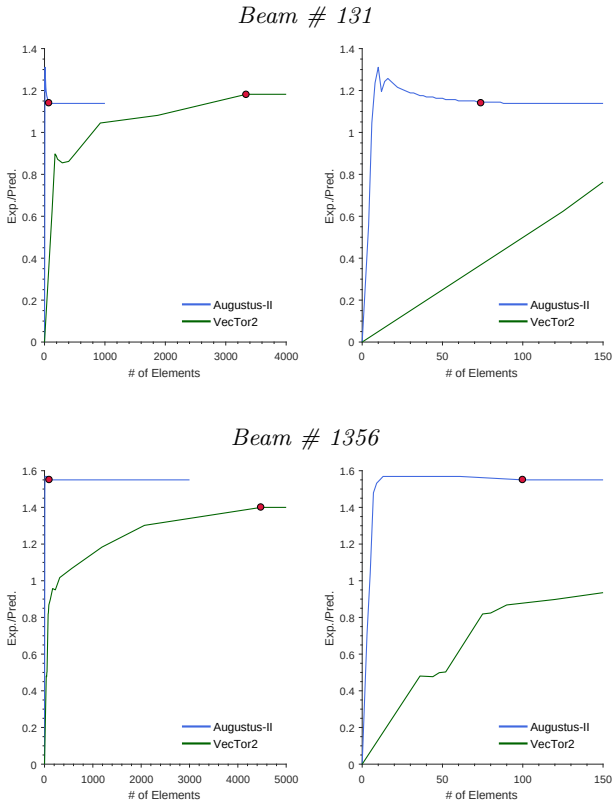


Figure 2.46: *Convergence Analysis (Right = Zoomed in Plot)*

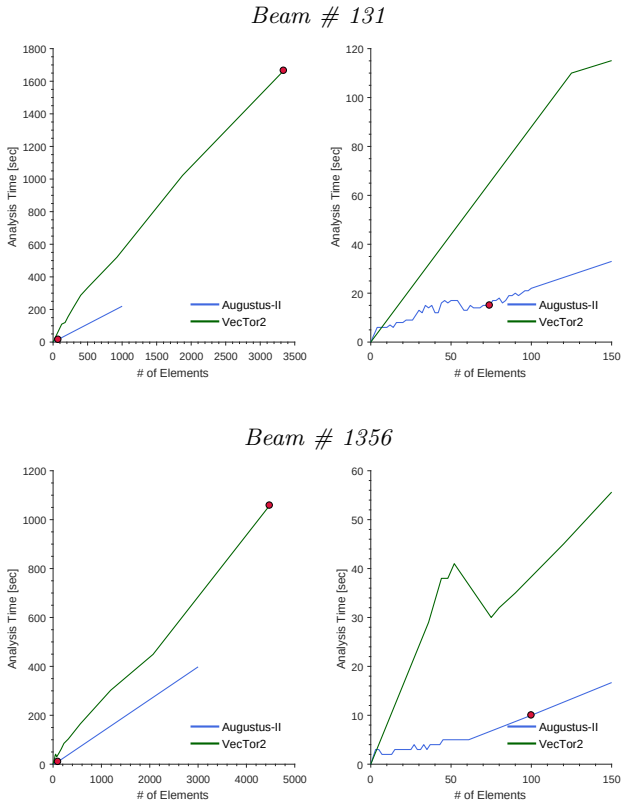


Figure 2.47: *Runtime Analysis (Right = Zoomed in Plot)*

Chapter 3

Description of Experimental Program

The following chapter will present the experimental component of this project, which consisted of constructing, instrumenting and conducting the world's first large-scale pure torsion tests on reinforced concrete shell specimens. The tests were performed using the Shell Element Tester (SET) located in the Mark Huggins Structural Laboratory at the University of Toronto. The chapter is organized into sections pertaining to the specimen design (Table 3.1), material properties, experimental set-up, and instrumentation.

Table 3.1: Summary of Specimen Properties

Test	Loading	[Days] Age	[MPa] f'_c	[MPa] $\rho_x \cdot f_{y,x}$	[MPa] $\rho_y \cdot f_{y,y}$	[MPa] $\rho_z \cdot f_{y,z}$
ES1	Torsion	26	30.4	15.0	9.93	-
ES2	Torsion	77	37.6	15.0	9.93	1.52

3.1 Specimen Design and Construction

The two specimens (ES1 & ES2) were designed as an extension to a previous experimental program undertaken at the University of Toronto [34, 35]. This previous research consisted of a partnership with the Seoul National University [36], hence the reinforcement ratios and concrete strengths selected in the current study are nominally the same as those typically seen in Korean nuclear containment structures [37] . Although the percentages used for the current program are higher, the ρf_y values are comparable when considering the higher strength steel in the Korean shells.

The two specimens presented in this thesis had nominal dimensions of 1626 x 1626 mm square, with a thickness of 285 mm. Both specimens had identical orthogonal in-plane longitudinal (X-direction) and transverse (Y-direction) reinforcement arrangements, equivalent to 2.95% and 1.95% of their respective cross-sectional areas. Despite some variation in the concrete strengths, the only significant experimental difference between the two specimens was the additional out-of-plane (Z-direction) T-head reinforcement included in ES2, equivalent to a ratio of 0.32% of the cross-sectional area. Keeping all other parameters constant across the two specimens meant that the effect of the out-of-plane reinforcement could be clearly discerned. The reinforcement spacing, and the resulting percentages are summarized in Table 3.2.

Table 3.2: Summary of Specimen Reinforcement

	[mm]	[mm]	[mm]	[mm]	[%]	[%]	[%]
Name	Dimensions	X-Bars	Y-Bars	Z-Bars	ρ_x	ρ_y	ρ_x
ES1	1626x1626x285	20M @ 72	20M @ 108	-	2.95	1.95	-
ES2	1626x1626x285	20M @ 72	20M @ 108	#4	2.95	1.95	0.32

20M bars = 300 mm^2
#4 bars = 129 mm^2

3.1.1 Reinforcement Schematic

Each specimen was constructed and assembled as two separate but identical reinforcement cages that represented the inner and outer faces of a shell structure. Each cage consisted of a layer of orthogonal X and Y direction reinforcement, but oriented at 45° to the plane of the applied loading. The X direction was considered the principal reinforcement direction and was therefore closest to the surface of the shell on either side. Henceforth these faces will be referred to as the the South and North faces respectively to stay consistent with the naming convention resulting from the orientation of the test set-up. Figures 3.1 & 3.2 show the North faces of specimens ES1 and ES2 respectively, note the T-head bars in specimen ES2.

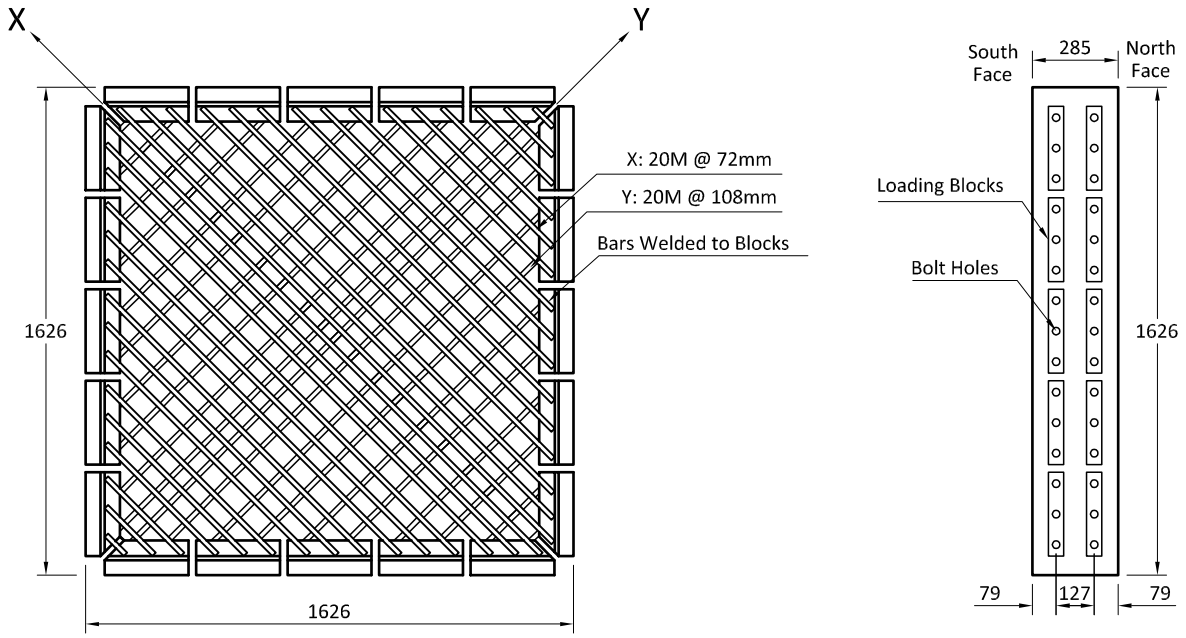


Figure 3.1: *ES1 North Face Cage (South Face is Identical)*

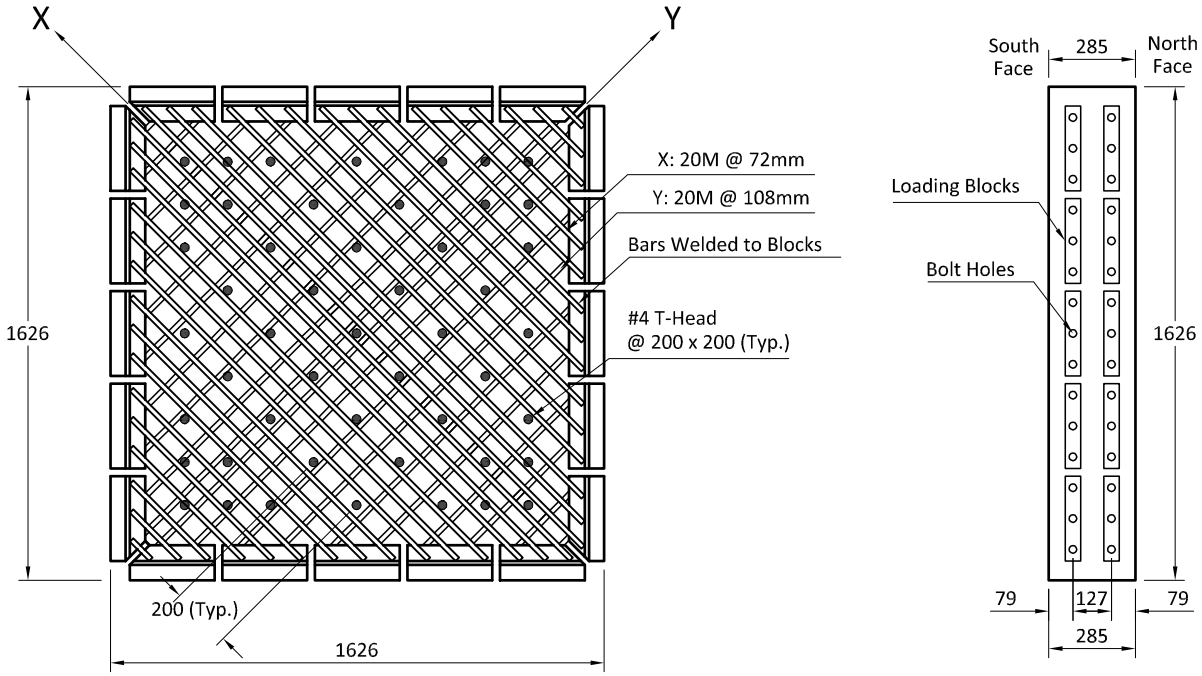


Figure 3.2: *ES2 North Face Cage (South Face is Identical)*

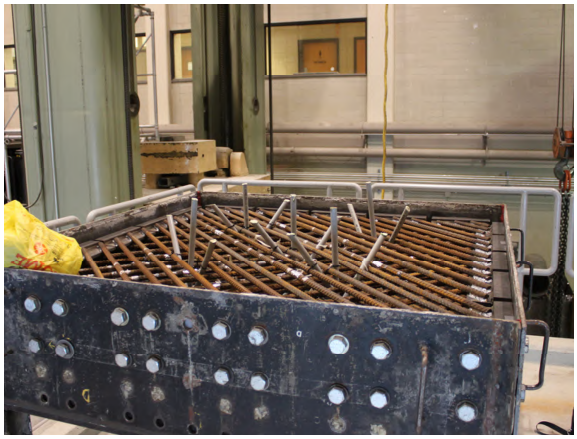
3.1.2 Specimen Construction

The longitudinal reinforcement bars were placed across the the face of the assembly jig and welded to the loading blocks at either end. The quality of the welds was of utmost importance in guaranteeing that the specimen could develop its full strength and not suffer an unwanted localized edge failure. Figure 3.3 shows a cage that has been fully welded and is in the process of being moved to the concrete casting forms. This cage represents half of the specimen, either the North or South face of the shell.

Figure 3.3: *Welded Reinforcement Cage*

Figure 3.4a shows an assembled specimen ready for casting, with the North and South face cages anchored to the casting forms. Figure 3.4b shows the same specimen after concrete casting, but before finishing of the surface. The hollow tubes sticking through the surface of the specimen are necessary for the out-of-plane instrumentation, which will be discussed further in Section 3.4.

Fully Assembled Specimen Reinforcement Cage



Specimen After Cast (Rough)

Figure 3.4: *Casting Reinforced Concrete Specimen*

Figure 3.5 shows a finished specimen with a painted surface awaiting the installation of all the in-plane and out-of-plane instrumentation. The thin coat of white paint makes identifying surface cracks during the test easier. The smaller holes are approximately 1 cm deep and are required for the in-plane instrumentation mounts, while the larger holes provide an uninterrupted path all the way through the specimen.

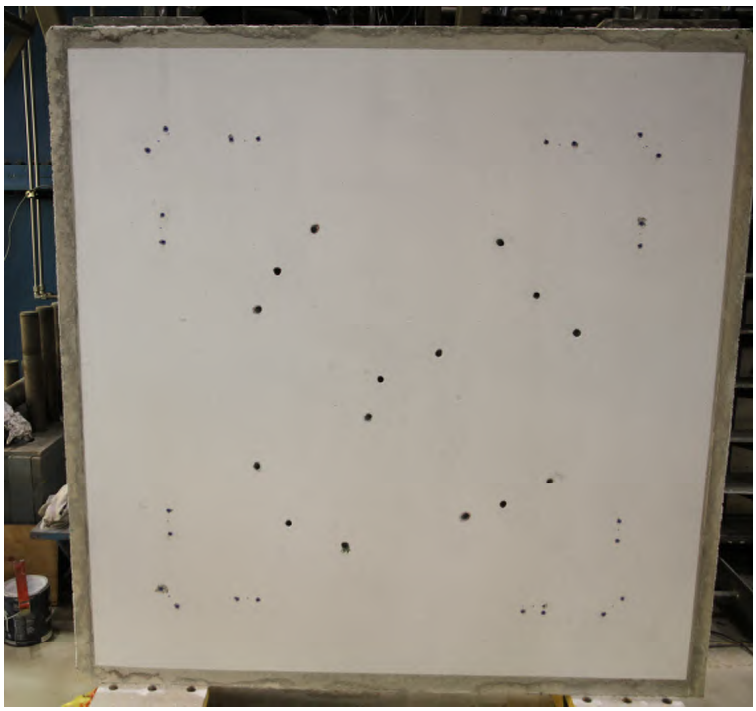


Figure 3.5: *Completed Shell Specimen*

3.2 Material Properties

The individual stress-strain responses of the steel and concrete components in reinforced concrete are necessary to properly model large-scale structural behaviour. Hence axial tests were performed on steel reinforcement bar coupons and concrete cylinders representative of the materials used to build the shell specimens.

3.2.1 Concrete Cylinder Tests

Plain concrete cylinders (6" x 12") were cast from the same concrete batch as the shell specimens. Both shells were cast on October 5th, 2016 - the results from the cylinder tests were used to determine the compressive strength gain curve (Figure 3.6). The points represent the average of three separate cylinder tests performed at 7, 21 & 28 days after the cast, and on the dates of the shell tests. Specimen ES1 was tested early, slightly before 28 days, since it was concluded that reasonable strength had already been achieved. The concrete compressive strength difference between the two specimens is reasonable for regular strength concrete, and will have to be accounted for when modelling the specimens. Concrete tensile strength was not a critical factor in the tests and was therefore not determined explicitly.

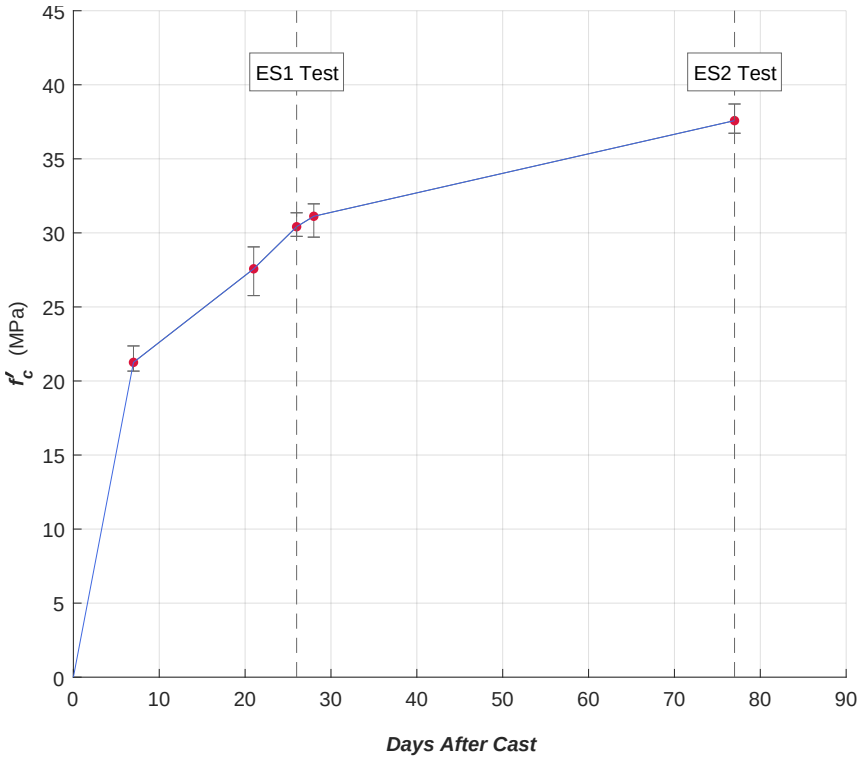


Figure 3.6: *Concrete Compressive Strength Gain*

Detailed compressive stress-strain curves were determined at 28 days (Figure 3.7) and on the dates of the actual shell tests (Figure 3.8). At each of these dates three separate cylinders were tested to account for the variability in concrete. Average peak stress and strain values on the test days are summarize in Table 3.3.

Table 3.3: Average Test Day Concrete Properties

Test	[MPa] f'_c	[x10^{-3}] ϵ'_c
ES1	30.4	1.75
ES2	37.6	1.87

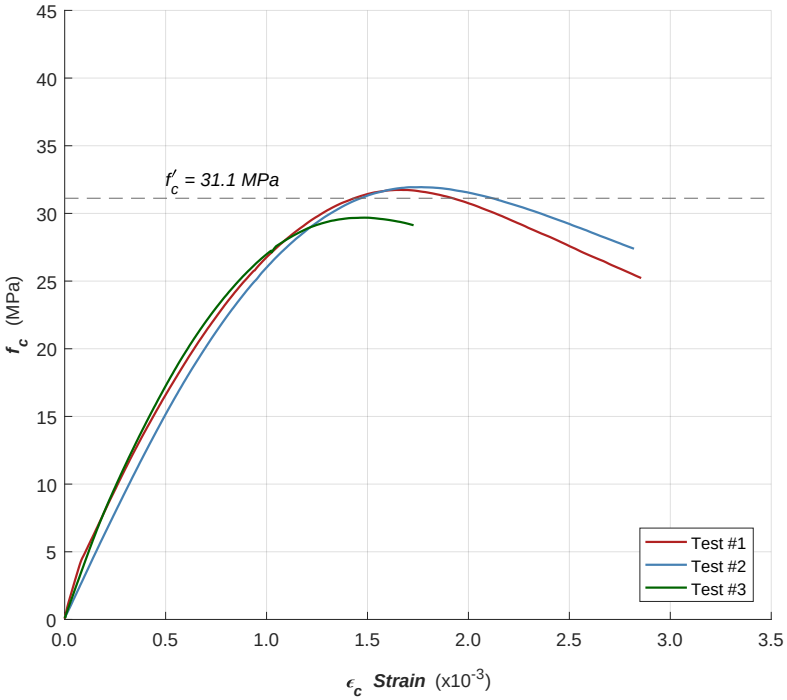


Figure 3.7: *Cylinder Stress-Strain Curve at 28 Days*

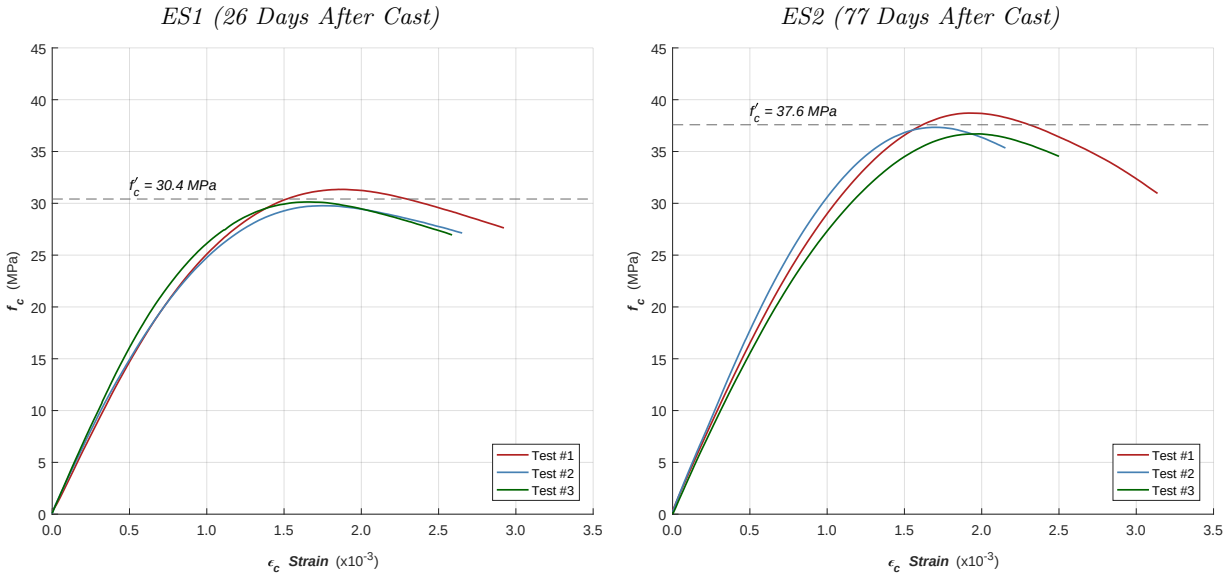


Figure 3.8: *Cylinder Stress-Strain on Test Day*

3.2.2 Steel Coupon Tests

Table 3.4: Average Reinforcement Steel Properties

Bar	$[mm^2]$ Area	[MPa] f_y	[MPa] f_u	[x10^{-3}] ϵ_y	[x10^{-3}] ϵ_{sh}	[x10^{-3}] ϵ_u
20M	200	509	636	3.45	15.1	110
#4	129	474	657	2.23	11.5	133

In-Plane Steel

20M steel reinforcement bars from the same batch were used for all the in-plane steel (X & Y Direction) in both specimens. Three separate coupon tests were performed; the results are shown in Figure 3.9.

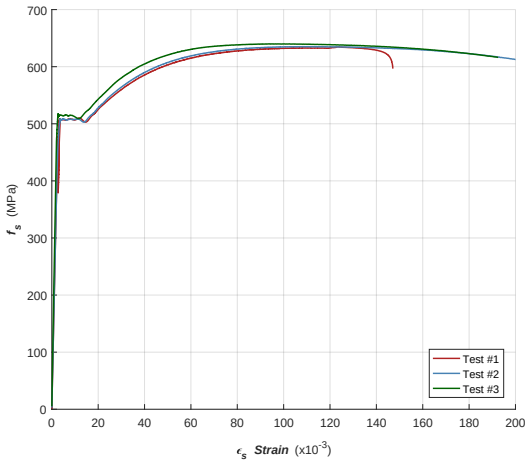


Figure 3.9: *Steel (XY) Coupon Stress-Strain Curve*

Out-of-Plane Steel

#4 steel T-headed bars were used as the out-of-plane shear reinforcement in specimen ES2. Six separate coupon tests were performed; the results are shown in Figure 3.10)

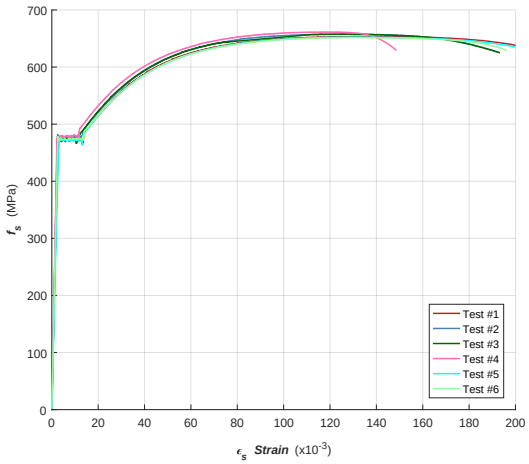


Figure 3.10: *Steel (Z) Coupon Stress-Strain Curve*

3.3 Experimental Set-up

The experiments were performed with the Shell Element Tester - a unique experimental set-up capable of applying any combination of the eight stress resultants potentially experienced by a shell structure. By varying the loading ratios and the orientation of the longitudinal reinforcement, different combinations of in-plane and out-of-plane shear stresses, axial stresses, and moments can be applied to the appropriate section. The Shell Element Tester consists of servo-controlled actuators operated with the MTS® FlexTest controller interfaced with a computer running the AeroPro™ Data Acquisition System [38], which allows for a high level of control and precision throughout the test. The actuators are connected to the shell specimen through loading yokes bolted to blocks cast into the concrete. For a detailed technical description of the Shell Element Tester and the preparation and installation of a specimen see the work of Dr. Ruggiero [39], Figure 3.11 is adapted from this PhD Thesis.

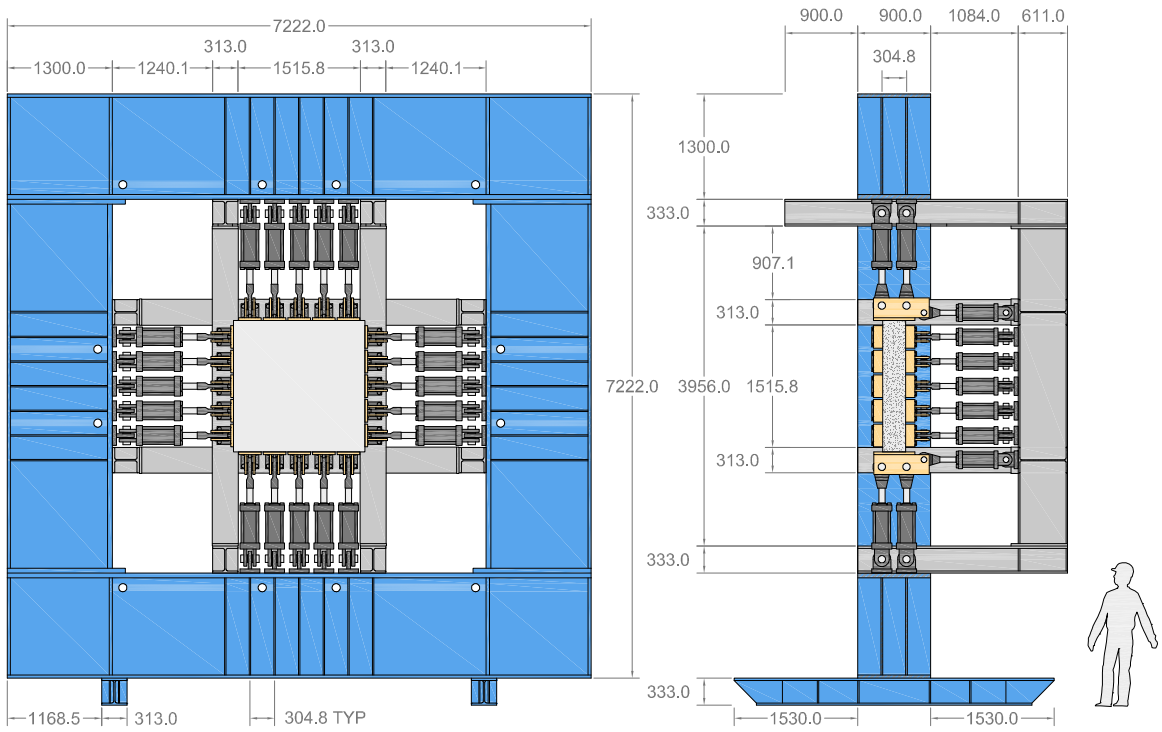


Figure 3.11: *Shell Element Tester Schematic (Ruggiero [39])*

3.3.1 Actuator Configuration

The Shell Element Tester consists of 60 servo-controlled hydraulic actuators, their properties are summarized in Table 3.5. The reported maximum values are based on achieving a system pressure of 4300 psi, which is considered to be the highest pressure that can be consistently maintained with the help of the laboratory's booster pump.

Table 3.5: Loading Actuator Summary

Location	Quantity	Type	[kN] Max. Tens.	[kN] Max. Comp.
In-Plane	40	100-ton	+765	-940
Out-of-Plane	20	50-ton	+440	-530

The actuators are positioned around the four sides of the frame. Each side has 10 in-plane actuators (aligned in two banks of 5), along with 5 out-of-plane actuators. Figure 3.12 shows the actuator numbering used in the control system, and a 2D representation of their arrangement. For example, the bottom face has in-plane actuators numbered 1-10 (1-5 on the front, 6-10 on the back), and out-of-plane actuators numbered 11-15.

To stabilize the specimen and prevent rigid body motion during the test, six of the actuators were placed in displacement control and set to maintain zero displacement. This is analogous to a simply-supported beam, where three restraints are needed to achieve statical determinacy. Fixing fewer points would lead to instability, while fixing more would lead to a statically indeterminate structure. Actuators #21, #25 & #40 (red box) provided the three necessary in-plane restraints, while actuators #11, #15 & #28 (blue box) provided the necessary out-of-plane restraints. Actuator #8 (green box) is the control displacement channel, which is discussed further in Section 3.3.3.

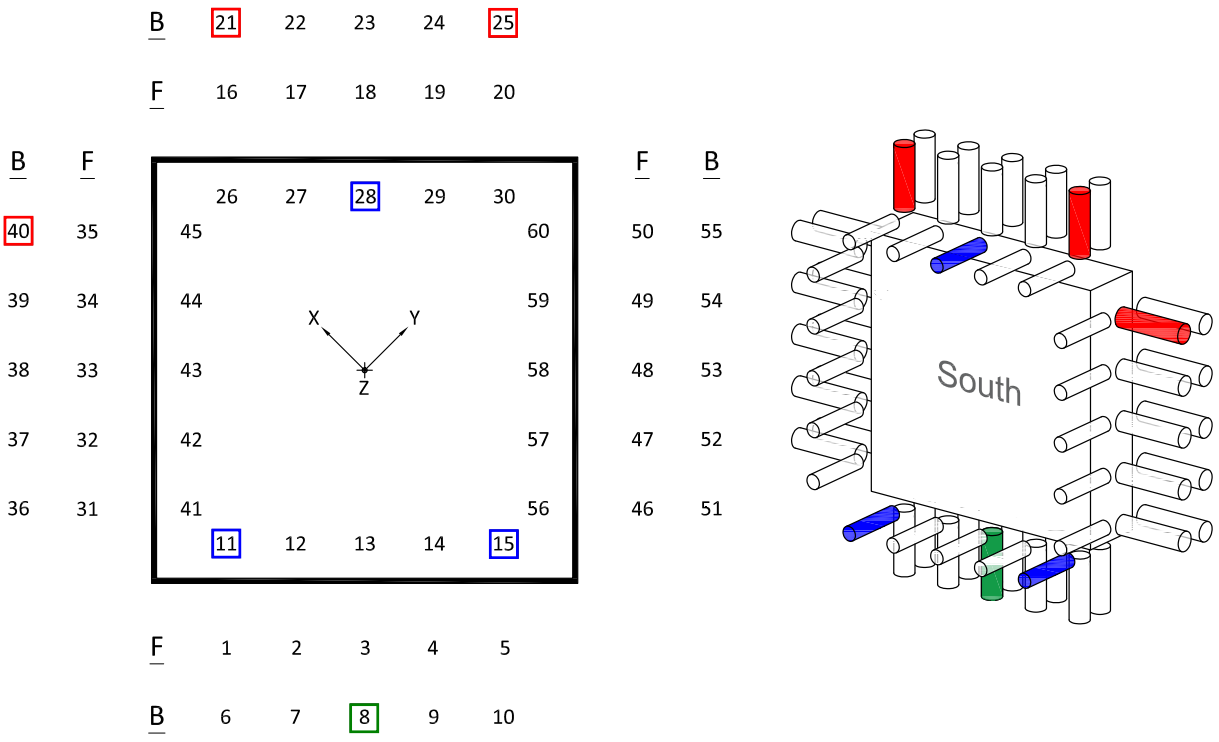


Figure 3.12: *Actuator Placement and Numbering*

3.3.2 Coordinate System

The specimen coordinate system (XY) is rotated 45° to the plane of the actuators (HV), where the XY-plane coincides with the location of the longitudinal reinforcement. The right-hand rule dictates that the +Z direction is taken into the page when looking from the North, which is the case for the left image in the actuator placement figure (3.12) from the previous section. It is important to note that previous experimental programs have defined the shell coordinate system differently, so care must be taken when comparing results across sources.

The nature of pure torsion loading, and the placement of the instrumentation, requires one to refer to the North and South face as separate entities at times. In such cases it is important to keep a consistent coordinate system - Figure 3.13 depicts the same coordinate systems viewed from either a North or South frame of reference. Subsequent discussion in this thesis will be consistent with this notation.

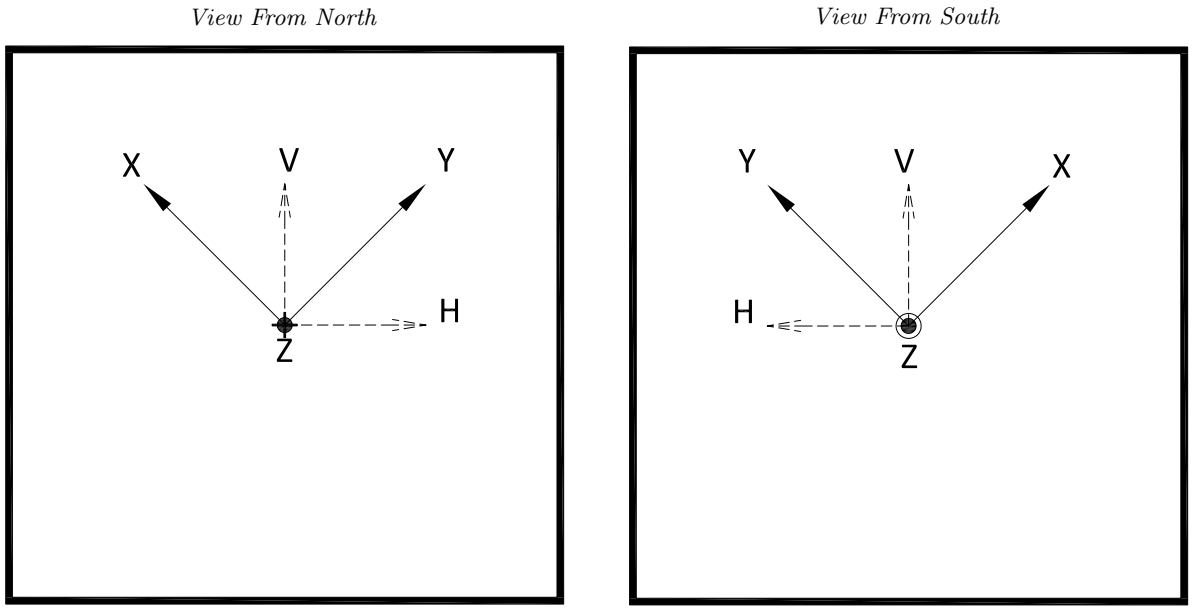


Figure 3.13: *Shell Element Coordinate System*

3.3.3 Loading Protocol

In both experiments only the 40 in-plane actuators were necessary to apply pure torsion to the shell specimen. The three out-of-plane rigid links were active to provide the necessary static restraint, but the remaining out-of-plane actuators were simply set to a constant ±5 kN of force during the test to further stabilize the shell and prevent buckling. These experiments were effectively in-plane tests, so for clarity the out-of-plane actuators are not included in subsequent images detailing the loading protocol.

Both experiments were performed in a displacement control mode, which is a new development in the capabilities and usage of the Shell Element Tester. Tests are typically conducted in a force-controlled mode, which meant that the user simply controlled and incremented the forces in the actuators until the specimen failed. Although this simplified the execution of the test, it did not allow for any post-peak behaviour and could on occasion lead to sudden and dangerous specimen failures. A displacement-controlled test was much more complicated to implement and execute, but allowed for accurate post-peak behaviour and user controlled load-shedding once the test was completed. In this experimental program the master displacement was assigned to actuator #8; the displacement on this channel was increased as the test progressed, and the load that was developed to achieve the target displacement was used as the input for all other actuators.

To apply pure torsion in the XY-plane, moments of equal magnitude and opposite sign were applied along the H & V edge of the shell. In the Shell Element Tester, moments are applied by setting one bank of actuators into tension, while simultaneously setting the adjacent bank to compression. In these tests the magnitude of the compression and tension along one face was kept equal, resulting in a pure couple with no net axial force. Figure 3.14 shows the sign of the force in each of the in-plane actuators throughout the test, while 3.15 shows the same loading condition represented on both the North and South faces respectively.

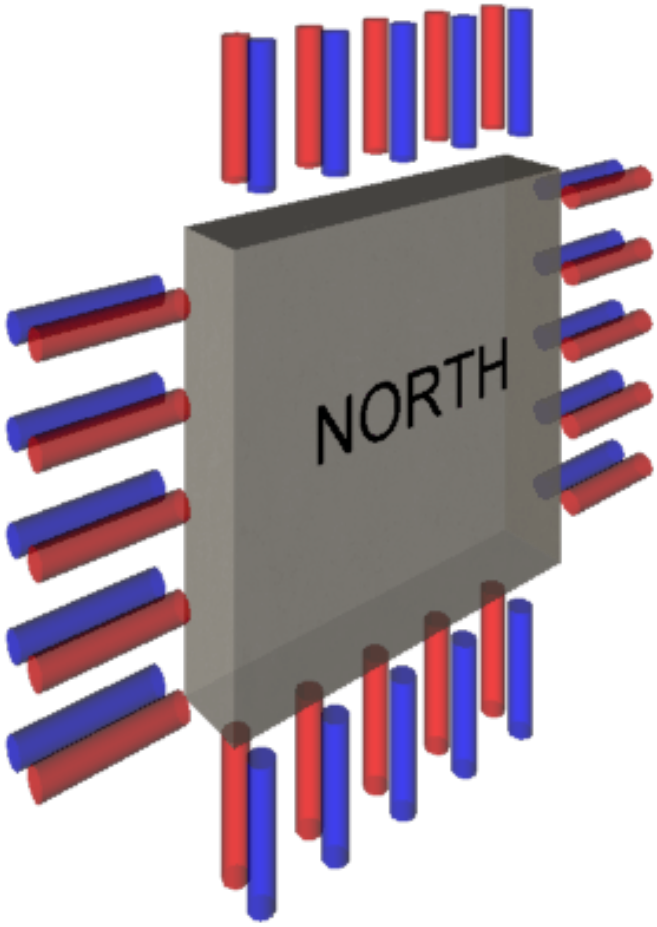


Figure 3.14: *In-Plane Actuator Forces During Test (Tension, Compression)*

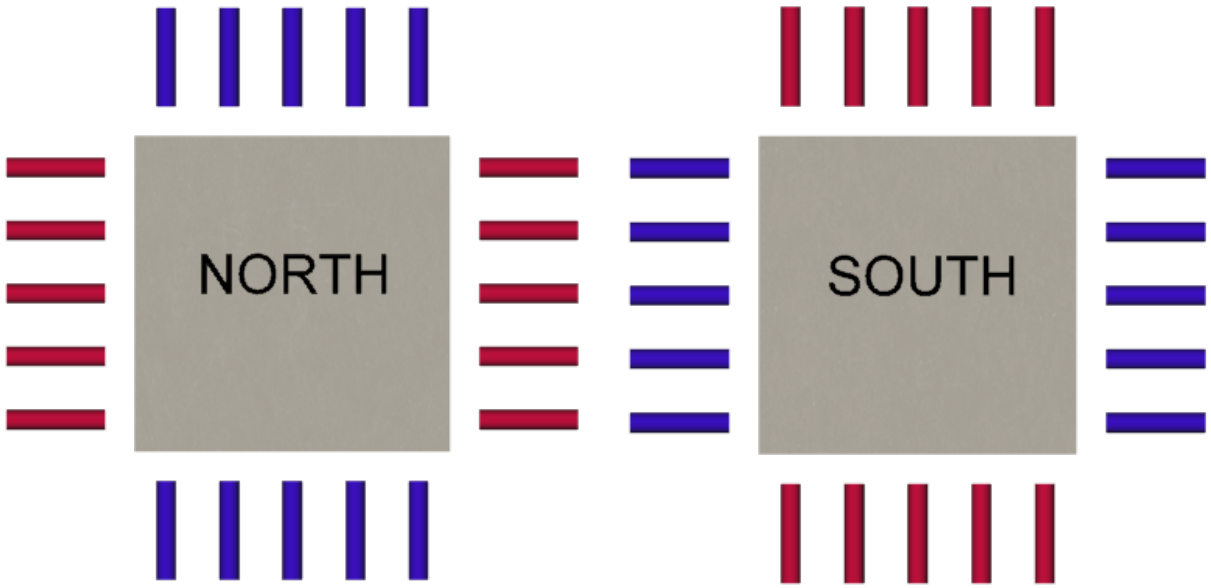


Figure 3.15: *Actuator Forces on North/South Face (Tension, Compression)*

The Shell Element Tester can only apply axial forces in the H & V directions. Yet the actual test region is defined by the orthogonal axis of the longitudinal reinforcement, which is rotated 45° to the HV-plane. The square element (XY-plane) inscribed inside the full shell specimen in Figure 3.16 represents the test region.

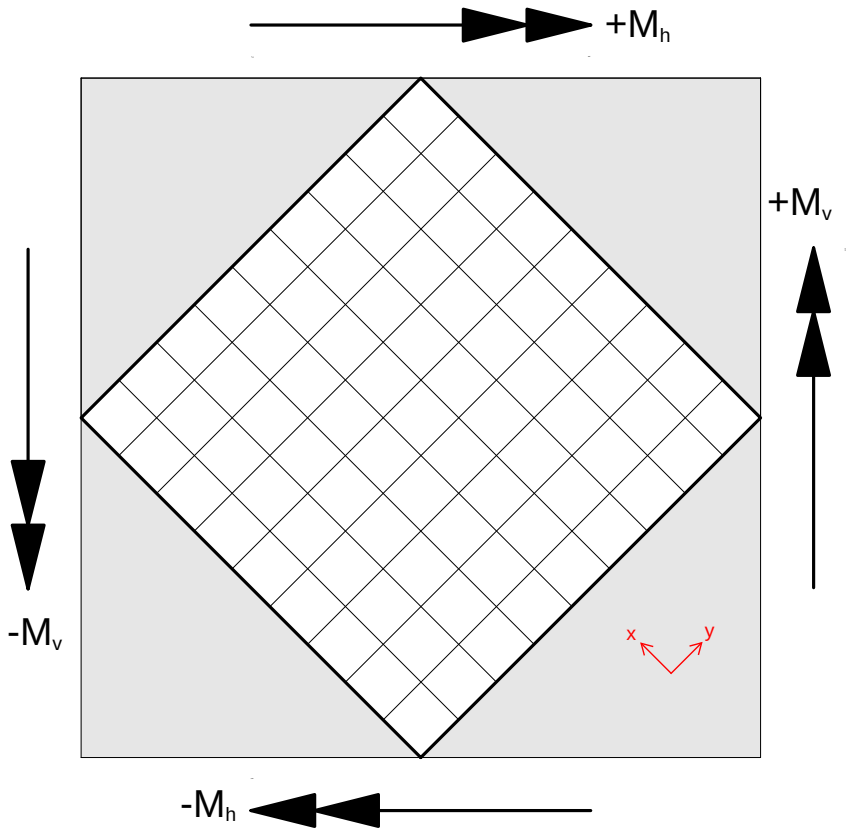


Figure 3.16: *External Moments Applied to the Specimen (Viewed from North)*

Resultants can be found by satisfying static equilibrium at the boundaries of the test region. This calculation is straightforward as the internal cut is at 45°, and the magnitudes of external moments on adjacent faces are equal (i.e. $|M_h| = |M_v|$). Figure 3.17 shows the free-body diagram of the resultant moment on the test region. The external moments clearly result in pure torsion on the test region (XY-plane), where the magnitudes of torsional moments on adjacent faces are equal (i.e. $|M_{xy}| = |M_{yx}|$).

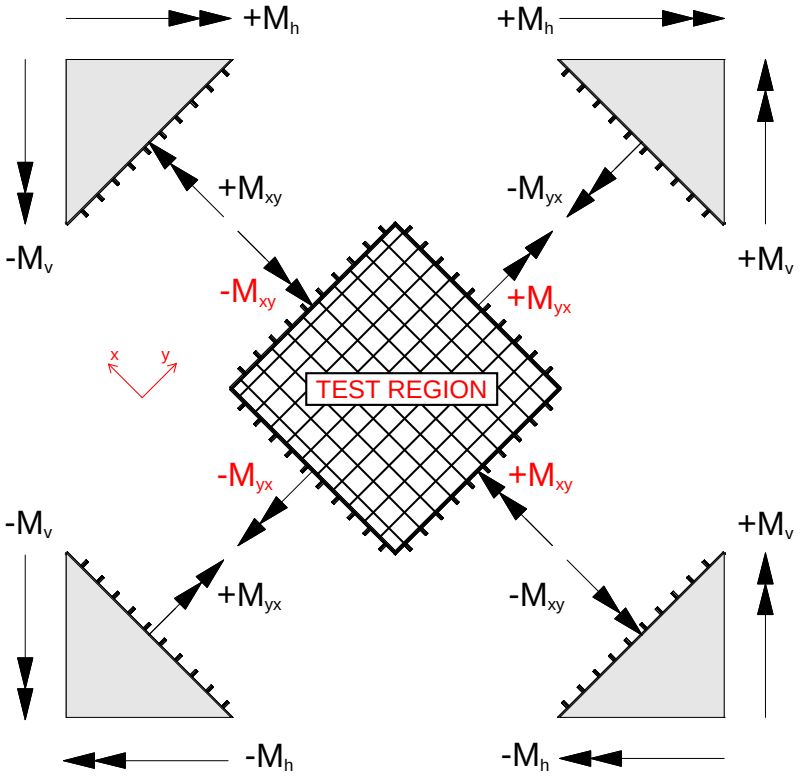


Figure 3.17: *Pure Torsion Applied to the Test Region*

Pure torsion can also be thought of as a couple resulting from pure in-plane shear forces on the North and South faces respectively. Figure 3.18 shows both faces of the shell as viewed from the North, the moment created by the shear forces is equivalent to the torsion on the test region (direction and magnitude).

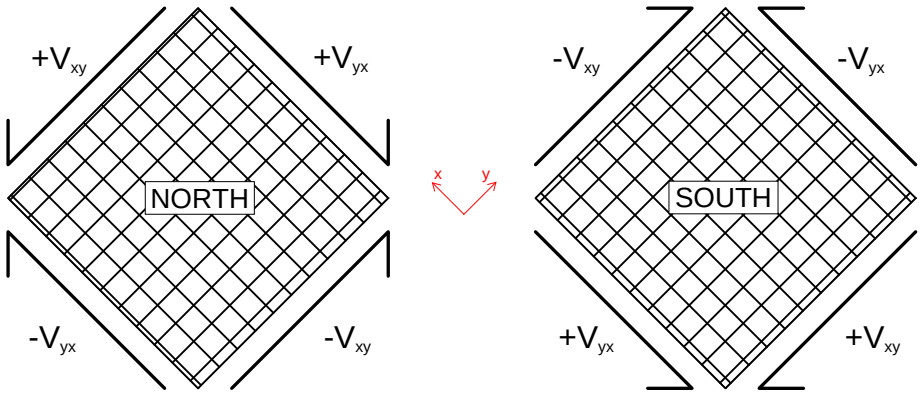


Figure 3.18: *Torsion Represented as In-Plane Shear Forces (Viewed from North)*

3.4 Instrumentation

The Shell Element Tester actuators come equipped with displacement and force sensors, but to improve the quality of data gathered additional surface and embedded measurement devices were included with the specimens. There were two main data streams for these external devices: the force and strain/displacement data routed through the AeroPro™ Data Acquisition System (DAQ), and the three-dimensional surface coordinate data captured by the Nikon® (formerly Metris) metrology system. The following sections will outline the placement and orientation of the additional instrumentation used in both experiments; to establish data consistency across the tests both ES1 & ES2 were instrumented in the same manner.

3.4.1 Built-in Actuator Sensors

Each of the 60 actuators on the Shell Element Tester had its own built-in sensors capable of providing continuous data: a load cell to measure the force exerted, and an external string potentiometer to measure the displacement. The proper functioning of these sensors was of particular importance to the test as they provided information regarding the external loading, and experimental control and execution. For example, the string potentiometer for actuator #8 was used as the master displacement control channel for the whole test, while the six string potentiometers on the rigid link actuators had to be kept at zero displacement throughout the test to ensure stability. Accurate load cell readings from the in-plane actuators were also used to determine the magnitude of torsion being applied to the shell specimen during the test.

3.4.2 Linear Variable Differential Transformers (LVDTs)

To measure average in-plane strains, six LVDTs were mounted on both the North and South face of the specimen: two horizontal, two vertical, one in the X-direction, and one in the Y-direction. Figure 3.19 shows the placement of the LVDTs on the specimen, both faces are shown from the North (i.e. the South face is shown like an x-ray view through the specimen). The diagonal LVDTs on the South face are slightly shifted to avoid interfering with the three-dimensional coordinate measurement system. The naming convention used is as follows: 1st letter = face, 2nd letter = measurement direction, 3rd letter = relative locations

Only two independent strain measurements are necessary to find the magnitude of the shear strain across an element, but defining the whole Mohr's circle of strain requires a third measurement. In this experimental set-up the LVDTs provide four independent strain measurements, so a Mohr's circle of best fit using all four measurements is calculated instead. This method is discussed further in Section 4.2.

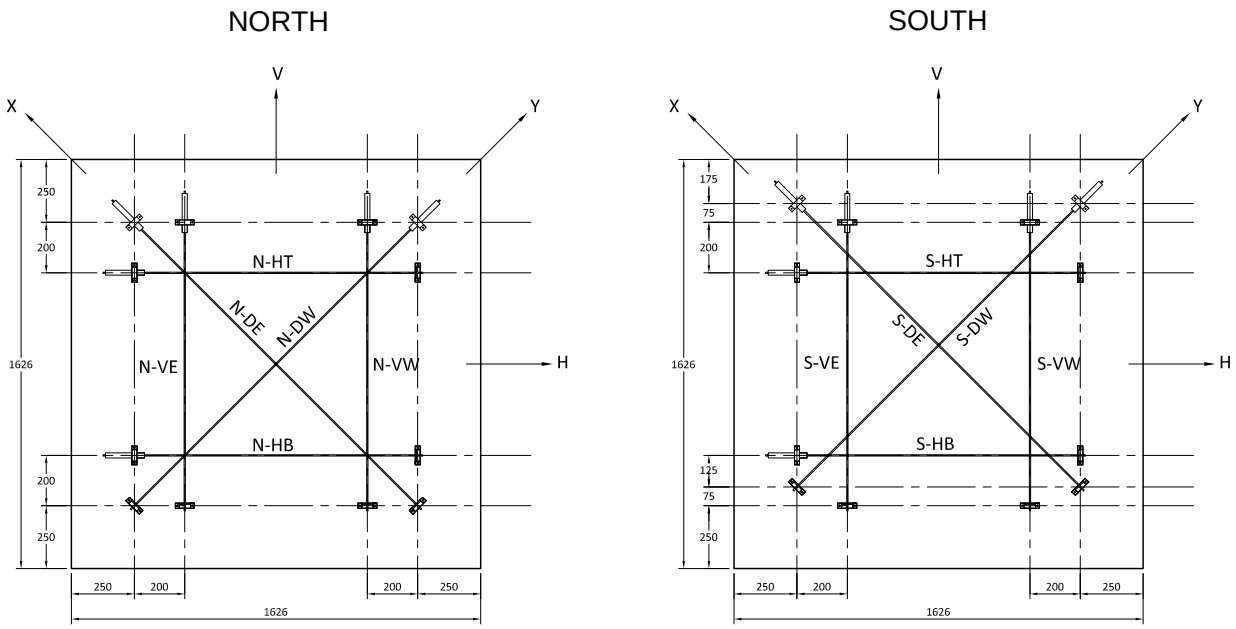


Figure 3.19: *In-Plane LVDT Locations (Viewed from North)*

3.4.3 Three-Dimensional Coordinate Measurement System

Surface displacements and in-plane strains on the South face were measured using a three-dimensional position tracking system, which consisted of a camera coupled with infrared light emitting diode (LED) targets. The positions of the LEDs was recorded throughout the test using the Metris software sampling the targets at 10 Hz, which was later synchronized with the data stream from the AeroPro™ Data Acquisition System (DAQ).

In both tests, a 6 x 6 rotated square grid of LEDs (total of 36) was placed so as to subdivide the test region into 25 equal sized elements (200 mm x 200 mm). Figure 3.20 shows the placement and numbering of the LED targets and the resulting elements (red text) as seen from the South. The LED displacement data is useful since it allows both a qualitative look at the three-dimensional displaced shape of the shell, and detailed in-plane strain measurements over the test region. The LVDTs are providing the same type of in-plane data as the LEDs, but are doing so over the whole surface of the shell and cannot therefore represent localized behaviour. Meanwhile, each square LED element can act as its own independent four-strain measurement system - the best fit Mohr's circle of strain can be calculated for each of the 25 LED elements, allowing a look at the South face in-plane strain on a finer spatial scale.

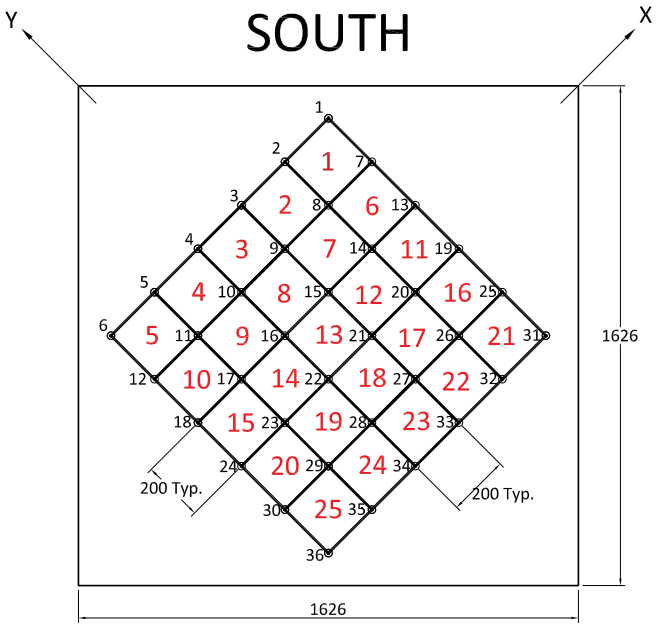


Figure 3.20: *In-Plane LED Locations (Viewed from South)*

3.4.4 Linear Potentiometers (LPs)

A total of 15 LPs were used to determine the out-of-plane strains over the full thickness of the shell. Hollow PVC pipes, which are visible during construction (Figure 3.4b & 3.27), were tied to the reinforcement cage and cast into the concrete at the specified locations. These embedded tubes provided a clear path through the shell, allowing the LPs to measure the relative strain between the North and South face.

The LPs were placed inside the test region, organized in sets of three along the orthogonal reinforcement directions. Three LP triplets (total of nine) were placed in the Y-direction, and two LP triplets (total of six) were placed in the X-Direction. In each set, one LP was placed directly through the thickness (Z-direction), while the remaining two were inclined at roughly ±45° to either the XZ or YZ planes as seen in Figure 3.21. Three independent strain readings at known directions provide enough information to define the complete Mohr's circle of strain over this area.

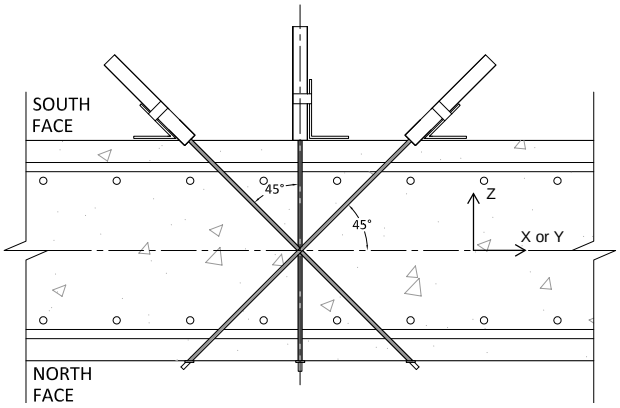
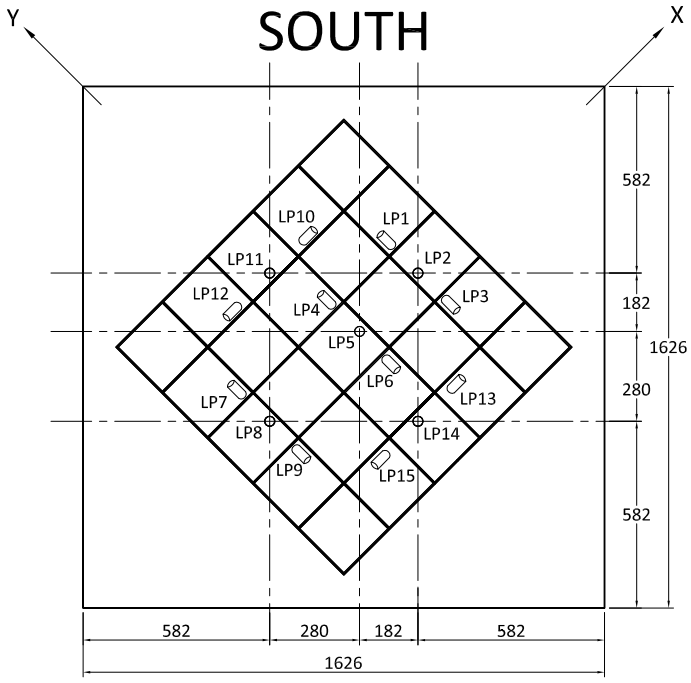


Figure 3.21: *LP Through-Thickness Placement*

Figure 3.22 is a schematic of the LP locations on the South face of the shell, and Table 3.6 summarizes information about each of the five LP triplets. The central Y-direction triplet is slightly shifted to avoid interfering with the three-dimensional coordinate measurement system.



Name	Plane	LP #'s
LP Y1	YZ	1,2,3
LP Y2	YZ	4,5,6
LP Y3	YZ	7,8,9
LP X1	XZ	10,11,12
LP X2	XZ	13,14,15

Figure 3.22 & Table 3.6: *Out-of-Plane LP Locations (Viewed from South)*

Figure 3.23 shows an example of what the LPs look like when installed on specimen ES1, the individual numbers have been added for clarity. When comparing the North and South face, note that the diagonal LPs change relative placement as they pass through the shell.

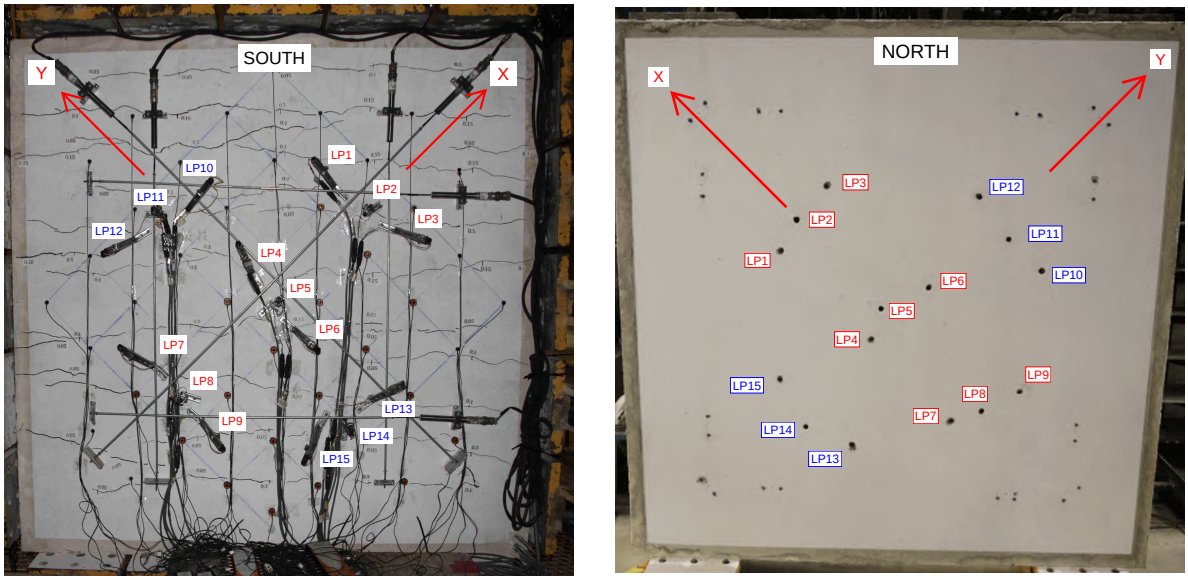


Figure 3.23: *LP Placement on Specimen ES1*

3.4.5 Embedded Concrete Strain Gauges (EGs)

A total of four EGs (PML with 60 mm gauge length) were used in each specimen to complement the out-of-plane measurements from the LPs. The EGs work on the same principal as the LP triplets, except in their case the three separate gauges are pre-arranged and fixed into a 45° rosette as shown in Figure 3.24.

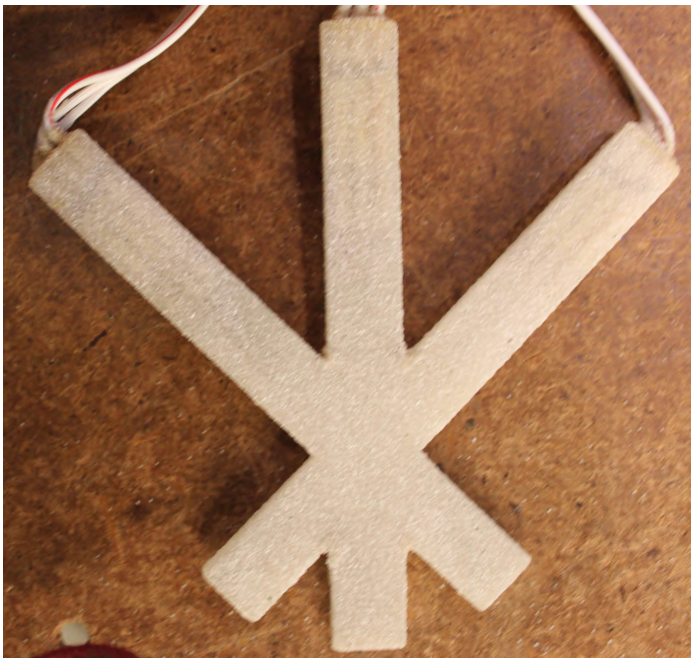


Figure 3.24: *Embedded Strain Gauge Rosette*

The main difference between the EGs and LPs, is that the EGs are fully encased in concrete and only define the Mohr's circle of strain at a localized internal point as show in Figure 3.25, while the LPs define the Mohr's circle of strain over the whole thickness of the shell. The likelihood of an internal local concrete crack occurring right across one of the individual gauges is high; such an occurrence would either cause the gauge to fail or skew the resulting Mohr's circle in an unrealistic way, both options effectively rendering the EG data useless. Hence relying on the EGs for more than simple verification is not recommended.

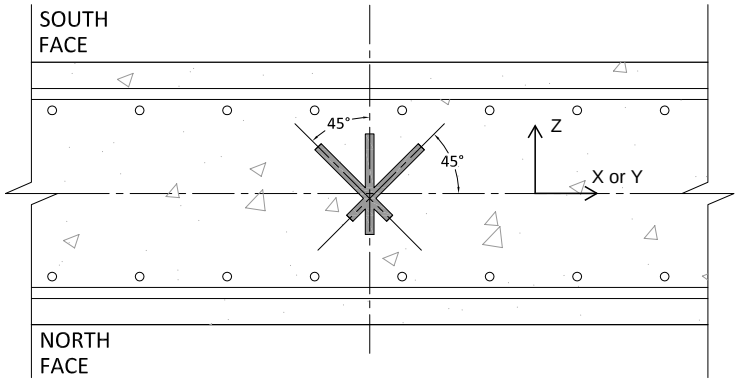


Figure 3.25: *EG Through-Thickness Placement*

Figure 3.26 is a schematic of the four EG locations inside the test region. Two of the EGs are oriented in the XZ plane, and the remaining two are oriented in the YZ plane. The naming convention simply indicates in which plane the EG is placed.

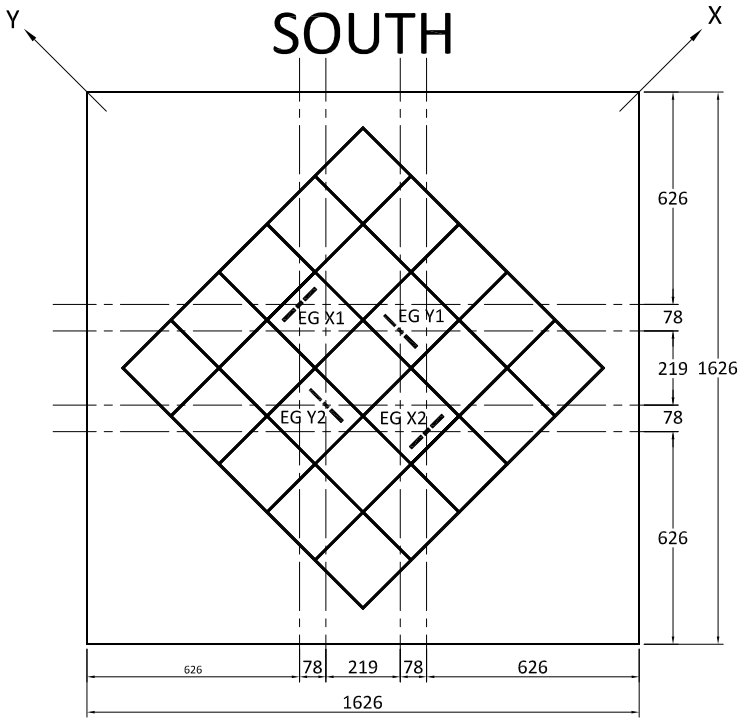


Figure 3.26: *Out-of-Plane EG Locations (Viewed from South)*

The EGs are placed as close as possible to the center of the shell between the North and South faces, and in the direction of the longitudinal reinforcement. Figure 3.27 shows a shell specimen cage before casting, with the EGs located just below the level of the top reinforcement. The hollow PVC ducts, which are necessary for the installation of the LPs, can be seen extending through the thickness of the shell.

Figure 3.27: *Out-of-Plane Instrumentation in Reinforcement Cage*

3.4.6 Reinforcement Strain Gauges (SGs)

To measure reinforcement strains during the test, each specimen had 20 foil SGs (FLA with 5 mm gauge length) placed on several longitudinal bars in the test region. These gauges were equally divided between the North and South cages: 6 in the Y-direction, and 4 in the X-direction per cage. Figure 3.28 is a schematic of the SG locations on the South reinforcement cage, and the North face cage is identically instrumented. The naming convention used is as follows: 1st letter = face, 2nd letter = direction, 3rd letter = relative location.

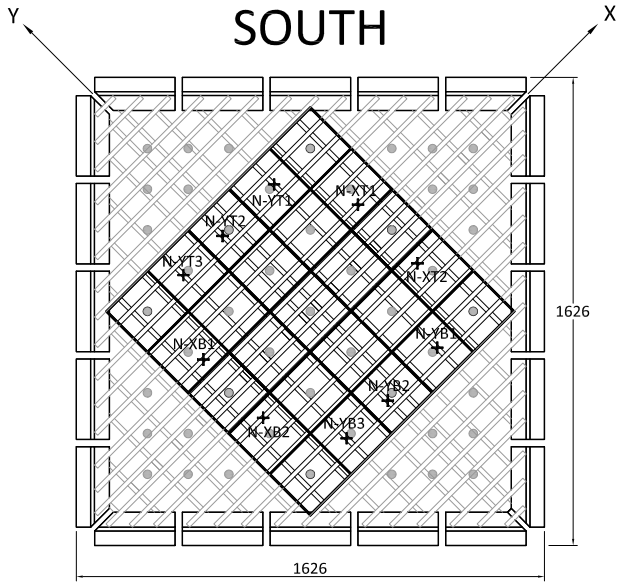


Figure 3.28: *Longitudinal Bar SG Locations (Viewed from South)*

Specimen ES2 had an additional 8 SGs, each placed in the center of an out-of-plane T-head reinforcement bar located in the test region. Figure 3.29 shows which T-head bars were instrumented.

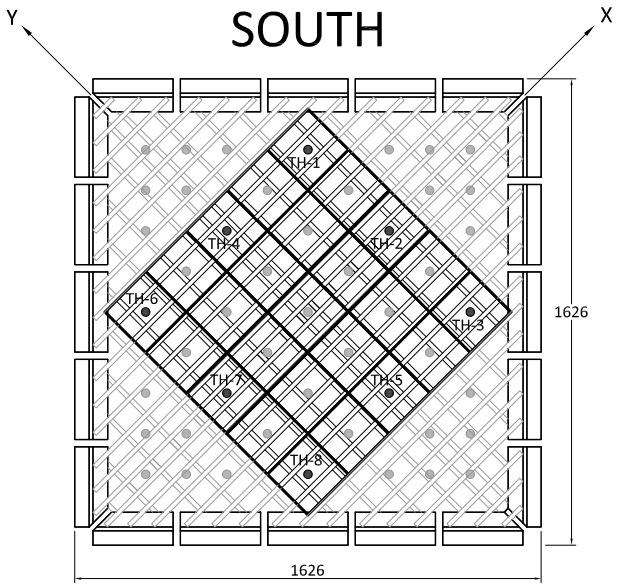


Figure 3.29: *T-Head Bar SG Locations in ES2 (Viewed from South)*

Chapter 4

Experimental Results

The following chapter will present the test data from all the instrumentation (Load Cell, LVDT, LED, LP, EG, and SG) placed on both torsion specimens. No discussion or comparison of the results is made, each type of instrumentation and its respective data are presented separately. A typical section starts with an explanation of how the readings from a certain type of instrumentation are processed, followed by a table summarizing the data, and concluding with plots of the processed data. Note that to plot the post-peak region of these tests the x-axis scale was often increased by an order of magnitude. Therefore, to maintain the readability of the plots across the whole test, the same data is always presented as a separate 'full' and 'pre-peak' plot.

For consistency, data gathered from the different instruments will be presented at the same points (load stages) in each test. These load stages correspond to applied external torsions shown in Table 4.1. All the reduced data from both experiments can be found in Appendix B.

Table 4.1: Applied Torsion at Load Stages

ES1		ES2	
	$[\frac{kN \cdot m}{m}]$ M_{xy}		$[\frac{kN \cdot m}{m}]$ M_{xy}
LS 1	86.8	LS 1	64.8
LS 2	168.8	LS 2	110.5
Peak	187.2	LS 3	173.4
LS 3	182.9	LS 4	214.7
LS 4	170.4	Peak	250.5
LS 5	147.9	LS 5	219.6
LS 6	101.8	LS 6	138.9

4.1 Actuator Load Cell Measurements

Table 4.2 summarizes the actuator forces, and the resulting moments, applied on each face of the shell and recored by the built-in load cells during the two tests. The values presented in the force columns represent the sum of all five actuators in each bank on the edge and face indicated. The moments are found by multiplying the force couple by the lever arm distance between the actuator banks (304.8 mm) and dividing this by the nominal side dimension of the shell (1524 mm). Recall that the magnitude of the moments along the Horizontal (top and bottom) and Vertical (east and west) axes are intended to be equal, although due to 2nd order effects in the shell there are minor discrepancies between the magnitude of forces applied between certain North and South face actuators. Yet this error is negligible, and the applied torsional moment at each load stage is simply taken as the average of the Horizontal and Vertical moments.

Table 4.2: Applied Forces and Resulting Moments

	$[kN]$ Top		$[kN]$ $Bottom$		$[kN]$ $East$		$[kN]$ $West$		$[\frac{kN \cdot m}{m}]$ M_{xy}	
	$North$	$South$	$North$	$South$	$North$	$South$	$North$	$South$	$\lvert M_h \rvert$	$\lvert M_v \rvert$
***ES*1**										
$LS1$	-416.3	447.7	-458.5	420.5	438.1	-397.4	438.1	-438.1	87.6	86.0
$LS2$	-829.2	844.5	-871.0	833.4	851.5	-783.2	851.3	-851.5	169.8	167.8
$Peak$	-921.9	932.6	-963.9	926.1	944.3	-871.3	944.3	-944.2	188.2	186.2
$LS3$	-900.2	911.8	-942.2	904.4	922.6	-850.9	922.6	-922.6	183.9	181.9
$LS4$	-837.6	851.0	-879.3	842.0	860.0	-790.2	859.8	-860.1	171.4	169.4
$LS5$	-725.0	740.5	-767.0	729.2	747.1	-683.6	747.0	-747.1	148.9	147.0
$LS6$	-492.8	512.9	-534.8	497.1	515.0	-467.3	514.9	-514.9	102.4	101.1
***ES*2**										
$LS1$	-305.2	342.5	-347.3	309.4	326.8	-294.6	326.8	-326.8	65.6	64.1
$LS2$	-535.8	565.8	-577.9	539.9	557.5	-504.0	557.6	-557.5	111.6	109.4
$LS3$	-853.0	869.9	-895.0	857.1	874.9	-800.1	874.9	-875.1	174.7	172.2
$LS4$	-1060.0	1072.1	-1101.8	1064.3	1082.5	-997.0	1082.4	-1082.4	216.0	213.3
$Peak$	-1240.8	1243.6	-1282.8	1245.0	1263.1	-1167.2	1263.1	-1263.1	251.9	249.1
$LS5$	-1085.6	1091.5	-1127.7	1089.7	1107.8	-1019.3	1107.9	-1107.8	220.9	218.3
$LS6$	-681.1	698.5	-722.9	685.5	703.0	-629.9	702.8	-703.1	140.1	137.7

4.2 In-Plane LVDT Measurements

The LVDTs were used to measure the average surface strains in four directions (H,V,X,Y) as defined on both the North and South face (Figure 3.13). The individual linear strains were found by dividing the recorded displacements over their respective gauge lengths, which were measured as the distance between the LVDT anchor points. A degree of redundancy was provided as two LVDTs were placed in both the H and V directions - their readings were averaged to produce a single strain measurement in the given direction.

Although LVDTs are precise devices (noise level of $\pm 5\mu m$), they can only measure the strains between discrete points over a large surface area. Hence the measured strains are considered to be averaged over the whole specimen, which provides no information about local nonlinearity in the test region. This can pose a problem in experiments where a non-uniform in-plane strain field is expected (e.g. applied out-of-plane forces, double curvature tests). But since pure torsion in a shell can be reduced to equal and opposite pure in-plane shears on opposing faces, the strain field across the faces was expected to be relatively uniform - the strains should be similar regardless of what point in the test region one observed. Therefore, it was concluded that the average strain data gathered by the LVDTs could also serve as a reasonable approximation of what was occurring in the test region of the shell.

The twist strain (ϕ_{xy}) was calculated using data from both the North and South face sets of LVDTs; together with the applied torsional moment (M_{xy}) this established the important torque-twist relationship for each specimen. Assuming small angles, the twist strain (in units of rad/length) was calculated as the change in the in-plane shear strains (γ_{xy}) over the thickness of the shell. The surface shear strains were approximately equal in magnitude, but "+" on the North and "-" on the South face, which corresponded to vertical and horizontal cracks respectively. These shear strains were assumed to vary linearly through the thickness of the shell, with the twist strain represented as the angle of the resulting strain profile (Figure 4.1).

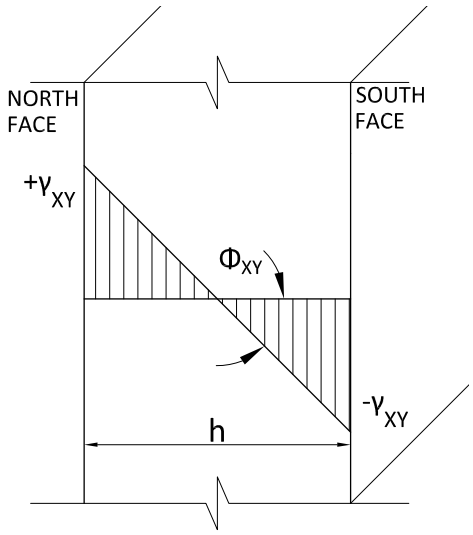


Figure 4.1: *Calculating Experimental Twist Strain*

It is not possible to explicitly measure shear strains in the reinforcement XY-plane, since shear deformations are an angular quantity and LVDTs can only measure linear quantities. Yet by determining two independent and orthogonal linear strains at 45° to the reinforcement (i.e. strains in the HV-plane) the magnitude of the XY-plane shear strain can be calculated as their difference. But with only two strains just the center of the Mohr's circle can be defined, not its exact size or orientation. Figure 4.2 shows how two drastically different but equally valid circles could be drawn from the same two measurements, where important information such as the principal angle and strains can not be determined.

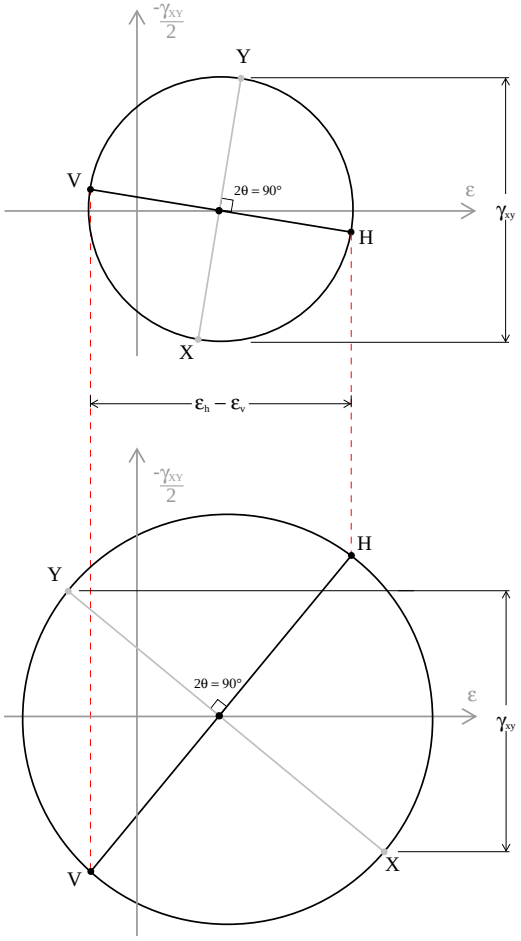


Figure 4.2: *Calculating Shear Strain from Two Linear Strains*

To fully define a Mohr's circle of strain (i.e allowing one to calculate the full strain state in any two-dimensional plane) three independent axial strain measurements at known angles are necessary. This is achieved by using an additional LVDT measurement, oriented in either the X or Y direction in this case, to explicitly calculate the size and position of the Mohr's circle. This means that one of the directions in our four LVDT set-up is not necessary (the Mohr's circle is considered over-defined) and is typically discarded to reduce it to a three strain system that can be explicitly calculated (Figure 4.3a). But rather than waste useful data, the Mohr's circle calculations in this thesis use a procedure that has been developed [39] to determine a Mohr's circle of best fit using all four LVDTs while minimizing the overall error (Figure 4.3b).

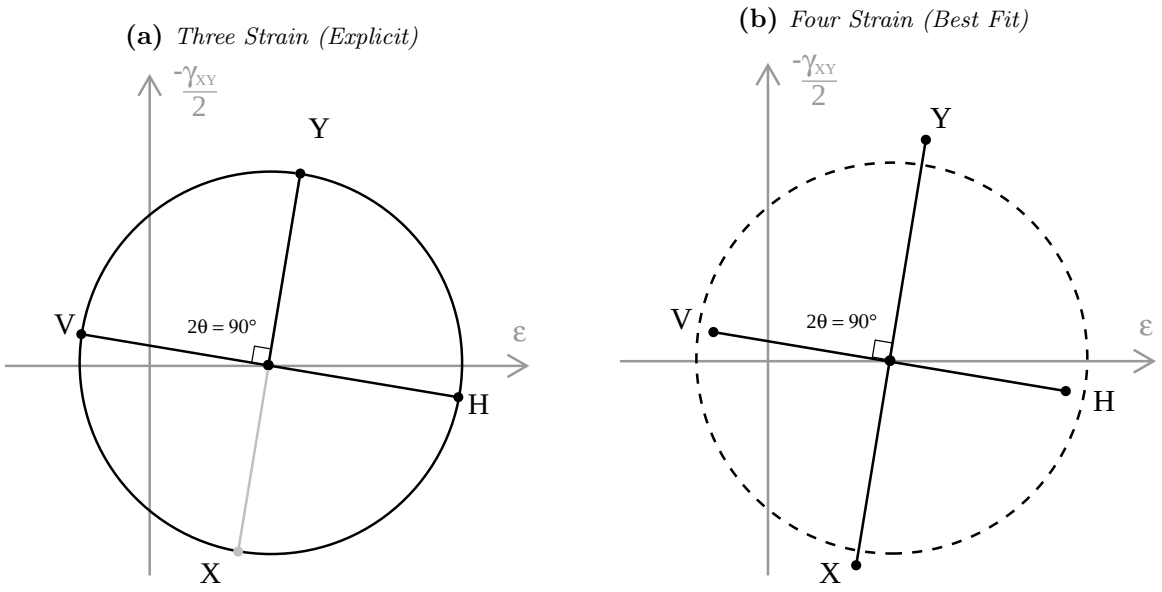


Figure 4.3: *Fully Defined Mohr's Circles*

Table 4.3 summarizes the calculated LVDT Mohr's circle data at the individual load stages for both tests. The North and South face sets are shown separately, but for consistency the perspective is always taken from the North face, which results in different signs for the shear strain. The same information is also presented in the subsequent graphs, which better show the actual progression of each test. Both faces are loaded with the same magnitude of pure in-plane shear as a result of the applied torsional moment, therefore similar behaviour is expected on either face. Both tests were run into the post-peak region, and while this was done in a controlled manner significant cover spalling and cracking makes these LVDT data less reliable. It is important to remember that the specimens are cast with the South side facing up. This results in more bleed water and hence a lower concrete modulus on the South face, which explains the higher strains measured.

Table 4.3: LVDT Data at Load Stages

	$\left[\frac{kN \cdot m}{m}\right]$	$\left[\frac{mrad}{m}\right]$	$[\times 10^{-3}]$		$[\times 10^{-3}]$		$[\times 10^{-3}]$		$[^{\circ}]$		$[\times 10^{-3}]$		$[\times 10^{-3}]$	
	M_{xy}	ϕ_{xy}	γ_{xy}		ϵ_x		ϵ_y		$\theta_{xy}{}^{*}$		ϵ_1		ϵ_2	
			North	*South*	*North*	*South*	*North*	*South*	*North*	*South*	*North*	*South*	*North*	*South*
***ES*1**														
*LS*1	86.8	15.5	1.94	-2.47	0.22	0.42	0.17	0.48	-0.7	89.3	1.16	1.68	-0.77	-0.79
*LS*2	168.8	46.3	6.18	-7.03	0.73	0.97	1.42	1.21	3.2	89.0	4.18	4.60	-2.03	-2.43
Peak	187.2	58.7	7.91	-8.83	0.84	1.07	1.75	1.40	3.3	89.0	5.28	5.65	-2.68	-3.18
*LS*3	182.9	60.4	8.11	-9.10	0.80	1.09	1.78	1.43	3.4	88.9	5.38	5.82	-2.80	-3.29
*LS*4	170.4	80.8	10.99	-12.05	1.99	1.36	1.90	1.89	-0.3	88.7	7.44	7.65	-3.55	-4.40
*LS*5	147.9	96.6	13.56	-13.99	3.76	1.50	1.70	2.41	-4.3	-88.2	9.59	8.96	-4.12	-5.05
*LS*6	101.8	139.7	19.74	-20.10	6.74	0.45	3.16	8.48	-5.1	79.1	14.98	15.28	-5.09	-6.35
***ES*2**														
*LS*1	64.8	8.2	0.99	-1.34	0.00	0.26	0.12	0.27	3.4	90.0	0.56	0.93	-0.44	-0.40
*LS*2	110.5	21.4	2.73	-3.38	0.23	0.68	0.59	0.70	3.7	89.8	1.78	2.38	-0.97	-1.00
*LS*3	173.4	39.0	5.14	-5.97	0.53	1.18	1.19	1.19	3.6	89.9	3.45	4.17	-1.74	-1.80
*LS*4	214.7	56.7	7.58	-8.58	0.79	1.56	1.63	1.69	3.1	89.6	5.02	5.91	-2.60	-2.66
Peak	250.5	89.4	12.07	-13.40	1.07	2.07	2.17	2.38	2.6	89.3	7.68	8.93	-4.45	-4.48
*LS*5	219.6	111.0	14.59	-17.02	1.17	2.18	2.39	2.60	2.4	89.3	9.10	-6.12	-5.54	-6.12
*LS*6	138.9	223.0	32.50	-31.10	1.21	2.05	2.76	6.53	1.4	85.9	18.24	20.00	-14.27	-11.43

* Measured from Horizontal Axis (CCW = +)

4.2.1 Specimen ES1

Torque-Twist Relationship

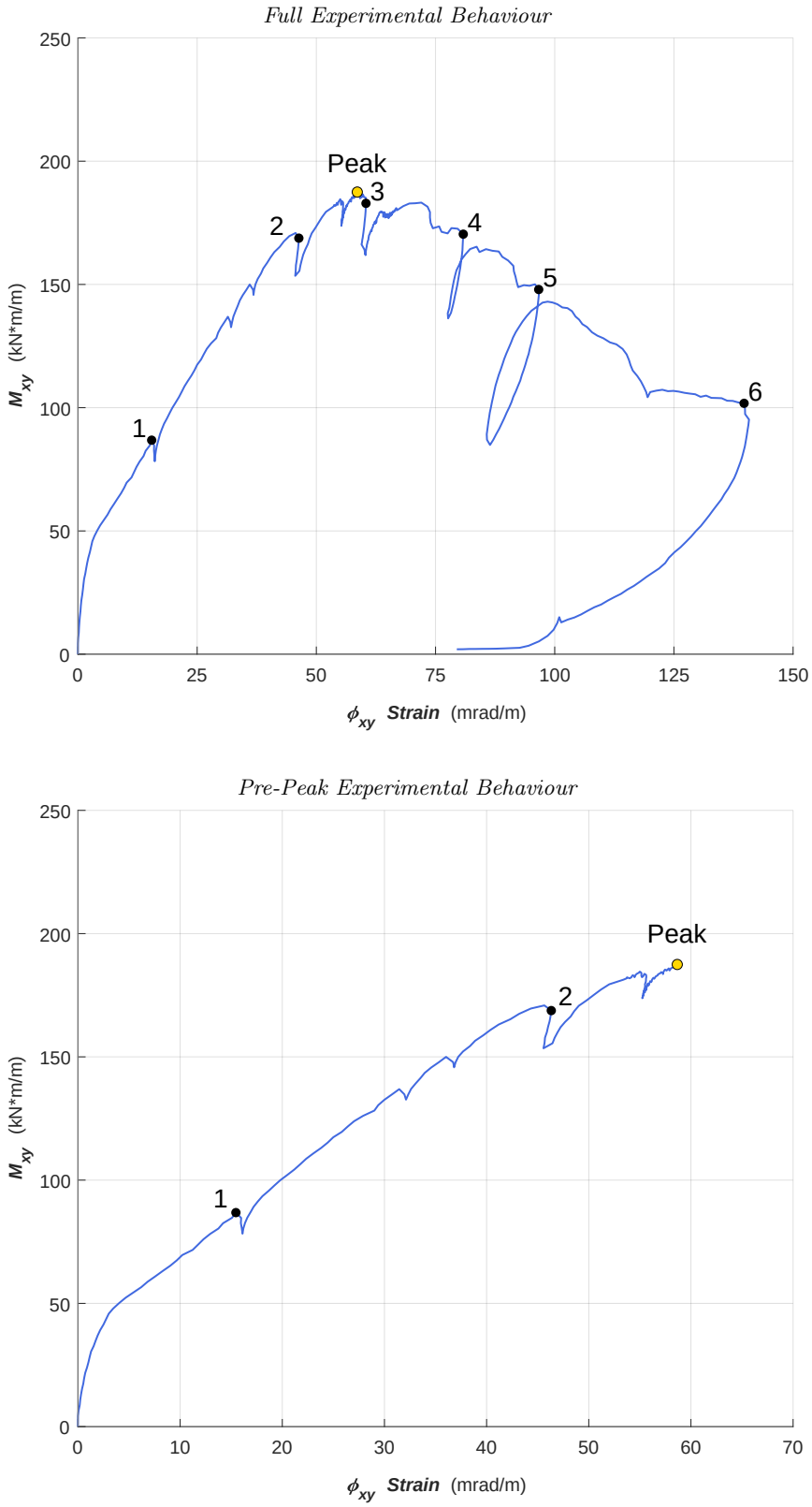


Figure 4.4: *ES1 Applied Torsion vs. Twist Strain*

In-Plane (XY) Strains

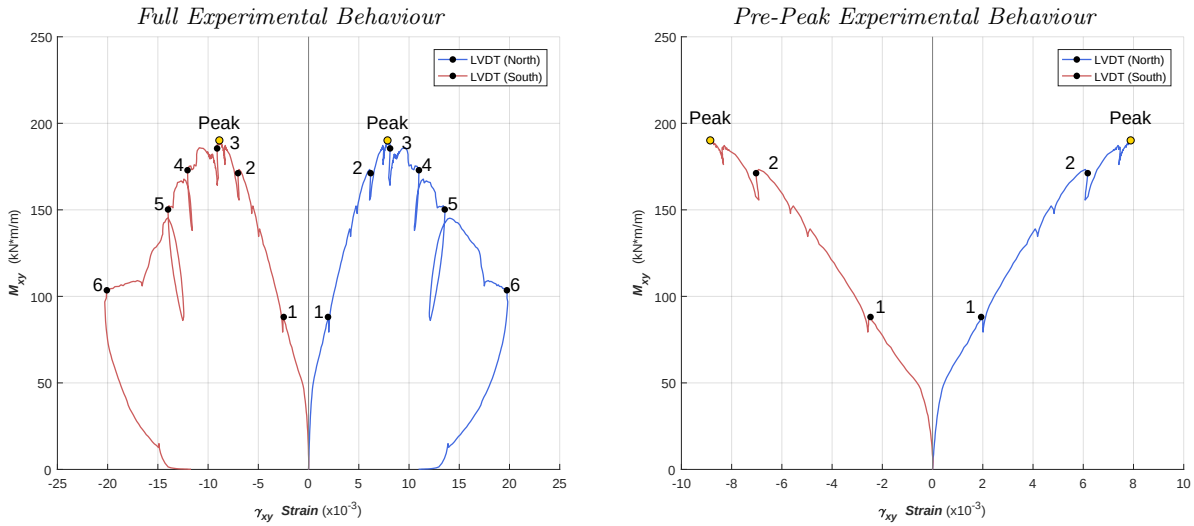


Figure 4.5: *ES1 Applied Torsion vs. In-Plane (XY) Shear Strain*

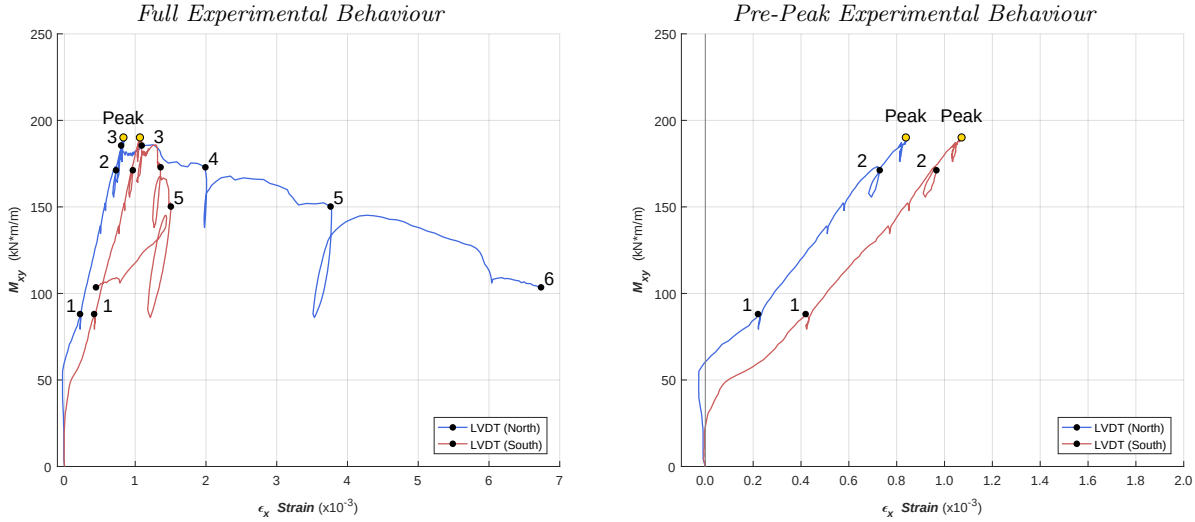


Figure 4.6: *ES1 Applied Torsion vs. X-Direction Strain*

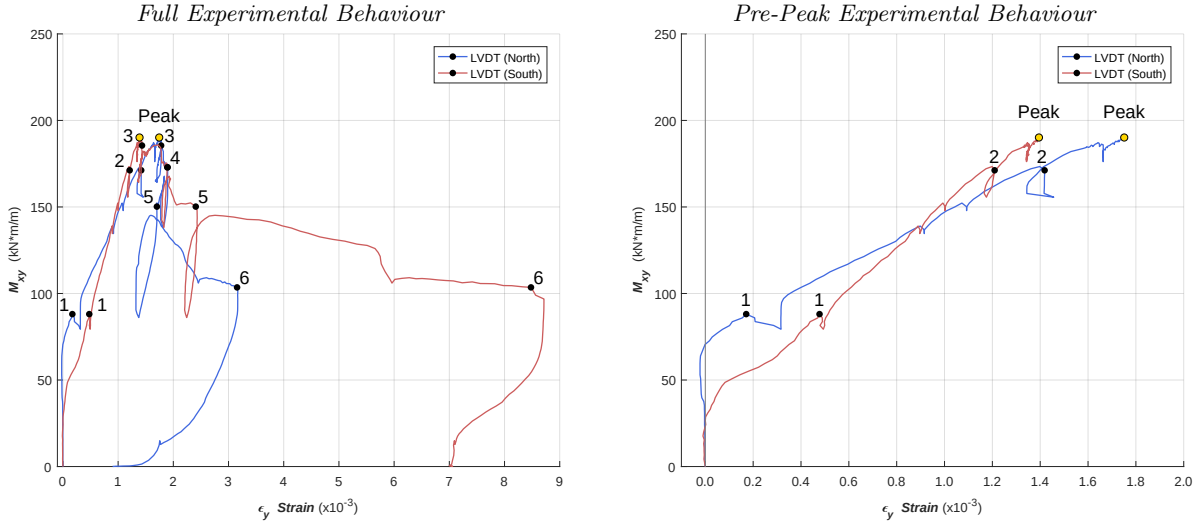


Figure 4.7: *ES1 Applied Torsion vs. Y-Direction Strain*

In-Plane (XY) Principal Strains

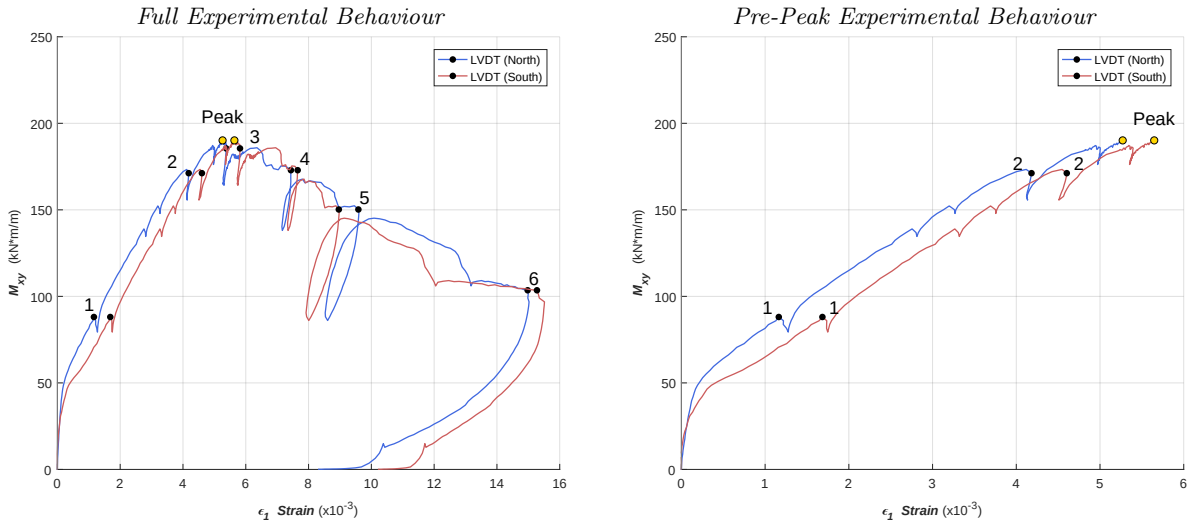


Figure 4.8: *ES1 Applied Torsion vs. Principal Tensile Strain*

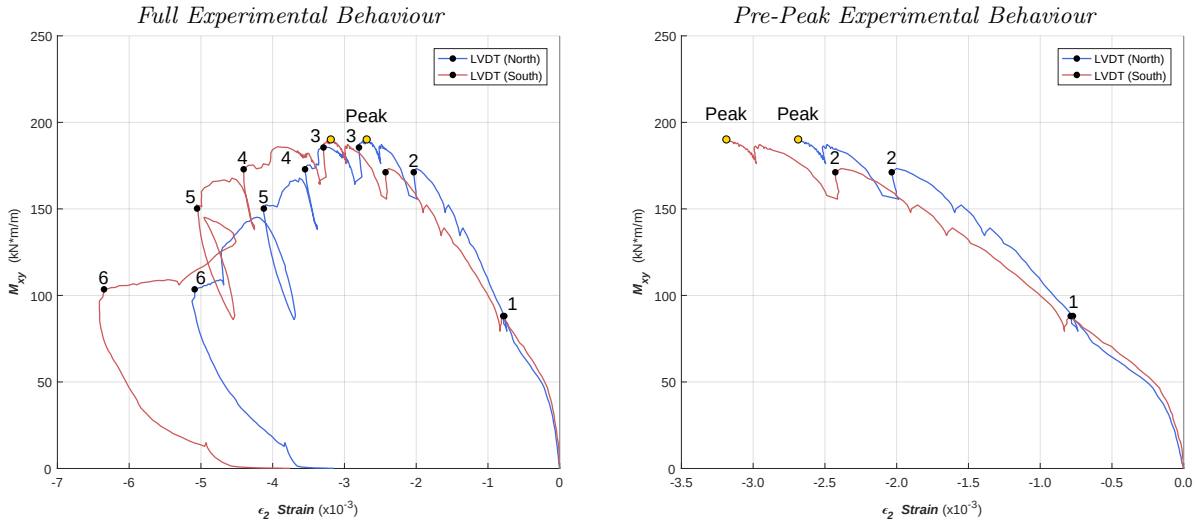


Figure 4.9: *ES1 Applied Torsion vs. Principal Compressive Strain*

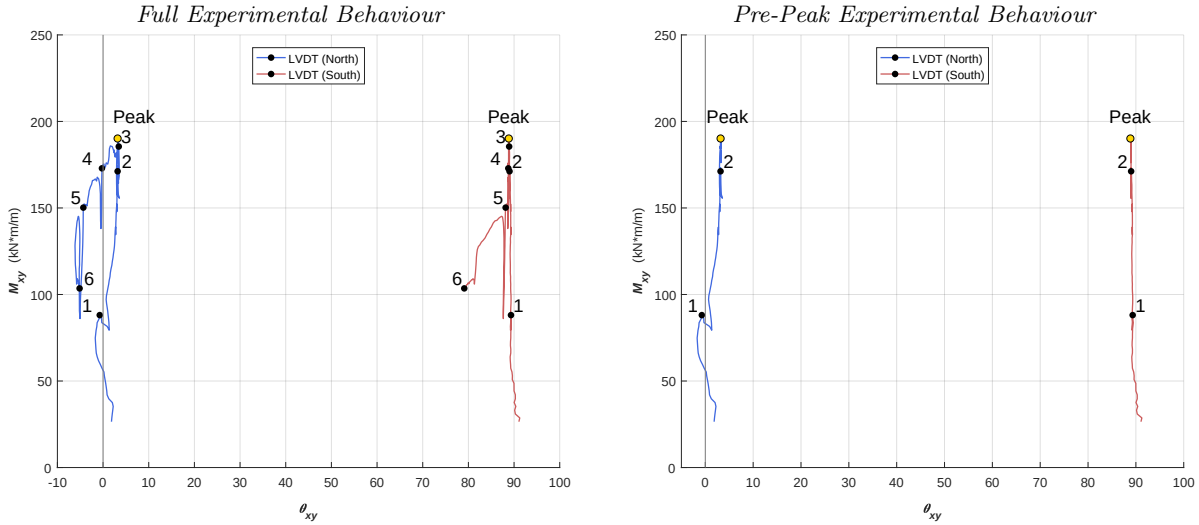


Figure 4.10: *ES1 Applied Torsion vs. Angle of Principal Strain (CCW+)*

4.2.2 Specimen ES2

Torque-Twist Relationship

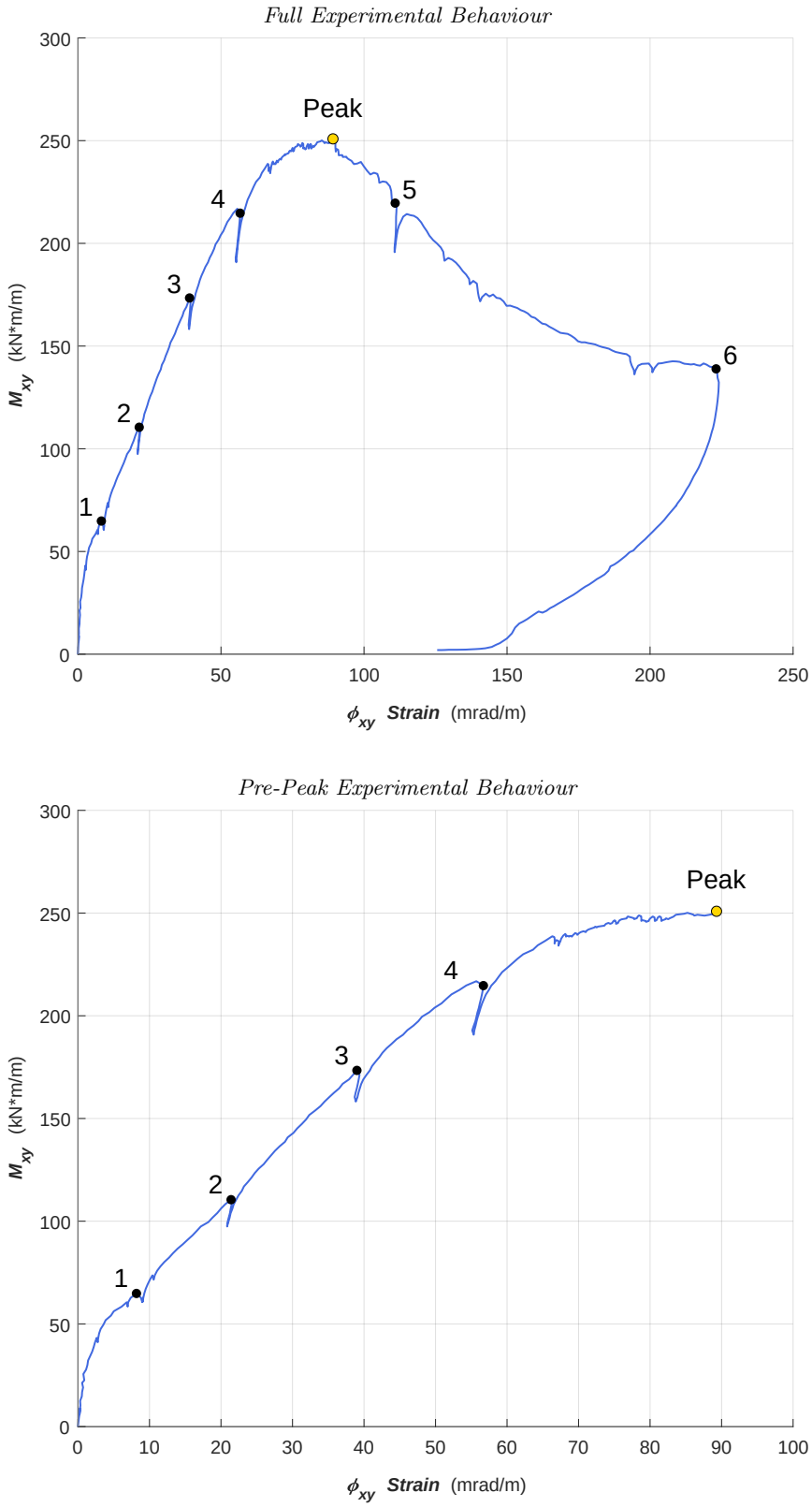


Figure 4.11: *ES2 Applied Torsion vs. Twist Strain*

In-Plane (XY) Strains

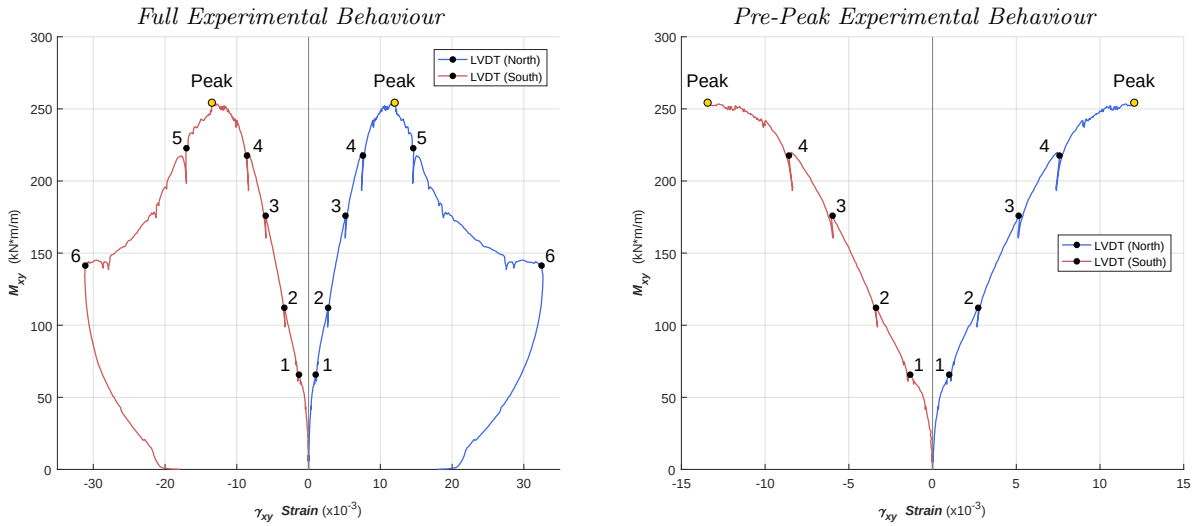


Figure 4.12: *ES2 Applied Torsion vs. In-Plane (XY) Shear Strain*

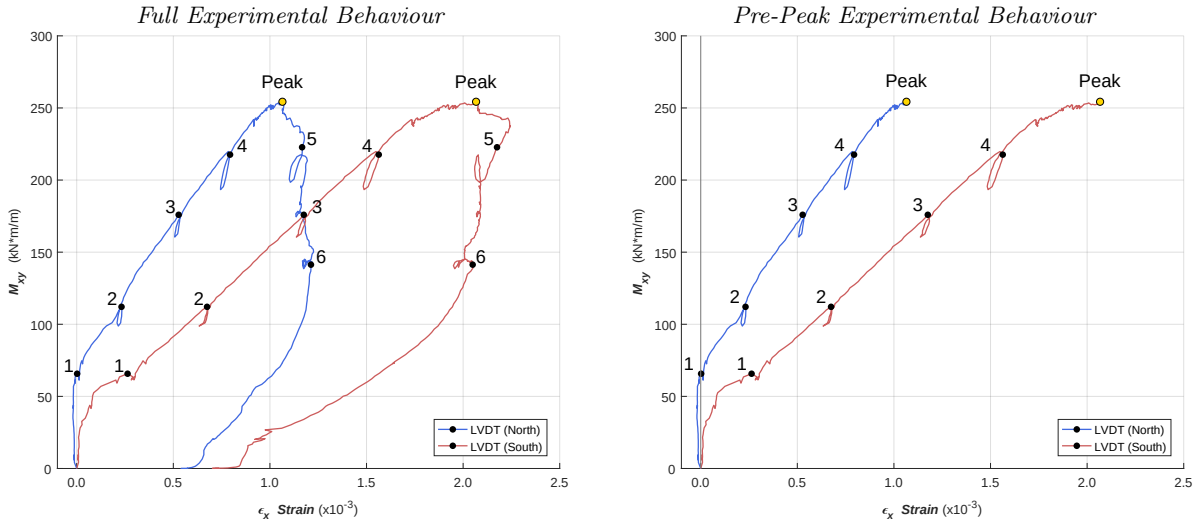


Figure 4.13: *ES2 Applied Torsion vs. X-Direction Strain*

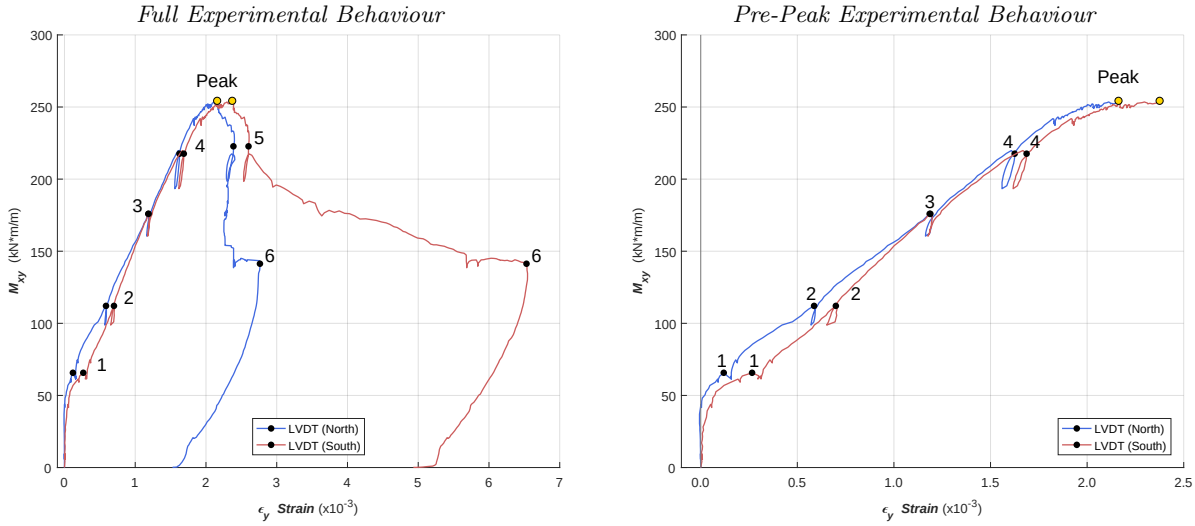


Figure 4.14: *ES2 Applied Torsion vs. Y-Direction Strain*

In-Plane (XY) Principal Strains

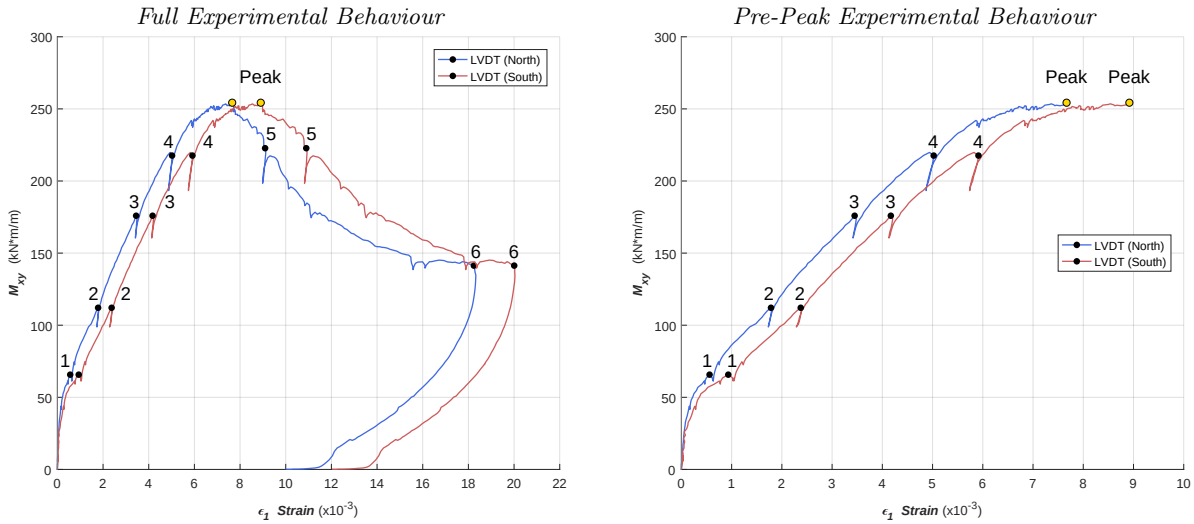


Figure 4.15: *ES2 Applied Torsion vs. Principal Tensile Strain*

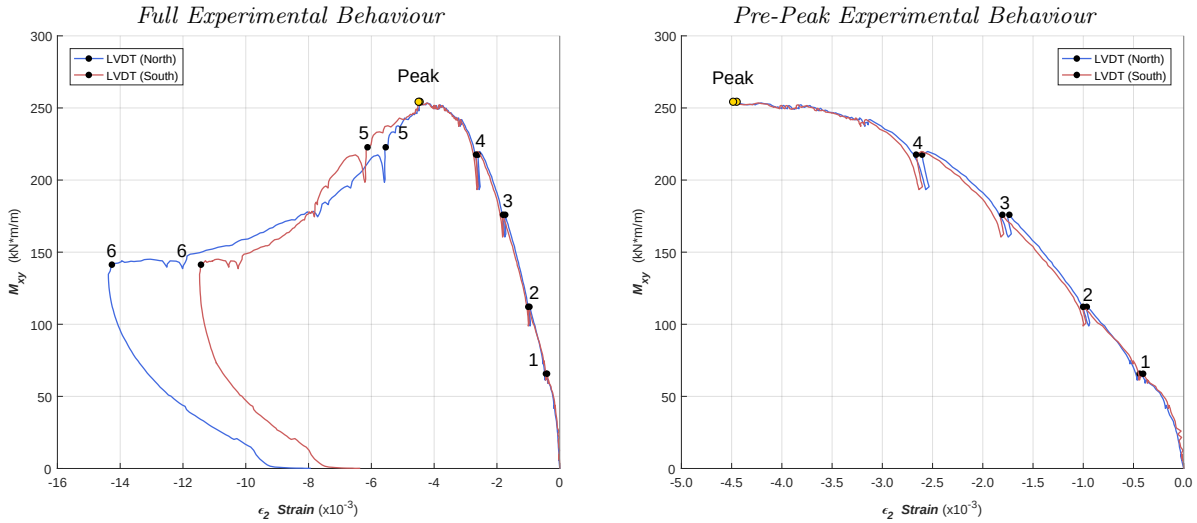


Figure 4.16: *ES2 Applied Torsion vs. Principal Compressive Strain*

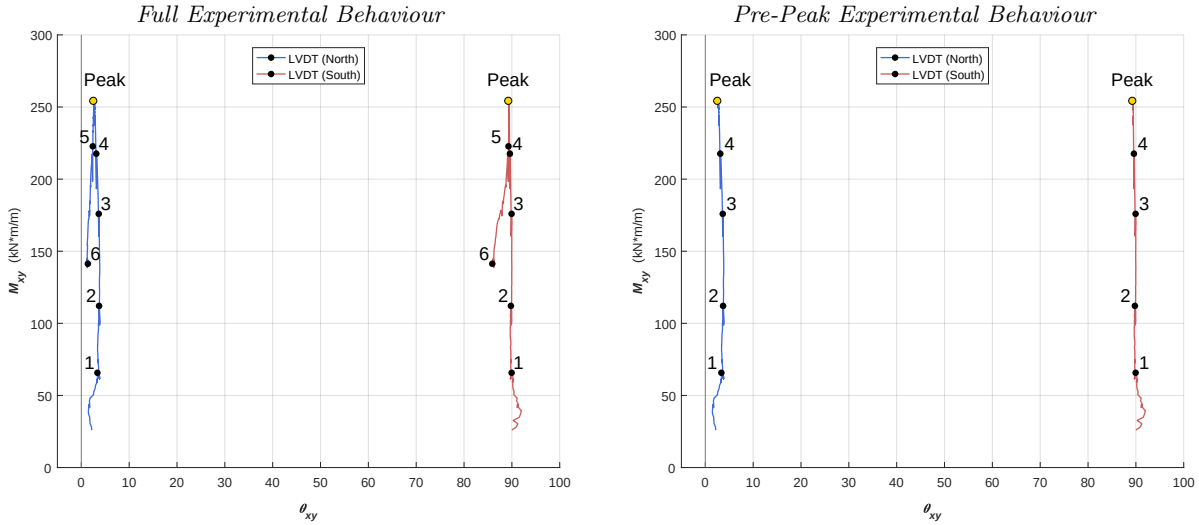


Figure 4.17: *ES2 Applied Torsion vs. Angle of Principal Strain (CCW+)*

4.3 In-Plane LED Measurements

The LED targets, arranged in a 6 x 6 grid on the South face, provided in-plane strain measurements throughout the tests. The test region was subdivided into 25 equal sized elements, where the deformations in each element were approximately uniform, and could therefore be represented by a Mohr's circle of strain. The same four-strain approach as described in the previous section was used for each of element, with the only difference being that the LED elements were already rotated to the plane of the reinforcement so there were two measurements averaged in both the X and Y directions. Figure 4.18 shows a sample element (#1) and the individual strain measurements used to define the Mohr's circle.

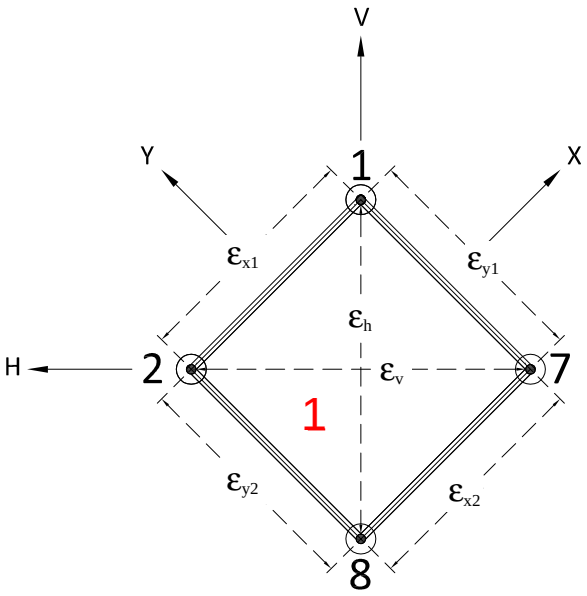


Figure 4.18: *LED Element Strains (Viewed from South)*

Table 4.4 summarizes the calculated LED Mohr's circle data at the individual load stages for both tests. Rather than list every single element individually, the average of all 25 elements is given, followed by the coefficients of variation for these data. In the post-peak region, localized regions of the shell begin to fail resulting in certain LED elements experiencing large non-uniform jumps in strain. This is reflected in the growing variation values, which imply that the LED average value is a less reliable measure in the post-peak region of the tests. For comparison, the LVDT data from the South face is also shown in this table; the LEDs and LVDTs are both measuring in-plane strains, and their similar measurements are validation for the data collected.

The full data range is also plotted in the subsequent figures, where the red line represents the average value of the individual LED elements shown in grey. A two-dimensional snapshot of the test region is also shown at the peak applied torsion value, showing the individual element readings. For the snapshots at each load stage see Appendix B.2

Table 4.4: LED Data at Load Stages

	$[\frac{kN \cdot m}{m}]$	$[\frac{mrad}{m}]$	$[\times 10^{-3}]$			$[\times 10^{-3}]$			$[\times 10^{-3}]$			$[^{\circ}]$			$[\times 10^{-3}]$			$[\times 10^{-3}]$		
	M_{xy}	ϕ_{xy}	γ_{xy}			ϵ_x			ϵ_y			θ_{xy}[1]			ϵ_1			ϵ_2		
			Avg.	*c.o.v.*	$LVDT^2$	*Avg.*	*c.o.v.*	$LVDT^2$	*Avg.*	*c.o.v.*	$LVDT^2$	*Avg.*	*c.o.v.*	$LVDT^2$	*Avg.*	*c.o.v.*	$LVDT^2$	*Avg.*	*c.o.v.*	$LVDT^2$
***ES*1**																				
*LS*1	86.8	15.5	-2.40	22.0%	-2.47	0.50	69.4%	0.42	0.52	64.7%	0.48	89.7	5.8%	89.3	1.72	28.7%	1.68	-0.71	27.1%	-0.79
*LS*2	168.8	46.3	-6.44	21.7%	-7.03	1.02	70.9%	0.97	1.12	80.6%	1.21	89.6	4.7%	89.0	4.32	30.4%	4.60	-2.18	20.3%	-2.43
Peak	187.2	58.7	-8.02	19.8%	-8.83	1.15	70.2%	1.07	1.25	83.5%	1.40	89.7	4.2%	89.0	5.24	27.9%	5.65	-2.84	21.1%	-3.18
*LS*3	182.9	60.4	-8.30	19.6%	-9.10	1.16	72.9%	1.09	1.31	80.6%	1.43	89.5	4.2%	88.9	5.42	27.5%	5.82	-2.94	21.5%	-3.29
*LS*4	170.4	80.8	-11.21	21.3%	-12.05	1.31	71.6%	1.36	1.63	85.4%	1.89	89.3	3.8%	88.7	7.11	27.3%	7.65	-4.17	25.0%	-4.40
*LS*5	147.9	96.6	-13.54	23.9%	-13.99	1.35	68.1%	1.50	2.01	95.0%	2.41	89.0	4.4%	-88.2	8.52	28.6%	8.96	-5.15	29.0%	-5.05
*LS*6	101.8	139.7	-22.27	45.0%	-20.10	-0.52	951.8%	0.45	2.14	241.3%	8.48	86.8	8.0%	79.1	12.35	27.7%	15.28	-10.73	80.1%	-6.35
***ES*2**																				
*LS*1	64.8	8.2	-1.26	21.6%	-1.34	0.32	57.9%	0.26	0.28	57.9%	0.27	91.1	4.9%	90.0	0.94	28.6%	0.93	-0.34	14.5%	-0.40
*LS*2	110.5	21.4	-3.16	18.0%	-3.38	0.79	49.6%	0.68	0.68	44.9%	0.70	91.0	4.2%	89.8	2.33	23.6%	2.38	-0.87	10.6%	-1.00
*LS*3	173.4	39.0	-5.57	16.0%	-5.97	1.28	52.1%	1.18	1.10	47.0%	1.19	90.9	4.2%	89.9	4.00	22.2%	4.17	-1.63	10.0%	-1.80
*LS*4	214.7	56.7	-7.95	15.0%	-8.58	1.68	56.0%	1.56	1.46	46.0%	1.69	90.8	4.4%	89.6	5.58	20.6%	5.91	-2.44	14.7%	-2.66
Peak	250.5	89.4	-12.35	17.3%	-13.4	2.09	82.7%	2.07	2.03	41.0%	2.38	90.2	5.9%	89.3	8.31	20.3%	8.93	-4.19	24.6%	-4.48
*LS*5	219.6	111.0	-16.47	22.7%	-17.02	1.88	107.0%	2.18	1.89	93.2%	2.60	90.4	3.9%	89.3	10.17	19.8%	-6.12	-6.40	45.3%	-6.12
*LS*6	138.9	223.0	-32.47	49.2%	-31.10	0.65	1755.0%	2.05	3.16	174.3%	6.53	89.4	10.0%	85.9	18.91	29.3%	20.00	-15.10	95.0%	-11.43

[1] Measured from Horizontal Axis (CCW = +)
[2] South Face

4.3.1 Specimen ES1

In-Plane Shear Strain

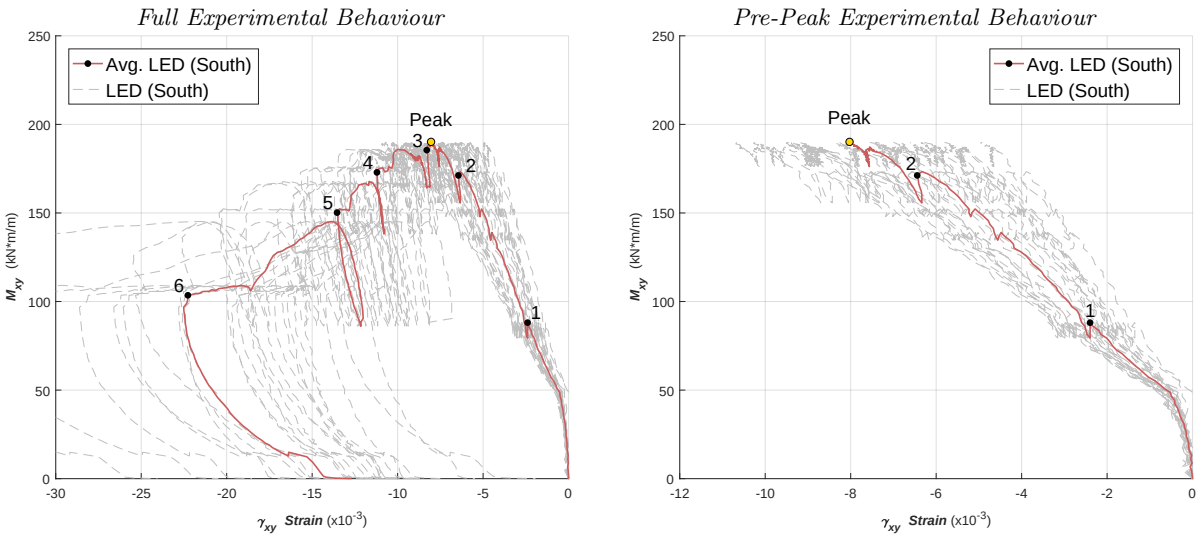


Figure 4.19: *ES1 Applied Torsion vs. In-Plane (XY) Shear Strain*

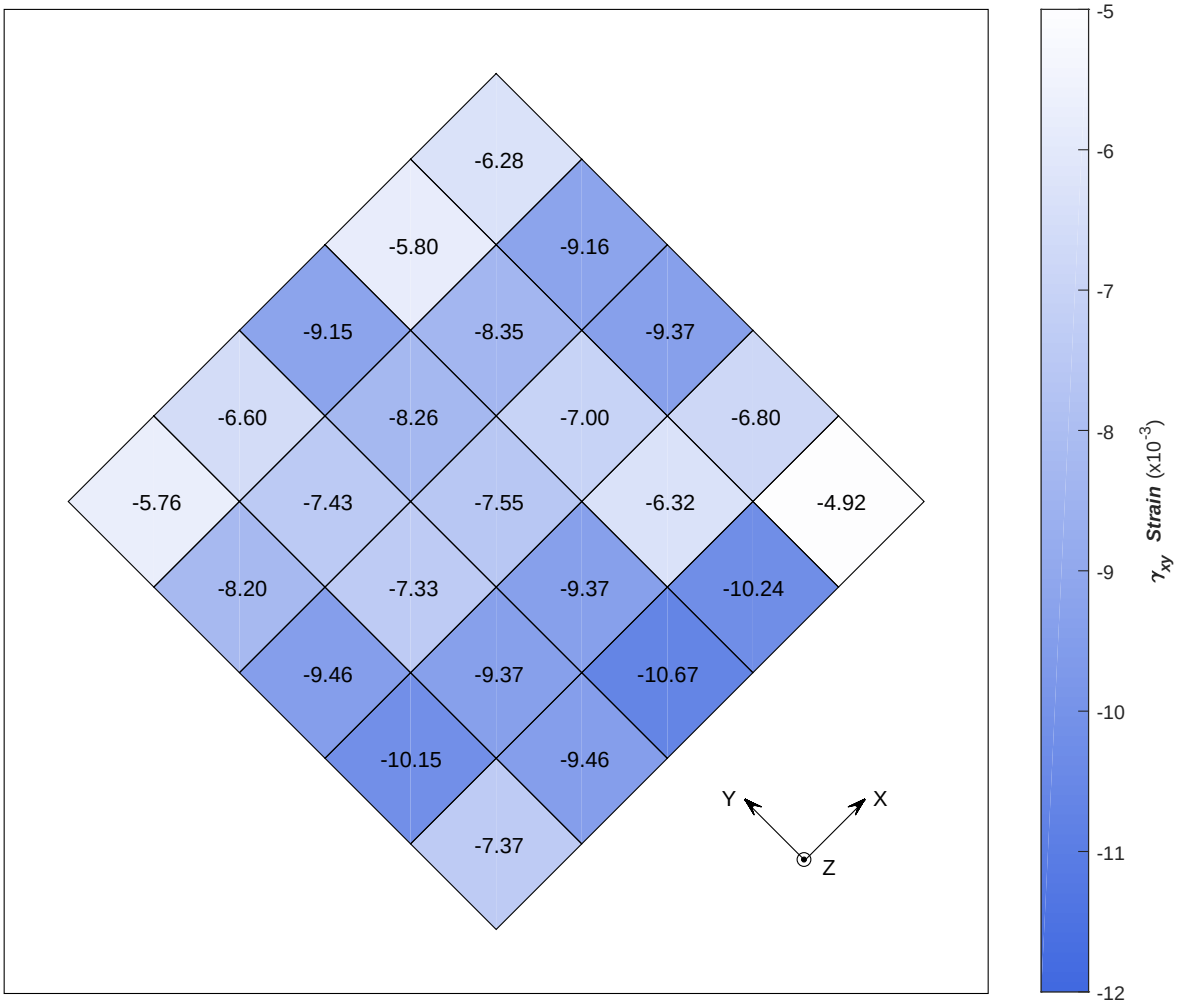


Figure 4.20: *ES1 In-Plane (XY) Shear Strain at 'Peak' Torsion*

X-Direction Strain

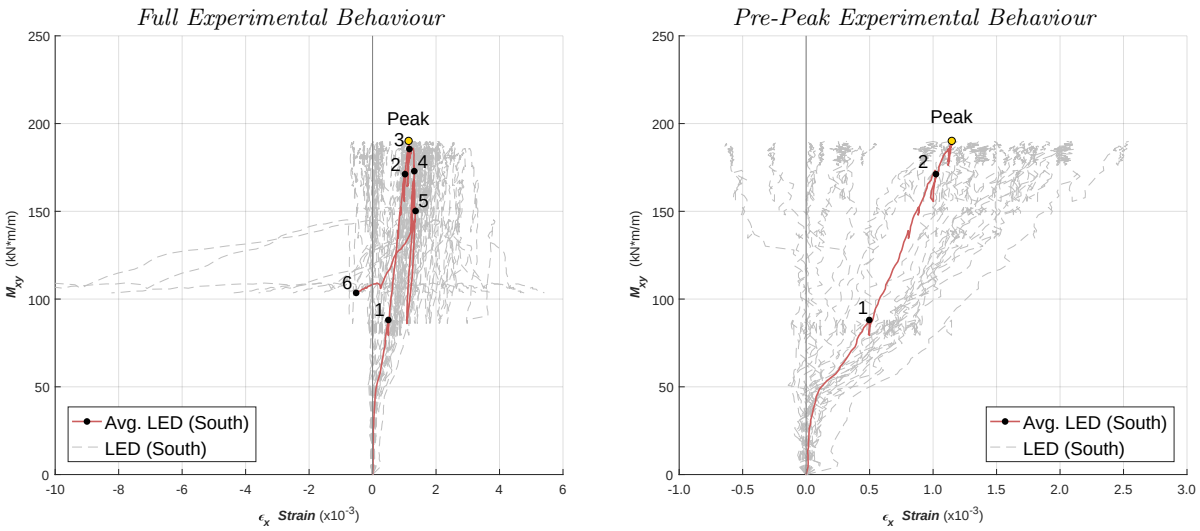


Figure 4.21: *ES1 Applied Torsion vs. X-Direction Strain*

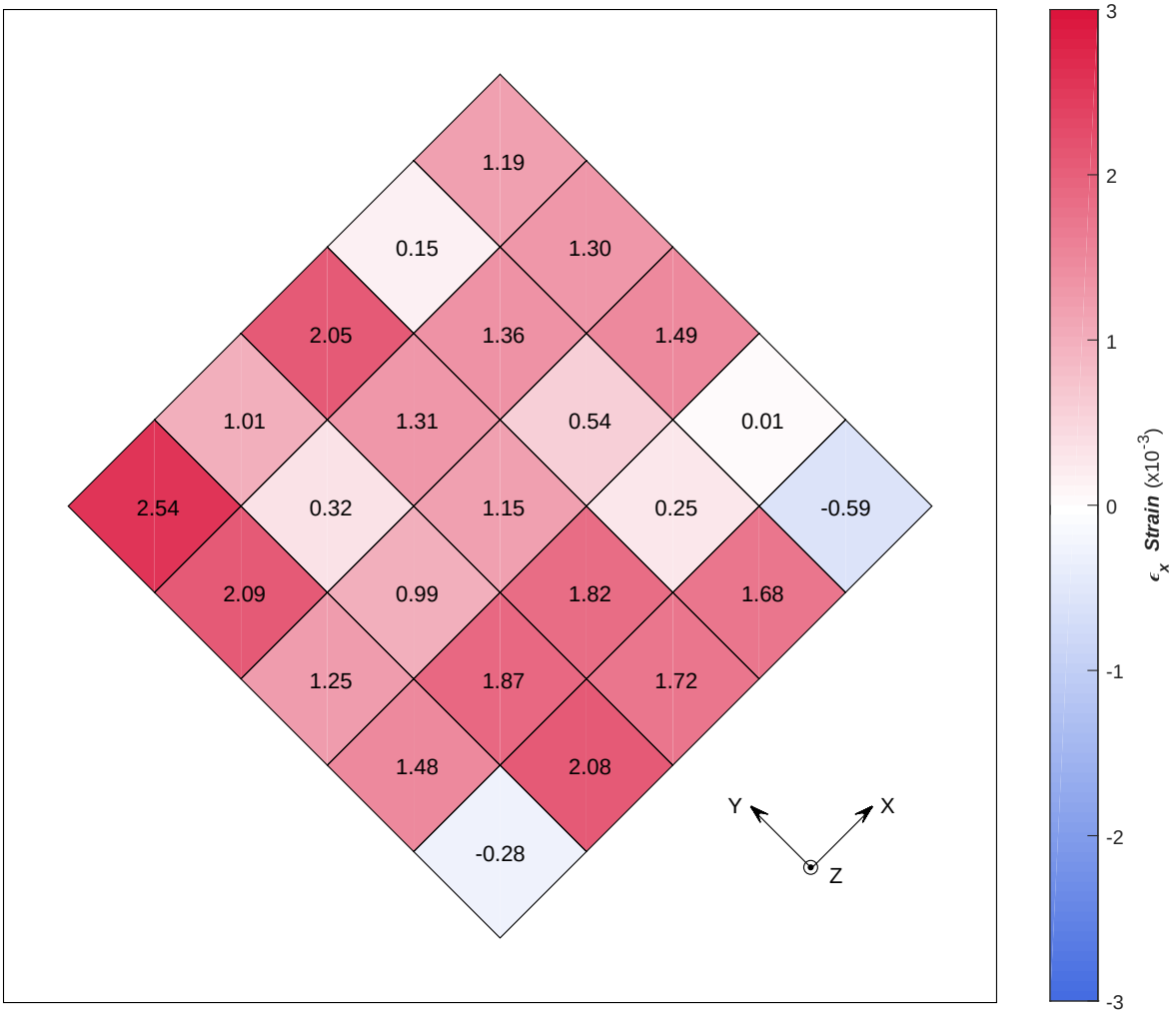


Figure 4.22: *ES1 X-Direction Strain at 'Peak' Torsion*

Y-Direction Strain

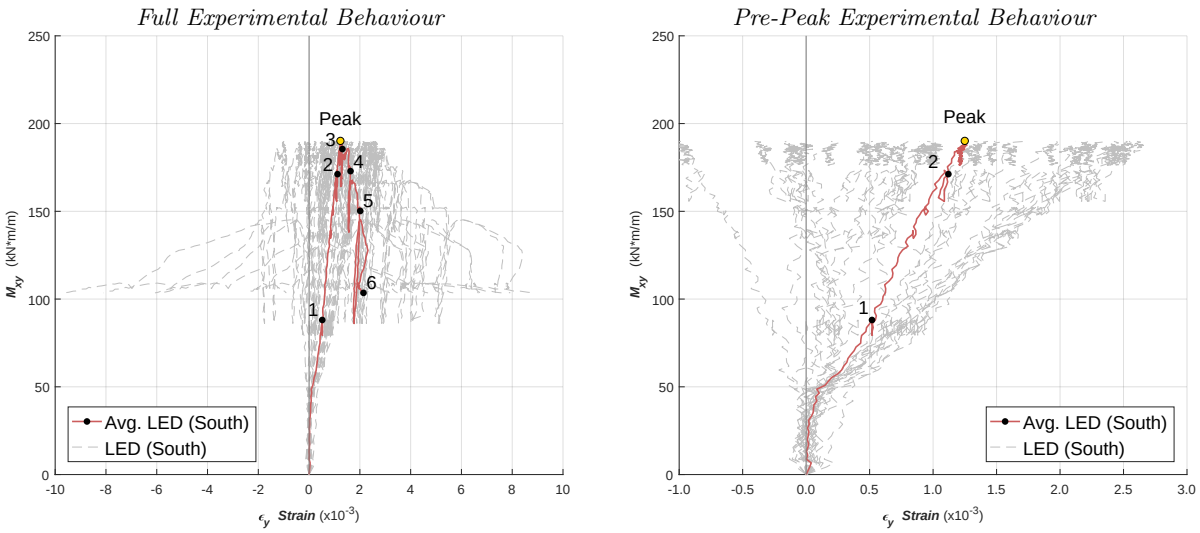


Figure 4.23: *ES1 Applied Torsion vs. Y-Direction Strain*

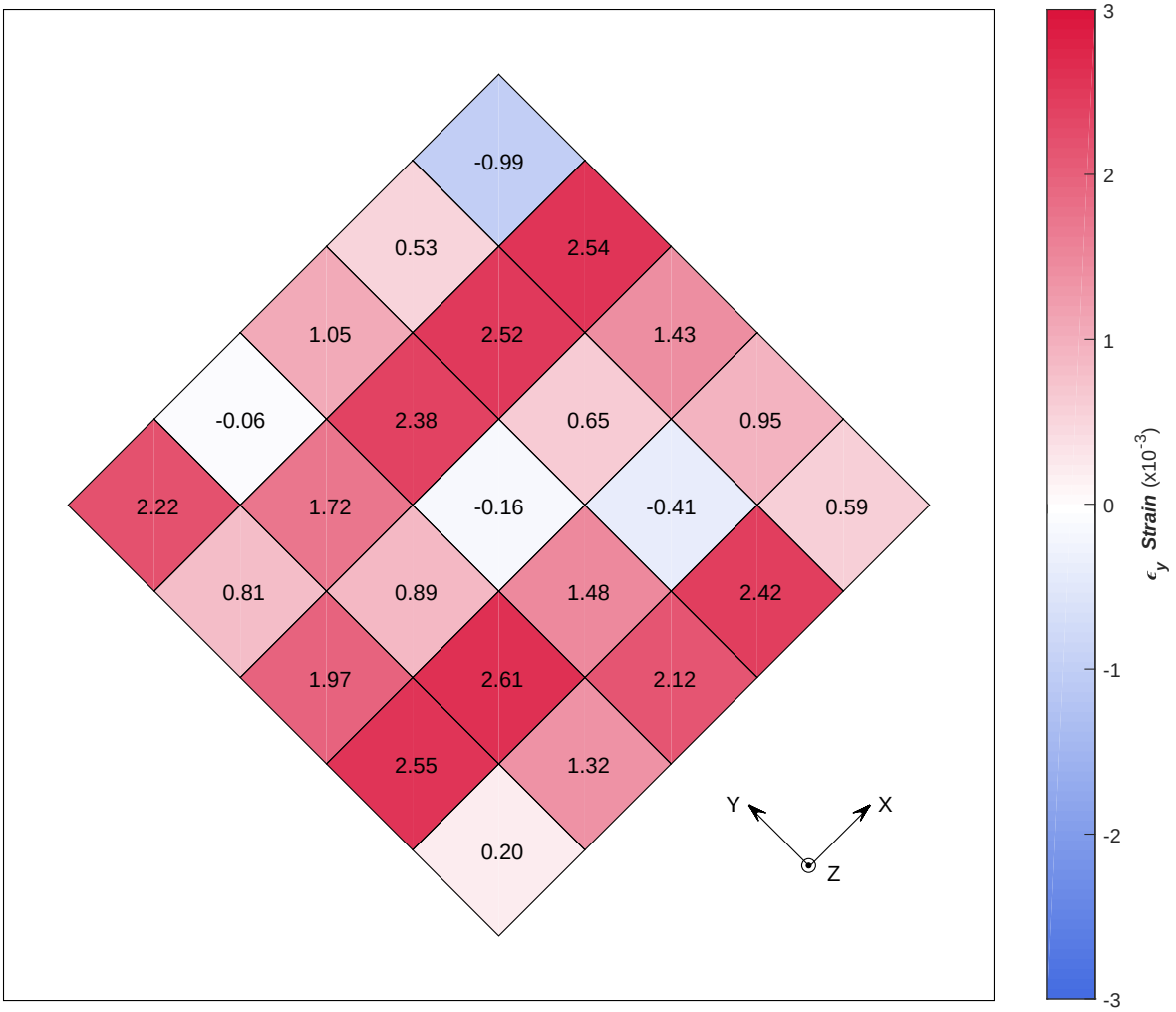


Figure 4.24: *ES1 Y-Direction Strain at 'Peak' Torsion*

Principal Tensile Strain

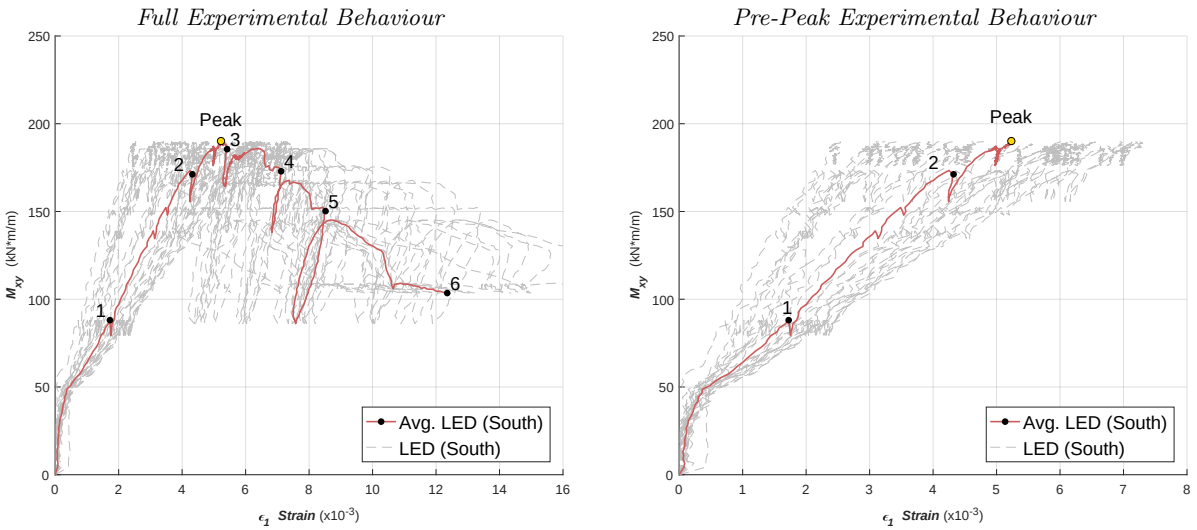


Figure 4.25: *ES1 Applied Torsion vs. Principal Tensile Strain*

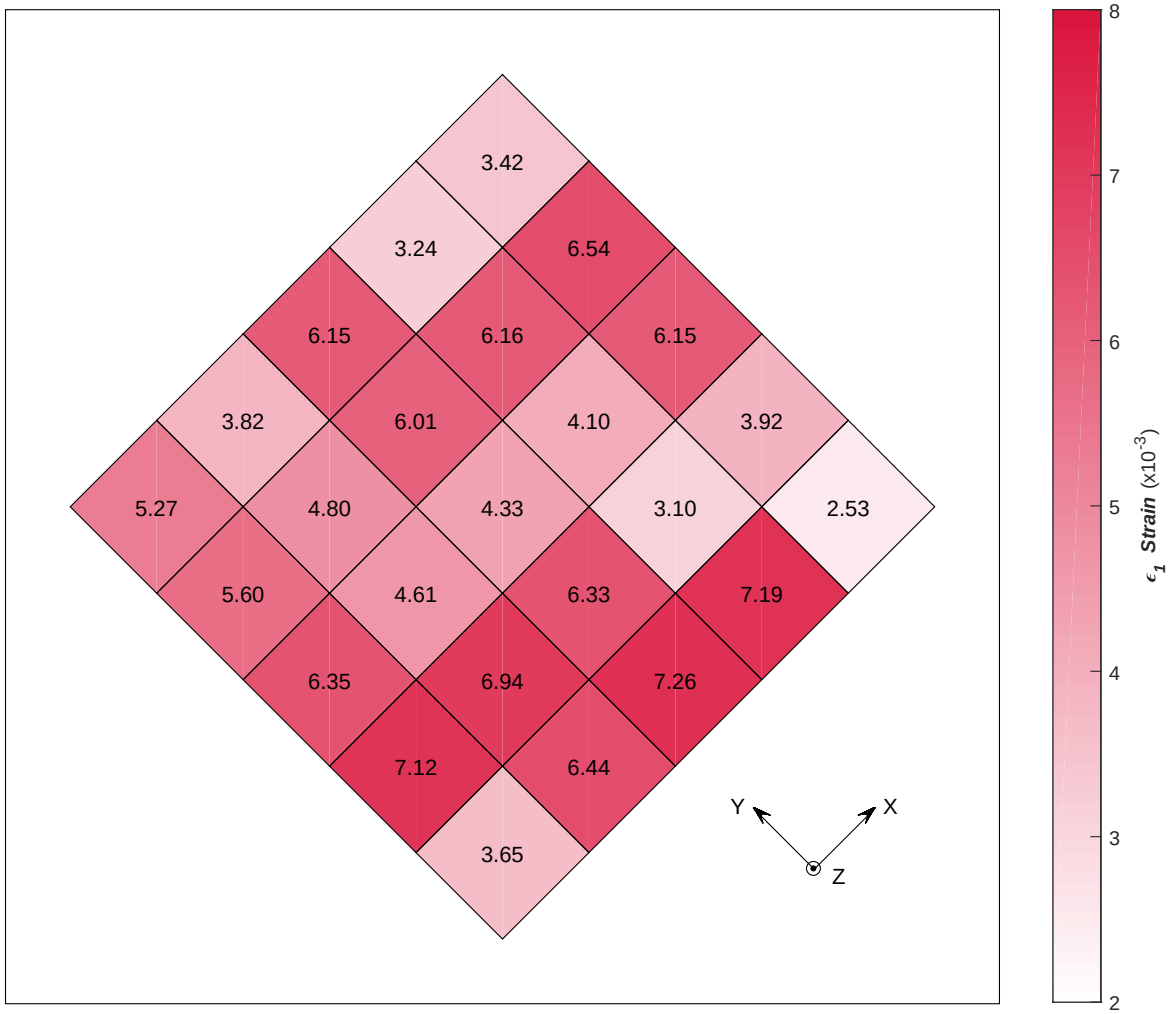


Figure 4.26: *ES1 Principal Tensile Strain at 'Peak' Torsion*

Principal Compressive Strain

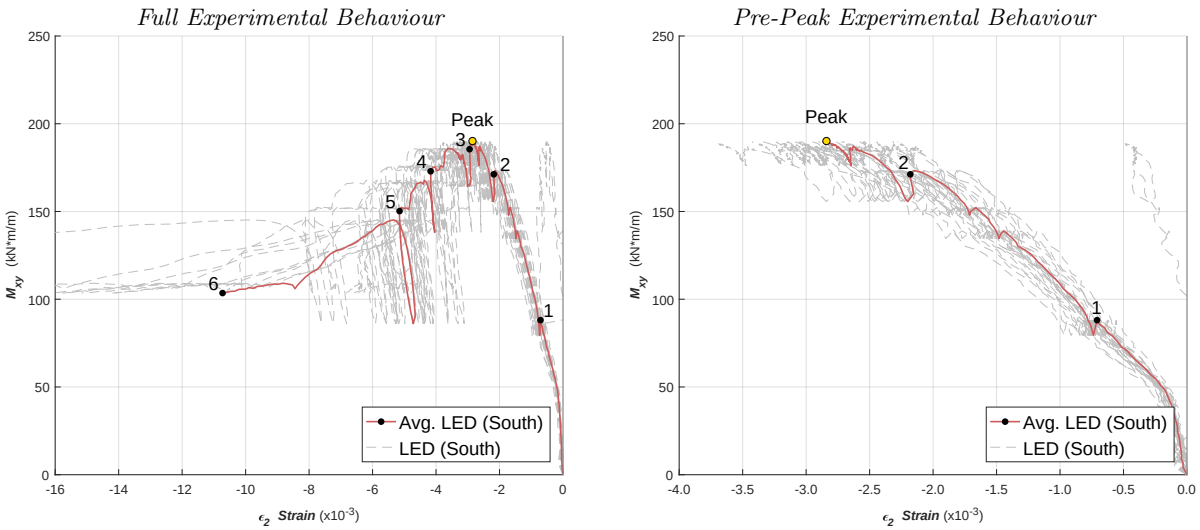


Figure 4.27: *ES1 Applied Torsion vs. Principal Compressive Strain*

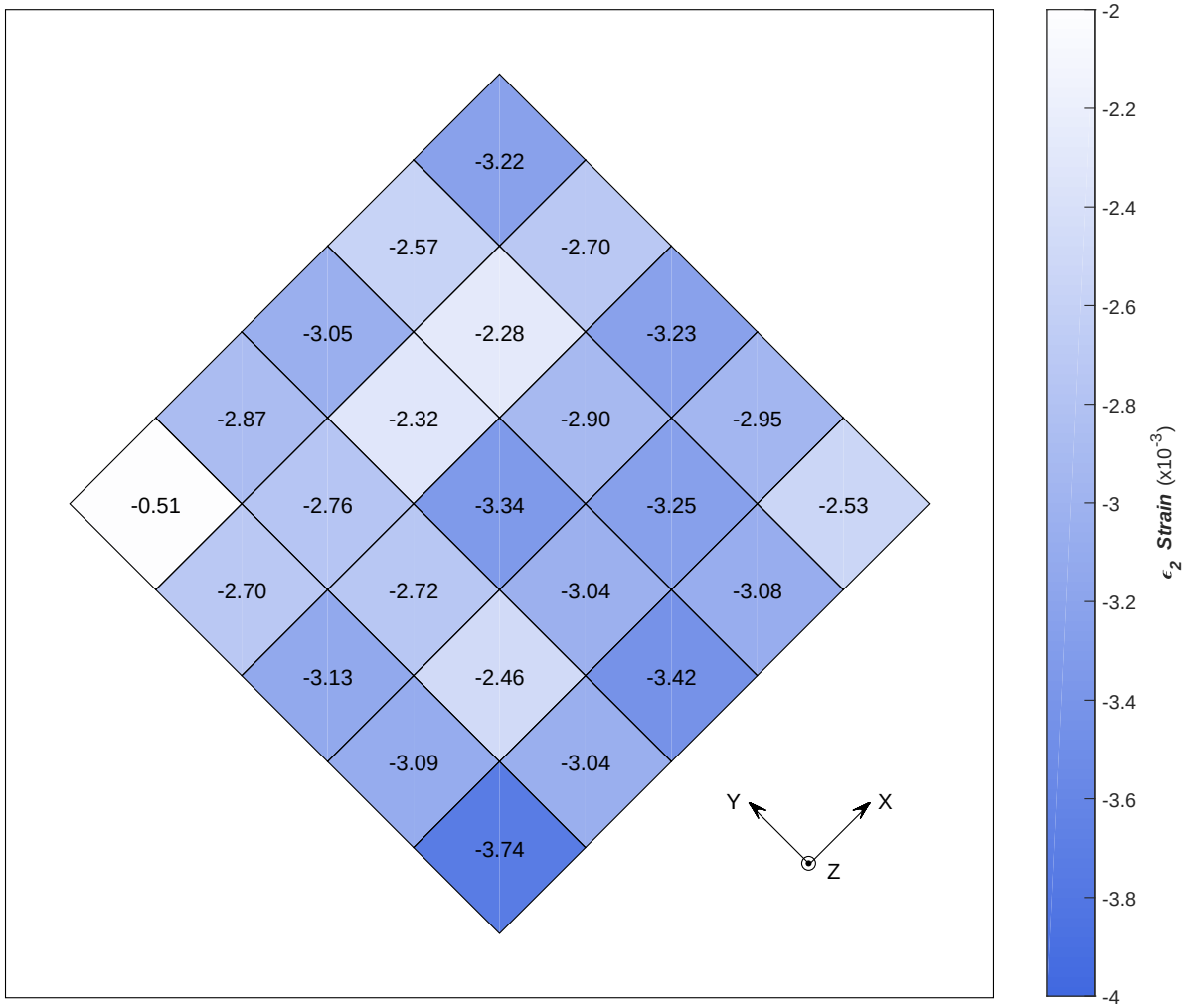


Figure 4.28: *ES1 Principal Compressive Strain at 'Peak' Torsion*

Angle of Principal Strain

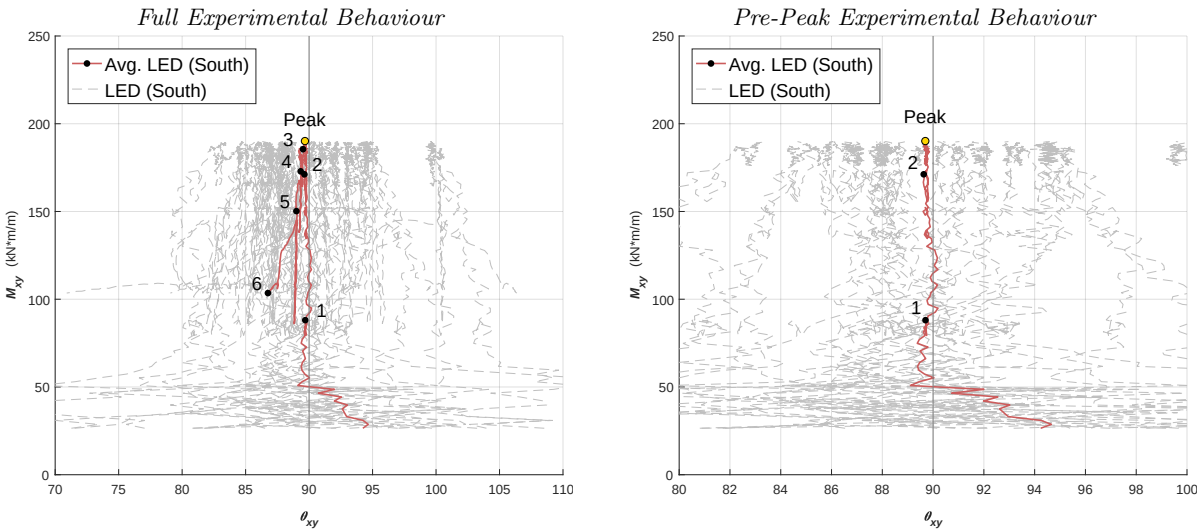


Figure 4.29: *ES1 Applied Torsion vs. Angle of Principal Strain (CCW+)*

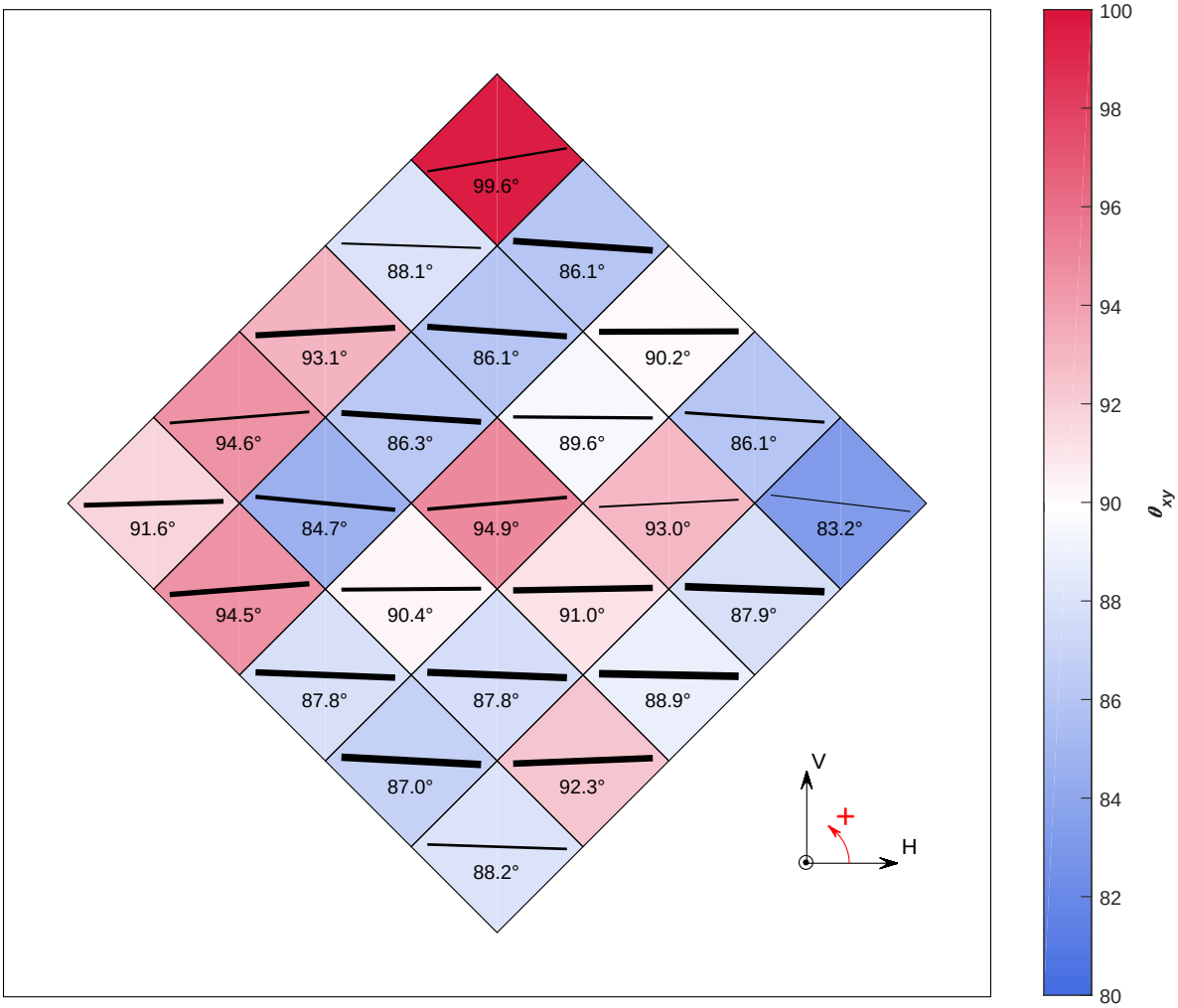


Figure 4.30: *ES1 Angle of Principal Strain (CCW+) at 'Peak' Torsion*

4.3.2 Specimen ES2

In-Plane Shear Strain

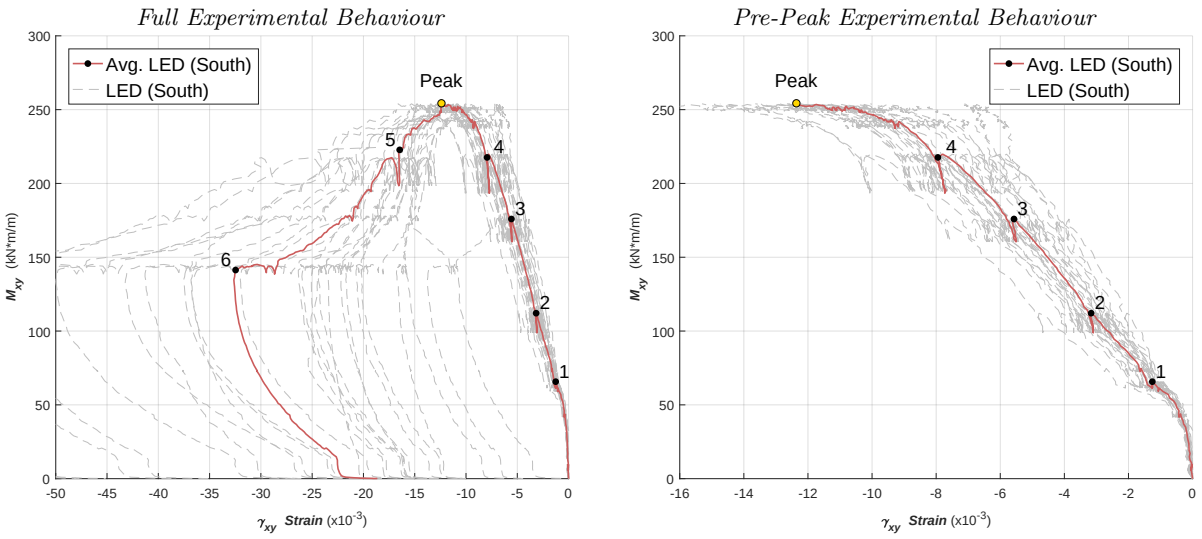


Figure 4.31: *ES2 Applied Torsion vs. In-Plane (XY) Shear Strain*

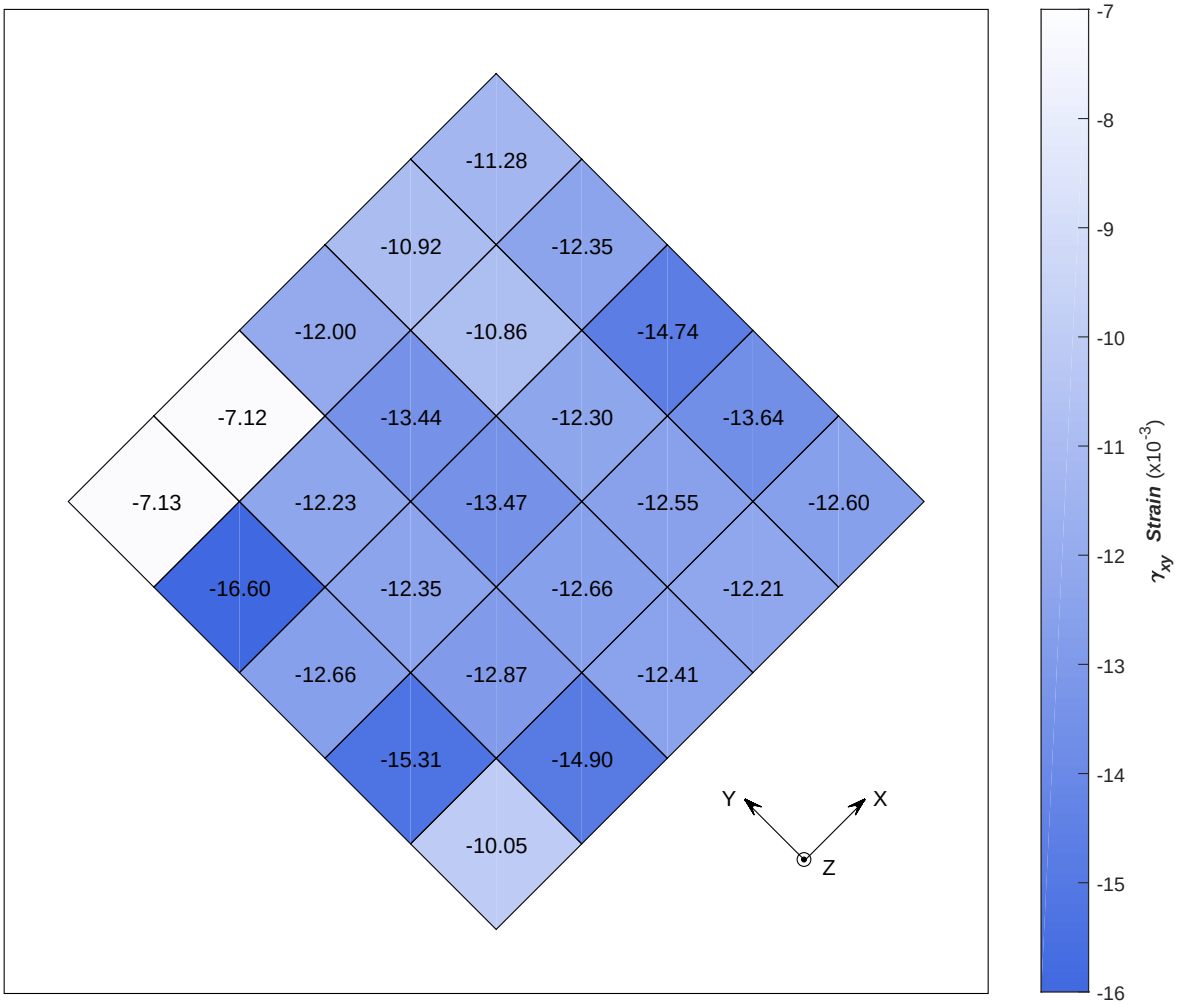


Figure 4.32: *ES2 In-Plane (XY) Shear Strain at 'Peak' Torsion*

X-Direction Strain

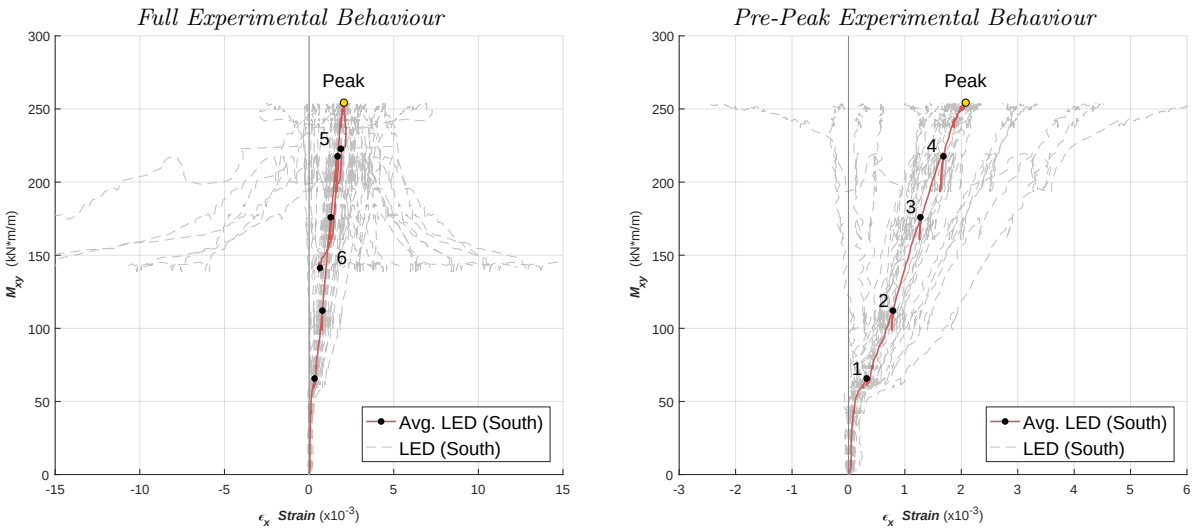


Figure 4.33: *ES2 Applied Torsion vs. X-Direction Strain*

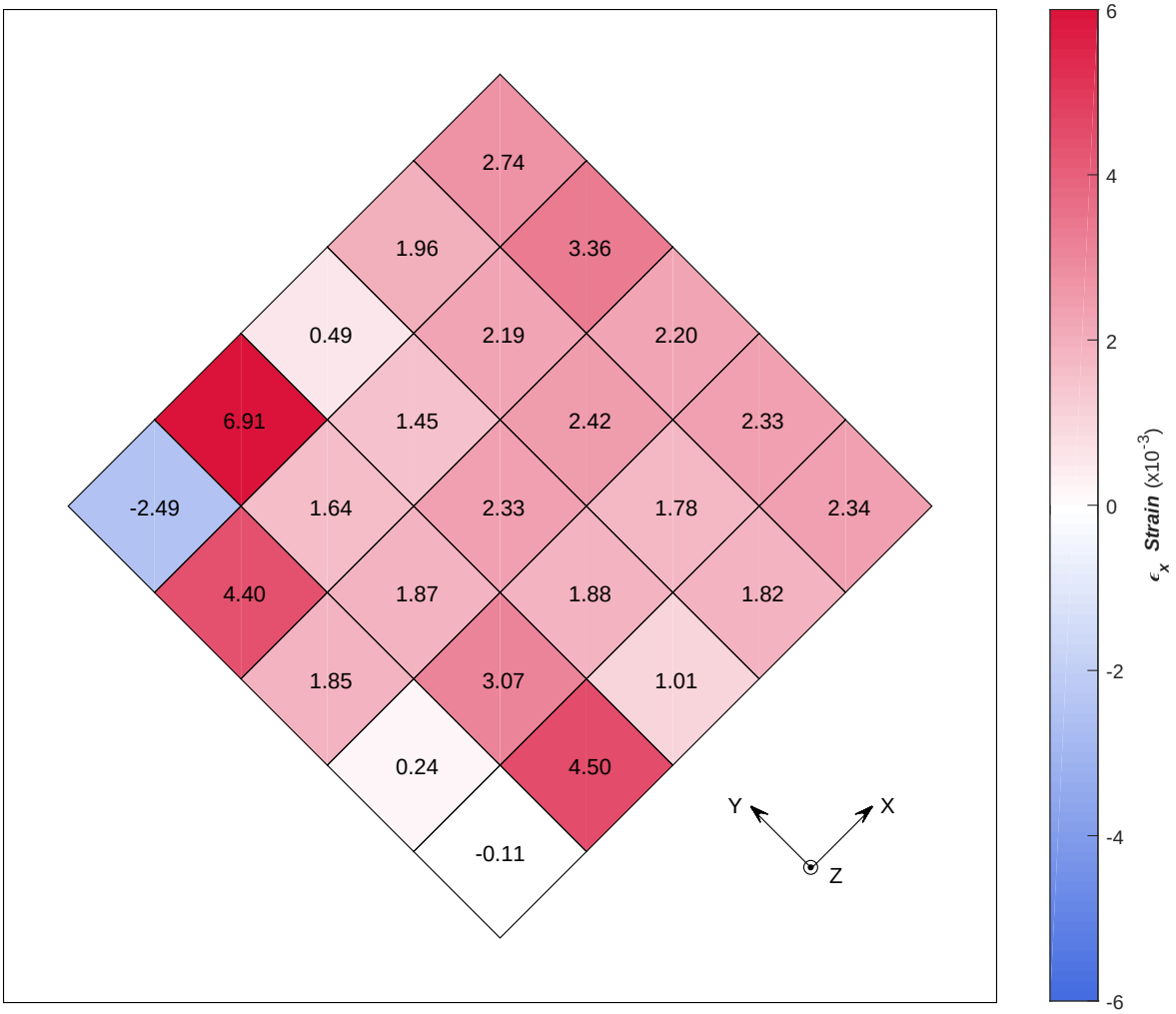


Figure 4.34: *ES2 X-Direction Strain at 'Peak' Torsion*

Y-Direction Strain

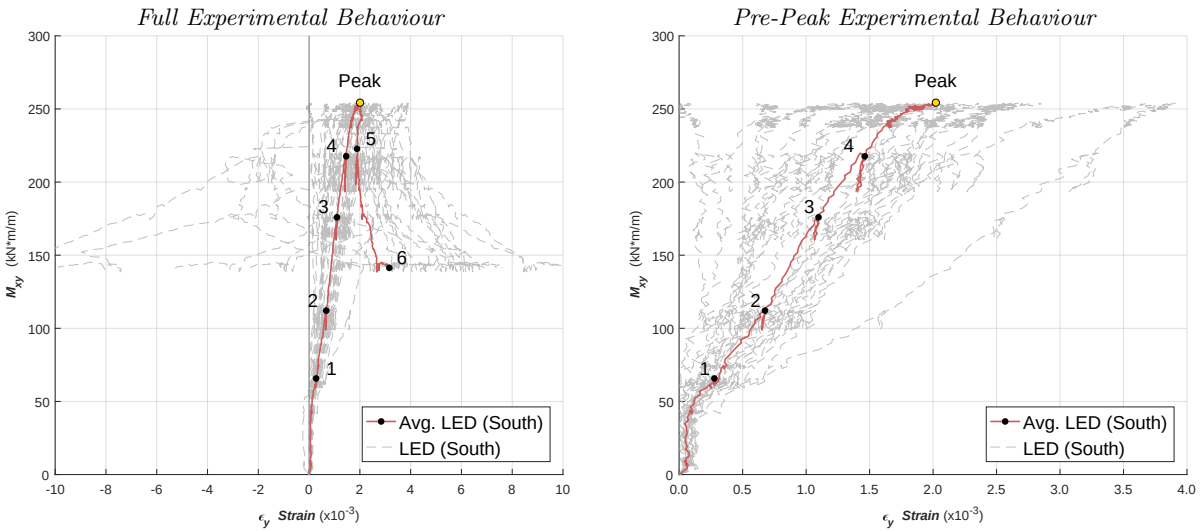


Figure 4.35: *ES2 Applied Torsion vs. Y-Direction Strain*

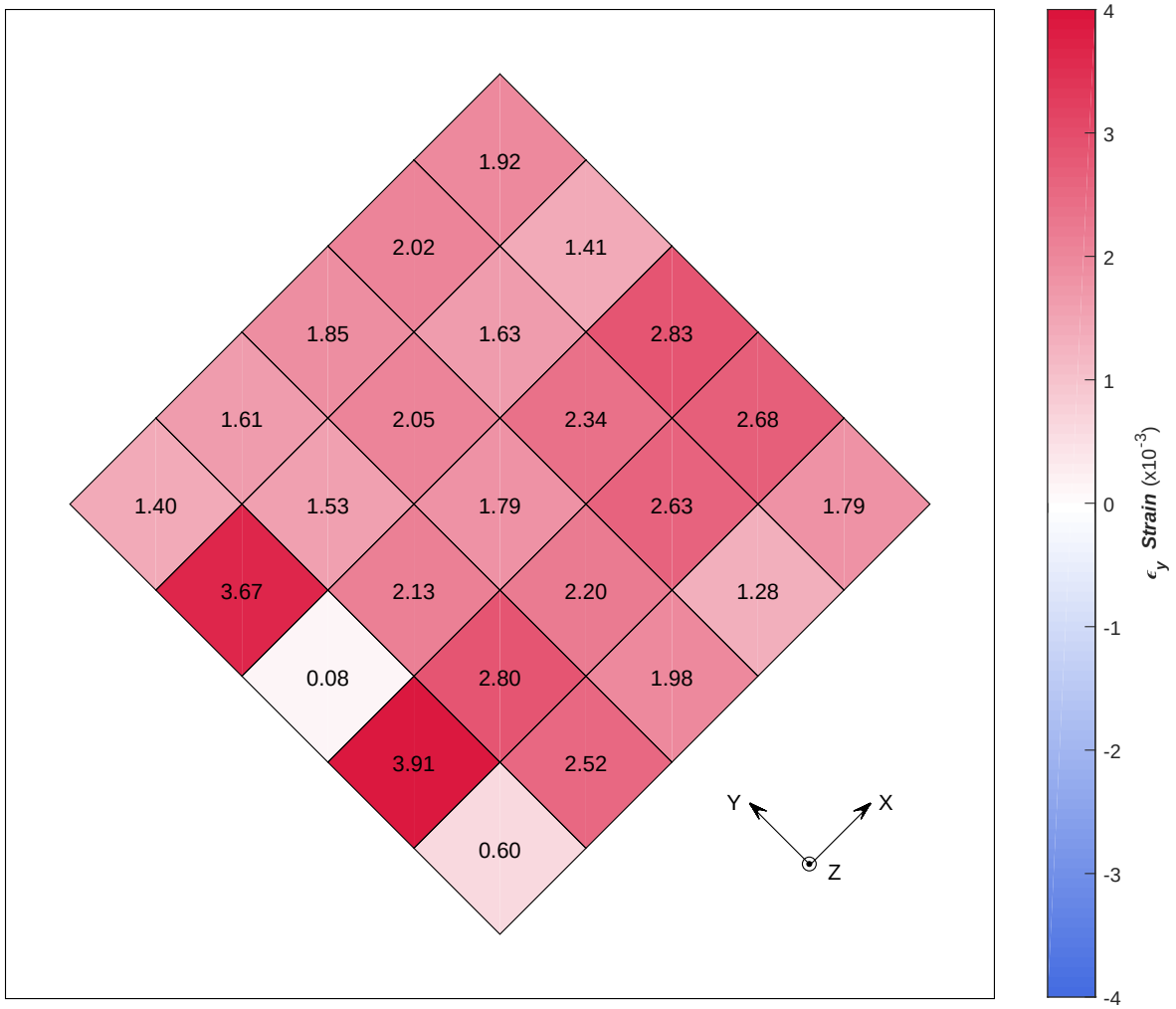


Figure 4.36: *ES2 Y-Direction Strain at 'Peak' Torsion*

Principal Tensile Strain

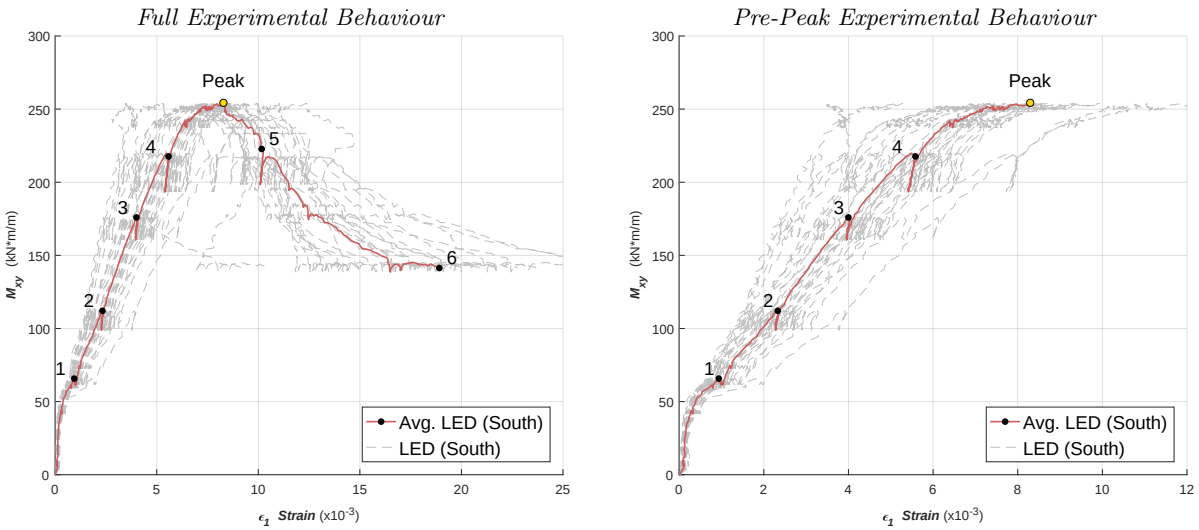


Figure 4.37: *ES2 Applied Torsion vs. Principal Tensile Strain*

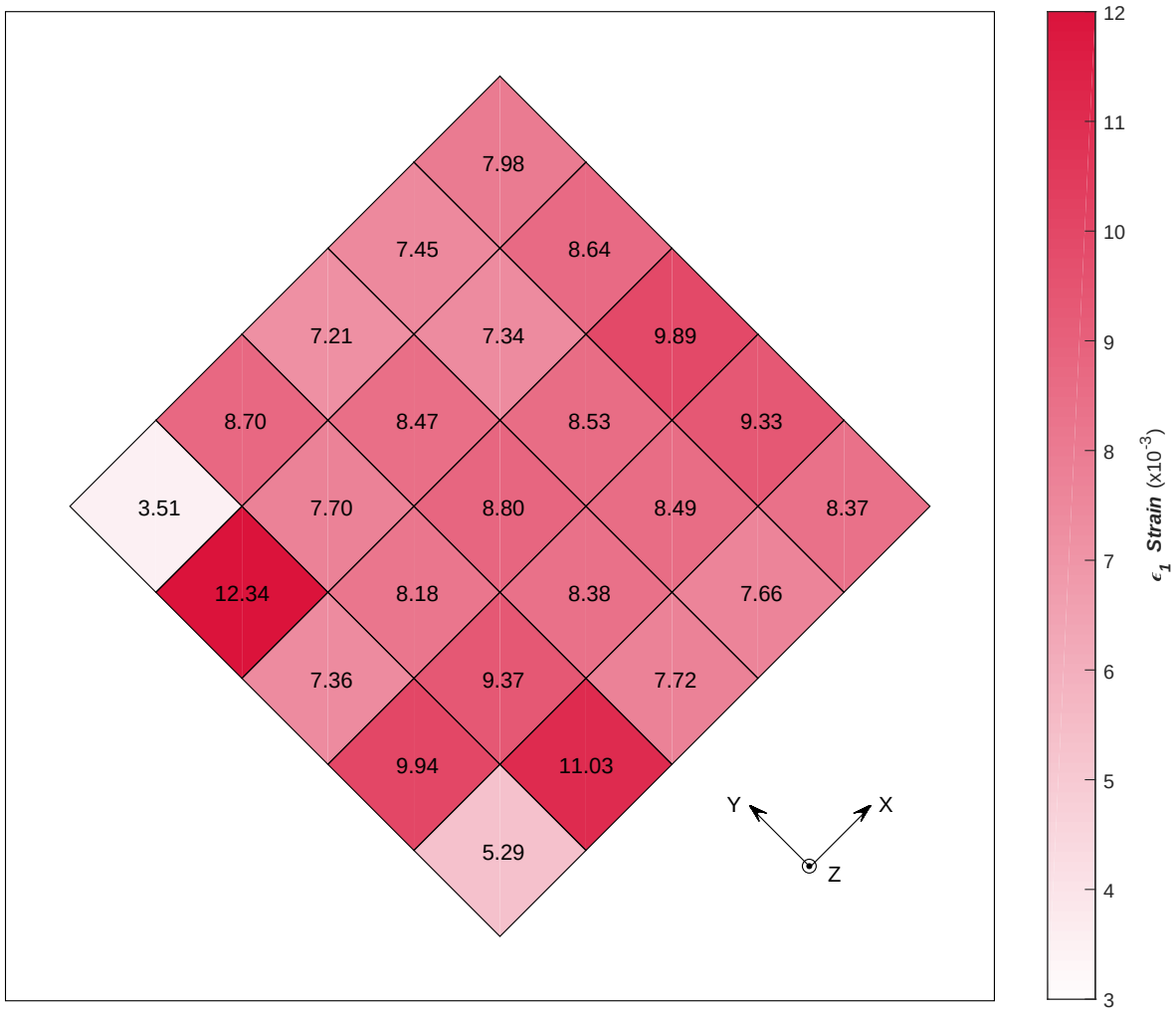


Figure 4.38: *ES2 Principal Tensile Strain at 'Peak' Torsion*

Principal Compressive Strain

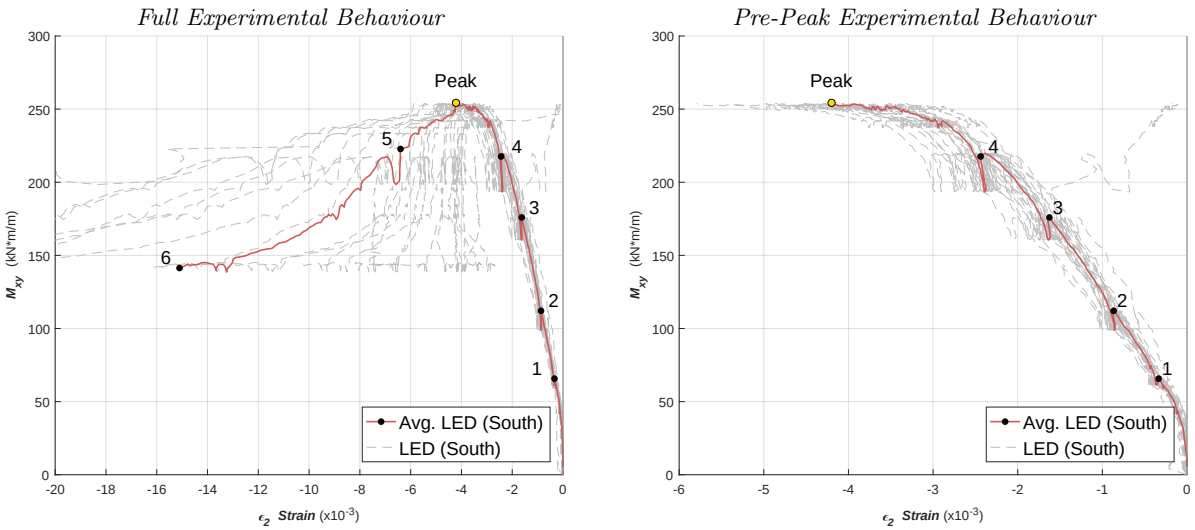


Figure 4.39: *ES2 Applied Torsion vs. Compressive Tensile Strain*

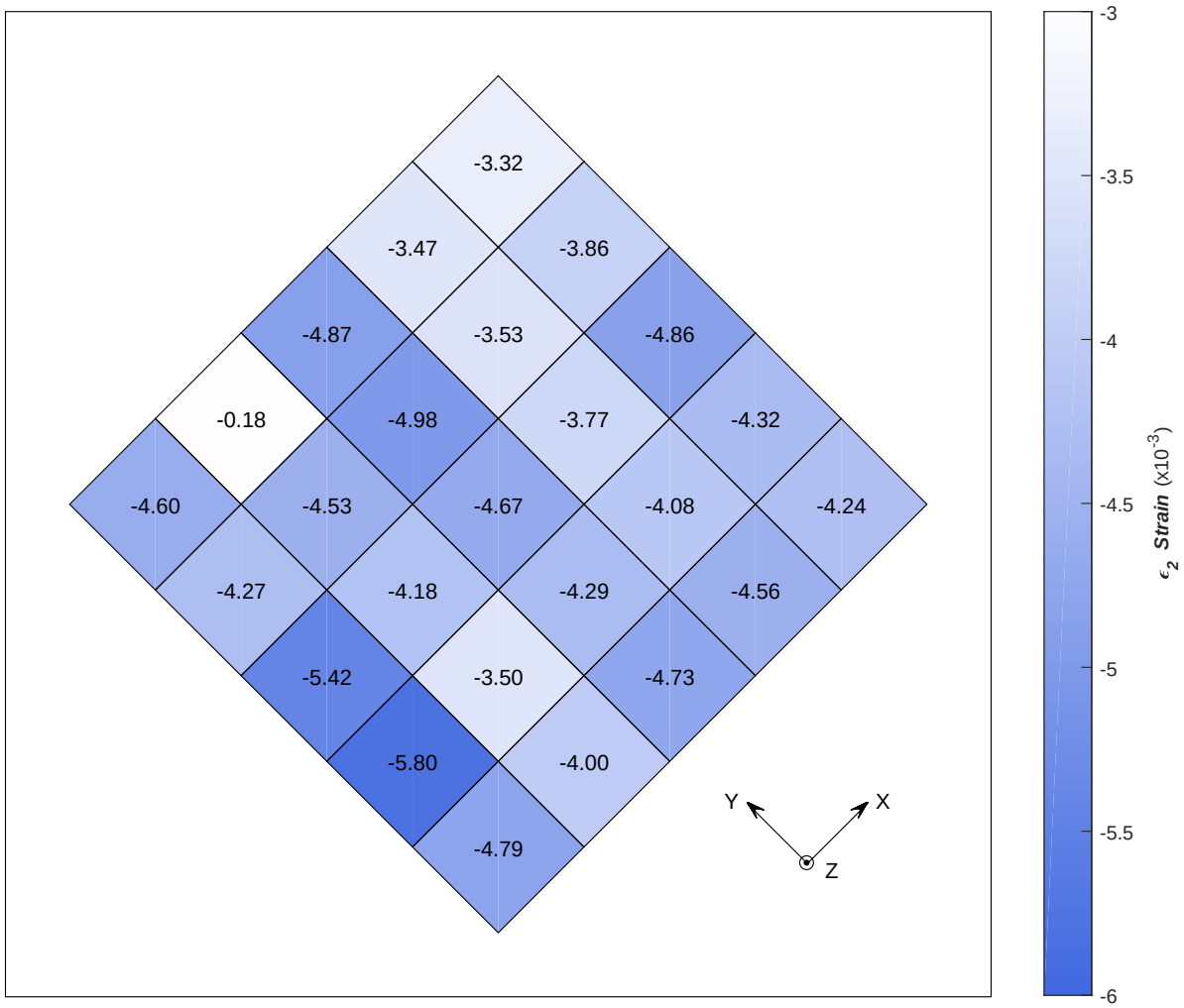


Figure 4.40: *ES2 Principal Compressive Strain at 'Peak' Torsion*

Angle of Principal Strain

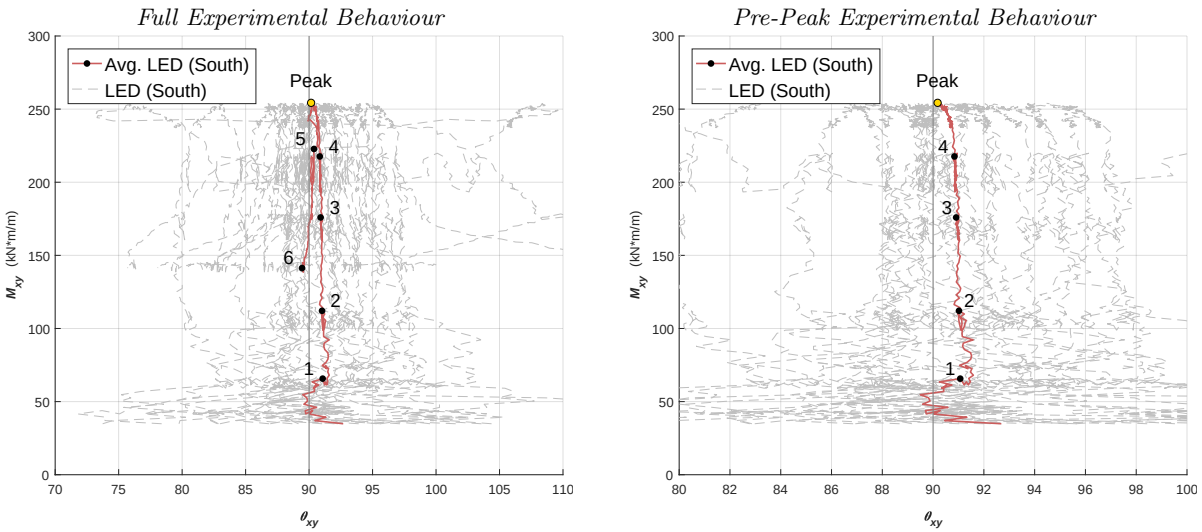


Figure 4.41: *ES2 Applied Torsion vs. Angle of Principal Strain (CCW+)*

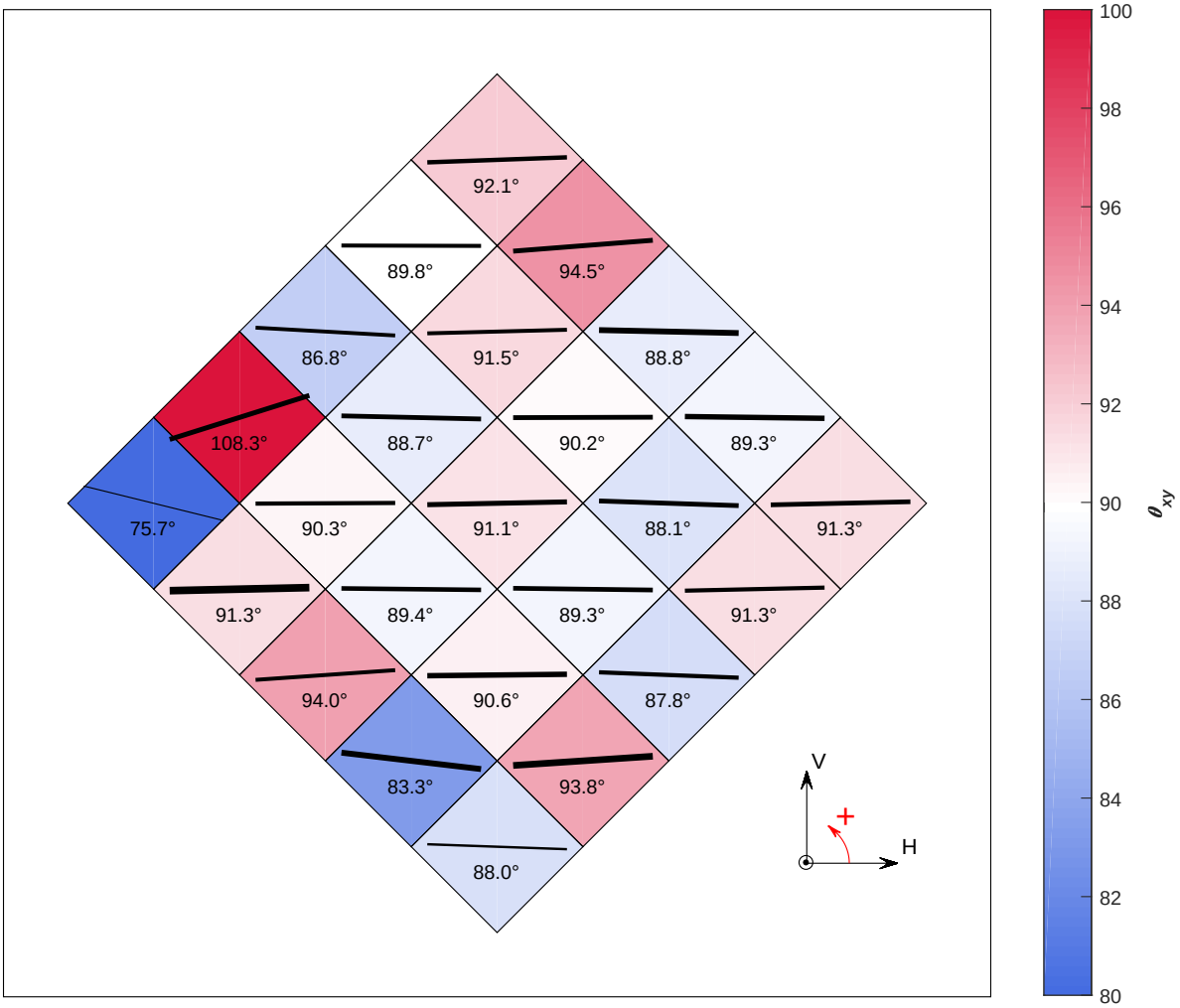


Figure 4.42: *ES2 Angle of Principal Strain (CCW+) at 'Peak' Torsion*

4.4 Out-of-Plane LP & EG Measurements

The LPs and EGs were used to measure the strain state through the thickness of the shell during the test. When analyzing the out-of-plane behaviour, it was considered important to distinguish between the strains in the XZ and YZ planes, defined by the direction of the X and Y reinforcement respectively (Figure 4.43). Therefore, in Tables 4.5 & 4.6 and the subsequent plots, the experimental strain information for the XZ and YZ planes is presented separately.

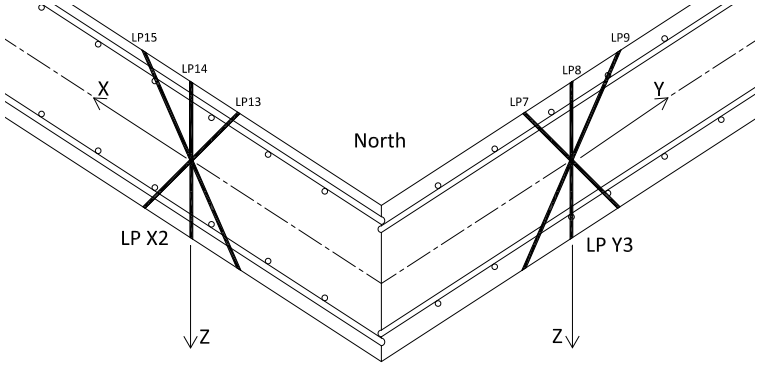
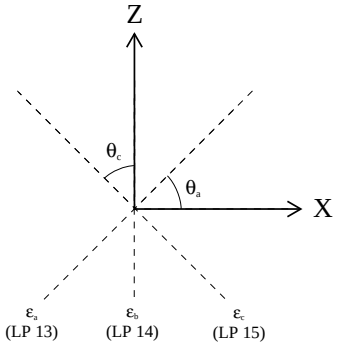


Figure 4.43: *Example of LP arrangement in XZ and YZ Planes*

Three independent strain measurements were taken at each location and the out-of-plane Mohr's circle of strain was then calculated explicitly. For the EGs, the angles between the individual gauges was fixed at 45°, while for the LP triplets these angles could vary by ±5° as the hollow tubes through the concrete shifted during casting. Equation 4.1 presents an explicit solution for the strain in the X-direction and shear strain in the XZ-plane given three strains at known angles in the same plane (same approach for YZ-plane). For simplicity, the central measurement is assumed to coincide perfectly with the Z-direction.



$$\epsilon_x = \left[A - B \cdot \frac{\tan(\theta_a - 90)}{\tan\theta_c} \right] \cdot \frac{\tan\theta_c}{\tan\theta_c - \tan(\theta_a - 90)}$$

$$\gamma_{xz} = B \cdot \tan(\theta_a - 90) - \epsilon_x \cdot \tan(\theta_a - 90) \tag{4.1}$$

$$\text{where: } A = \frac{\epsilon_c - \epsilon_b \cdot \cos^2\theta_c}{\sin^2\theta_c},\ B = \frac{\epsilon_a - \epsilon_b \cdot \sin^2\theta_a}{\cos^2\theta_a}$$

It is important to reiterate that the LPs measured the average strains through the thickness, as the relative displacement between the North and South faces. They provided accurate information about the shell on a macro scale, but were not reliable in the post-peak region of the test as the surface concrete began to spall. Meanwhile, the EGs measured strains through the thickness of the shell at discrete points, but the general out-of-plane behaviour should not be characterized on the basis of this localized information alone. In addition, the XZ-plane EGs for ES1 were damaged, and only the Z-direction strain readings were salvageable.

Table 4.5: LP & EG Data in XZ-Plane at Load Stages

	$\left[\frac{kN \cdot m}{m}\right]$ M_{xy}	$\left[\frac{mrad}{m}\right]$ ϕ_{xy}	$[\times 10^{-3}]$ γ_{xz}				$[\times 10^{-3}]$ ϵ_x				$[\times 10^{-3}]$ ϵ_z			
			*LPX*1	*LPX*2	*EGX*1	*EGX*2	*LPX*1	*LPX*2	*EGX*1	*EGX*2	*LPX*1	*LPX*2	*EGX*1	*EGX*2
***ES*1**														
*LS*1	86.8	15.5	-63	-74	-	-	105	383	-	-	78	-51	-63	8
*LS*2	168.8	46.3	274	-563	-	-	-203	2180	-	-	527	-353	-30	159
Peak	187.2	58.7	557	-571	-	-	-199	2640	-	-	754	-255	13	209
*LS*3	182.9	60.4	572	-661	-	-	-267	2810	-	-	826	-212	41	219
*LS*4	170.4	80.8	819	-7130	-	-	-508	11760	-	-	1434	2370	389	797
*LS*5	147.9	96.6	1620	-12010	-	-	72	5040	-	-	2740	16810	1326	1250
*LS*6	101.8	139.7	12030	-2080	-	-	9120	-904	-	-	13880	53000	1450	2617
***ES*2**														
*LS*1	64.8	8.2	-65	-37	-31	119	-21	-45	146	-118	57	7	-17	-11
*LS*2	110.5	21.4	-149	-66	-110	207	-43	113	596	252	138	45	-30	3
*LS*3	173.4	39.0	-234	215	-191	35	-54	506	843	675	276	87	-73	31
*LS*4	214.7	56.7	-560	354	-268	-92	464	666	905	912	435	336	-18	144
Peak	250.5	89.4	-736	798	119	-559	606	1324	813	1276	1544	1259	176	370
*LS*5	219.6	111.0	-1664	1378	989	-660	-2320	2040	642	1124	5360	2430	703	503
*LS*6	138.9	223.0	-21400	10680	195	907	11940	14660	-273	845	20200	10220	3350	3100

	$\left[\frac{kN \cdot m}{m}\right]$ M_{xy}	$\left[\frac{mrad}{m}\right]$ ϕ_{xy}	$[^\circ]$ θ_{xz}				$[\times 10^{-3}]$ ϵ_1				$[\times 10^{-3}]$ ϵ_2			
			*LPX*1	*LPX*2	*EGX*1	*EGX*2	*LPX*1	*LPX*2	*EGX*1	*EGX*2	*LPX*1	*LPX*2	*EGX*1	*EGX*2
***ES*1**														
*LS*1	86.8	15.5	-33.7	-4.8	-	-	125	387	-	-	57	-54	-	-
*LS*2	168.8	46.3	-100.3	-6.4	-	-	552	2210	-	-	-228	-353	-	-
Peak	187.2	58.7	-105.1	-5.6	-	-	830	2670	-	-	-275	-283	-	-
*LS*3	182.9	60.4	-103.8	-6.2	-	-	896	2840	-	-	-337	-247	-	-
*LS*4	170.4	80.8	-101.4	-18.6	-	-	1517	12960	-	-	-591	1170	-	-
*LS*5	147.9	96.6	-105.6	-67.2	-	-	1970	19330	-	-	-154	2519	-	-
*LS*6	101.8	139.7	-124.2	-88.9	-	-	17970	53000	-	-	5030	-924	-	-
***ES*2**														
*LS*1	64.8	8.2	-70.1	-72.3	-5.4	66.1	68	13	147	16	-33	-51	-19	-145
*LS*2	110.5	21.4	-70.2	-22.2	-5.0	19.9	165	127	601	289	-69	32	-34	-34
*LS*3	173.4	39.0	-72.3	13.6	-5.9	1.6	313	532	853	675	-91	61	-82	30
*LS*4	214.7	56.7	-43.5	23.5	-8.1	-3.4	730	743	924	915	169	259	-37	141
Peak	250.5	89.4	-70.9	42.7	5.3	-15.8	1671	1692	818	1356	479	891	170	291
*LS*5	219.6	111.0	-83.9	53.0	46.8	-23.4	5450	2950	1168	1267	-2400	1521	177	361
*LS*6	138.9	223.0	-55.6	33.7	88.5	-100.9	27600	18220	3350	3190	4590	6660	-275	757

Table 4.6: LP & EG Data in YZ-Plane at Load Stages

	$\left[\frac{kN\cdot m}{m}\right]$ M_{xy}	$\left[\frac{mrad}{m}\right]$ ϕ_{xy}	$[\times 10^{-3}]$ γ_{yz}					$[\times 10^{-3}]$ ϵ_y					$[\times 10^{-3}]$ ϵ_z				
			*LPY*1	*LPY*2	*LPY*3	*EGY*1	*EGY*2	*LPY*1	*LPY*2	*LPY*3	*EGY*1	*EGY*2	*LPY*1	*LPY*2	*LPY*3	*EGY*1	*EGY*2
***ES*1**																	
*LS*1	86.8	15.5	-145	-243	100	63	112	470	347	208	374	149	18	-18	83	29	-3
*LS*2	168.8	46.3	-258	-192	359	-19	297	886	861	1036	659	583	469	47	304	109	187
Peak	187.2	58.7	-268	-93	438	-66	349	830	1210	1350	775	686	705	195	453	116	220
*LS*3	182.9	60.4	-278	-112	452	-78	362	857	1216	1340	800	699	745	238	496	114	225
*LS*4	170.4	80.8	-3590	129	1119	-6	370	7260	1876	2850	851	815	2620	1162	1141	77	200
*LS*5	147.9	96.6	-10370	-294	8570	209	74	17510	2200	13690	859	911	3920	3250	2650	397	252
*LS*6	101.8	139.7	-13960	-12430	11190	232	-247	77100	3000	24900	680	1354	25600	19120	15470	1557	1295
***ES*2**																	
*LS*1	64.8	8.2	-227	-151	-40	-36	-98	-282	231	98	38	279	64	-11	-18	-87	32
*LS*2	110.5	21.4	-364	-277	-34	-79	-153	190	489	142	240	1141	249	0	28	-28	106
*LS*3	173.4	39.0	-722	-226	132	84	-322	444	1045	486	888	1924	495	4	88	164	152
*LS*4	214.7	56.7	-1113	-334	-132	273	-417	363	1033	1242	1230	2420	893	230	145	229	237
Peak	250.5	89.4	-2157	-426	-1822	396	-819	-4110	1023	5810	1580	2790	4590	1247	1258	414	416
*LS*5	219.6	111.0	-4670	-210	-1495	551	-1505	-3430	234	8350	1593	2700	7210	3340	6570	659	737
*LS*6	138.9	223.0	-12060	3820	1645	140	-2880	-28200	3960	20900	693	2530	36900	11480	25700	2230	2180

	$\left[\frac{kN\cdot m}{m}\right]$ M_{xy}	$\left[\frac{mrad}{m}\right]$ ϕ_{xy}	$[^\circ]$ θ_{yz}					$[\times 10^{-3}]$ ϵ_1					$[\times 10^{-3}]$ ϵ_2				
			*LPY*1	*LPY*2	*LPY*3	*EGY*1	*EGY*2	*LPY*1	*LPY*2	*LPY*3	*EGY*1	*EGY*2	*LPY*1	*LPY*2	*LPY*3	*EGY*1	*EGY*2
***ES*1**																	
*LS*1	86.8	15.5	8.9	16.9	-19.3	-5.2	-18.3	481	384	225	377	167	7	-55	66	26	-21
*LS*2	168.8	46.3	15.9	6.6	-13.1	1.0	-18.4	923	872	1078	659	633	432	36	263	109	138
Peak	187.2	58.7	32.6	2.6	-13.0	2.9	-18.4	915	1212	1401	777	744	620	193	402	115	162
*LS*3	182.9	60.4	34.1	3.3	-14.1	3.2	-18.7	951	1219	1397	802	760	652	235	440	112	164
*LS*4	170.4	80.8	18.8	-5.2	-16.7	0.2	-15.5	7870	1876	3010	851	866	2000	1157	974	77	148
*LS*5	147.9	96.6	18.7	-97.8	-18.9	-12.2	-3.2	19260	3270	15160	882	913	2170	2180	1177	375	250
*LS*6	101.8	139.7	7.6	-108.8	-24.9	-82.6	38.2	78000	21200	27500	1572	1451	24700	884	12870	665	1198
***ES*2**																	
*LS*1	64.8	8.2	73.4	16.0	9.5	8.1	10.9	98	253	101	41	288	-316	-32	-21	-89	23
*LS*2	110.5	21.4	49.6	14.8	8.3	8.2	4.2	404	526	145	246	1147	35	-36	26	-34	100
*LS*3	173.4	39.0	47.0	6.1	-9.2	-3.3	5.2	831	1057	497	891	1939	107	-9	78	162	137
*LS*4	214.7	56.7	57.8	11.3	3.4	-7.6	5.4	1244	1066	1246	1248	2430	12	196	141	211	217
Peak	250.5	89.4	83.0	58.9	10.9	-9.4	9.5	4720	1376	5980	1613	2850	-4240	894	1082	382	347
*LS*5	219.6	111.0	78.2	88.1	20.1	-15.3	18.7	7700	3350	8620	1668	2950	-3920	230	6300	584	481
*LS*6	138.9	223.0	84.8	103.5	99.4	-87.4	41.5	37500	11940	25900	2230	3810	-28700	3510	20800	690	906

4.4.1 Specimen ES1

Out-of-Plane (XZ) Strains

Note: No Embeddment Gauge data available for specimen ES1 in XZ-plane

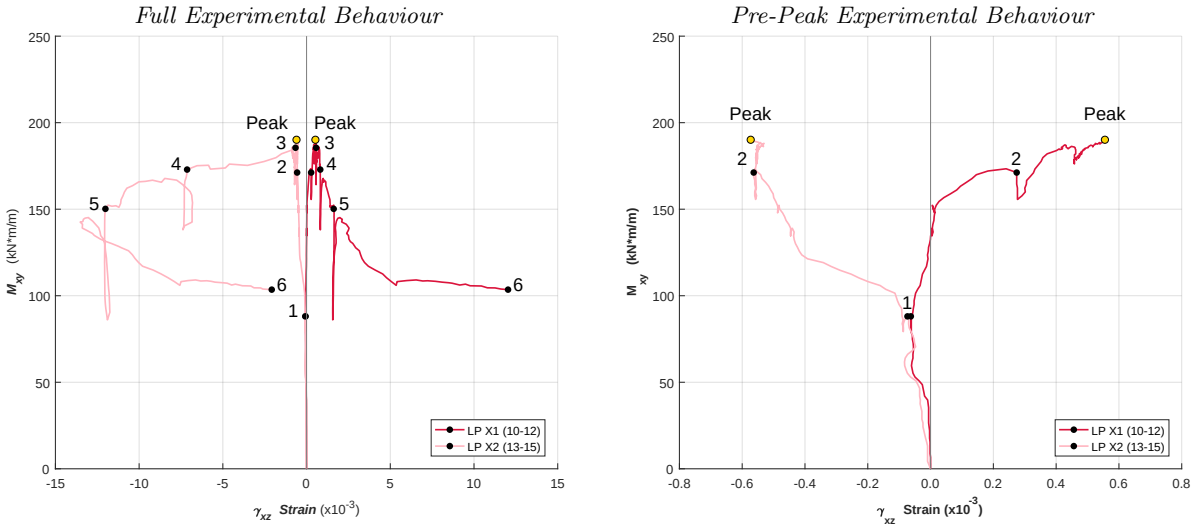


Figure 4.44: *ES1 Applied Torsion vs. Out-of-Plane (XZ) Shear Strain*

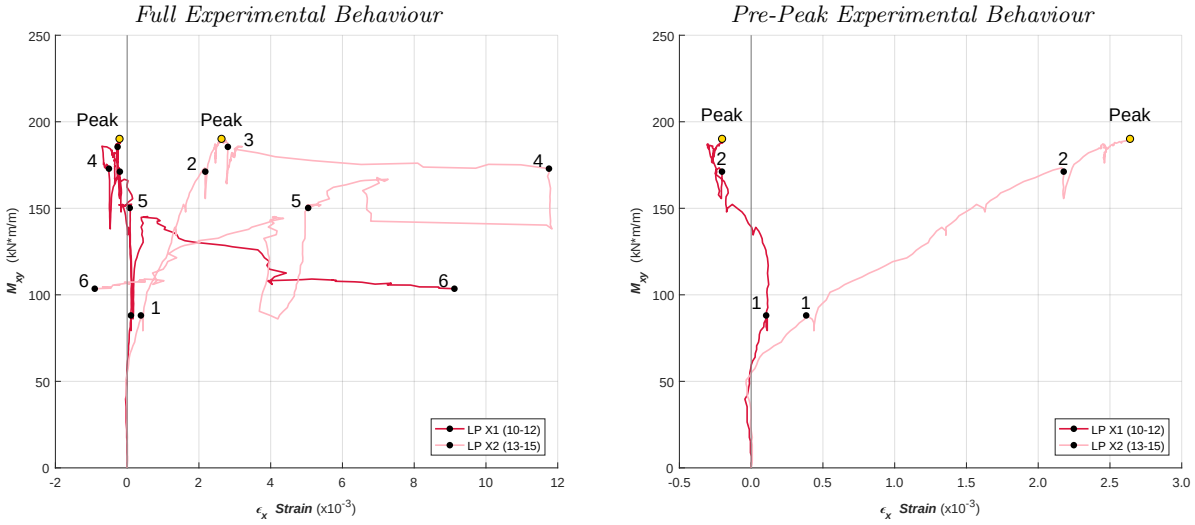


Figure 4.45: *ES1 Applied Torsion vs. X-Direction Strain*

Out-of-Plane (XZ) Principal Strains

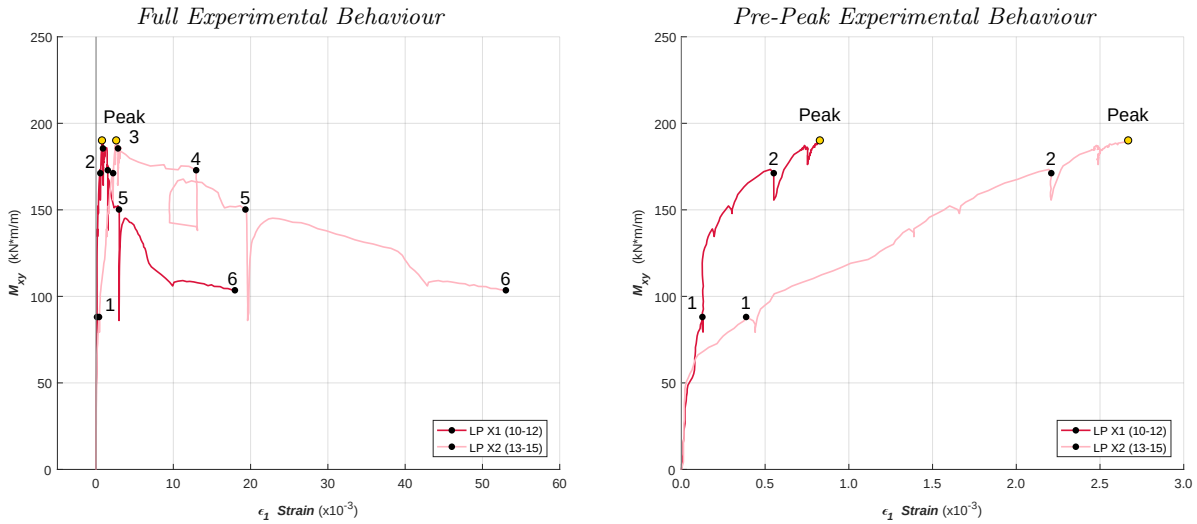


Figure 4.46: *ES1 Applied Torsion vs. Principal Tensile Strain*

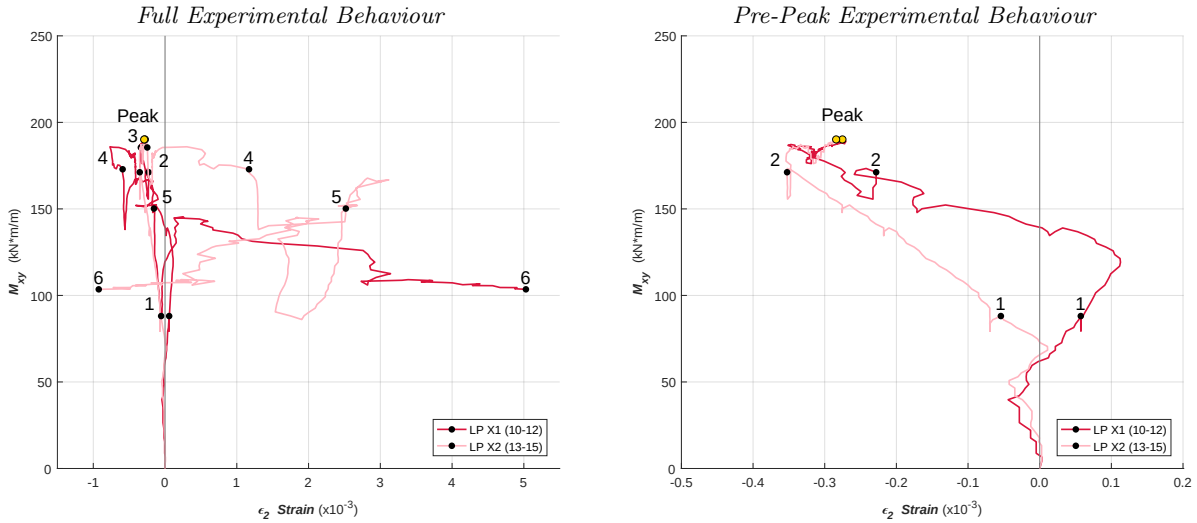


Figure 4.47: *ES1 Applied Torsion vs. Principal Compressive Strain*

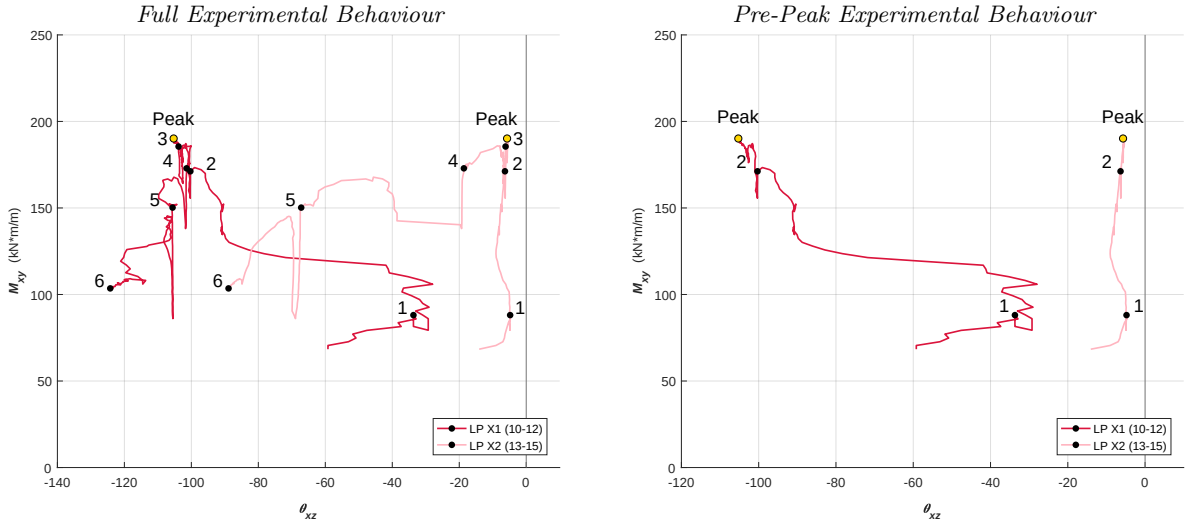


Figure 4.48: *ES1 Applied Torsion vs. Principal Angle*

Out-of-Plane (YZ) Strains

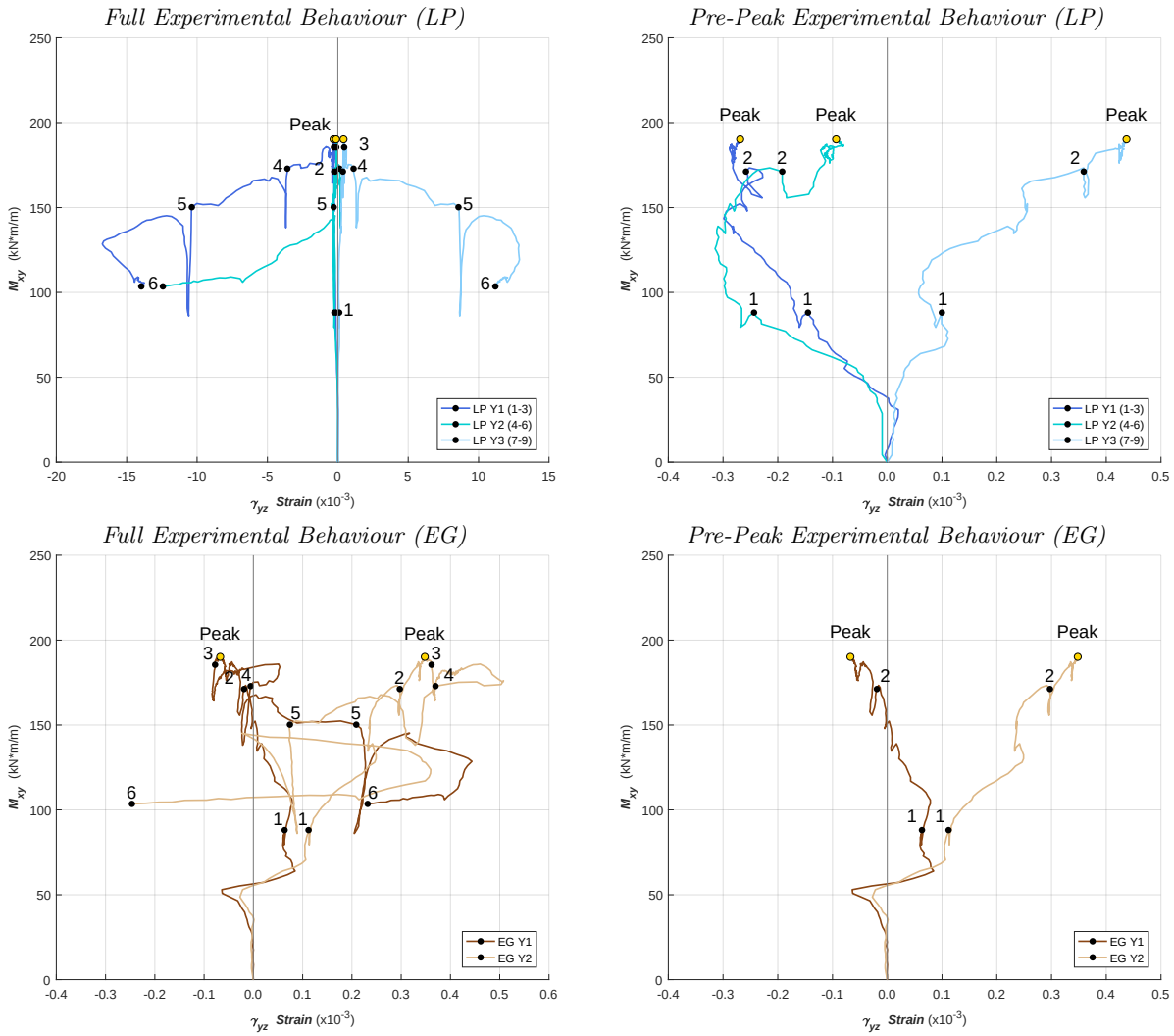


Figure 4.49: *ES1 Applied Torsion vs. Out-of-Plane (YZ) Shear Strain*

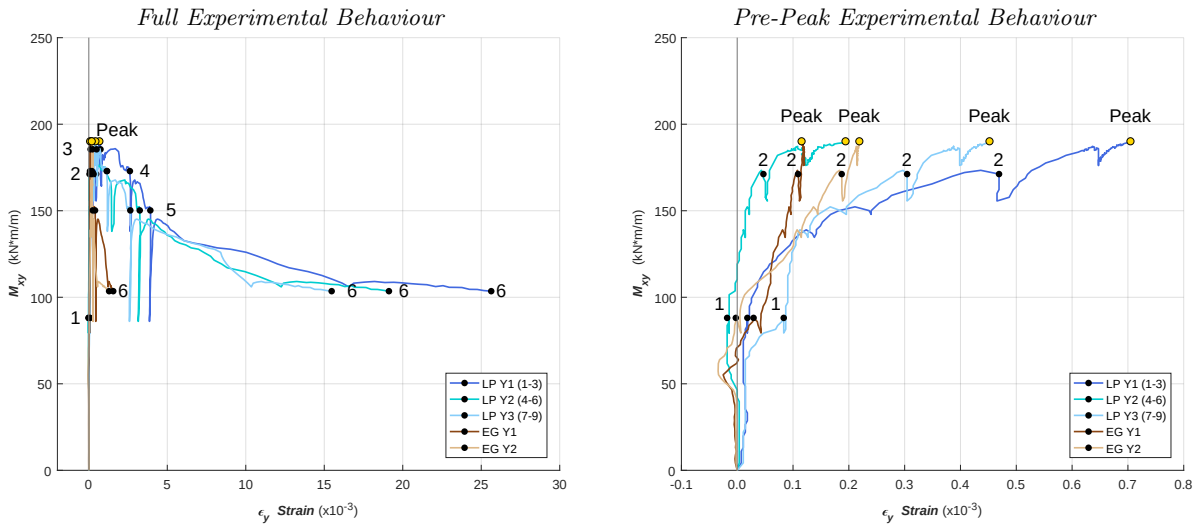


Figure 4.50: *ES1 Applied Torsion vs. Y-Direction Strain*

Out-of-Plane (YZ) Principal Strains

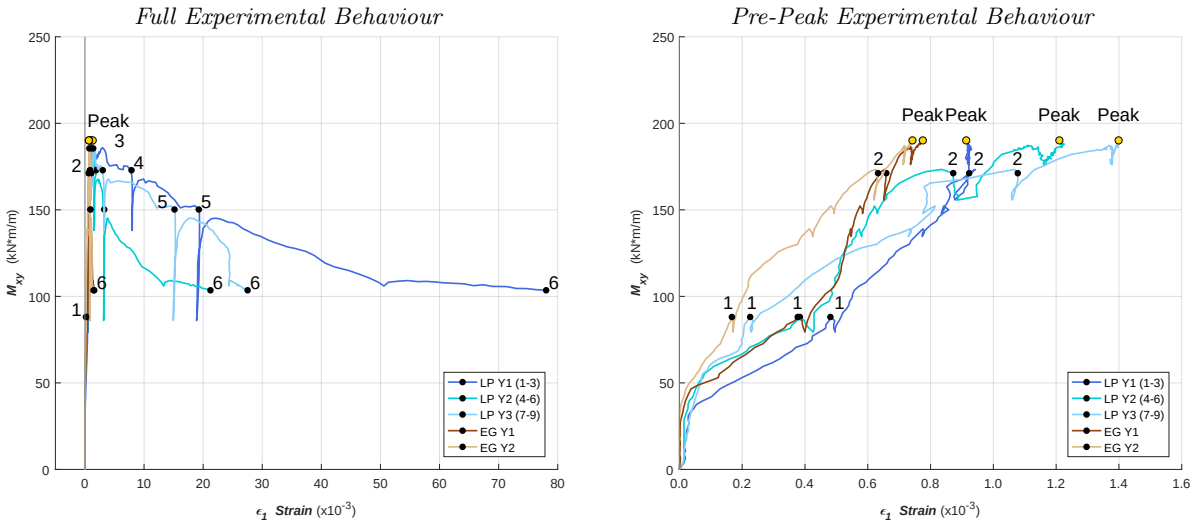


Figure 4.51: *ES1 Applied Torsion vs. Principal Tensile Strain*

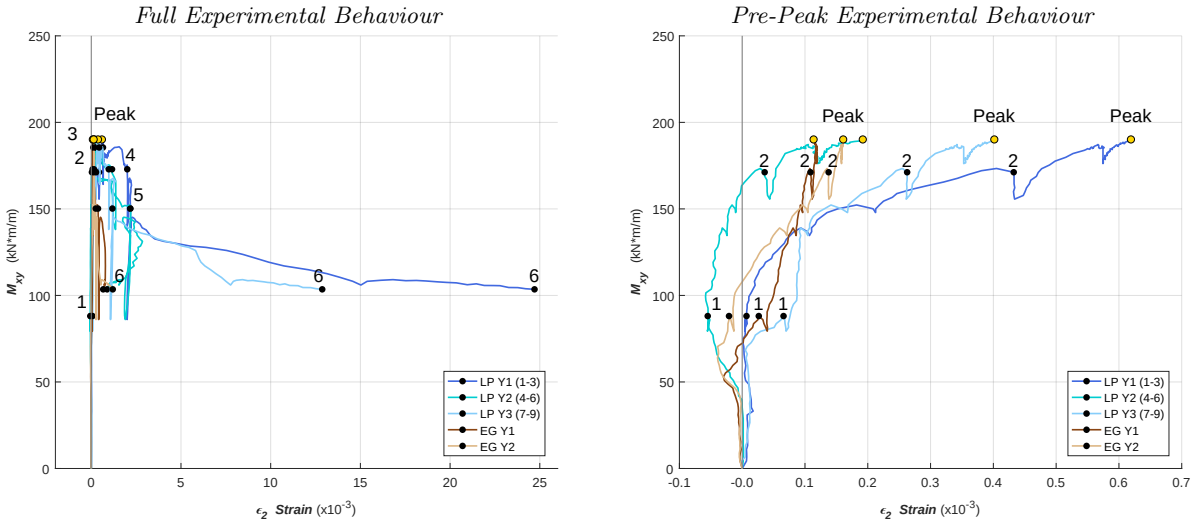


Figure 4.52: *ES1 Applied Torsion vs. Principal Compressive Strain*

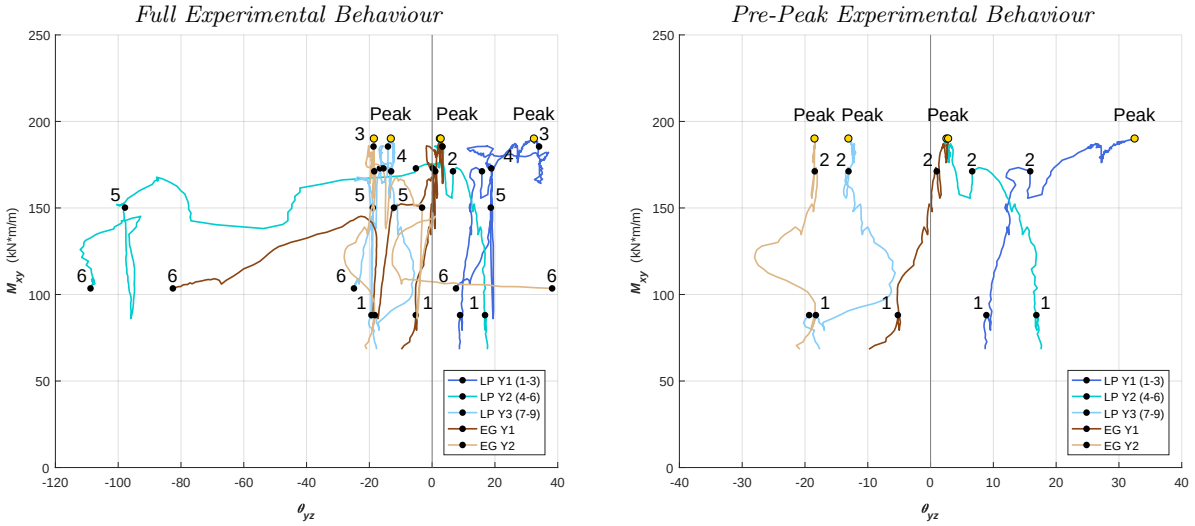


Figure 4.53: *ES1 Applied Torsion vs. Principal Angle*

Out-of-Plane (YZ & XZ) Z-Direction Strains

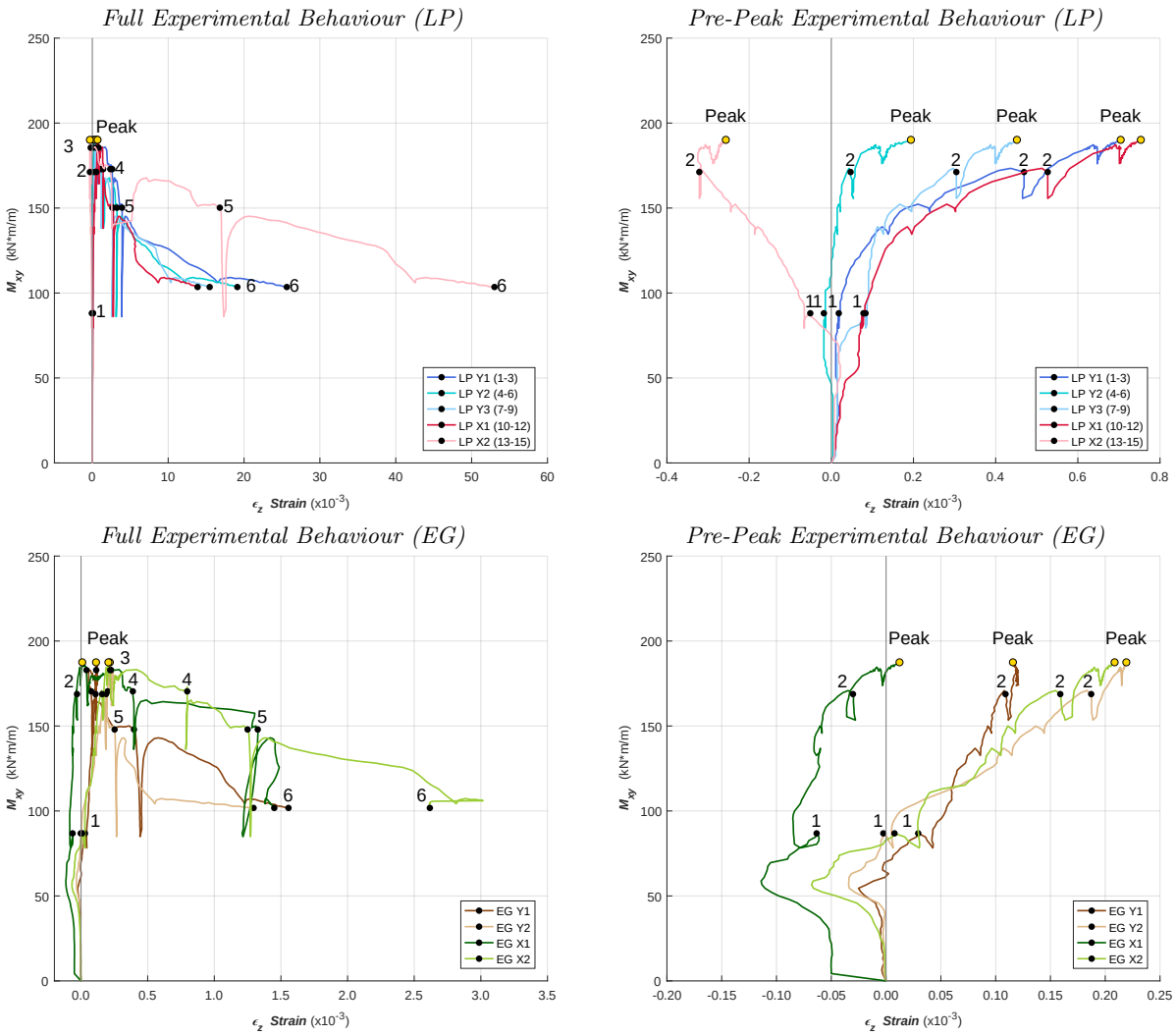


Figure 4.54: *ES1 Applied Torsion vs. Through the Thickness (Z) Strain*

4.4.2 Specimen ES2

Out-of-Plane (XZ) Strains

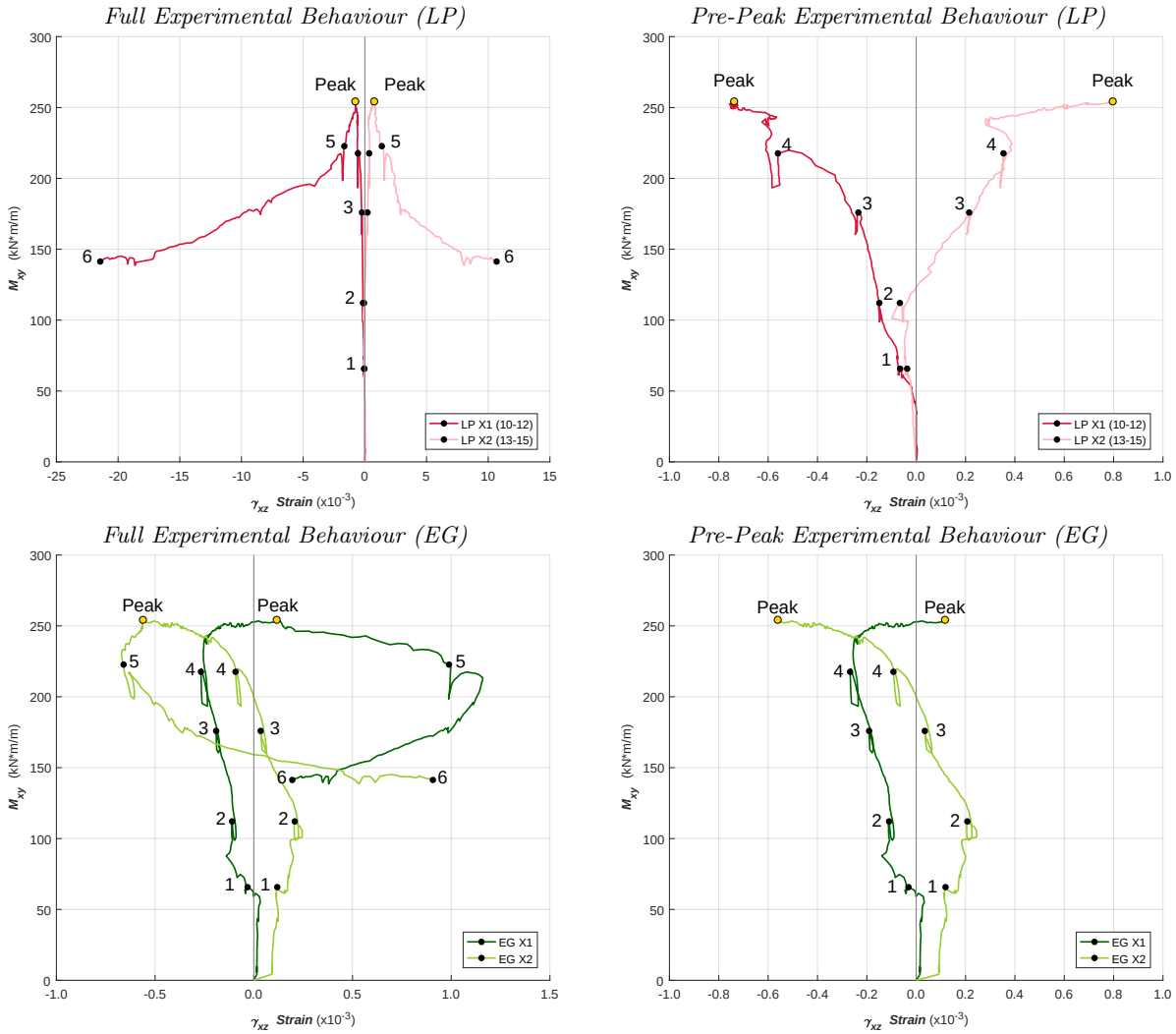


Figure 4.55: *ES2 Applied Torsion vs. Out-of-Plane (XZ) Shear Strain*

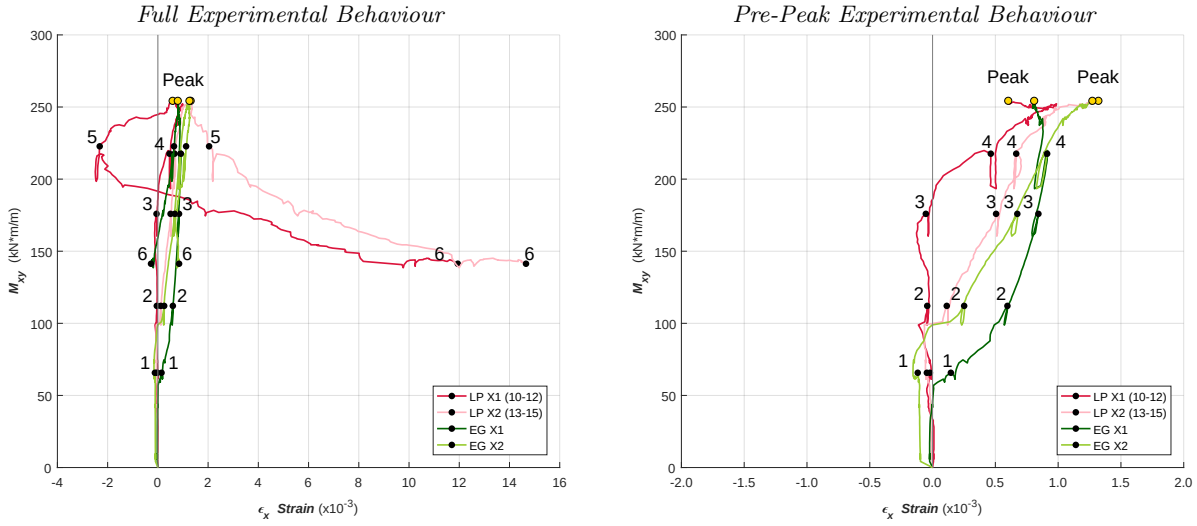


Figure 4.56: *ES2 Applied Torsion vs. X-Direction Strain*

Out-of-Plane (XZ) Principal Strains

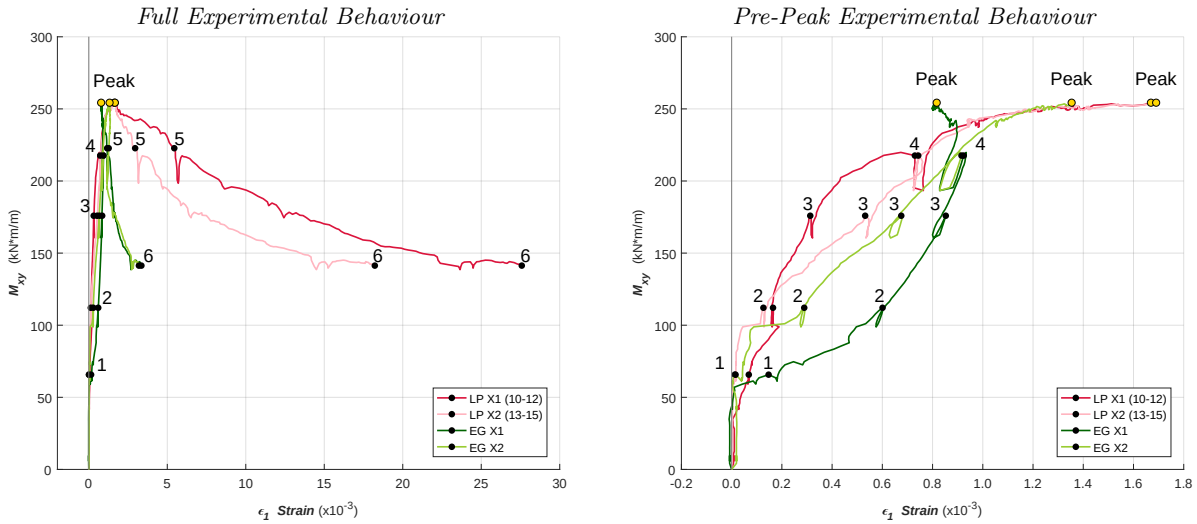


Figure 4.57: *ES2 Applied Torsion vs. Principal Tensile Strain*

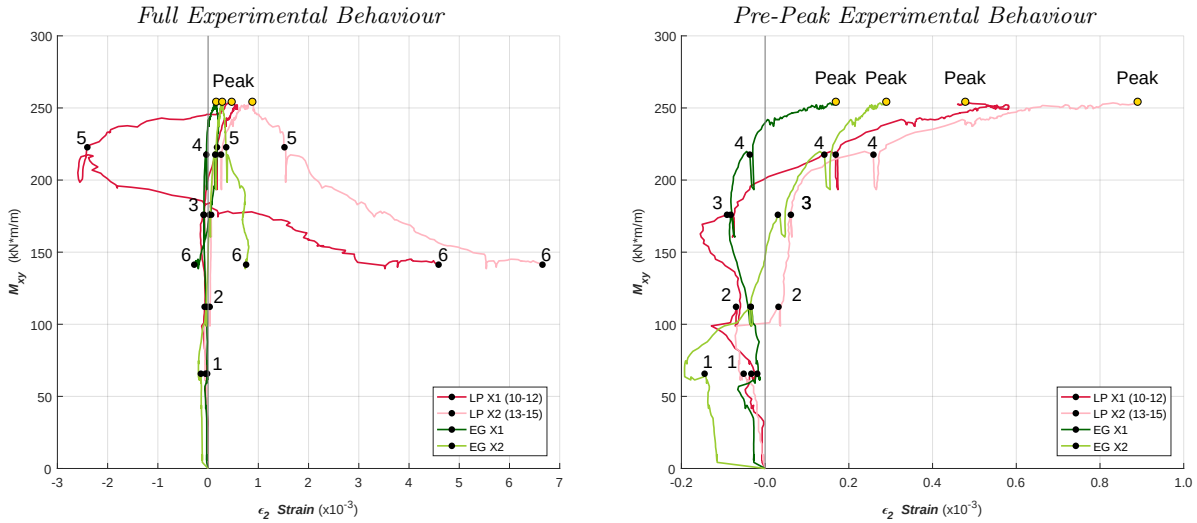


Figure 4.58: *ES2 Applied Torsion vs. Principal Compressive Strain*

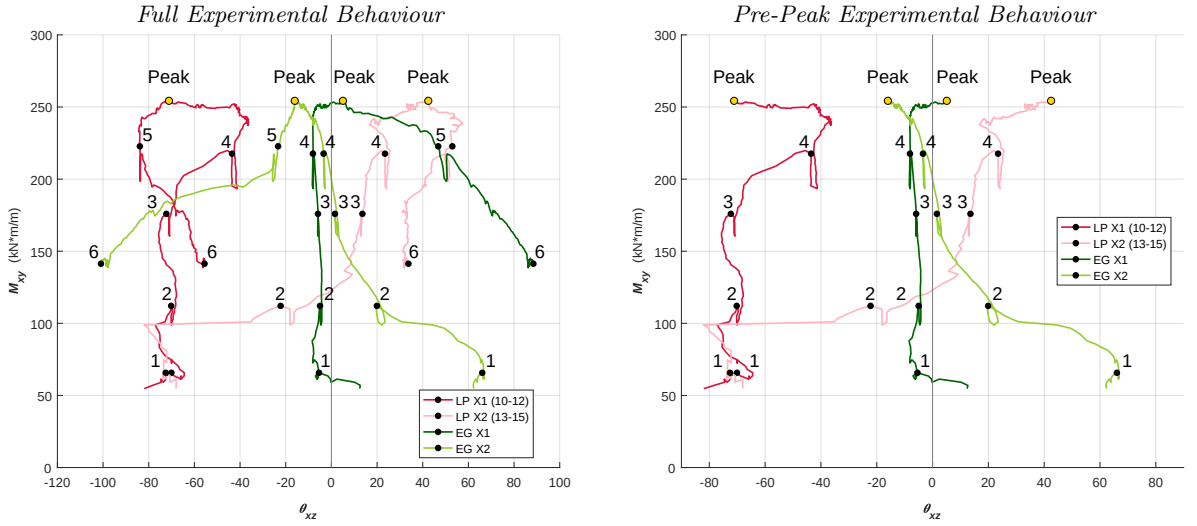


Figure 4.59: *ES2 Applied Torsion vs. Principal Angle*

Out-of-Plane (YZ) Strains

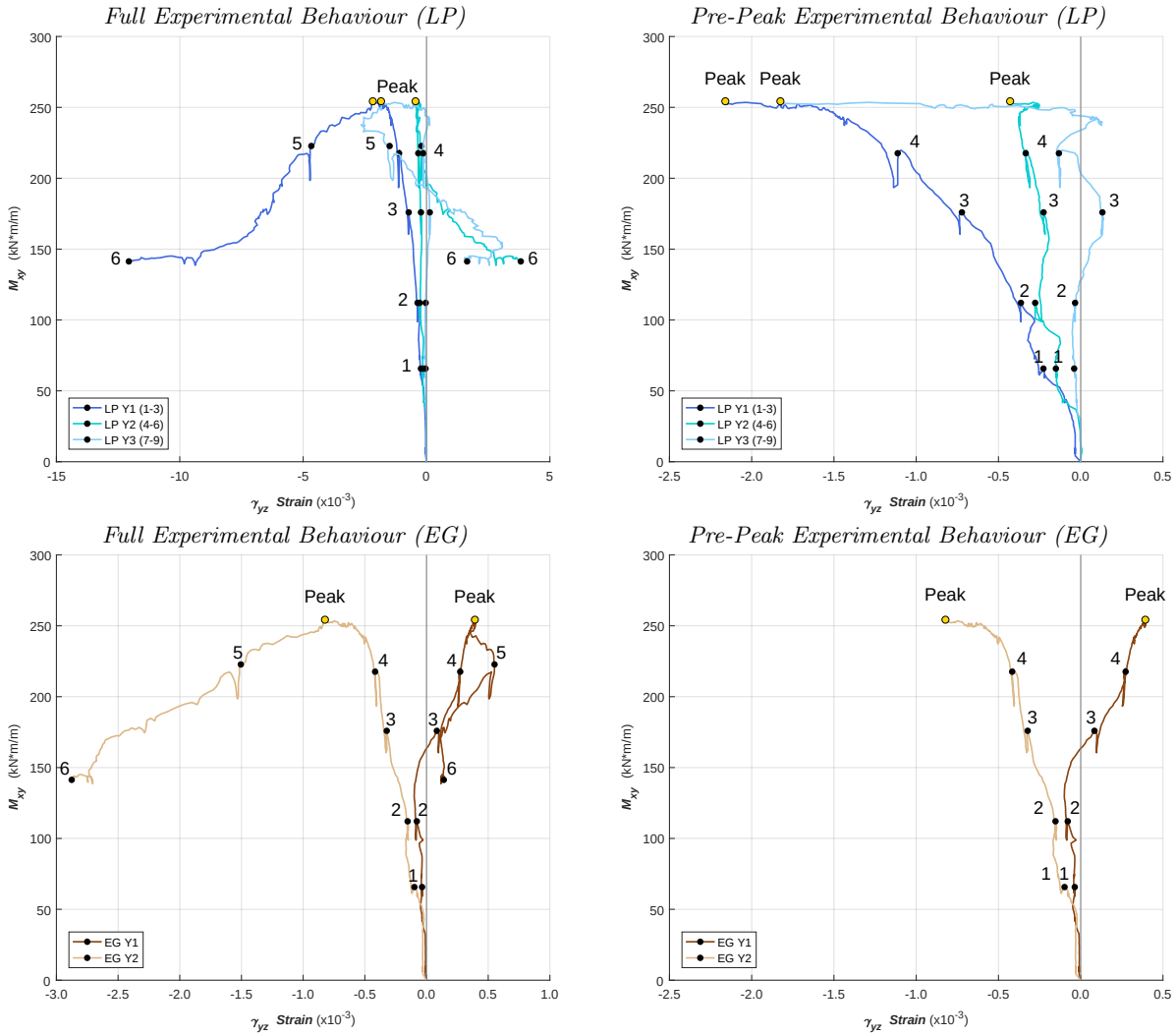


Figure 4.60: *ES2 Applied Torsion vs. Out-of-Plane (YZ) Shear Strain*

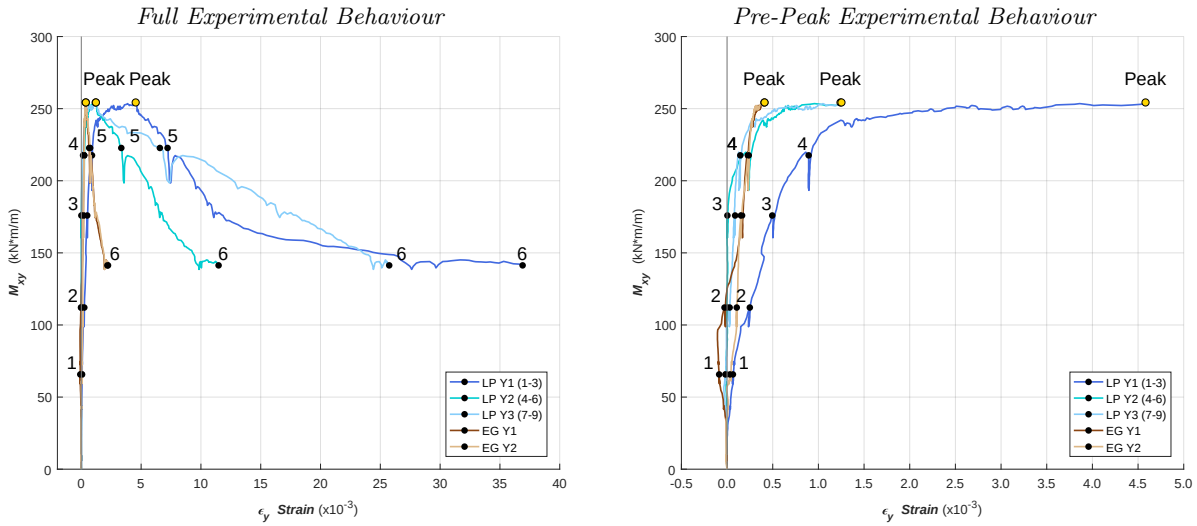


Figure 4.61: *ES2 Applied Torsion vs. Y-Direction Strain*

Out-of-Plane (YZ) Principal Strains

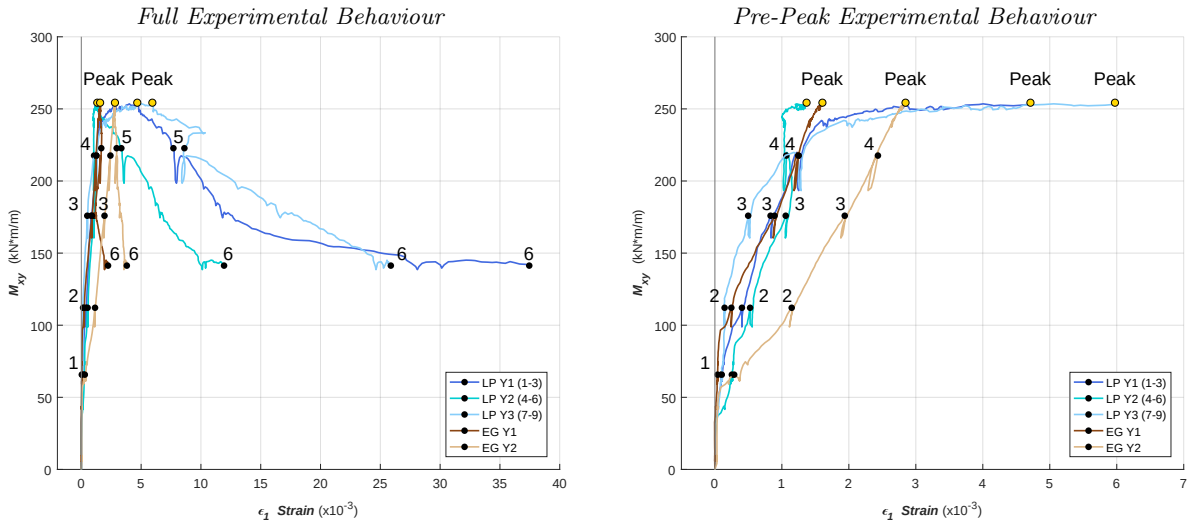


Figure 4.62: *ES2 Applied Torsion vs. Principal Tensile Strain*

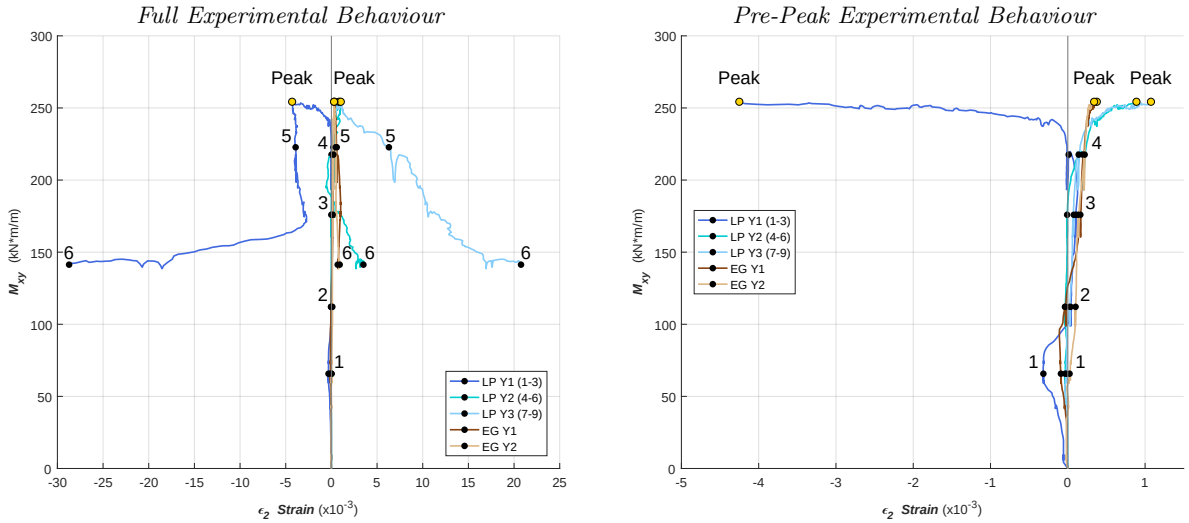


Figure 4.63: *ES2 Applied Torsion vs. Principal Compressive Strain*

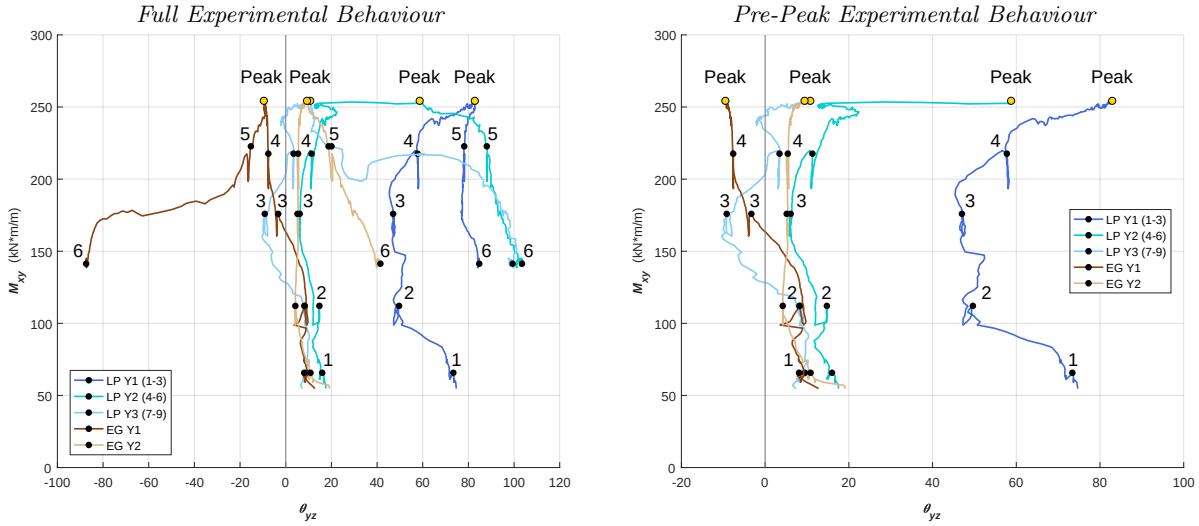


Figure 4.64: *ES2 Applied Torsion vs. Principal Angle*

Out-of-Plane (YZ & XZ) Z-Direction Strains

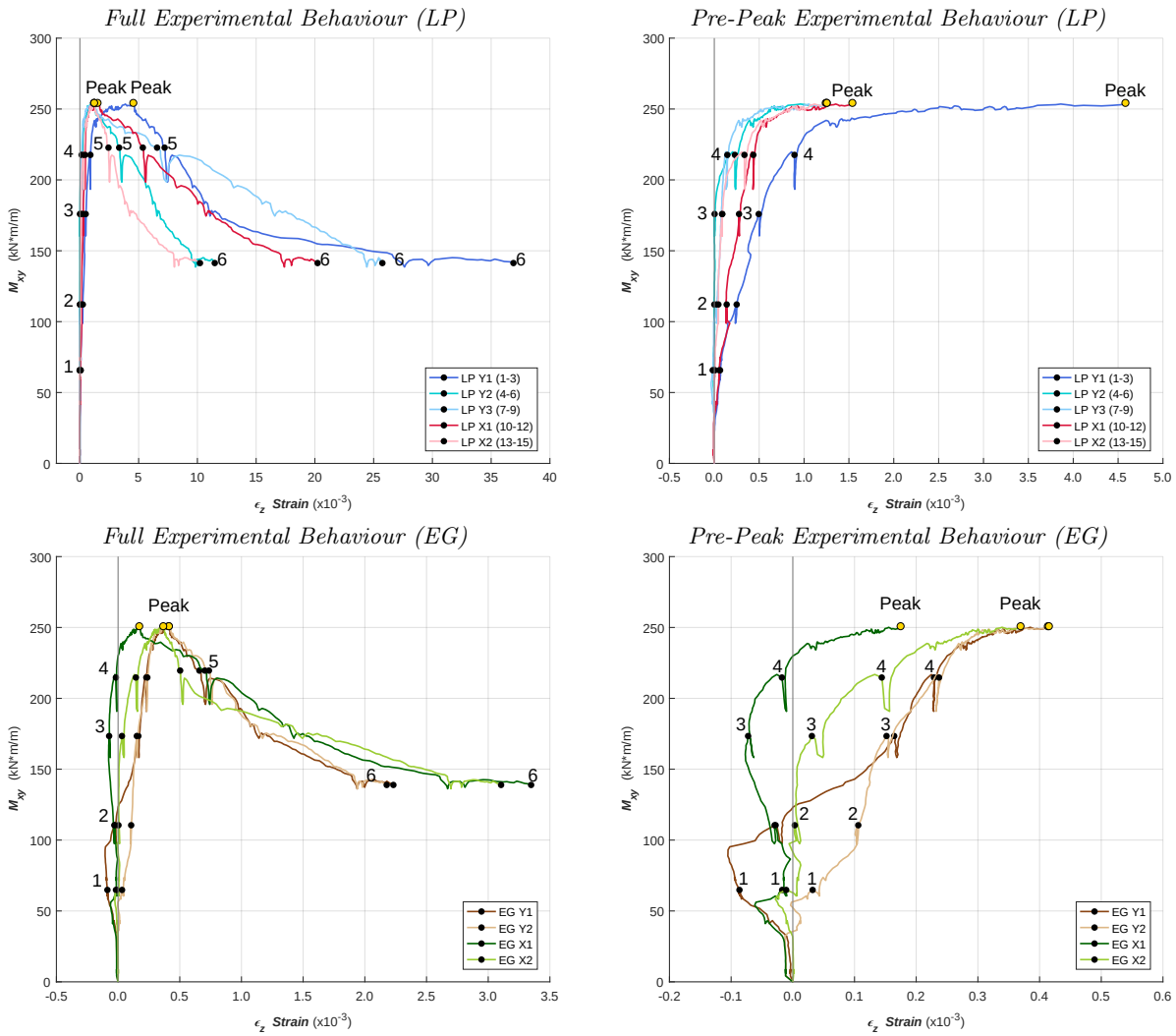


Figure 4.65: *ES2 Applied Torsion vs. Through the Thickness (Z) Strain*

4.5 Reinforcement SG Measurements

The gauges mounted on the steel reinforcement provided axial strain data for the duration of the tests. No additional calculations were required, the averaged data for each reinforcement direction and specimen face are simply presented in Table 4.7 and in the subsequent figures. Several gauges failed before LS 6 in specimen ES1, hence the omission of this row. Also, there were no T-heads used in ES1, hence the lack of data in the $\epsilon_{s,z}$ column.

Table 4.7: SG Data at Load Stages

	$\left[\frac{kN \cdot m}{m}\right]$	$\left[\frac{rad}{km}\right]$	$\left[\times 10^{-3}\right]$		$\left[\times 10^{-3}\right]$		$\left[\times 10^{-3}\right]$
	M_{xy}	ϕ_{xy}	$\epsilon_{s,x}$		$\epsilon_{s,y}$		$\epsilon_{s,z}$
			North	*South*	*North*	*South*	
ES1							
*LS*1	86.8	15.5	0.272	0.432	0.435	0.451	-
*LS*2	168.8	46.3	0.939	1.036	1.189	1.153	-
Peak	187.2	58.7	1.101	1.205	1.348	1.394	-
*LS*3	182.9	60.4	1.120	1.223	1.346	1.422	-
*LS*4	170.4	80.8	1.222	1.435	1.364	1.630	-
*LS*5	147.9	96.6	1.369	1.521	1.250	1.660	-
*LS*6	101.8	139.7	-	-	-	-	-
ES2							
*LS*1	64.8	8.2	0.166	0.186	0.170	0.234	0.000
*LS*2	110.5	21.4	0.442	0.572	0.571	0.657	0.046
*LS*3	173.4	39.0	0.768	1.055	1.081	1.131	0.102
*LS*4	214.7	56.7	1.058	1.459	1.484	1.517	0.157
Peak	250.5	89.4	1.481	1.905	1.976	1.974	0.315
*LS*5	219.6	111.0	1.554	1.961	2.020	2.040	0.572
*LS*6	138.9	223.0	1.824	1.827	2.000	1.927	1.421

4.5.1 Specimen ES1

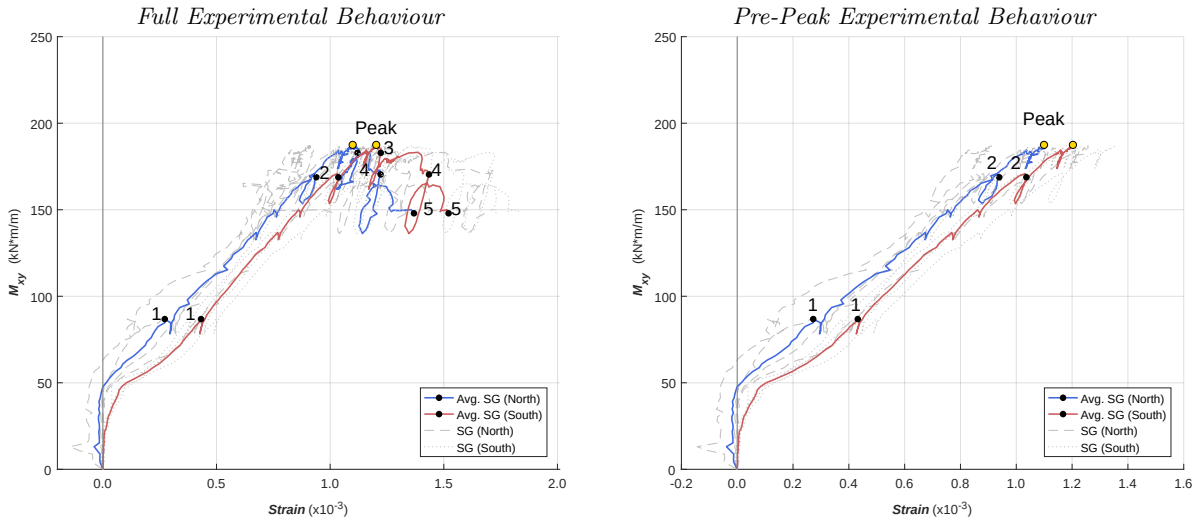


Figure 4.66: *ES1 Applied Torsion vs. X-Reinforcement Strain*

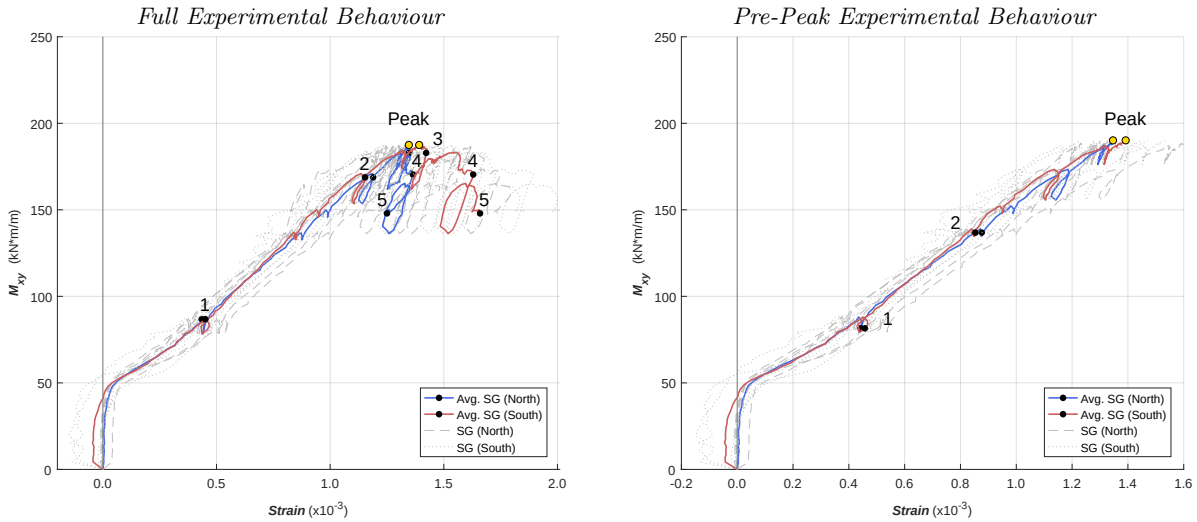


Figure 4.67: *ES1 Applied Torsion vs. Y-Reinforcement Strain*

4.5.2 Specimen ES2

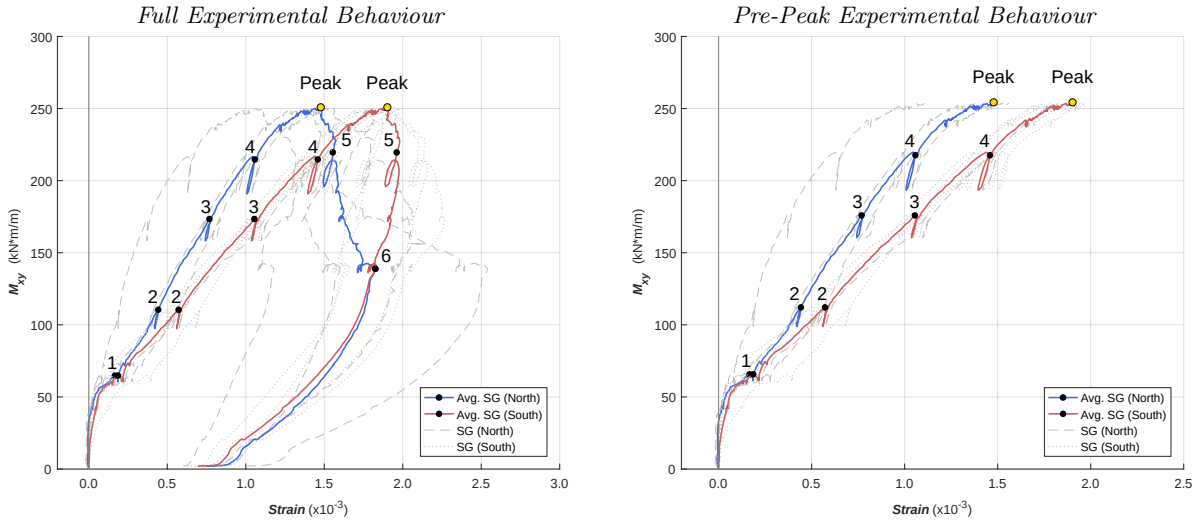


Figure 4.68: *ES2 Applied Torsion vs. X-Reinforcement Strain*

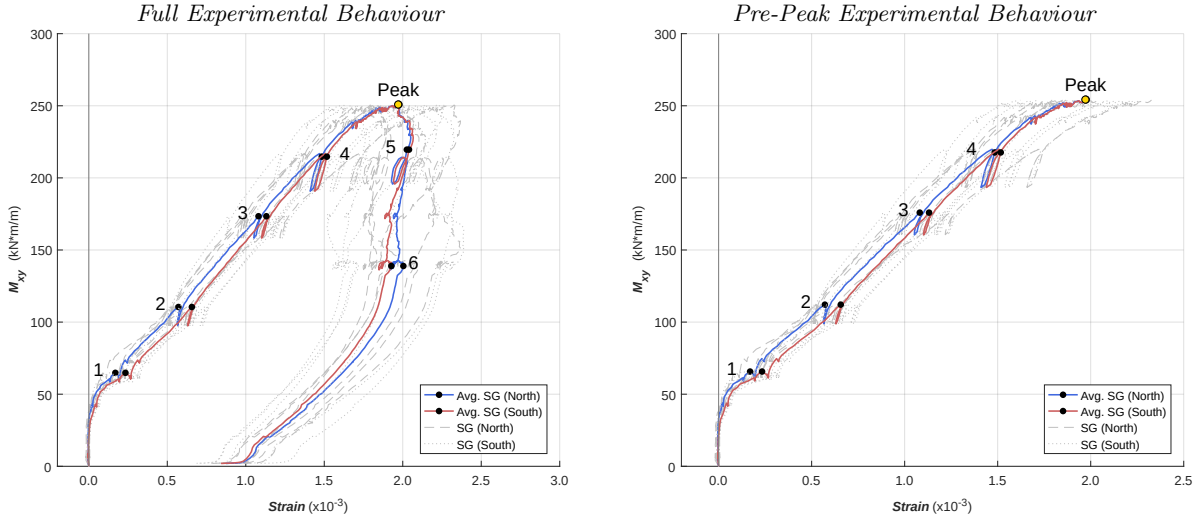


Figure 4.69: *ES2 Applied Torsion vs. Y-Reinforcement Strain*

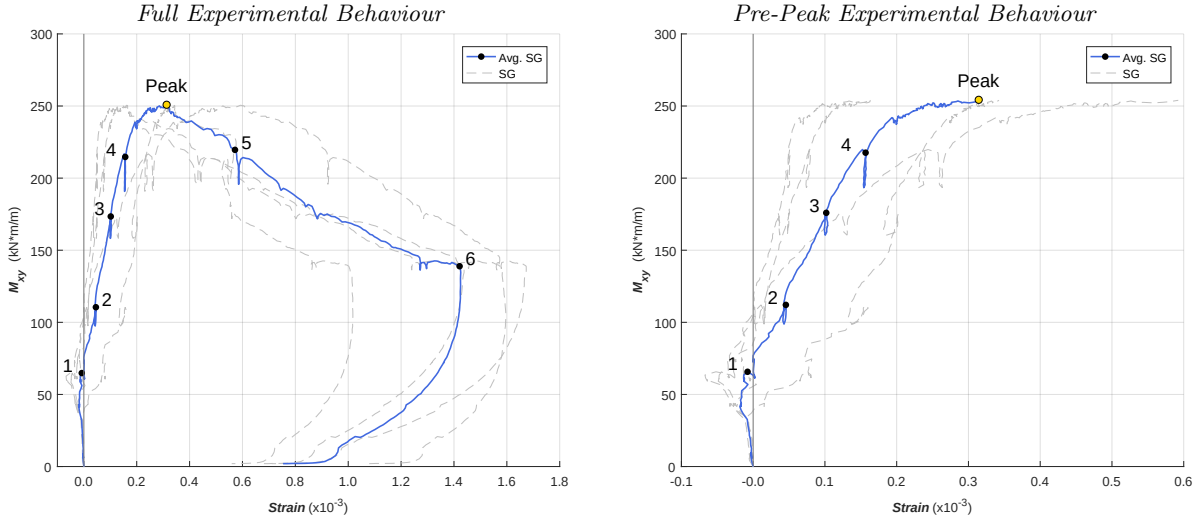


Figure 4.70: *ES2 Applied Torsion vs. Z-Reinforcement Strain*

Chapter 5

Discussion of Experimental Results and Observations

The following chapter will present a discussion on the qualitative observations made during both tests, followed by numerical comparisons and further analysis of certain important variables that were introduced in the previous chapter.

The first part of the chapter describes the progression of the experiments, with reference to photographs taken at the load stages for both tests. This is followed by a discussion on the physical deformation of the specimens as represented by the LED element grid position data, along with photos of the specimens post-failure. The purpose is to visually show the deformation patterns associated with applied torsion while introducing cover-spalling as the ultimate failure mechanism in both specimens.

The discussion of the numerical results in the second part of the chapter is based on the comparison of the important in-plane and out-of-plane variables for both specimens. This is used to determine what effect adding T-head reinforcement had on the peak strength and post-peak behaviour, and to justify the conclusion that cover-spalling resulted in the failure of both specimens. To simplify the comparison and discussion, averages are taken of the individual instrument readings that were shown in the previous chapter. In addition to presenting the first comprehensive analysis of pure torsion on reinforced concrete shells, this section will also be used to introduce and validate certain assumptions that were made in the derivation of the 3d-HyPT element presented in the following chapter.

5.1 Experimental Progression

The progress through the ES1 and ES2 experiments is detailed in Sections 5.1.1 & 5.1.2 through images taken of the North face of the specimens during the load stages. For reference, the torque-twist data is presented again to show what stage in the tests these images correspond to. Both the North and South faces are also shown at failure once the specimen was unloaded and the instrumentation was removed - the different crack directions visible (vertical and horizontal) are expected for a torsion test where equal and opposite in-plane shear stresses are applied on the North and South faces.

Table 5.1 summarizes the relevant information from the North face load stage photos: the number of vertical cracks, the characteristic crack width range, the maximum crack width, and additional observations. The crack width range and maximum values are in units of 'mm', and are based on the cracks measured in the test region. The cracks around the edges of the specimen are typically larger and spaced further apart due to the additional stiffness provided by the loading yokes; they are omitted from this summary as not being representative of the structural test region.

Table 5.1 is not intended as precise data since the crack measurements are based on visual inspection and are hence prone to human error. Yet this summary of the surface cracks is enough to illustrate the different behaviour in the pre-peak and post-peak phases of the tests. In the pre-peak load stages the number and size of the cracks steadily increases with the applied torsion, while in the post-peak region the surface cracking is virtually unchanged as the applied torsion drops. This is evidence of surface spalling occurring in the specimen at the peak load. As the surface concrete begins to separate from the specimen core it is essentially free to bulge outwards as the specimen progressively weakens and sheds the applied load.

Table 5.1: North Face Crack Width Summary at Load Stages

	M_{xy} $\left[\frac{kN \cdot m}{m}\right]$	*Type*	*Cracks*			*Observations*
			#	*Width*	*Max.*	
ES1						
LS1	86.8	Pre-peak	11	0.05 - 0.10	0.15	-
LS2	168.8	Pre-peak	16	0.10 - 0.15	0.35	-
LS3*	182.9	Pre-peak	18	0.15 - 0.20	0.40	-
LS4	170.4	Post-peak	18	0.15 - 0.20	0.40	Crushing at top edge
LS5	147.9	Post-peak	19	-	-	Crack slipping and flaking
LS6	101.8	Post-peak	19	-	-	Visible spalling
ES2						
LS1	64.8	Pre-peak	6	0.05 - 0.10	0.10	-
LS2	110.5	Pre-peak	11	0.10 - 0.15	0.20	-
LS3	173.4	Pre-peak	15	0.10 - 0.20	0.35	-
LS4	214.7	Pre-peak	16	0.15 - 0.25	0.55	-
LS5	219.6	Post-peak	16	0.15 - 0.25	0.55	Surface flaking
LS6	138.9	Post-peak	16	-	-	Significant cover spalling

* Slightly past the peak value, but considered in pre-peak group

5.1.1 Specimen ES1 Load Stage Photographs

Figure 5.1 presents the torque-twist relationship for specimen ES1, which corresponds to the images shown in Figures 5.2 and 5.3 at failure and at the load stages respectively.

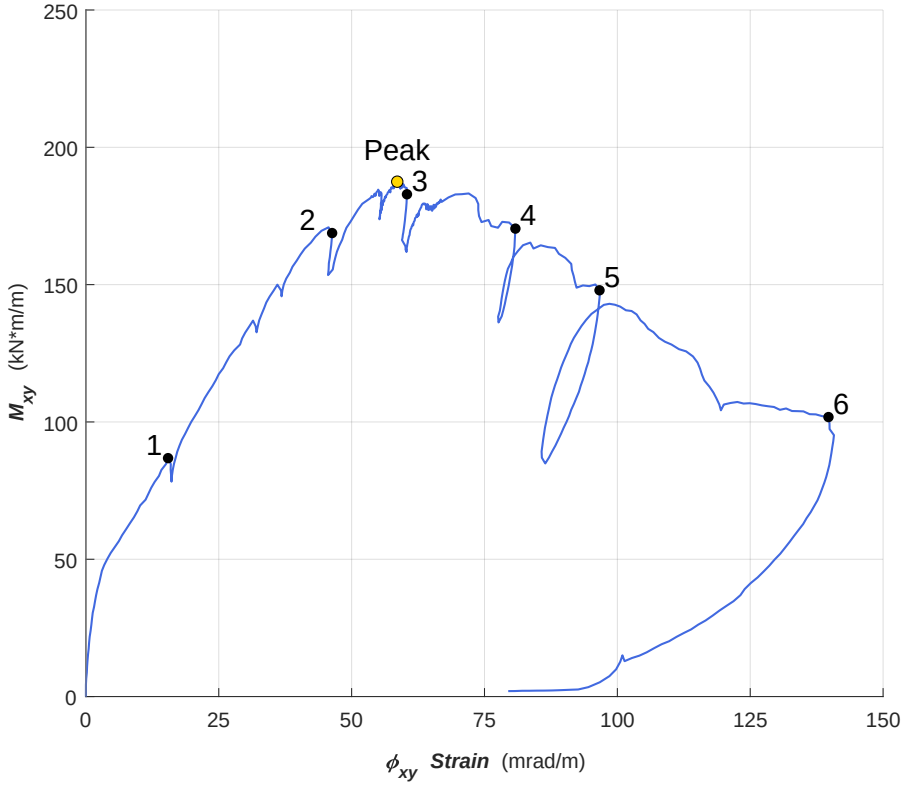


Figure 5.1: *ES1 Applied Torsion-Twist at Load Stages*

North Face *South Face*

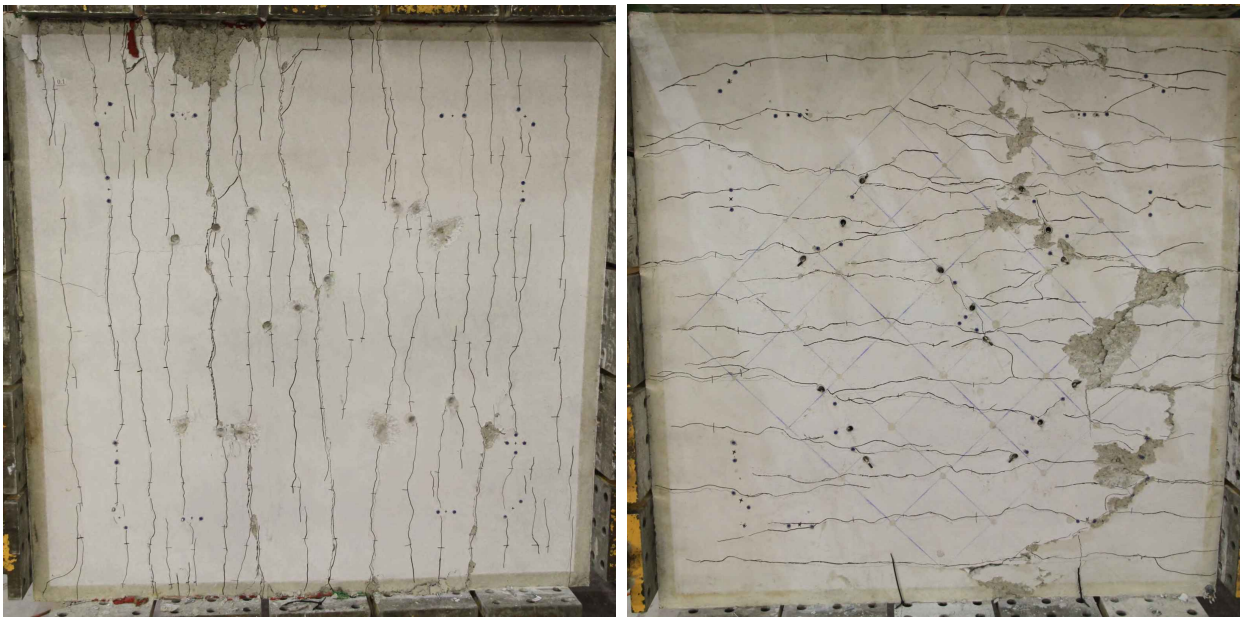


Figure 5.2: *ES1 at Failure (Black Lines = Cracks)*

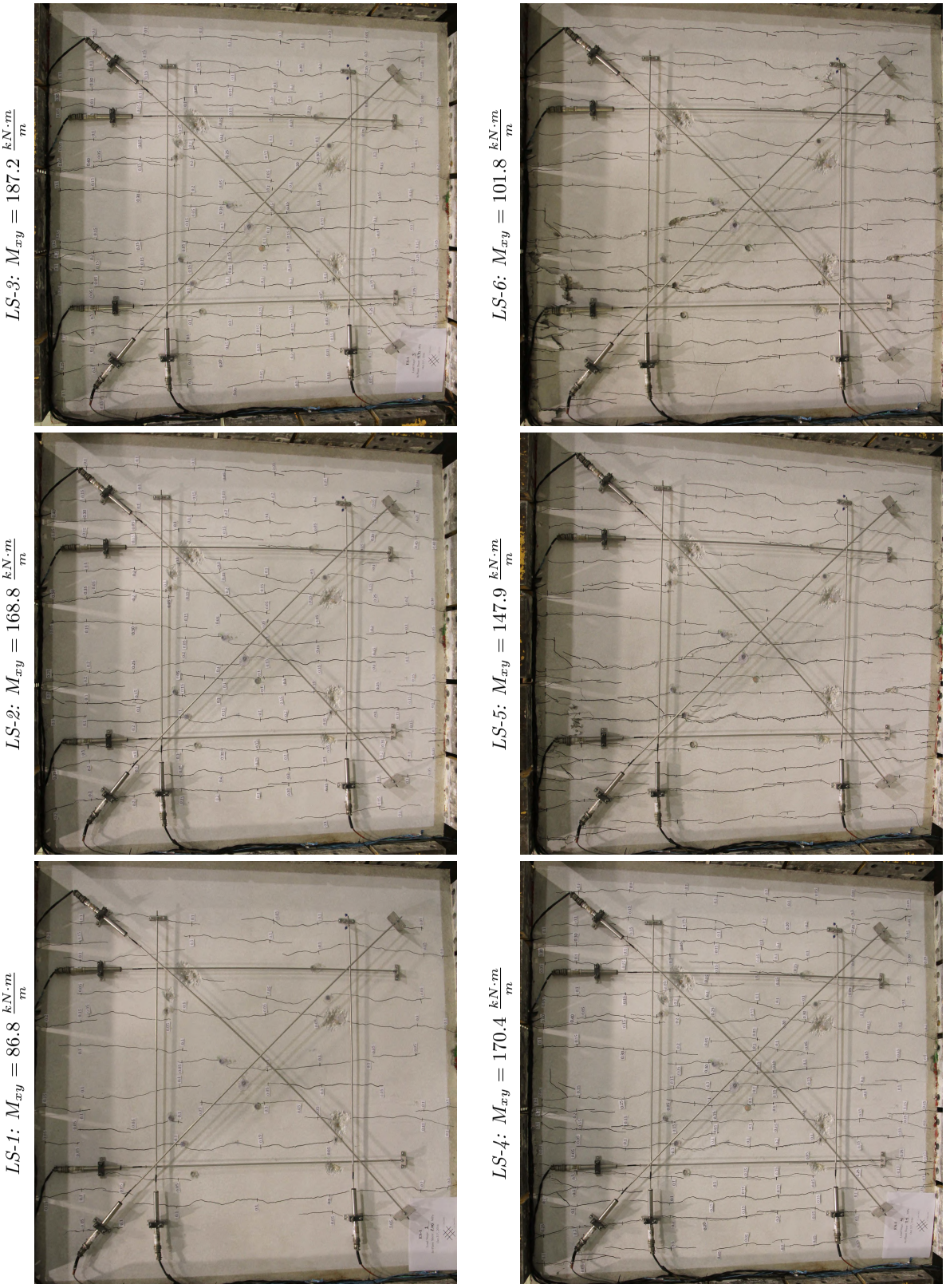


Figure 5.3: *ES1 Load Stage Photographs (North Face)*

5.1.2 Specimen ES2 Load Stage Photographs

Figure 5.4 presents the torque-twist relationship for specimen ES2, which corresponds to the images shown in Figures 5.5 and 5.6 at failure and at the load stages respectively.

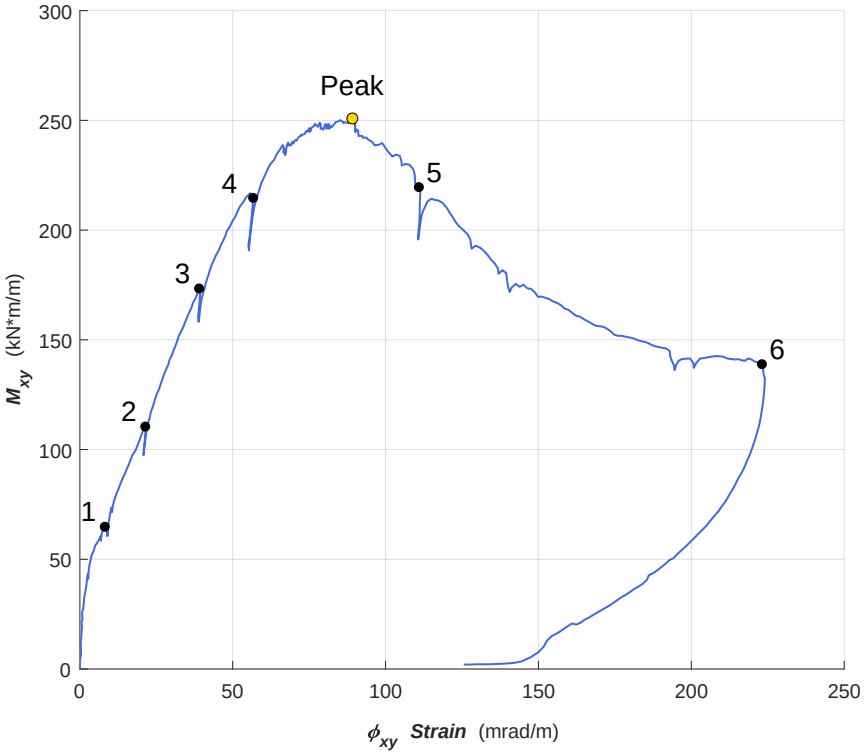
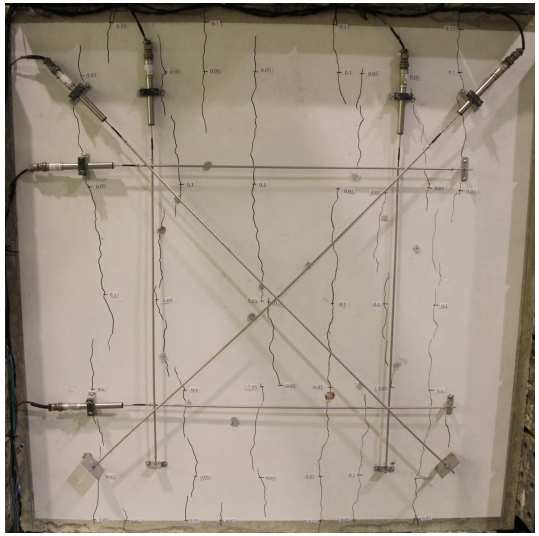


Figure 5.4: *ES2 Applied Torsion-Twist at Load Stages*

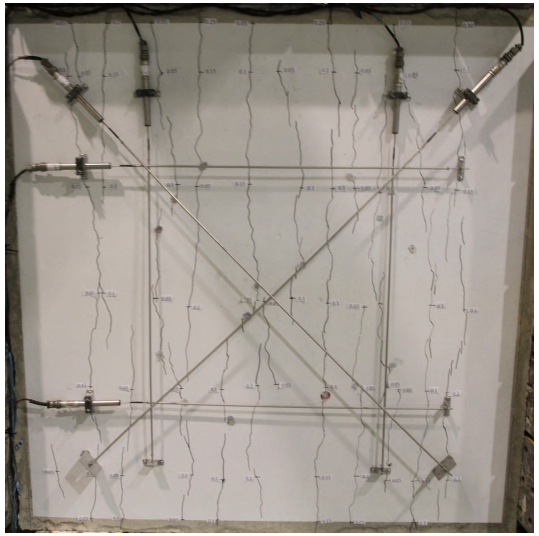
North Face *South Face*

Figure 5.5: *ES2 at Failure (Black Lines = Cracks)*

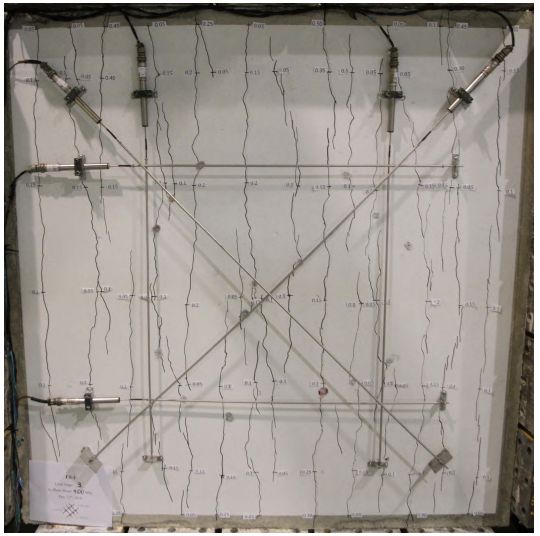
LS-1: $M_{xy} = 64.8\ \frac{kN \cdot m}{m}$



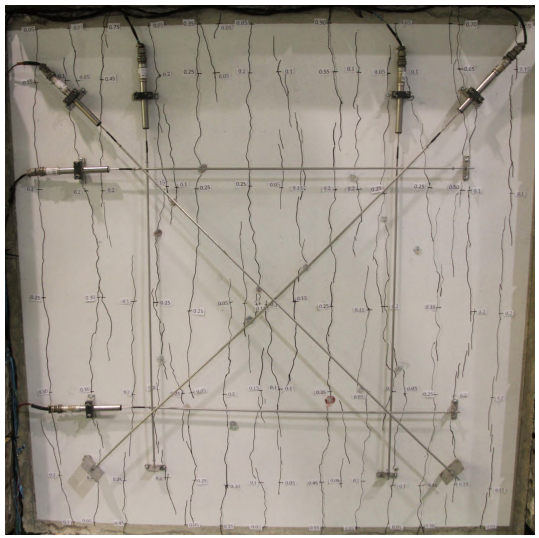
LS-2: $M_{xy} = 110.5\ \frac{kN \cdot m}{m}$



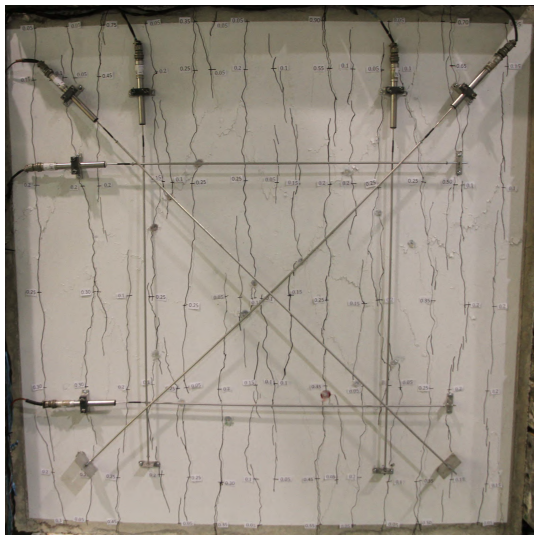
LS-3: $M_{xy} = 173.4\ \frac{kN \cdot m}{m}$



LS-4: $M_{xy} = 214.7\ \frac{kN \cdot m}{m}$



LS-5: $M_{xy} = 219.3\ \frac{kN \cdot m}{m}$



LS-6: $M_{xy} = 138.9\ \frac{kN \cdot m}{m}$

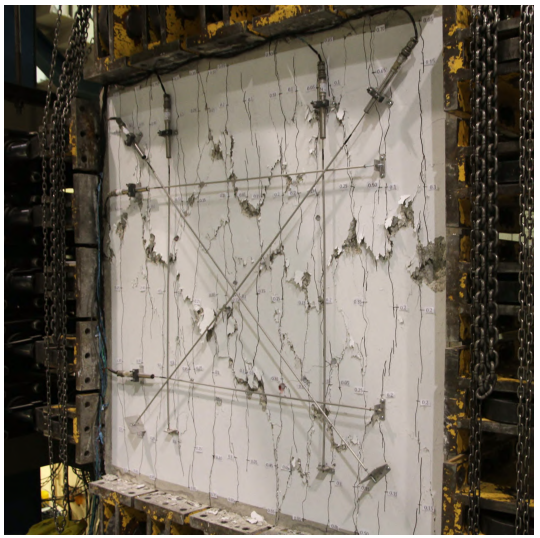


Figure 5.6: *ES2 Load Stage Photographs (North Face)*

5.2 Specimen Deformation and Damage

Looking more closely at the deformations and the type of damage sustained is helpful in understanding the behaviour of the specimens. Using the position data from the LED target system provides further evidence of significant cover spalling between the peak and final load stages, while the photographs of the cored locations shows separation between the core and surface concrete.

5.2.1 Surface Deformation Pattern

The surface displacement of both specimens can be mapped with a high level of precision with the LED targets that are placed on the South face. While this data is intended for the calculation of the in-plane strain state of the specimen, it can also be used to show the deformed shape of the specimen (Figure 5.7 and Figure 5.8). The initial position of the LEDs is represented by the grey plane, while the new position at either the 'Peak' or 'Final' load stage is shown in red; the corresponding point on the torque-twist plot is also shown for reference. The relative displacements between load stages and the deformed shape of the LED plane will be referred to in the following discussion.

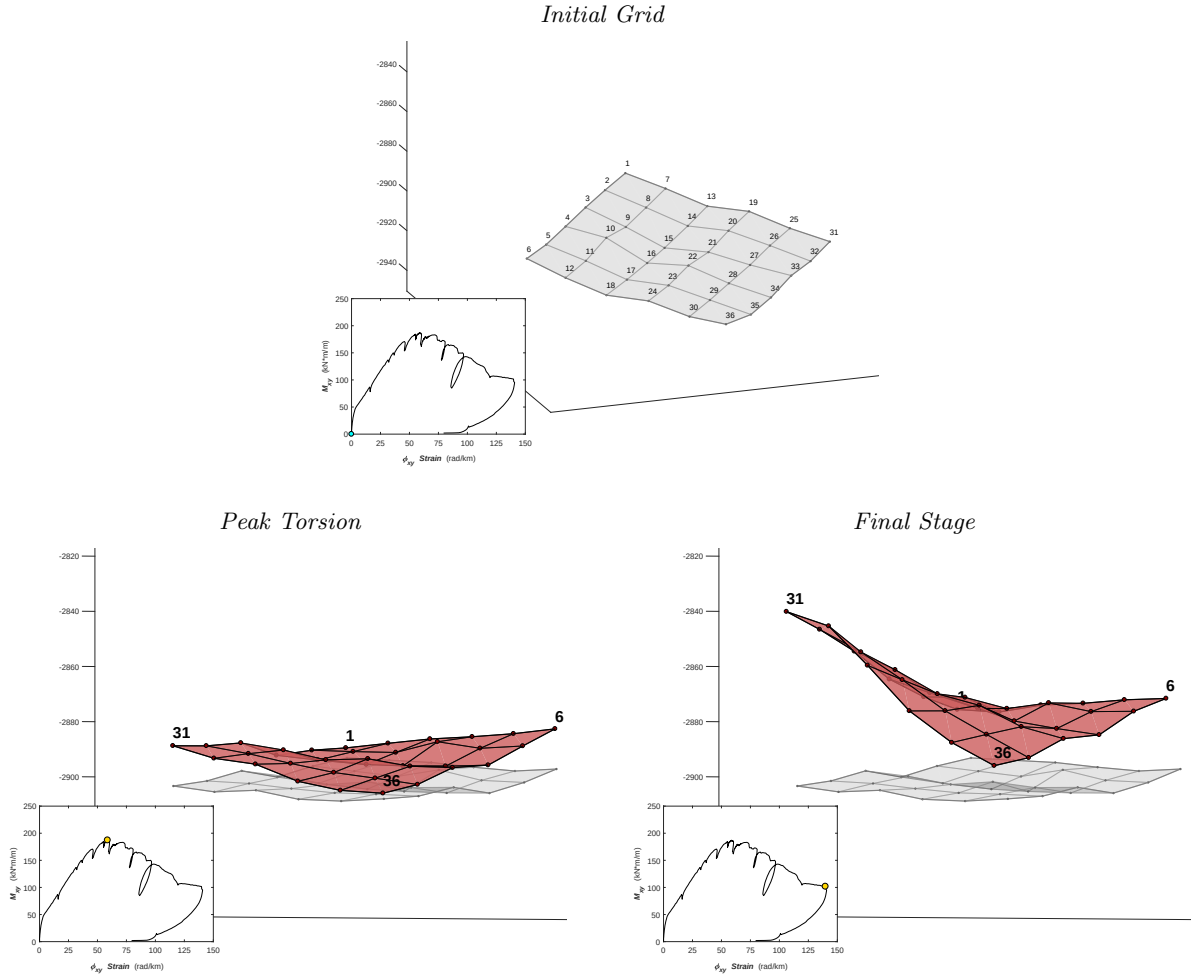


Figure 5.7: *ES1 Surface Deformations Measured by LED Targets*

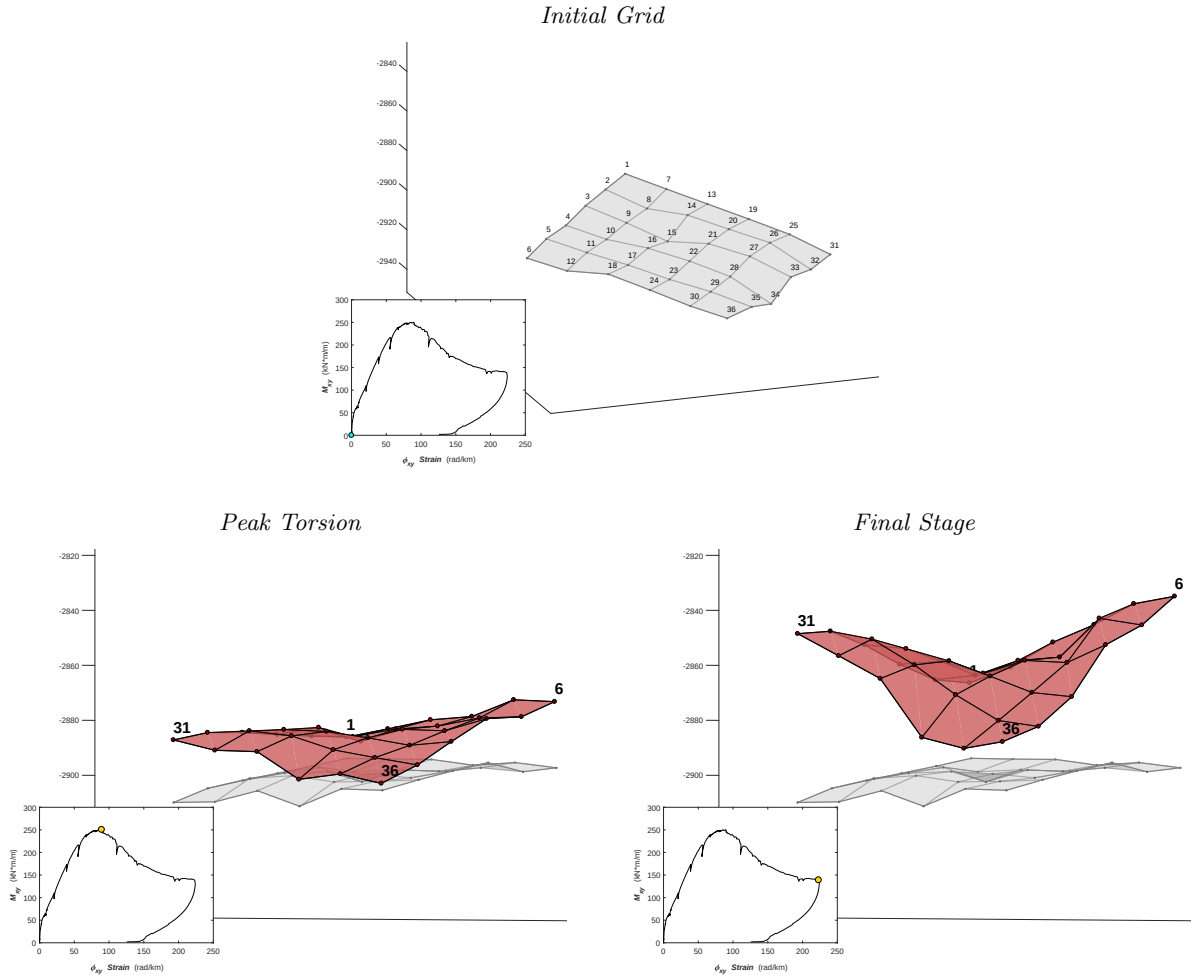


Figure 5.8: *ES2 Surface Deformations Measured by LED Targets*

The four corner LEDs in the deformed plane have been annotated according to the convention presented in Section 3.4.3, where LED #1 corresponds to the top of the test region. For any readers skeptical of the load application procedure used in the Shell Element Tester to create torsion, the deformations visible at both load stages are characteristic of applied torsion in a shell and serve as evidence for the successful execution of the test. The adjacent corners move in opposite direction relative to each other (i.e. 1 & 36 down, 6 & 31 up), forming a saddle point in the middle of the specimen. At the scale shown, this shape is beginning to form at the peak and is clearly visible at the final load stage. Another important observation from these surface deformation plots is the rate at which the cover bulges out. Between the start of the test and the peak, the surface moves proportionally much less than between the peak and the final load stage, which is evidence of cover spalling beginning at the peak and accelerating in the post-peak region. This conclusion can be inferred more easily in a frame-by-frame look at the surface deformations, which is better suited to presentation as a video rather than snapshots.

5.2.2 Spalling of Cover Concrete

Further evidence of cover spalling was documented as the specimen was removed from the testing set-up. Figure 5.9 shows the vertical cracks visible at the edge of the specimens where the front layer has separated almost completely from the core concrete. The loading yokes partially obscure the cracks and are only kept in the image because they are holding the concrete in place.

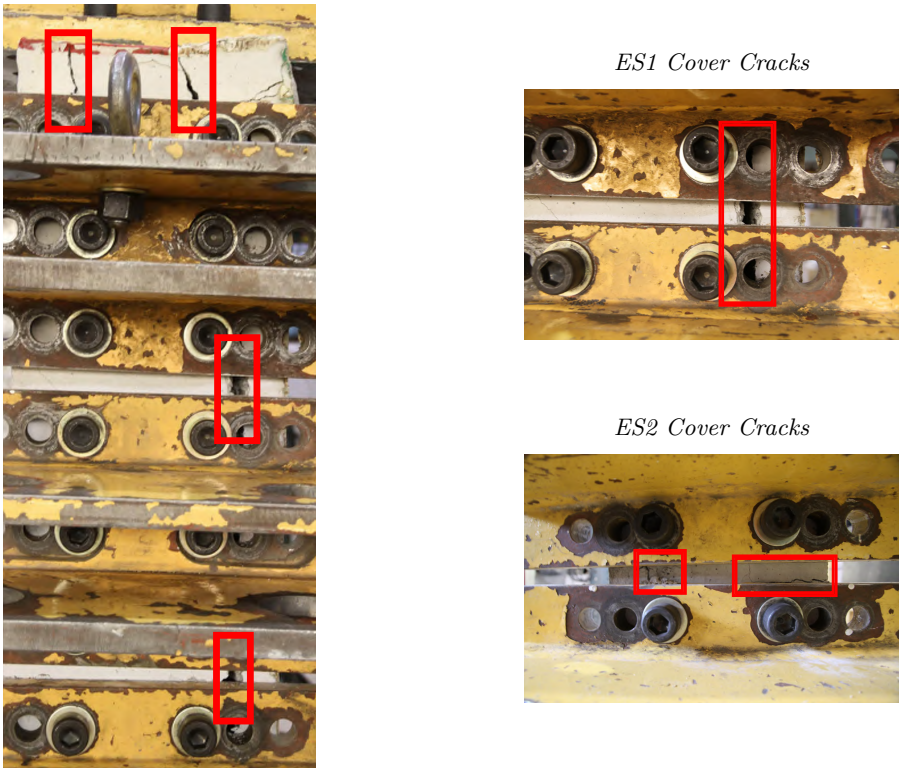


Figure 5.9: *Visible Cover Spalling at Specimen Edge*

Figure 5.10 shows the middle of the test region, where cores were extracted after completion of the experiment to better observe the interior damage. The surface concrete, at the elevation of the top layer of reinforcement, is clearly separated from the rest of the specimen. Four of these probes were made throughout the test region in both specimens, with the same observation at each location.

Figure 5.10: *Visible Cover Spalling at Cored Locations*

5.2.3 Additional Observations

The specimen was relatively intact at the conclusion of the experiment, which is an added benefit of using a displacement-controlled loading protocol. This presented a rare opportunity to observe certain characteristic mechanisms in reinforced concrete that are typically lost when a specimen fails in a load-controlled test. For example, Figure 5.11 clearly shows the post-peak slipping of the main surface crack on the North face of specimen ES1 - the horizontal black lines are marked crossing the crack at its initial formation, and the final offset indicates a relative displacement of either side.

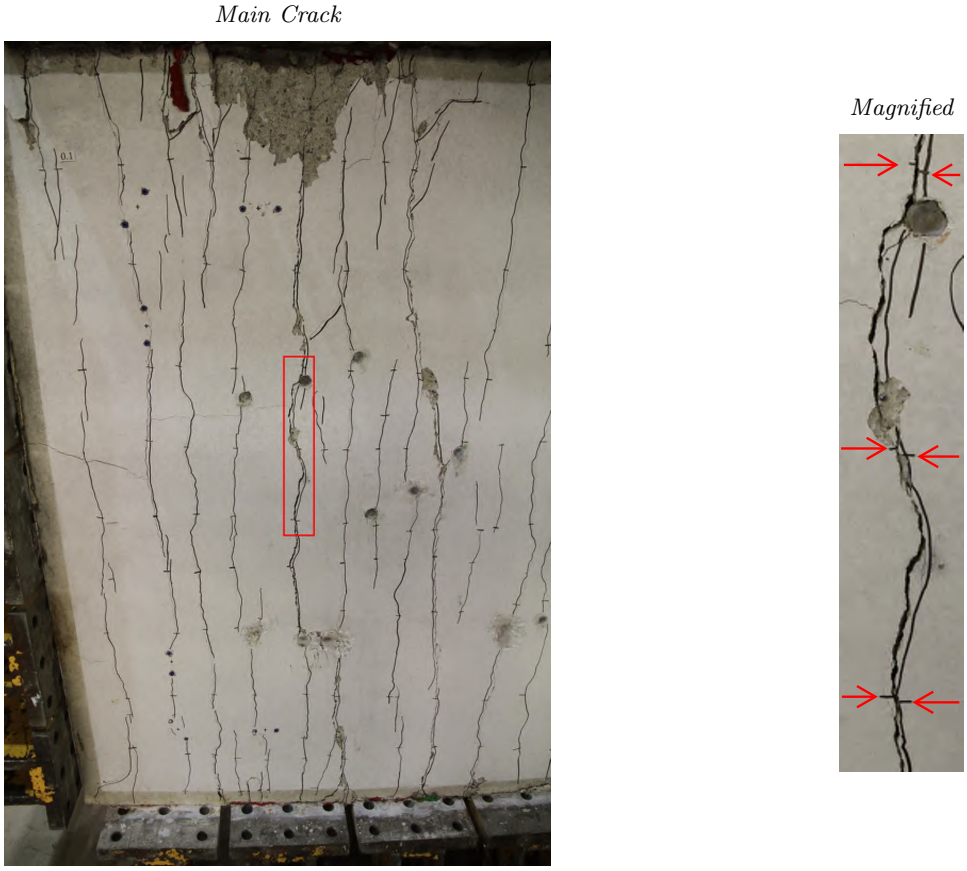


Figure 5.11: *Crack Slip in Failed ES1 Specimen (North Face)*

Figure 5.12 shows the bottom edge of the shell where the residual curvature at the end of the test is visible - the central portion covers more of the loading yoke holes than the outer edges.

Figure 5.12: *Bulging Cover and Residual Curvature in Failed ES1 Specimen (North Face)*

5.3 In-Plane Experimental Data Comparison

The following section will present a closer look at the in-plane experimental data, consisting of the LED targets, surface LVDTs, X & Y reinforcement strain gauges. The results will be compared across both specimens and different types of instrumentation, to clearly explain the differences and similarities in the experimental behaviour. For the sake of clarity, only the peak torsion points for each specimen are explicitly shown on the following plots, data on the specific load stages can be found in the previous chapter.

5.3.1 Torque-Twist

Figure 5.13 presents the high-level behaviour of both specimens in the form of the applied torsion in relation to the twist strain. The two specimens initially exhibit the same cracked stiffness, which was expected since their concrete strengths and longitudinal reinforcement ratios were the same. Although specimen ES1 begins to soften towards its peak torsion point, deviating from the linear stiffness. The addition of T-head reinforcement has a significant impact on both the strength and ductility of specimen ES2, an improvement over ES1 of 33.8% and 52.2% respectively. While experimental variability and the difference in concrete strength could possibly accounts for some of the variation, the magnitude of the difference implies that there is an inherent benefit when including T-heads. The post-peak stiffness is similar as in this region as cover spalling continues to develop in both specimens.

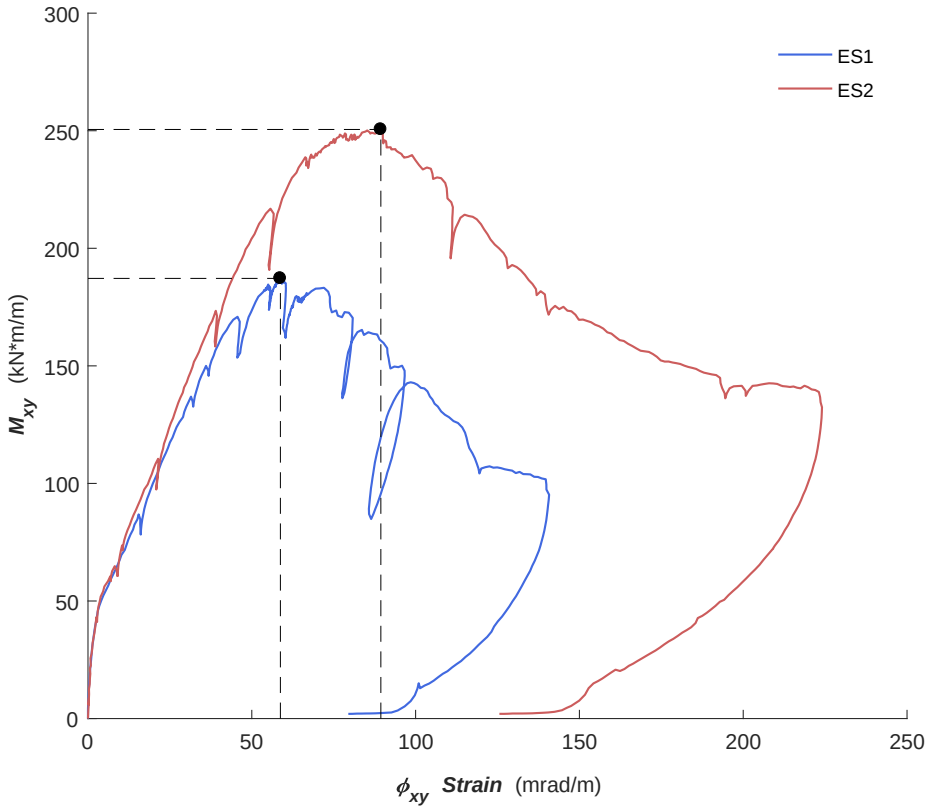


Figure 5.13: *Applied Torsion-Twist Comparison*

5.3.2 In-Plane Shear Strain

Figure 5.14 presents the in-plane shear strain as a function of the applied torsion for both specimens. The average of the 25 LED elements are plotted against the South face LVDT results only - the excellent agreement across these two measurement systems is validation for using either method. The results begin to diverge in the post-peak region as certain individual LED elements experience a greater degree of cracking and spalling than others, yet even this difference is minimal. Recall that the twist strain is calculated from the change in the in-plane shear strains across the thickness of the specimen, hence the similarity to the shape of the curve in the previous figure.

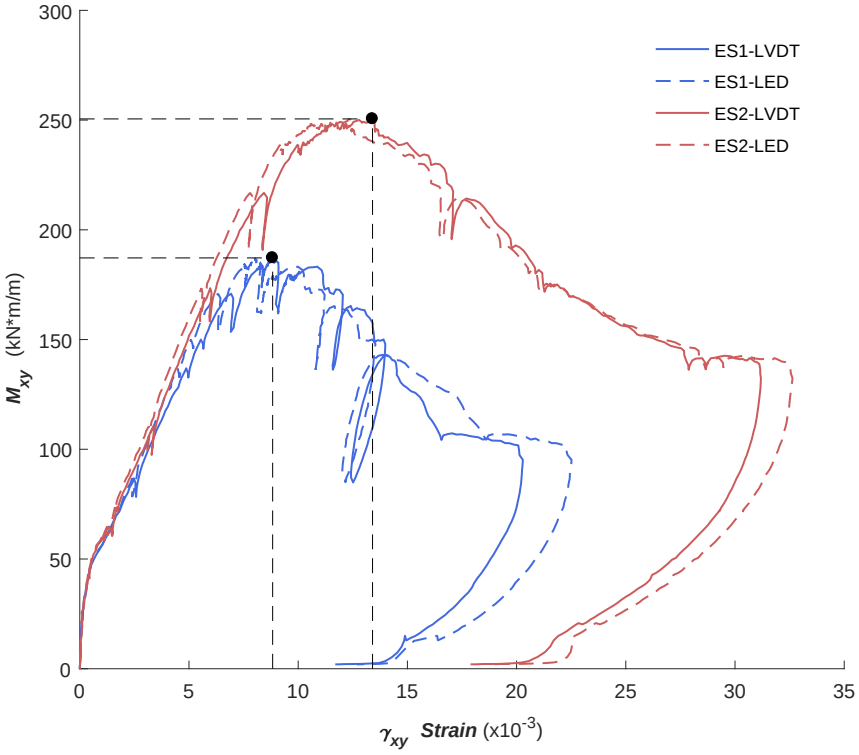


Figure 5.14: *In-Plane Shear Strain Comparison (South Face LVDTs and LEDs)*

5.3.3 Principal Tensile & Compressive Strain

The principal tensile and compressive strains in ES1 and ES2, based on the averged LVDT data, are seen in Figure 5.15 to follow a similar trend - the same initial behaviour, followed by a deviation from the cracked linear response prior to the peak. ES2 exceeds the strains seen at the peak torsion in ES1 by 52.2% and 51.7%, for the compressive and tensile strains at respectively. Such large principal strains would typically imply either crushing of the concrete or yielding of the reinforcement, neither of which was happening based on the physical observations and data. A possible explanation for such values is the separation and subsequent deformation of the surface concrete - the curvatures achieved by such a delaminated surface would affect the readings of surface mounted instrumentation and explain such high principal strains.

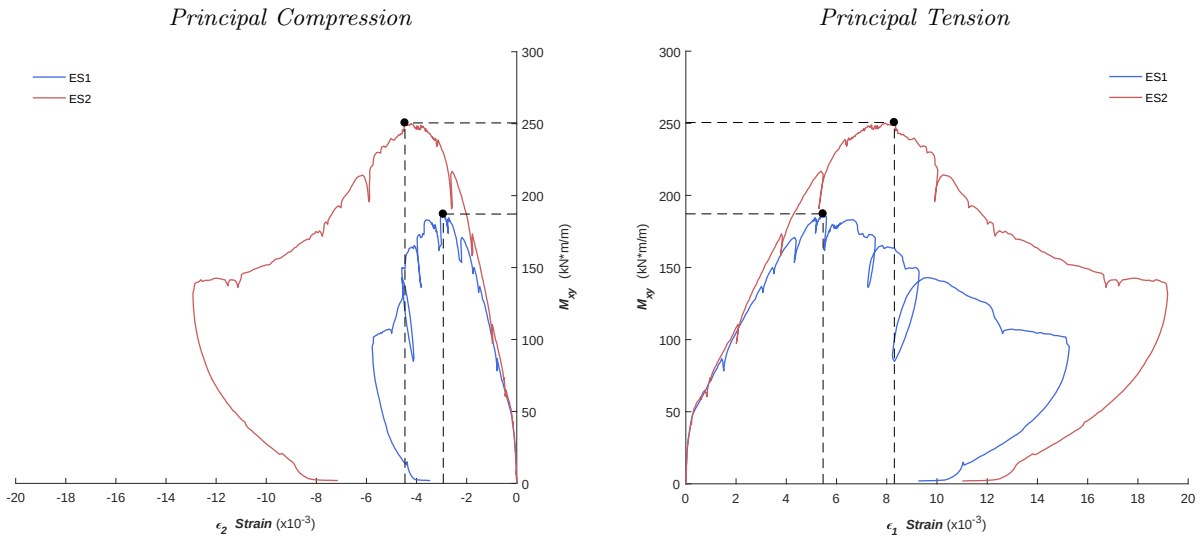


Figure 5.15: *In-Plane Principal Strain Comparison*

To further investigate these experimental results, a simplified model of ES1 was made in the program Membrane-2000, which is able to calculate the nonlinear response of a two-dimensional reinforced concrete membrane element. The North or South half of the specimen can each be roughly approximated as membranes subjected to in-plane shear stresses, the resultants of which together create a torsion in the shell. It is important to note that the nature of this program leads to several limitations in the context of recreating the real experimental conditions: no out-of-plane effects are considered, and the shear stresses are uniform over the thickness. Nonetheless, this analysis is still helpful in validating the in-plane test results.

Figure 5.16 shows a schematic of the membrane model, and the results at the peak applied shear. When compared to the experimental results for ES1 at the peak torsion there is some agreement: 7.57×10^{-3} vs. 8.37×10^{-3} for the in-plane shear strain, 6.14×10^{-3} vs. 5.47×10^{-3} for the principal tensile strain, and -1.44×10^{-3} vs. -2.93×10^{-3} for the principal compressive strain. This comparison is far from perfect, but does show that the experimental results fall within a range that can be reasonably captured by existing models. Yet these results are significantly worse when used to represent ES2 - the simplified membrane analogy is harder to justify in this case since as there are out-of-plane effects that should not be ignored.

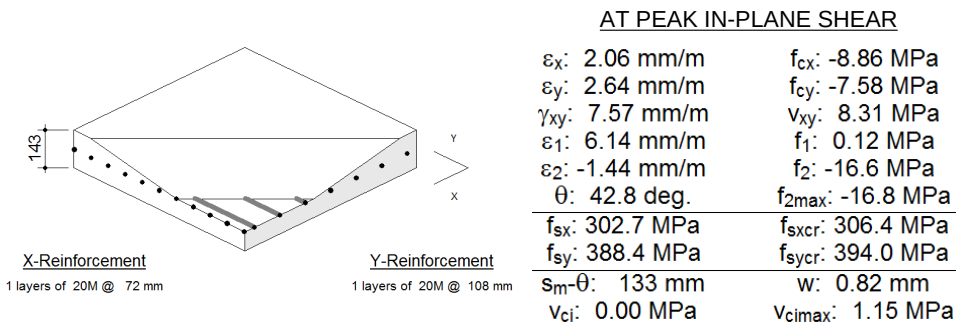


Figure 5.16: *Membrane Representation of ES1 and Results at Peak Shear Stress*

5.3.4 Strain Gauges

Figure 5.17 shows the experimental strain in the X & Y direction in-plane reinforcement as a function of the applied torsion, where the strain is an average of all gauges in both the North and South face cages. The South cage gauges typically experienced higher strains than their counterparts on the North, which is expected as the specimen was cast with the South face upwards, resulting in weaker concrete due to bleed water. The Y-direction strains are expected to be be higher than the X-direction since this direction was more weakly reinforced (1.95% vs. 2.95%).

There was one fundamental conclusion drawn from these results - yielding of the reinforcement was not a factor in the failure of the specimens. Based on the material tests presented in Chapter 3, the yield strain of the 20M reinforcement bars was 3.45×10^{-3}, which is significantly higher than the average values measured in the bars at the peak torsion. On an individual basis, the highest reinforcement strain recorded at the peak torsion is approximately 2.40×10^{-3}, which is still significantly below the yielding strain.

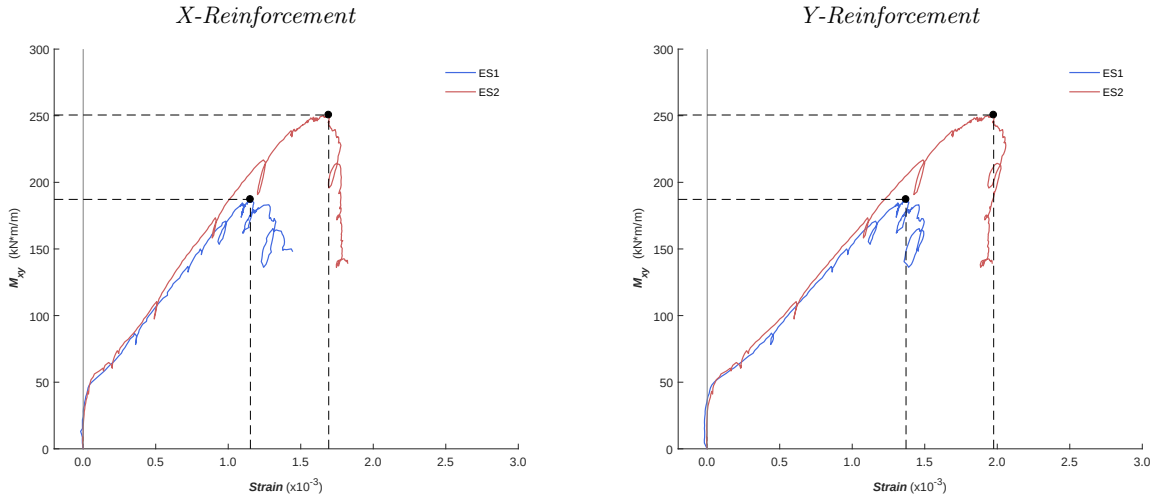


Figure 5.17: *In-Plane Reinforcement Strain Comparison*

The results from the membrane analysis also support this conclusion, as Figure 5.18 shows that the reinforcement stresses in the X & Y direction in-plane reinforcement are only 76% (2.62×10^{-3}) and 59% (2.04×10^{-3}) of their respective yield points. These values are much higher than what was observed in the experiments, but can be taken as an upper-bound estimate since they are based on a uniformly applied shear stress.

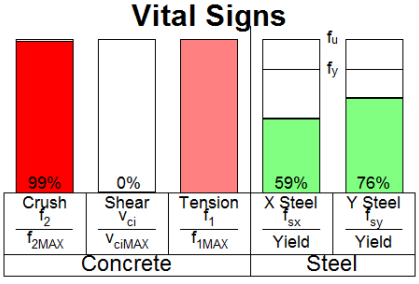


Figure 5.18: *Membrane Vital Signs for ES1 at Peak Shear Stress*

5.4 Out-of-Plane Experimental Data Comparison

The following section will present a closer look at the out-of-plane experimental data, consisting of the LPs and EGs in both the XZ and YZ planes, and the T-head reinforcement strain gauges. For the sake of clarity, only the peak torsion points for each specimen are explicitly indicated on the following plots. The full post-peak data is not shown since it is highly erratic, and beyond showing that failure has occurred and that the specimen cover has begun to spall is no longer useful in representing the behaviour of the specimens.

5.4.1 Out-of-Plane Shear Strain

Figure 5.19 presents the out-of-plane shear strain data as a function of the applied torsion for both specimens, where absolute values are taken of the shear strains and averaged across the type of instrumentation. The behaviour between the XZ and YZ planes was found to be similar, therefore there is no distinction between these planes in this comparison. Note that the two EGs in the YZ plane in ES1 were damaged during the casting of the specimen, which meant that no shear strain data could be calculated for these strain rosettes. Since LP-Y2 was located at the center of the specimen (in the saddle point), while all the other LPs were offset around the edges of the test region, it has been omitted from the average values for consistency.

The data from the EGs and LPs is shown separately since including them in the same average would be forcing a false equivalency. While they both measure the deformations in the XZ and YZ planes, they do so at different scales: the EGs measure the strains at a point in the core of the specimen, while the LPs measure the strains across the whole width of the specimen. For example, as the cover concrete begins to spall the LPs will record a deformation that will not be captured by the EGs located in the core of the specimen. This difference is clearly manifested in the data when comparing the the pre-peak and post-peak regions. The ratio of the LP/EG strain at the point where flattening of the curves begins (indicating that failure is imminent) occurs at 2.19 and 1.62 for ES1 and ES2 respectively. Looking one load stage into the post-peak region these ratios have increased to 3.07 and 2.18 for ES1 and ES2 respectively.

These data show that there are significant deformations in the out-of-plane direction in both specimens, which was a hypothesis this experimental program was designed to investigate. The flattening of the shear strain curves, indicating the cracking and relative separation of the North and South face of the shells, clearly precedes the peak loads in both experiments. As the out-of-plane shear strain in the core increases (see EGs), ES1 as a whole weakens and the peak load is reached as the cover begins to spall shortly after. Meanwhile, ES2 exhibits similar behaviour up to the point where ES1 fails, but has a stiffer response beyond this. The specimen is clearly softening beyond this point (see EGs), but does so in a much more gradual manner resulting in a higher peak torsion. An explanation for this is that the out-of-plane T-head reinforcement provides additional resistance to the core of the specimen, giving the specimen as a whole more capacity in resisting the out-of-plane deformations and delaying the core failure and subsequent cover spalling.

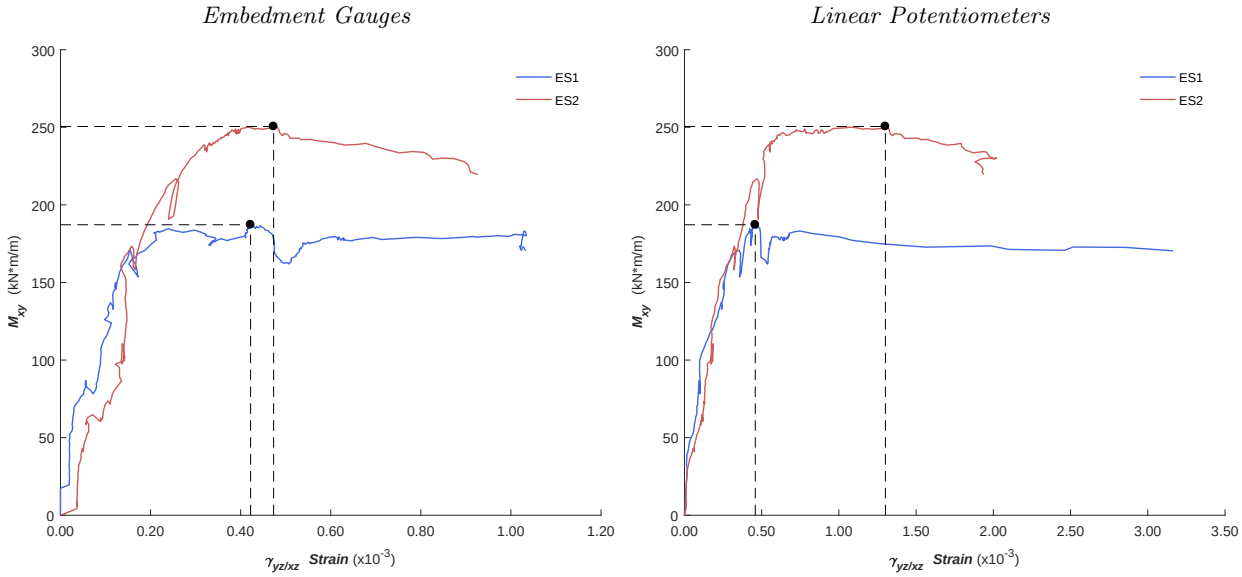


Figure 5.19: *Out-of-Plane Shear Strain Comparison*

5.4.2 Through the Thickness Strain (Z-dir)

The relative deformation of the North and South face, or the expansion of the specimen, is represented by the strain in the Z-direction shown in Figure 5.20. These averaged values are based on all the out-of-plane instrumentation, even the EGs in the YZ plane for ES1 were useful as the Z-direction gauge was functional. As the cover begins to spall the strains increase rapidly, which continues into the post-peak region as seen by the data one load stage into this region (plotted in Figure 5.20). The relative difference in the magnitude of the EGs and LPs also indicates that bulging of the surface is where the subsequent deformations were concentrated.

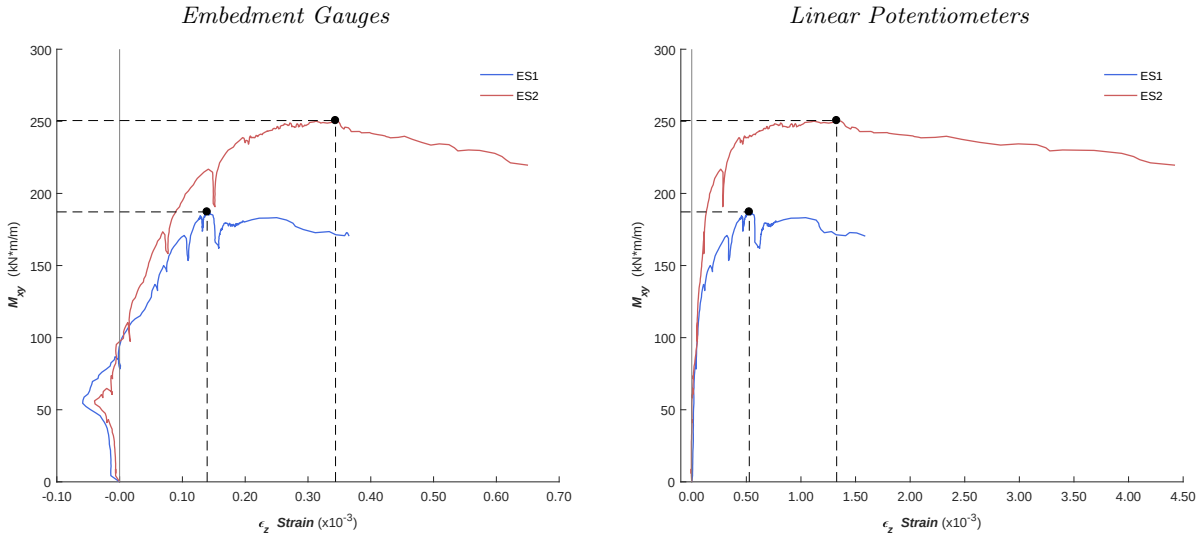


Figure 5.20: *Out-of-Plane Concrete Expansion Comparison*

A critical piece of information gathered from the testing of ES2 were the strains measured in the out-of-plane T-head reinforcement. While only 4 out of the 8 strain gauges were functional during the experiment, they were enough to show that these reinforcement bars played an active part in improving the capacity of the specimen. The strains at the peak are similar to the those measured in the concrete by the EGs, indicating that the strains in the core of the specimen were consistently measured. Unlike the in-plane reinforcement in the X & Y directions, the reinforcement in the Z-direction continues to develop strain in the post-peak region of the test. This suggests that the post-peak deformations in the specimen are concentrated in the relative separation of the North and South faces of the specimen.

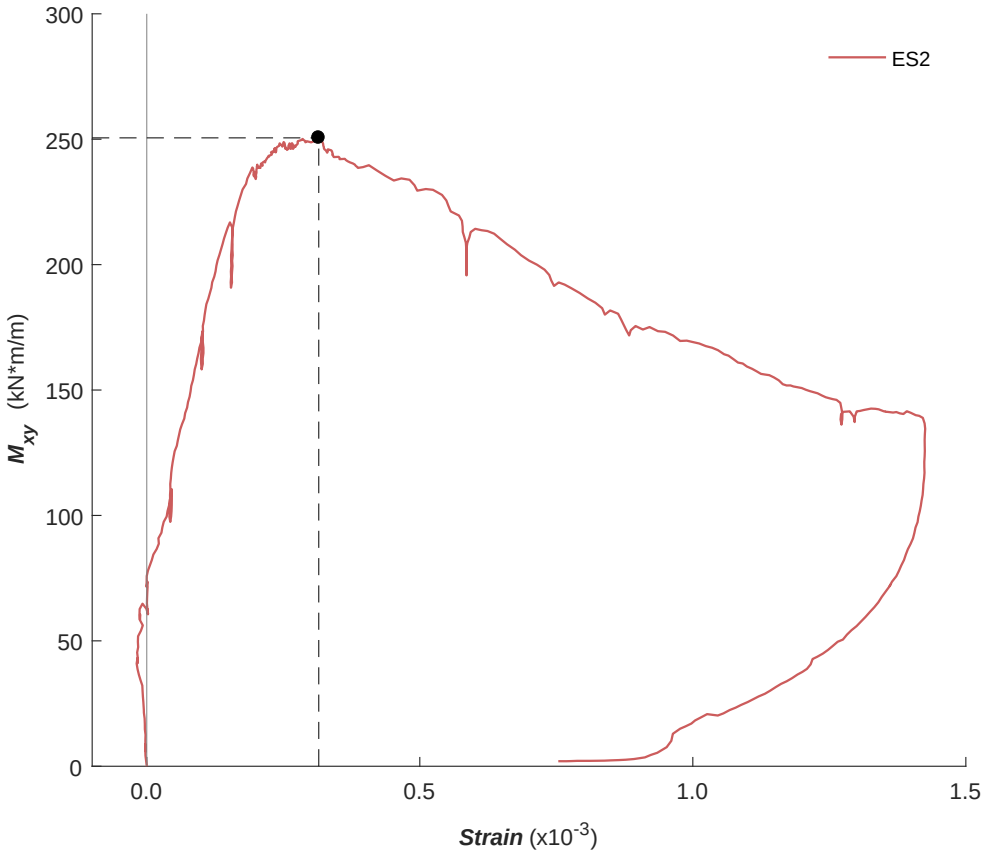


Figure 5.21: *Out-of-Plane T-Head Reinforcement Strain*

Chapter 6

A Finite Element for the Analysis of Reinforced Concrete Shells: Derivation and Verification

The following chapter will present the numerical derivation and verification of a finite element for the non-linear structural analysis of reinforced concrete shells subject to all eight sectional resultants. This element, referred to as the three-dimensional Hybrid Panel-Truss (3d-HyPT) element, builds heavily upon the two-dimensional derivation presented in Chapter 2. Therefore, the current chapter is not intended to be a standalone document - wherever possible references to the work presented in previous chapters will be made to avoid repetition.

This chapter begins by discussing how the information from the two pure torsion tests have influenced the 3d-HyPT derivation; the main conclusion being that out-of-plane deformations must be explicitly dealt with in the element. Next, a schematic description of the element is given, followed by the mathematical derivation of the various components of the stiffness matrix. Lastly, the finite element computer program that was written to implement the element is explained, and the numerical results produced by this program are evaluated against the experimental results.

6.1 Preliminary Modelling Considerations

At the outset of this thesis there was ambiguity regarding the out-of-plane deformations that would result from applying pure torsion. Therefore, the results from the experimental program were necessary to answer this question before commencing the derivation of the 3d-HyPT element.

With respect to the experiments, one preliminary hypothesis was that since no out-of-plane forces were directly applied to create torsion there would not be any out-of-plane deformations, and hence the T-head reinforcement would have no impact on the strength of the specimen. The other possibility was that since the North and South faces were being pulled in opposite directions relative to each other there would be resultant out-of-plane strains, and hence the addition of steel through the thickness of the specimen would result in better performance.

6.1.1 Shell-2000 Prediction

The program Shell-2000 [40], developed by Professor Bentz at the University of Toronto, was used to test the first hypothesis. In this program, a shell is constructed by stacking a series of in-plane membranes through the thickness, where the overall stress resultants are taken as an aggregate of these membranes. Therefore, when representing torsion as a linearly varying in-plane strain through the thickness, this formulation results in all the out-of-plane stresses being zero (plane stress). Figure 6.1 shows a schematic of the two models made in the program, the only difference between them is the addition of transverse T-head reinforcement and higher concrete strength in ES2.

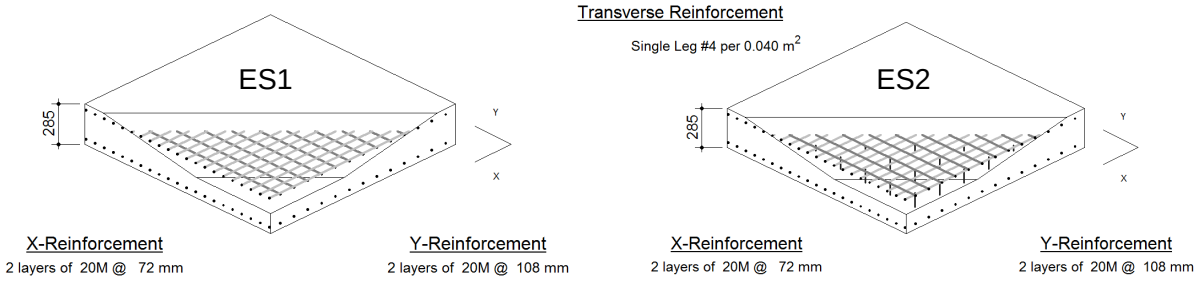


Figure 6.1: *Shell-2000 Models of Experimental Specimens*

As expected, in both models the in-plane shear strain (γ_{xy}) follows a linear distribution through the thickness, but the out-of-plane shear stresses (σ_{xz} & σ_{yz}) are zero. This meant that the T-head reinforcement in ES2 was not engaged. Therefore, the program predicted similar torque-twist behaviour for both specimens where the difference is thought to result from the higher concrete strength in ES2. The in-plane shear strain distribution through the thickness at peak torsion, along with the torque-twist behaviour for specimen ES1 are shown in Figure 6.2.

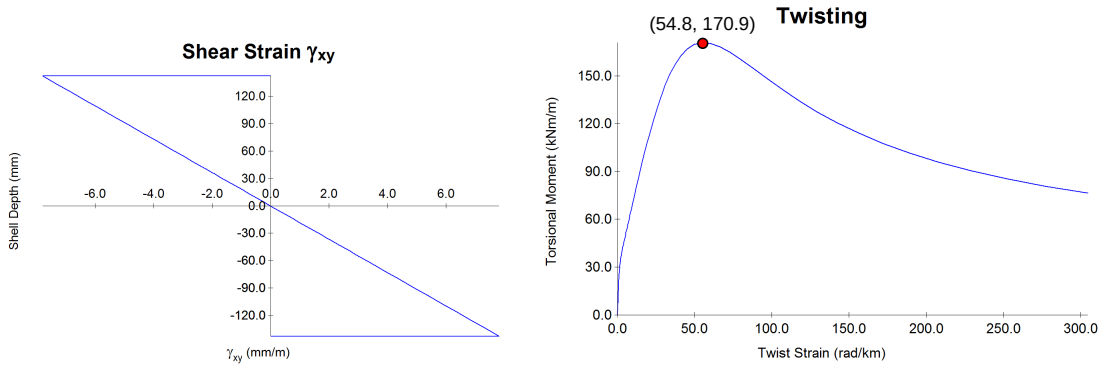


Figure 6.2: *Shell-2000 In-Plane Shear Strain and Torque-Twist Behaviour*

6.1.2 Lessons Learned

From the previous chapter's discussion, it is evident that the out-of-plane shear strain is not negligible and that the addition of T-head reinforcement played a role in improving the strength and ductility of ES2. Figure 6.3 shows the experimental torque-twist behaviour plotted against the Shell-2000 predictions, where the predicted peak is at 170.9 $\frac{kN \cdot m}{m}$ and 54.8 $\frac{mrad}{m}$ for ES1, 193 $\frac{kN \cdot m}{m}$ and 60.2 $\frac{mrad}{m}$ for ES2. When compared to the experimental results, the Exp./Pred. ratios for the peak are 1.10 and 1.07 for the torsion and twist in ES1, while the peak ratios are 1.30 and 1.49 for ES2. The conclusion is that the behaviour of specimens subjected to pure torsion without any out-of-plane strengthening is well-predicted by Shell-2000, which is not the case when out-of-plane reinforcement is added.

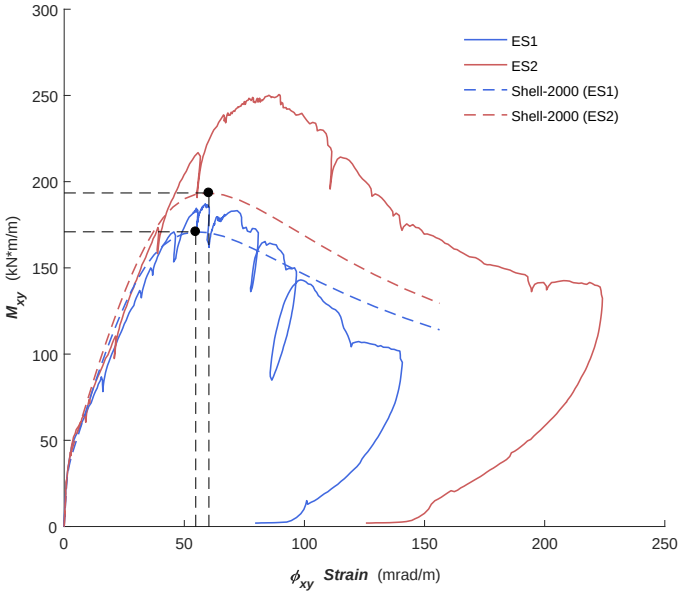


Figure 6.3: *Shell-2000 Torque-Twist Compared to Experimental Results*

Based on this comparison, the takeaway for the 3d-HyPT element is that it must explicitly account for out-of-plane deformations. Making the assumption that they are negligible, as was done in Shell-2000, has the potential to under-estimate the capacity of shells with transverse reinforcement in certain loading scenarios.

6.2 Description of 3d-HyPT Element

The three-dimensional Hybrid Panel-Truss (3d-HyPT) element has a total of eight nodes and 24 Degrees of Freedom (DOFs). Unlike most standard shell finite elements there are no explicit rotational DOFs, the formulation is therefore greatly simplified by only having three orthogonal translational DOFs (oriented in the cartesian plane) per node as shown in Figure 6.4. For consistency with the two-dimensional element derivation and the experimental data, the notation for the 3d-HyPT element has been kept as follows: the X-direction represents the main longitudinal direction, the Y-direction represents the secondary longitudinal direction, and the Z-direction is through the thickness of the member. Recall that in the two-dimensional case the Y-direction was simply a constant based on the cross-sectional width of the member, in three dimensions this direction is a variable based on the extent of the shell plane.

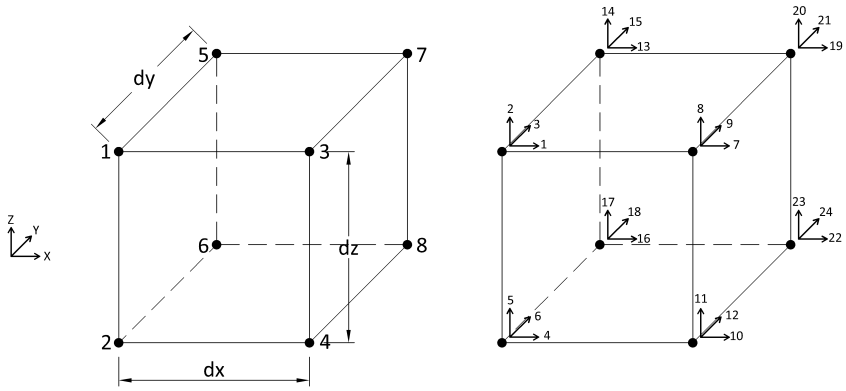


Figure 6.4: *3d-HyPT Element Numbering Convention: Nodes (Left) & DOFs (Right)*

Just like the two-dimensional version, the efficiency of this element comes from the combination of the flexure/axial truss and shear panel subcomponents that together are able to represent the internal action in reinforced concrete. Figure 6.5 is a schematic representation of the element showing the relative placement of these subcomponents.

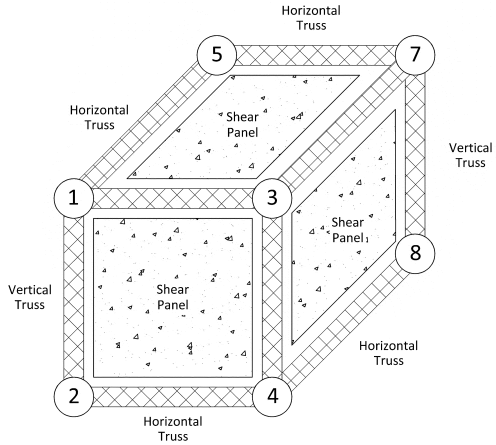


Figure 6.5: *Vizualization of 3d-HyPT Element Subcomponents*

6.2.1 Two-Dimensional Vizualization

The 3d-HyPT element can be thought of as a box where each of the six sides is represented by a separate 2d-HyPT element. Using this formulation has the benefit of improving the overall computation time since a complex 3d-element can be expressed as the aggregate of much simpler elements. The derivation is also a direct extension of the Panel and Truss concepts explained in Chapter 2, which have been adapted to account for three-dimensional effects as will be discussed in Section 6.3. Each face represents half the thickness of the element in the plane in which it lies (XZ, YZ or XY). So while a 2d-HyPT element can be thought of as just one face in the XZ-plane, the 3d-HyPT would split the element into a front and back face (XZ1 & XZ2) half the thickness of the original element, doing the same for the YZ and XY-planes. Figure 6.6 shows the six two-dimensional faces and their respective DOFs.

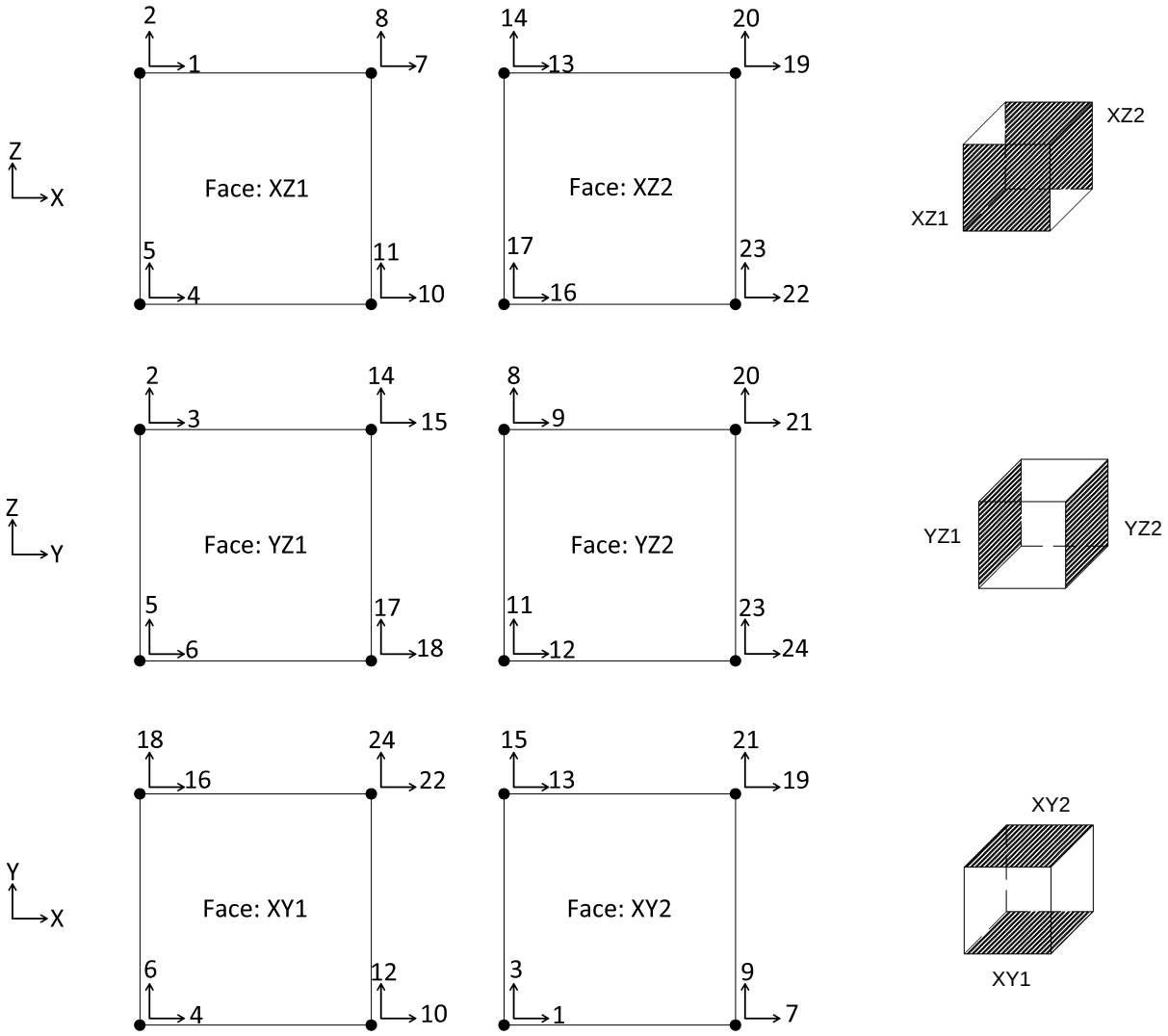


Figure 6.6: *Six Faces Representing the 3d-HyPT Element*

6.2.2 Full Member Representation

The 3d-HyPT element is similar to its two-dimensional counterpart in that the full height of a cross-section is represented by only one element. While the element has been derived with the intention of analyzing shells, its generalized form is also applicable to the analysis of beams. Figure 6.7 shows the same beam that was used as a schematic example of the 2d-HyPT application (Chapter 2, Figure 2.2) modelled with nine 3d-HyPT elements instead.

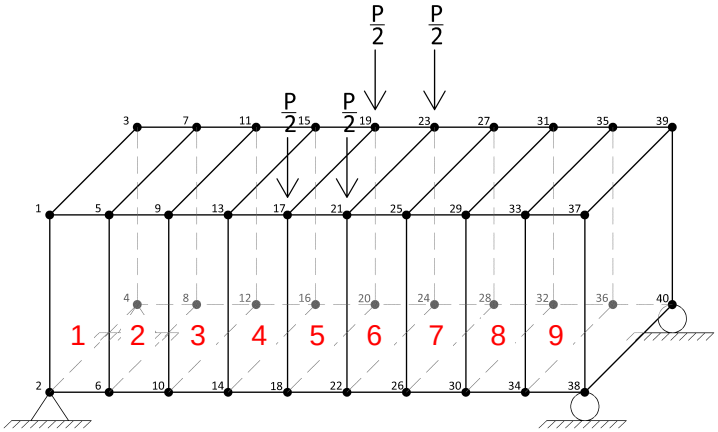


Figure 6.7: *Simply Supported Beam Modelled with 3d-HyPT Elements Placed in Series*

The structural analysis problem depicted in Figure 6.7 is effectively a two-dimensional problem since the loading is applied symmetrically to a rectangular beam. Therefore, modelling it with 3d-HyPT elements is unnecessarily complex, the analysis would take longer due to the large number of nodes but the final result would be the same as if one had used 2d-HyPT elements. Yet the three-dimensional application allows for the analysis of much more complex loading situations that cannot be captured in a 2d model. For example, Figure 6.8 shows the same beam subjected to a series of unbalanced loads acting in several different planes resulting in complex biaxial and twisting behaviour.

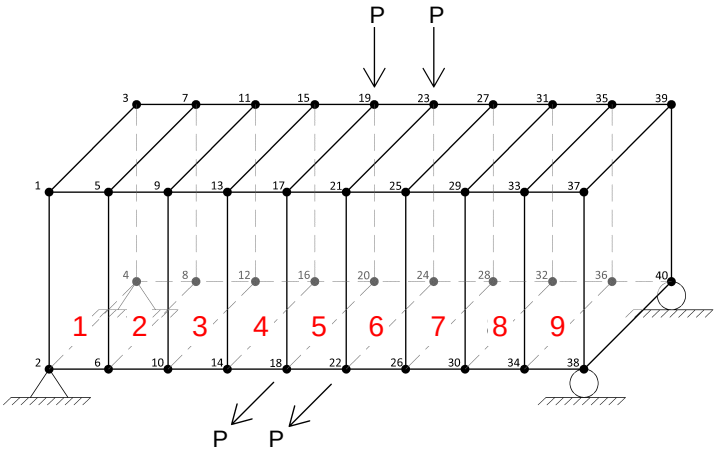


Figure 6.8: *Simply Supported Beam with Complex Loading*

Figure 6.9 shows how the 3d-HyPT element can be used to model a simply-supported flat slab with an off-center concentrated load at one end. The slab is represented with a 6x5 grid of elements where the supports and loads are specified at nodal locations.

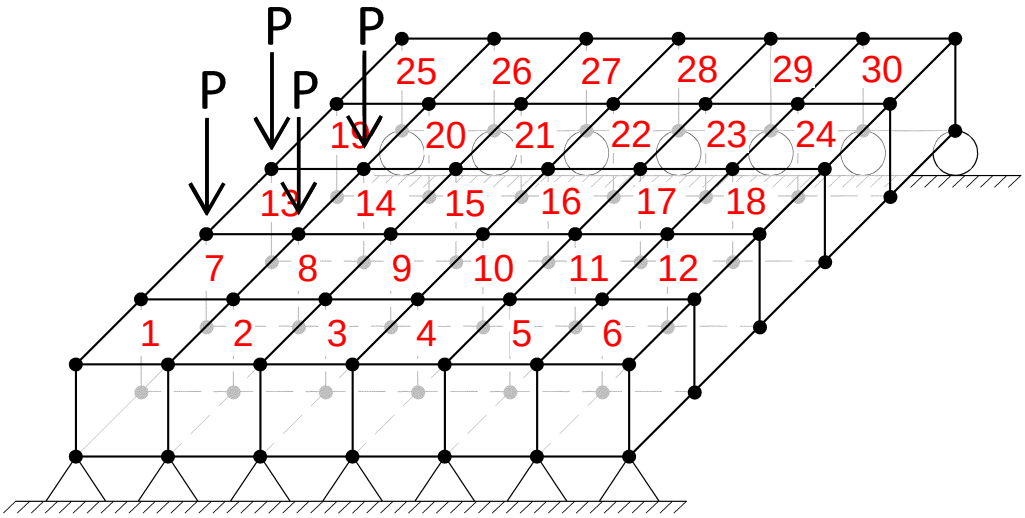


Figure 6.9: *Simply Supported Slab Modelled with 3d-HyPT Elements Placed in a Grid*

In general, the element can be used to model a wide range of three-dimensional structures with complex boundary conditions. For example, Figure 6.10 shows a schematic of a cantilevered member with off-center loading, a fixed condition is achieved by using pins at the top and bottom of the element.

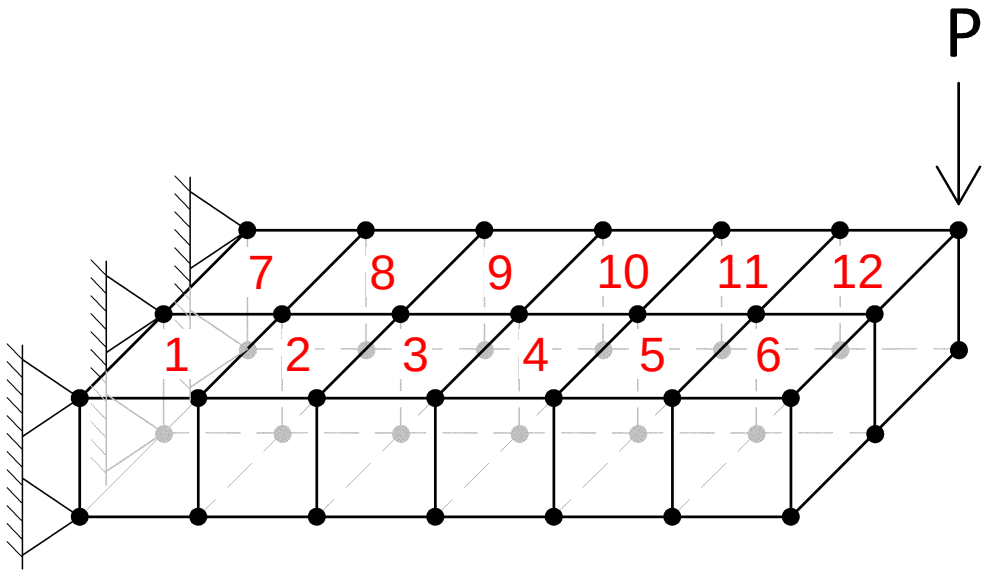


Figure 6.10: *Cantilevered Slab Modelled with 3d-HyPT Elements*

6.3 Derivation of Stiffness Matrix

The 3d-HyPT element is based on similar principles used to derive the two-dimensional element - the deformation patterns and rationale behind the different subcomponents is the same. The truss bars, which can only carry axial forces, link two adjacent nodes together, while panels provide shear stiffness and link the four nodes of a face together. But while the overall element appears to be taking a 2d-HyPT element and repeating it for each face of the cube, the derivation of the stiffness matrix is more complex as parallel faces must be linked to account for 3d effects. In the following section, only the additional modifications that are necessary will be explicitly discussed. For the basic justification and explanation of a truss or a panel stiffness matrix refer to the derivations presented in Chapter 2.

6.3.1 Horizontal Truss Stiffness Terms

In two dimensions there was only one moment resultant (about the y-axis), so just the relative displacement of the top and bottom horizontal trusses were needed to represent this deformation. It gets more complex in three dimensions, and with the 3d-HyPT element an added challenge was accounting for the relative displacement of the parallel faces. It is not certain that the front and back faces will deform in the same manner and the effects of any asymmetry must be explicitly captured in the stiffness matrix. Figure 6.11 illustrates such a case in the XZ-plane, where due to some asymmetric loading scenario the front face is experiencing positive flexure while the back face is experiencing negative flexure and tension.

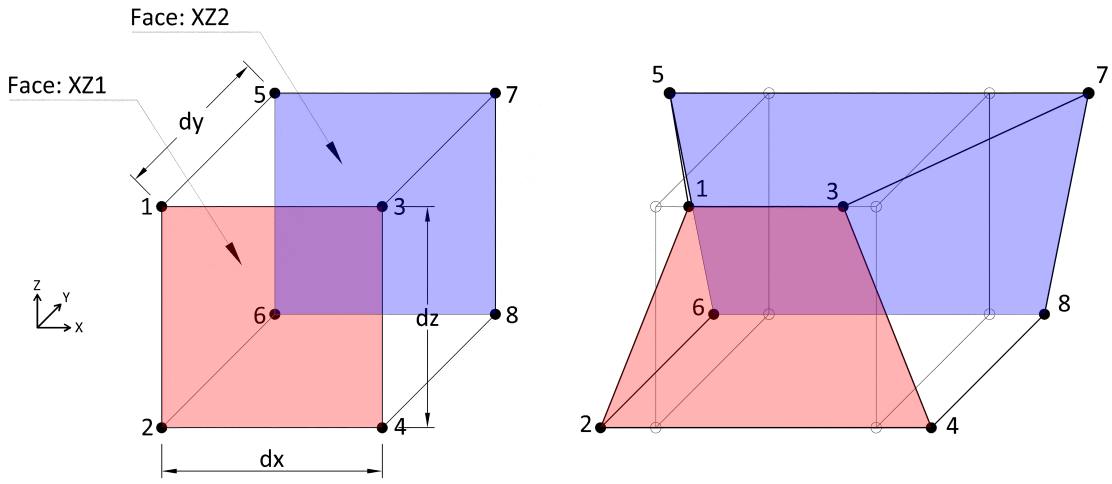


Figure 6.11: *Relative Deformations of Trusses in XZ-Plane Faces*

A simple way to formulate the stiffness matrix for such a case would be to completely decouple the action of the two parallel faces, allowing each to deform without influencing its neighbour. While this would allow a direct application of the 2d-HyPT truss terms already derived, it is too great a simplification of the internal connectivity in reinforced concrete members.

A more realistic approximation is shown in Figure 6.12, where the strains across whole element are based on a set of linear interpolations between the parallel faces. For clarity, only the "right" side of the element (nodes 3,4,7,8) is shown, note that the "left" face of the element (nodes 1,2,5,6) is experiencing the same strain profile. This differs from the two-dimensional case where the cross-section was only divided across the height into equal slices - in three dimensions the cross-section is divided into a grid, where each sub-element (or fiber) has its own strain value and corresponding force based on the material secant stiffness (Steps #1 & #2 in Section 2.2.4). The number of divisions across the height and width of the cross-section is optional, a finer mesh would result in a more accurate strain profile but would also increase the computation time.

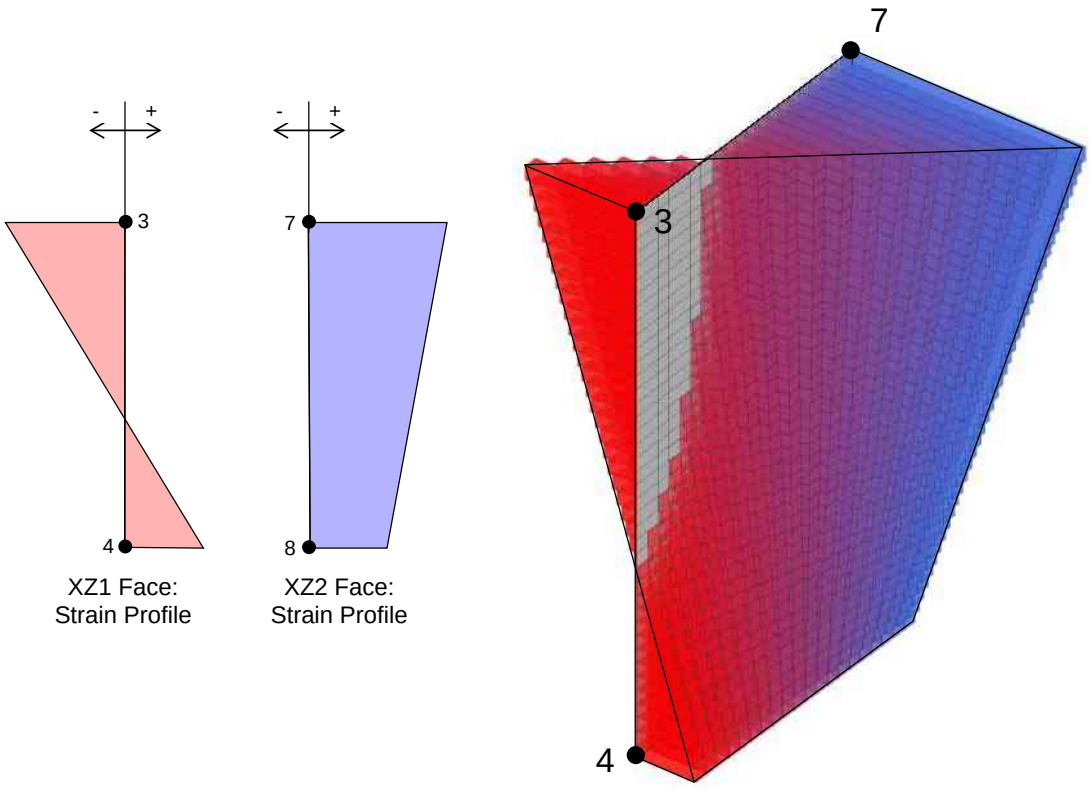


Figure 6.12: *Interpolated Strains Between Parallel Faces*

Just like in the 2d-HyPT derivation, a displacement applied to one of the nodes would have an effect on all the adjacent nodes, hence the need for off-diagonal terms in the stiffness matrix. While there was only one unique off-diagonal term in two dimensions ($K_{TB} = K_{BT}$), in three dimensions there are three adjacent nodes and therefore three unique off-diagonal terms that must be calculated. To derive the diagonal and off-diagonal stiffness terms associated with the current strain state the procedures outlined in Steps #3 through #6 in Section 2.2.4 are to be followed. The important thing to remember is that summations must be made over the height and width of the section, and transforming a section force to an equivalent nodal force requires solving moment equilibrium across two axes.

To solve for all the truss bar stiffness terms the stiffness method must be formulated four separate times, applying a unit displacement at the DOF of interest and keeping all others at zero while calculating the forces that develop at the nodes. As before, the incremented strain is assumed to distribute through the cross-section in a linear manner in both directions - a strain increment at each of the four X-Direction horizontal DOFs results in the distributions shown in Figure 6.13.

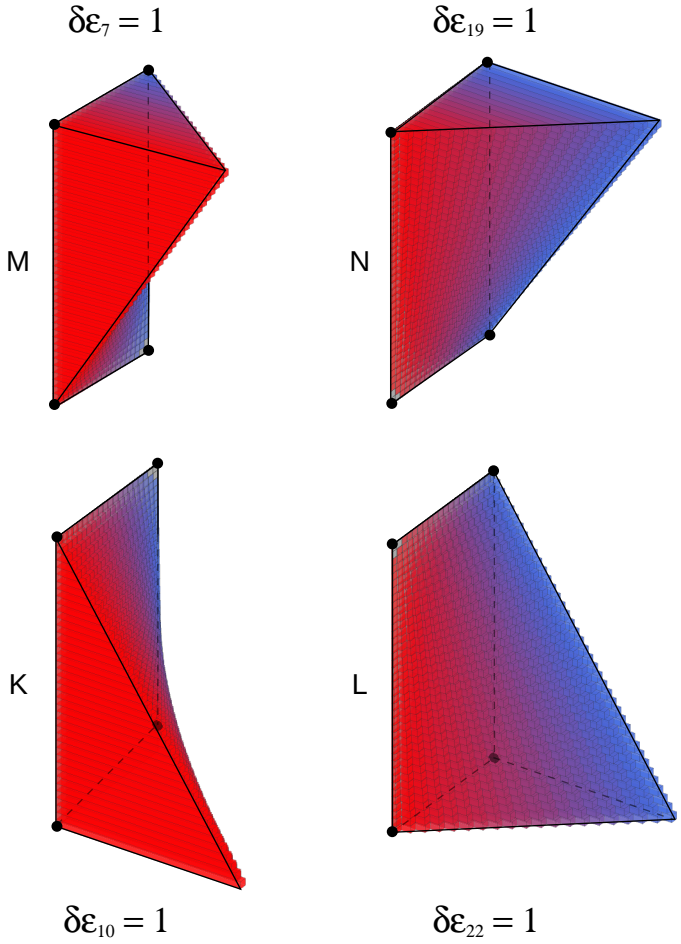


Figure 6.13: *Unit Increments at Right Side of Element*

The horizontal truss stiffness terms being solved for are shown in the reduced Equation 6.1, where each row corresponds to one of the increment cases. For example, the four terms in the 1^{st} row are solved by looking at the $\delta\varepsilon_7 = 1$ case. Note that the stiffness matrix is symmetric (i.e. $K_{7,10} = K_{10,7}$, $K_{7,19} = K_{19,7}$, etc.) and is mirrored on the left side of the element (i.e. $K_{7,7} = K_{1,1}$, $K_{7,10} = K_{1,4}$, etc.).

$$\begin{bmatrix} K_{7,7} & K_{7,10} & K_{7,19} & K_{7,22} \\ K_{10,7} & K_{10,10} & K_{10,19} & K_{10,22} \\ K_{19,7} & K_{19,10} & K_{19,19} & K_{19,22} \\ K_{22,7} & K_{22,10} & K_{22,19} & K_{22,22} \end{bmatrix} \begin{Bmatrix} \Delta_7 \\ \Delta_{10} \\ \Delta_{19} \\ \Delta_{22} \end{Bmatrix} = \begin{Bmatrix} F_7 \\ F_{10} \\ F_{19} \\ F_{22} \end{Bmatrix} \tag{6.1}$$

Looking at just the 1^{st} row in more detail, the stiffness terms are expressed in Equation 6.2.

$$\begin{aligned} K_{7,7} &= \frac{dF_7}{d\mathcal{E}_7 \cdot d_x} &&= M_{TL} \\ K_{7,10} &= \frac{dF_{10}}{d\mathcal{E}_7 \cdot d_x} &&= M_{BL} \\ K_{7,19} &= \frac{dF_{19}}{d\mathcal{E}_7 \cdot d_x} &&= M_{TR} \\ K_{7,22} &= \frac{dF_{22}}{d\mathcal{E}_7 \cdot d_x} &&= M_{BR} \end{aligned} \tag{6.2}$$

The incremental nodal forces are found by transforming the cross-sectional forces to their respective nodes. This is best illustrated through a diagram, Figure 6.14 shows how the four different nodal forces are found through moment equilibrium. For example, the two top forces (δF_7 and δF_{19}) are found by first transforming the cross-section forces to the top by equating them to the resultant moment about the bottom, and then equating them to either the left or right moment resultant. For more information regarding these calculations see the two dimensional approach outlined in Step # 5 in Section 2.2.4.

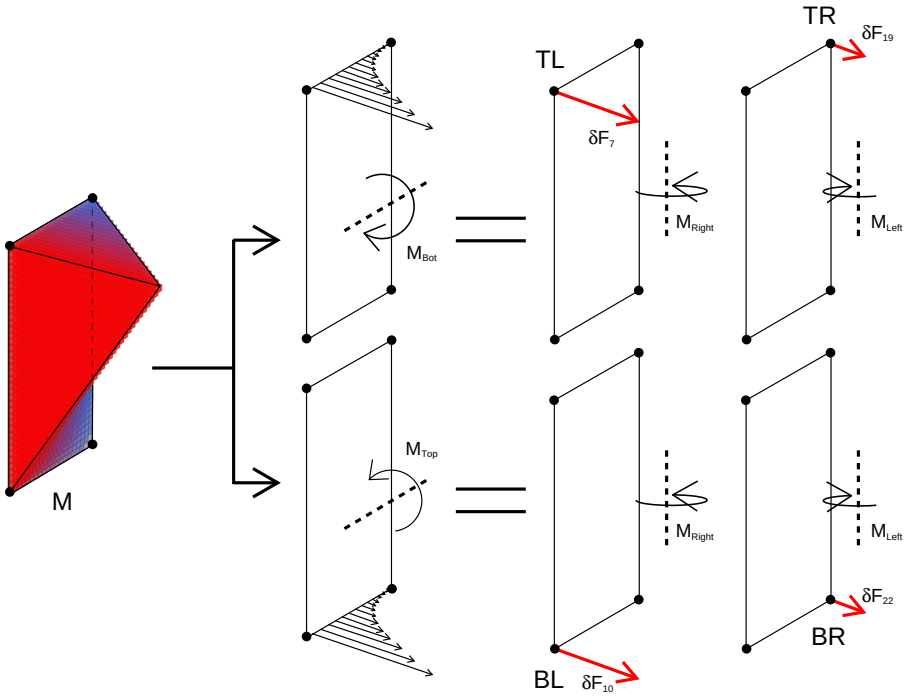


Figure 6.14: *Equivalent Nodal Forces Based on Strain Increment at DOF #7*

Repeat the process outlined in Figure 6.14 for the remaining incremented strain profiles for the XZ-plane. Equation 6.3 shows the complete horizontal truss stiffness matrix, where the capital letter refers to the type of increment, and the subscript refers to where the forces are resolved to when calculating the term. Equivalent off-diagonal terms are highlighted with the same colour, while the different diagonal terms are left clear for clarity. This whole process is then repeated for the YZ-plane.

$$
\begin{bmatrix}
M_{TL} & 0 & 0 & J_{TL} & 0 & 0 & -M_{TL} & 0 & 0 & -J_{TL} & 0 & 0 & N_{TL} & 0 & 0 & K_{TL} & 0 & 0 & -N_{TL} & 0 & 0 & -K_{TL} & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
M_{BL} & 0 & 0 & J_{BL} & 0 & 0 & -M_{BL} & 0 & 0 & -J_{BL} & 0 & 0 & N_{BL} & 0 & 0 & K_{BL} & 0 & 0 & -N_{BL} & 0 & 0 & -K_{BL} & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
-M_{TL} & 0 & 0 & -M_{BL} & 0 & 0 & M_{TL} & 0 & 0 & M_{BL} & 0 & 0 & -M_{TR} & 0 & 0 & -M_{BR} & 0 & 0 & M_{TR} & 0 & 0 & M_{BR} & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
-J_{TL} & 0 & 0 & -J_{BL} & 0 & 0 & J_{TL} & 0 & 0 & J_{BL} & 0 & 0 & -J_{TR} & 0 & 0 & -J_{BR} & 0 & 0 & J_{TR} & 0 & 0 & J_{BR} & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
M_{TR} & 0 & 0 & J_{TR} & 0 & 0 & -M_{TR} & 0 & 0 & -J_{TR} & 0 & 0 & N_{TR} & 0 & 0 & K_{TR} & 0 & 0 & -N_{TR} & 0 & 0 & -K_{TR} & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
M_{BR} & 0 & 0 & J_{BR} & 0 & 0 & -M_{BR} & 0 & 0 & -J_{BR} & 0 & 0 & N_{BR} & 0 & 0 & K_{BR} & 0 & 0 & -N_{BR} & 0 & 0 & -K_{BR} & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
-N_{TL} & 0 & 0 & -N_{BL} & 0 & 0 & N_{TL} & 0 & 0 & N_{BL} & 0 & 0 & -N_{TR} & 0 & 0 & -N_{BR} & 0 & 0 & N_{TR} & 0 & 0 & N_{BR} & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
-K_{TL} & 0 & 0 & -K_{BL} & 0 & 0 & K_{TL} & 0 & 0 & K_{BL} & 0 & 0 & -K_{TR} & 0 & 0 & -K_{BR} & 0 & 0 & K_{TR} & 0 & 0 & K_{BR} & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix}
\begin{Bmatrix}
u_1 \\ u_2 \\ u_3 \\ u_4 \\ u_5 \\ u_6 \\ u_7 \\ u_8 \\ u_9 \\ u_{10} \\ u_{11} \\ u_{12} \\ u_{13} \\ u_{14} \\ u_{15} \\ u_{16} \\ u_{17} \\ u_{18} \\ u_{19} \\ u_{20} \\ u_{21} \\ u_{22} \\ u_{23} \\ u_{24}
\end{Bmatrix}
=
\begin{Bmatrix}
F_1 \\ F_2 \\ F_3 \\ F_4 \\ F_5 \\ F_6 \\ F_7 \\ F_8 \\ F_9 \\ F_{10} \\ F_{11} \\ F_{12} \\ F_{13} \\ F_{14} \\ F_{15} \\ F_{16} \\ F_{17} \\ F_{18} \\ F_{19} \\ F_{20} \\ F_{21} \\ F_{22} \\ F_{23} \\ F_{24}
\end{Bmatrix}
\tag{6.3}
$$

6.3.2 Vertical Truss Stiffness Terms

The vertical trusses link the faces in the XY-plane, and provide stiffness through the thickness of the element in the Z-direction by connecting the following nodes: 1-2, 3-4, 5-6, and 7-8.

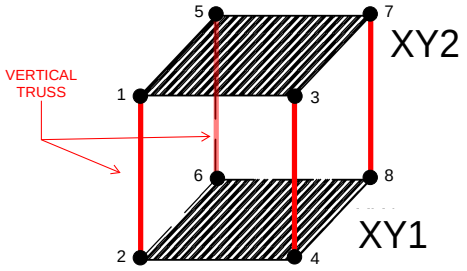


Figure 6.15: *Vertical Trusses in the 3d-HyPT Element*

When deriving the two-dimensional element clamping stresses were considered negligible, and therefore the stiffness of the vertical trusses was taken as a constant based on the uncracked stiffness and gross area of concrete. An added benefit of this decision was that the large stiffness in the vertical trusses helped improve the numerical stability of the finite element solution. Yet this simplification is unrealistic in a three-dimensional case - the experiments proved that the out-of-plane cracking and expansion in the Z-direction were significant under torsional loading, which should be explicitly reflected in the derivation of the vertical truss stiffness terms. The relationship between the internal Z-direction strain (measured by the EGs) is plotted against the experimental twist strain in Figure 6.16. This curve could perhaps be generalized by relating the Z-direction strain to some material property, such as the poissons ratio, although based on the data from the two shell experiments there was no clear trend.

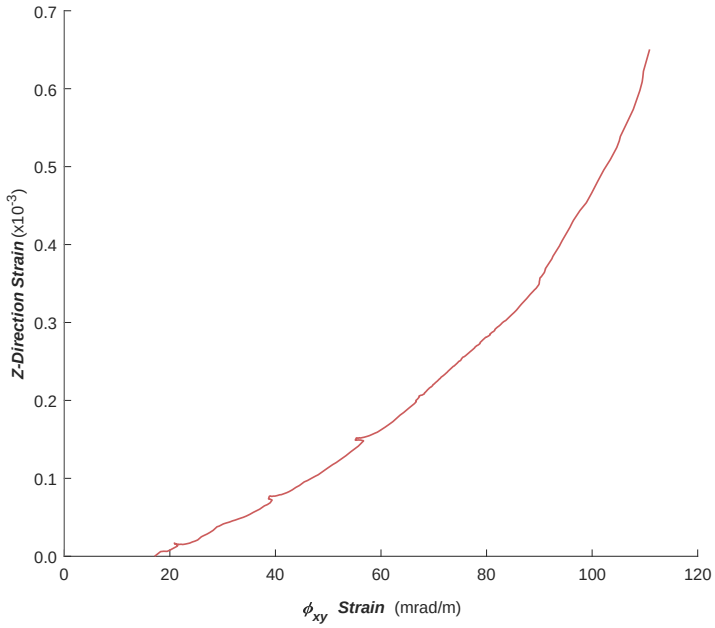


Figure 6.16: *Axial Strain in Vertical Direction Based on Twist Strain*

Based on the relative in-plane shear strain between the XY1 and XY2 faces (twist strain), the corresponding axial strain from Figure 6.16 is imposed on the vertical trusses. The stiffness is then calculated by the same procedure that was used for the the horizontal trusses - incrementing strains at the four nodes, and summing resultant forces. Without this modification to the stiffness of the vertical trusses, the 3d-HyPT element would over-predict the failure load since cover spalling and out-of-plane cracking would not be allowed to occur. Figure 6.17 shows the strain distribution through the element along with the physical representation of one vertical truss volume. The symmetrical distribution of strains, along with the fact that the cross-section is uniform, means that the vertical trusses are the same; only one set of calculations is necessary to calculate all the vertical truss stiffness terms.

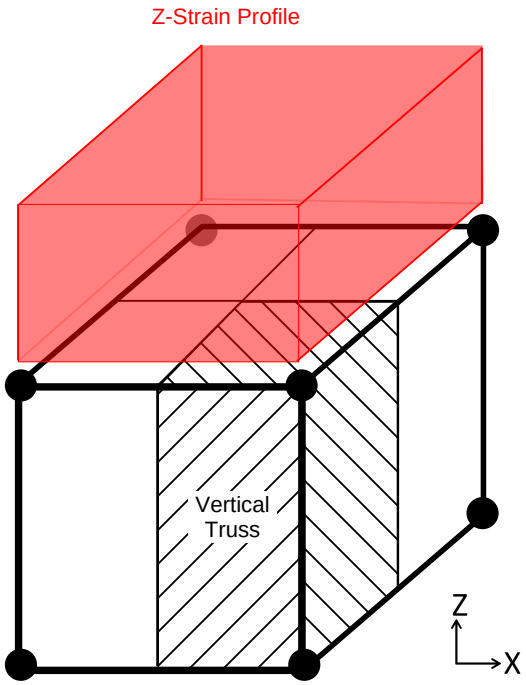


Figure 6.17: *Z-Direction Strain Applied to Vertical Trusses*

6.3.3 Shear Panel Stiffness Terms

The stiffness matrix for a shear panel representing one face of the 3d-HyPT element is based on the two dimensional geometric formulation derived in Section 2.3.4 - the shear modulus of the panel is determined from an MCFT analysis based on the nodal displacements in the plane of interest. The shear modulus and the cross-sectional geometry are then used to express the individual stiffness terms (8x8 matrix). When calculating these terms note that in the 3d-HyPT element there are two parallel panels per plane (front and back), therefore the total area represented by each is halved. Looking at the XZ-plane, the constant terms in the stiffness matrix for the front and back panel (XZ1 & XZ2) are shown in Equation 6.4.

$$C_1 = \frac{\bar{G}_1 \cdot d_y d_v}{8 d_z}$$
$$C_2 = \frac{\bar{G}_2 \cdot d_y d_v}{8 d_z} \tag{6.4}$$

Yet the deformations and forces developed in each panel must be linked through the stiffness matrix, otherwise the implication is that when one face of the element deforms in shear the adjacent parallel face experiences no force. From the relationship between load and stiffness (i.e. load path) comes the idea that the 'relative stiffness' and 'degree of connectivity' of two parallel faces are inversely related properties. Connectivity defines to what degree an imposed action on one face is experienced by the other face, and is represented by the off-diagonal (cross-stiffness) terms in the stiffness matrix. It is proposed that these terms be calculated by taking the average stiffness of the two faces as a starting point, and multiplying this value by two modification factor based on the relative difference between the panel shear stiffnesses and deformations (Equation 6.5).

$$C_x = F_1 \cdot F_2 \cdot \frac{C_1 + C_2}{2} \tag{6.5}$$

The first modification factor is calculated from Equation 6.6, but cannot be negative since this would imply negative stiffness (a negative value is rounded to 0). If the two panel stiffnesses are the same then perfect connectivity is assumed, which means that an applied displacement on one face would result in an even distribution of shear forces between both the faces. When a difference between the two stiffnesses exists the connectivity is no longer perfect, with the intuitive result that the stiffer face attracts proportionally more shear force when a displacement is applied to it. As the ratio between the stiffnesses approaches zero the connectivity does as well, which from a physical perspective means that the parallel faces begin to act more independently as one of them suffers more damage.

$$F_1 = 1 - 2 \cdot \frac{|\bar{G}_1 - \bar{G}_2|}{\bar{G}_1 + \bar{G}_2} \qquad \text{where: } 0 \leq F_1 \tag{6.6}$$

The cross-stiffness terms exist only if the the two parallel faces are experiencing different deformations, measured as the difference in the calculated shear strain between them. If the shear strains are the same, the calculation of the shear forces on the element should collapse back to a two-dimensional case where no cross-stiffness terms are necessary since the whole element can be represented by just one panel. The second factor is calculated from Equation 6.7, depending on the direction of deformation the shear strains will be either positive or negative.

$$F_2 = 1 - \frac{\gamma_1 + \gamma_2}{2 \cdot |\gamma_{max}|} \qquad \text{where: } F_2 \leq 1 \tag{6.7}$$

The reasoning behind this second factor is justified by comparing the resulting forces from a two-dimensional case with those from a three-dimensional case where the parallel panels deform the same. Equation 6.8 shows the stiffness formulation for a two-dimensional panel, where the total force on the element is equal to the stiffness matrix times the shear deformations on the panel.

$$\left\{F_T\right\} = \left\{F_1\right\} = 2 \cdot \left[P_1\right] \left\{u_1\right\} \quad \text{where: } P_1 = \text{The stiffness of half the element} \tag{6.8}$$

Meanwhile, Equation 6.9 shows the stiffness formulation for a three dimensional element in the same plane. The stiffness matrix is made up of sub-matrices, which are 8x8 in size, and represent the front and back panels respectively.

$$\begin{bmatrix}\{F_1\}\\ \{F_2\}\end{bmatrix} = \begin{bmatrix}\left[P_1\right] & \left[P_x\right]\\ \left[P_x\right] & \left[P_2\right]\end{bmatrix} = \begin{bmatrix}\{u_1\}\\ \{u_2\}\end{bmatrix} \quad \text{where: } P_x = \text{The cross-stiffness terms} \tag{6.9}$$

Expanding Equation 6.9 and summing the forces in the element results in Equation 6.10.

$$\left\{F_T\right\} = \left\{F_1\right\} + \left\{F_2\right\} = \left(\left[P_1\right] \left\{u_1\right\} + \left[P_x\right] \left\{u_2\right\} \right) + \left(\left[P_x\right] \left\{u_1\right\} + \left[P_2\right] \left\{u_2\right\} \right) \tag{6.10}$$

Now assume that we have a case where the front and back panel have the same stifness ($P_1 = P_2$) and both faces experience the same nodal displacement ($u_1 = u_2$). The summation is simplified to Equation 6.11.

$$\left\{F_T\right\} = \left\{F_1\right\} = 2 \cdot \left(\left[P_1\right] \left\{u_1\right\} + \left[P_x\right] \left\{u_2\right\} \right) \tag{6.11}$$

The two and three-dimensional formulations should give the exact same result in this case (i.e. Equation 6.8 = Equation 6.11) but the cross-stiffness terms are leading to an unrealistic amplification of the forces in the element. The conclusion is that the closer the two panels are to deforming in unison, the closer the element is to resembling a two-dimensional problem and hence the value of the cross-stiffness terms must be reduced - the second modification factor looks at the magnitude of the average shear strain in proportion to the largest strain and adjusts the cross-stiffness terms accordingly.

Figures 6.18 and 6.19 show the calculated stiffness matrices for the XZ-plane panels under two different scenarios. The values of stiffness and displacement are arbitrarily set to illustrate a case where the two panels have different stiffnesses but are experiencing either equal and unequal shear strains. The blue and green terms represent the XZ1 and XZ2 panels respectively, where the lighter colours are the cross-stiffness terms. The dimensions of the element are as follows: $d_x = 200, d_y = 300, d_z = 600$. While the shear stiffnesses of the panels are set to: $\bar{G}_1 = 8000, \bar{G}_2 = 5000$. Note that to complete the 3d-HyPT element stiffness matrix this whole process must be repeated for the YZ-plane and XY-plane shear panels.

DOF	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	U	F
1	100,000	-300,000	0	-100,000	-300,000	0	-100,000	300,000	0	-100,000	300,000	0	0	0	0	0	0	0	0	0	0	0	0	0	1	100,000
2	-300,000	900,000	0	300,000	900,000	0	-300,000	-900,000	0	300,000	-900,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-300,000
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	-100,000	300,000	0	100,000	300,000	0	100,000	-300,000	0	100,000	-300,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-100,000
5	-300,000	900,000	0	300,000	900,000	0	-300,000	-900,000	0	300,000	-900,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-300,000
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	100,000	-300,000	0	-100,000	-300,000	0	-100,000	300,000	0	-100,000	300,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100,000
8	300,000	-900,000	0	-300,000	-900,000	0	300,000	900,000	0	-300,000	900,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	300,000
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	-100,000	300,000	0	100,000	300,000	0	100,000	-300,000	0	100,000	-300,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-100,000
11	300,000	-900,000	0	-300,000	-900,000	0	300,000	900,000	0	-300,000	900,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	300,000
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	62,500	-187,500	0	-62,500	-187,500	0	-62,500	187,500	0	-62,500	187,500	0	1	62,500
14	0	0	0	0	0	0	0	0	0	0	0	0	-187,500	562,500	0	187,500	562,500	0	-187,500	-562,500	0	187,500	-562,500	0	0	-187,500
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	-62,500	187,500	0	62,500	187,500	0	62,500	-187,500	0	62,500	-187,500	0	0	-62,500
17	0	0	0	0	0	0	0	0	0	0	0	0	-187,500	562,500	0	187,500	562,500	0	-187,500	-562,500	0	187,500	-562,500	0	0	-187,500
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	-62,500	187,500	0	62,500	187,500	0	62,500	-187,500	0	62,500	-187,500	0	0	-62,500
20	0	0	0	0	0	0	0	0	0	0	0	0	187,500	-562,500	0	-187,500	-562,500	0	187,500	562,500	0	-187,500	562,500	0	0	187,500
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	187,500	-562,500	0	-187,500	-562,500	0	187,500	562,500	0	-187,500	562,500	0	0	187,500
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 6.18: *XZ-Plane Panel Stiffness Matrix (Equal In-Plane Shear Strains)*

DOF	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	U	F
1	100,000	-300,000	0	-100,000	-300,000	0	-100,000	300,000	0	-100,000	300,000	0	21,875	-80,769	0	-21,875	-80,769	0	-21,875	80,769	0	-21,875	80,769	0	1	100,000
2	-300,000	900,000	0	300,000	900,000	0	-300,000	-900,000	0	300,000	-900,000	0	-80,769	242,308	0	80,769	242,308	0	-80,769	-242,308	0	80,769	-242,308	0	0	-300,000
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	-100,000	300,000	0	100,000	300,000	0	100,000	-300,000	0	100,000	-300,000	0	-21,875	80,769	0	21,875	80,769	0	21,875	-80,769	0	21,875	-80,769	0	0	-100,000
5	-300,000	900,000	0	300,000	900,000	0	-300,000	-900,000	0	300,000	-900,000	0	-80,769	242,308	0	80,769	242,308	0	-80,769	-242,308	0	80,769	-242,308	0	0	-300,000
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	100,000	-300,000	0	-100,000	-300,000	0	-100,000	300,000	0	-100,000	300,000	0	21,875	-80,769	0	-21,875	-80,769	0	-21,875	80,769	0	-21,875	80,769	0	0	100,000
8	300,000	-900,000	0	-300,000	-900,000	0	300,000	900,000	0	-300,000	900,000	0	80,769	-242,308	0	-80,769	-242,308	0	80,769	242,308	0	-80,769	242,308	0	0	300,000
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	-100,000	300,000	0	100,000	300,000	0	100,000	-300,000	0	100,000	-300,000	0	-21,875	80,769	0	21,875	80,769	0	21,875	-80,769	0	21,875	-80,769	0	0	-100,000
11	300,000	-900,000	0	-300,000	-900,000	0	300,000	900,000	0	-300,000	900,000	0	80,769	-242,308	0	-80,769	-242,308	0	80,769	242,308	0	-80,769	242,308	0	0	300,000
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	21,875	-80,769	0	-21,875	-80,769	0	-21,875	80,769	0	-21,875	80,769	0	62,500	-187,500	0	-62,500	-187,500	0	-62,500	187,500	0	-62,500	187,500	0	0	21,875
14	-80,769	242,308	0	80,769	242,308	0	-80,769	-242,308	0	80,769	-242,308	0	-187,500	562,500	0	187,500	562,500	0	-187,500	-562,500	0	187,500	-562,500	0	0	-80,769
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	-21,875	80,769	0	21,875	80,769	0	21,875	-80,769	0	21,875	-80,769	0	-62,500	187,500	0	62,500	187,500	0	62,500	-187,500	0	62,500	-187,500	0	0	-21,875
17	-80,769	242,308	0	80,769	242,308	0	-80,769	-242,308	0	80,769	-242,308	0	-187,500	562,500	0	187,500	562,500	0	-187,500	-562,500	0	187,500	-562,500	0	0	-80,769
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	21,875	-80,769	0	-21,875	-80,769	0	-21,875	80,769	0	-21,875	80,769	0	-62,500	187,500	0	62,500	187,500	0	62,500	-187,500	0	62,500	-187,500	0	0	21,875
20	80,769	-242,308	0	-80,769	-242,308	0	80,769	242,308	0	-80,769	242,308	0	187,500	-562,500	0	-187,500	-562,500	0	187,500	562,500	0	-187,500	562,500	0	0	80,769
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	-21,875	80,769	0	21,875	80,769	0	21,875	-80,769	0	21,875	-80,769	0	-26,923	80,769	0	26,923	80,769	0	26,923	-80,769	0	26,923	-80,769	0	0	-21,875
23	80,769	-242,308	0	-80,769	-242,308	0	80,769	242,308	0	-80,769	242,308	0	187,500	-562,500	0	-187,500	-562,500	0	187,500	562,500	0	-187,500	562,500	0	0	80,769
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 6.19: *XZ-Plane Panel Stiffness Matrix (Unequal In-Plane Shear Strains)*

6.4 Explanation of Analysis Program

Both the 2d and 3d-HyPT elements derived in the previous sections are implemented in a program written in MATLAB. The following section will outline the high-level organization and operation of this program, with a focus on the input/output and analysis structure. for the sake of brevity, a detailed presentation of the code is omitted from this thesis.

6.4.1 MATLAB Main File

The program is executed through a main MATLAB file that is included for reference in Appendix D. To improve the organization of the analysis program, functions and variables are organized into separate classes that each serve a specific purpose. The names of these classes and their descriptions are as follows:

- IO.m = Input and output class. Serves as the master class where all program default variables and user defined variables are specified. Creates the preliminary "Global Summary" and "Section Summary" text files, and creates and updates the "Load Stage Iteration" and "Load Stage Summary" output text files.

- R_Global.m = Global structure definition class. Reads and saves the data specified in the "Global Input" structure text file. Holds all the node, restraint, load, and element data. Produces the undeformed structure plot so that the definitions in the text file can be verified.

- R_Section.m = HyPT element cross-section class. Reads the "Section Input" text files that are specified in the "Global Input" text file and assigns the properties to the appropriate element - more than one type of section can be used in a problem. Holds all the section geometry and reinforcement bar layout information. Calculates the reinforcement ratios and regions of tension stiffening. Displays a two-dimensional and three-dimensional representation of a single element so that the section definitions in the text file can be verified.

- R_Material.m = HyPT element material class. Reads the material information specified in the "Section Input" text files. Calculates the tension and compression curves for concrete and steel, which are referenced when finding the secant stiffnesses during the analysis.

- Solver.m = Stiffness method solver class. Initializes and populates the loading and displacement vectors based on the load stage and previous iteration results. Initializes the global stiffness matrix, and sums the element level stiffness matrices calculated for each element at each iteration. Checks the global convergence criteria and increments the load stage number if convergence has been reached. Plots the displaced shape and crack locations for chosen load stages.

- Truss.m = Truss bars stiffness class. Calculates the horizontal and vertical truss stiffness terms for each element and the face being analyzed. Determines the additional cross-stiffness terms if the problem is a three-dimensional analysis.
- Panel.m = Shear panel stiffness class. Calculates the secant shear stiffness based on an MCFT formulation. Iterates on the MCFT panel formulation until convergence has been reached. Determines the cross-stiffness terms if the problem is a three-dimensional analysis.
- Crack.m = Element cracking stiffness class. Records the location, type and size of cracks in each element. Calculates the shear-flexure cracked interaction stiffness terms for elements that are cracked and outside the disturbed region.

6.4.2 Input Files and Structure Generation

The first part of the program deals with specifying the analysis task and reading in all the relevant information that is necessary to create the finite element model. This section corresponds to Step #1 & #2 in the main program code structure shown in Appendix D. The operational structure is represented by the flowchart in Figure 6.20, where the user initiates the process by specifying the name of the "Global Input" text file.

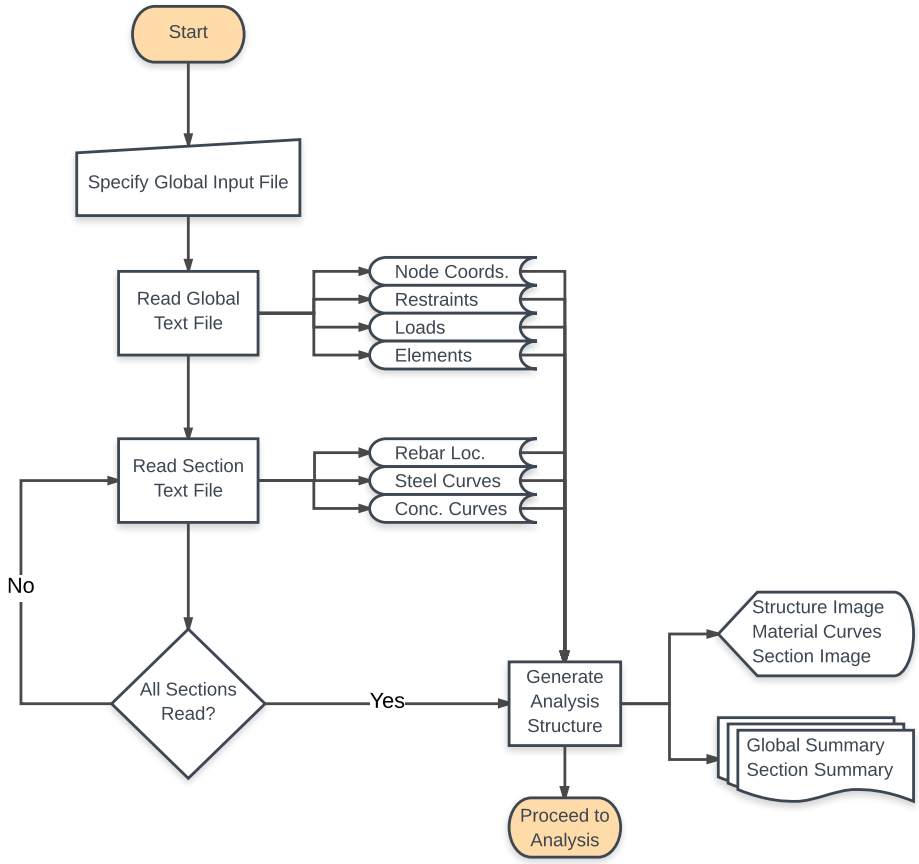


Figure 6.20: *Preliminary Program Operational Flowchart*

There is no preprocessor for the program, so all the problem specific information required for the computer analysis must be passed to the program through text files. A sample "Global Input" text file, for the creation of a fully fixed generic slab with a point load at the center, is shown in Figure 6.21. This text file also specifies the name(s) of the "Section Input" text files that are necessary to define the physical and material properties of the HyPT elements.

```
////////////////////////////////////////////////////////////////////////////////////////////////////
// Name:    Edvard Bruun
// Project: Generic Slab Demo
// Created: March 25th, 2016
// Updated: July 1st, 2017
//
//
////////////////////////////////////////////////////////////////////////////////////////////////////

// Global file must be in same directory as the program

// FORMAT: Type = '2D' or '3D' (If 2D then ignore Y-data)
//           Number of Name Entries Must Match # of Sections Precisely
//         Enter the exact text file name to read
// NOTES : No Empty Lines in this list
//         Section names must be one word
//         For Multiple Sections, Add Additional Name Rows
-INPUT FILE-
Type     = 3D
Sections = 2
Name     = section_shell.txt
Name     = section_shell2.txt
-INPUT FILE END-


// FORMAT: [X_Start (mm), Y_Start (mm), Z_Start (mm)] / [#_nodes, d_node_#, d_x, d_y, d_z] / [#_lines, d_node_#, d_x, d_y, d_z] /
// NOTES : White space is not important so long as information lies between ' / '
//         Start a line with '//' if you want it to not be read
//         If '2D' Problem then the Y-data will be ignored
-NODE LIST-
//
0 0    0 / 9 9 300 0 0 / 9 1 0 -300 0 /
0 0 -300 / 9 9 300 0 0 / 9 1 0 -300 0 /
//
-NODE LIST END-


// FORMAT: [node #] / [X_restrain (0 | 1 | 2), Y_restrain (0 | 1 | 2), Z_restrain (0 | 1 | 2)] / [ #_Restraints d_node_#]
// NOTES : 0 = Unrestrained
//         1 = Fully Restrained
//         2 = Conditionally Restrained
-RESTRAINT LIST-
//
1   / 1 1 1 / 9 1 /
82  / 1 1 1 / 9 1 /
73  / 1 1 1 / 9 1 /
154 / 1 1 1 / 9 1 /
//
10 / 1 1 1 / 7 9 /
73 / 1 1 1 / 7 9 /
//
18 / 1 1 1 / 7 9 /
99 / 1 1 1 / 7 9 /
//
-RESTRAINT LIST END-


// FORMAT: [node #] / [X_Load, Y_Load, Z_Load] / [#_Loads, d_node_#, d_Fx, d_Fy, d_Fz ] / [Constant Toggle] / #_steps d_Fx d_Fy d_Fz /
// NOTES : 1 = Constant - ON
//         0 = Constant - OFF
//         Loads on Repeating Nodes are Cumulative
-LOAD LIST-
//
41  / 0 0 -200000 / 2 81 0 0 0 / 0 / 10 0 0 -50000 /
//
-LOAD LIST END-


// FORMAT: [N_1, N_2, N_3, N_4] [N_5, N_6, N_7, N_8] / [Section File Name] / [ #_Elements, d_node_#] / [#_lines d_node_#] /
// NOTES : Front (XZ-Face) defined first - Left nodes first followed by right nodes
//         Back  (XZ-Face) defined next  - Left nodes first followed by right nodes (ONLY IF 3D)
//         Last Entry Section is only for 3D (not possible to do lines of elements in 2D)
-BEAM LIST-
//
2 83 11 92 1 82 10 91 / section_shell.txt  / 8 9 / 8 1 /
//
-BEAM LIST END-
```

Figure 6.21: *Sample Global Input File for Fixed Slab Model*

The "Global Input" file indicates that the structure is composed of two distinct types of sections. A sample "Section Input" file, for a 300 mm cubed section with shear reinforcement, is shown in Figure 6.22. All the material properties for this particular section are also defined in this file, and will be assigned to the HyPT elements that make up the structure. Creating this text file is analogous to creating a section in Response-2000 when performing an Augustus-II analysis.

```
////////////////////////////////////////////////////////////////////////////////////////////////////
// Name:    Edvard Bruun
// Project: Generic Shells (Stirrups)
// Created: June 8th, 2016
// Updated: July 1st, 2017
//
// Do Not Include Empty Rows Between Titles
// Do Not Change Title Names
//
////////////////////////////////////////////////////////////////////////////////////////////////////

// Unknown = 0 (Use Default Value)
-MATERIAL-
Concrete Comp. Str. [MPa] = 35
Concrete Tens. Str. [MPa] = 0
Poisson Ratio             = 0.15
Aggregate Size      [mm]  = 10
X-Steel Yield       [MPa] = 420
X-Steel Ultimate    [MPa] = 515
X-Steel Modulus     [MPa] = 200000
Y-Steel Yield       [MPa] = 400
Y-Steel Ultimate    [MPa] = 515
Y-Steel Modulus     [MPa] = 200000
Z-Steel Yield       [MPa] = 300
Z-Steel Ultimate    [MPa] = 500
Z-Steel Modulus     [MPa] = 200000

// All Units in 'mm'
// 2D Problem: X = Element Length,  Y = Section Width,   Z = Section Height
// 3D Problem: X = Length in X-Dir, Y = Length in Y-Dir, Z = Out-of-Plane Thickness
-GEOMETRY-
X-width       = 300
Y-width       = 300
Z-width       = 300
Clear Cover   = 40
Filename      = section_shell.txt

// 1 Row:    bot_layers = 1 / rebar_size = 25       / num_bars = 7     / d = 572         /
// 1+ Row:   bot_layers = 3 / rebar_size = 25 20 15 / num_bars = 7 3 3 / d = 572 500 400 /
// No Rebar: bot_layers = 0 /
// Use '/' Between Inputs, Whitespace on Both Sides

// 'd' is Measured From Top of Section (i.e. Towards Negative Z-dir)
-X-REINFORCEMENT-
xy-inclination = 0
xz-inclination = 0
bot_layers = 1 / rebar_size = 15 / num_bars = 2 / d = 250 /
top_layers = 1 / rebar_size = 15 / num_bars = 2 / d = 50 /

// 'd' is Measured From Top of Section (i.e. Towards Negative Z-dir)
-Y-REINFORCEMENT-
yx-inclination = 90
yz-inclination = 0
bot_layers = 1 / rebar_size = 10 / num_bars = 2 / d = 250 /
top_layers = 1 / rebar_size = 10 / num_bars = 2 / d = 50 /

// 'd' is Measured From Left of Section (i.e. Towards Positive X-dir)
-Z-REINFORCEMENT-
zx-inclination = 90
zy-inclination = 90
bot_layers = 1 / rebar_size = 10 / num_bars = 2 / d = 250 /
top_layers = 1 / rebar_size = 10 / num_bars = 2 / d = 50 /
```

Figure 6.22: *Sample Section Input File for Fixed Slab Model*

The output from the first part of the program is summarized in Figure 6.23. The top shows a schematic of the global geometry, where the nodal numbering, nodal restraints, element connectivity, and loading on the structure based on the "Global Input" file can be visually confirmed. This is followed by the material/section information, which takes the form of a series of stress/strain curves for the materials, and a schematic of a single element that shows the arrangement of reinforcement specified in the "Section Input" file. The images for the second section are not included since they closely resemble those below (no shear reinforcement).

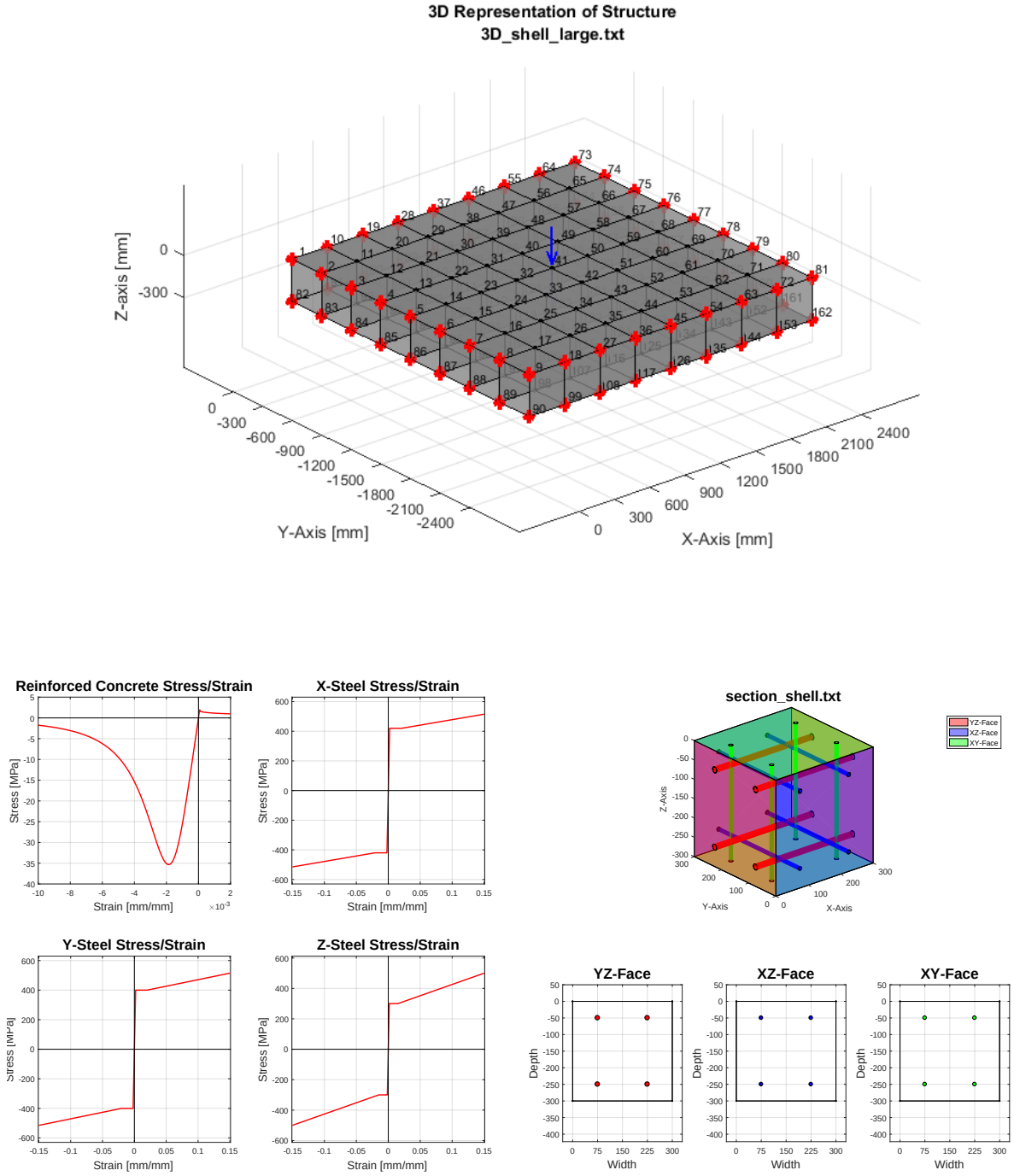


Figure 6.23: *Program Output from Structural Analysis Input Files (Slab)*

Figure 6.24 shows the output from another sample structural analysis problem, a cantilever beam with torsional loading applied to it.

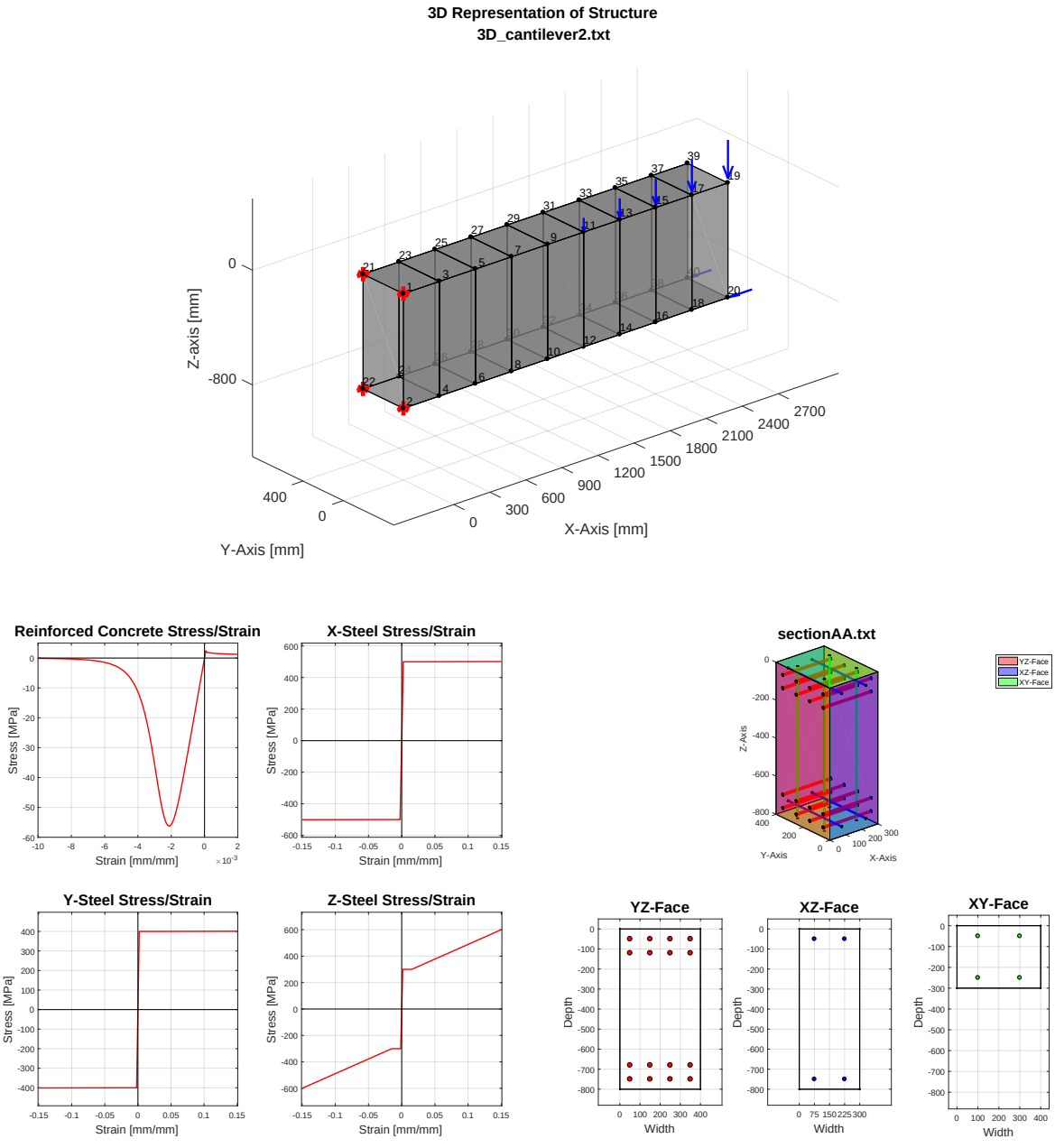


Figure 6.24: *Program Output from Structural Analysis Input Files (Beam)*

The program also produces two files that present an expanded textual summary of the structure as it has been generated. The "Global Summary" and "Section Summary" files are intended to be an easier way for the user to understand how the structure is defined, since the input text files are dense and sometimes difficult to parse. Examples of these files, for the analysis model of torsional shell specimen ES2, can be found in Appendix E.2.

6.4.3 Structural Analysis and Program Output

The second part of the program deals with performing the specified analysis task. This section corresponds to Step #3 in the main program code structure shown in Appendix D. The operational structure is represented by the flowchart in Figure 6.25, which is a continuation of the flowchart shown in Figure 6.20.

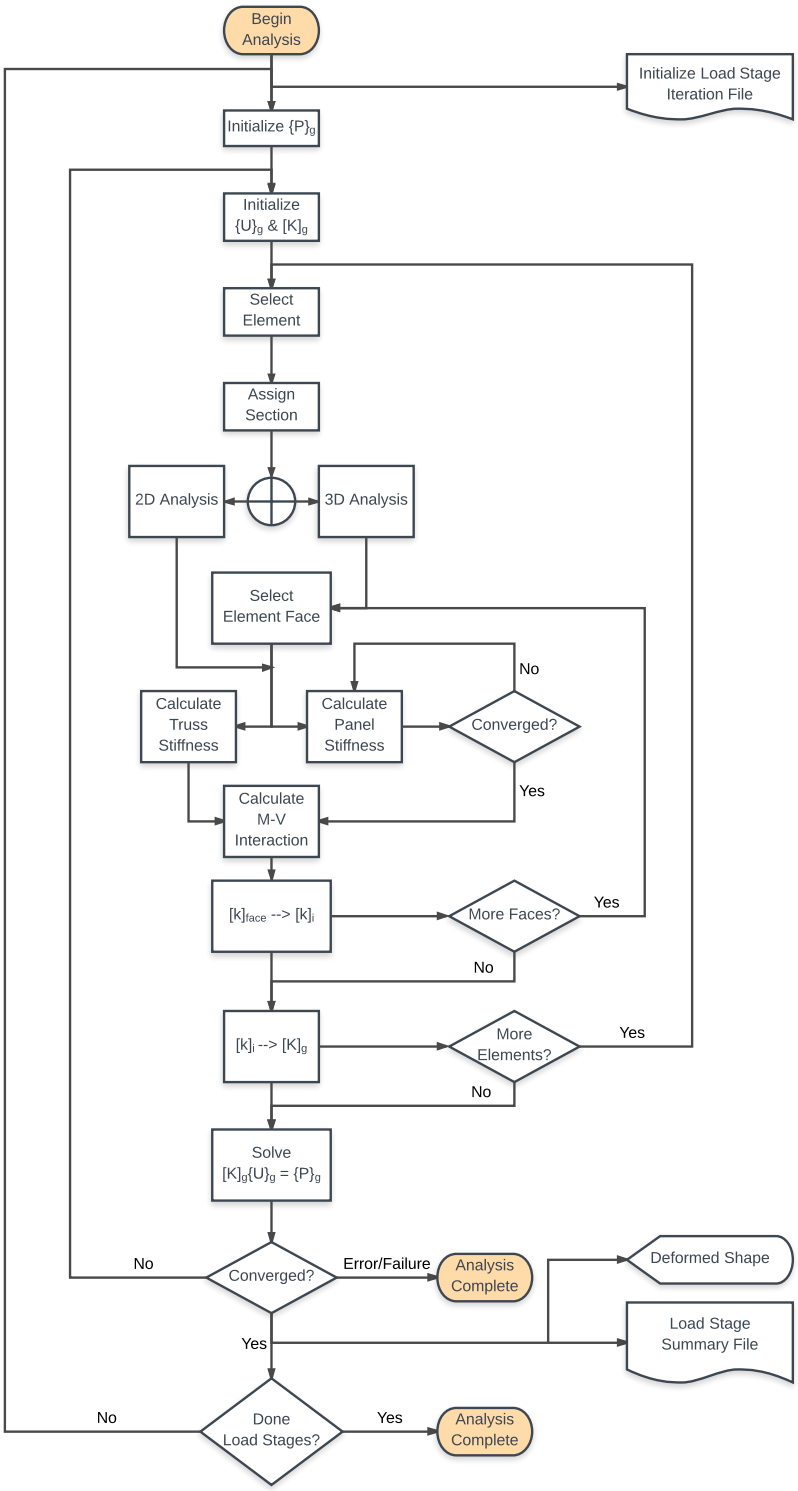


Figure 6.25: *Analysis Program Operational Flowchart*

For a load stage to be considered completed the analysis must satisfy one of the two global convergence criteria that are set manually by the user. For these analyses, the absolute and relative convergence tolerance in the global displacements is set to 0.005 mm and 0.05% respectively. If the maximum number of iterations is reached or the solution becomes unstable, the structure is considered to have failed and the analysis terminates. After each completed load stage, the program also produces an image of the deformed shape and the location of cracks to assist the user in understanding the failure mechanism. The cracks are simply to indicate how a face of an element is behaving, and should not be taken as a realistic representations of the behaviour. Figure 6.26 Figure 6.27 shows the output from a single load stage in the analysis of the slab and beam respectively, note that the actual output is a 3D plot that can be rotated to better view the structure.

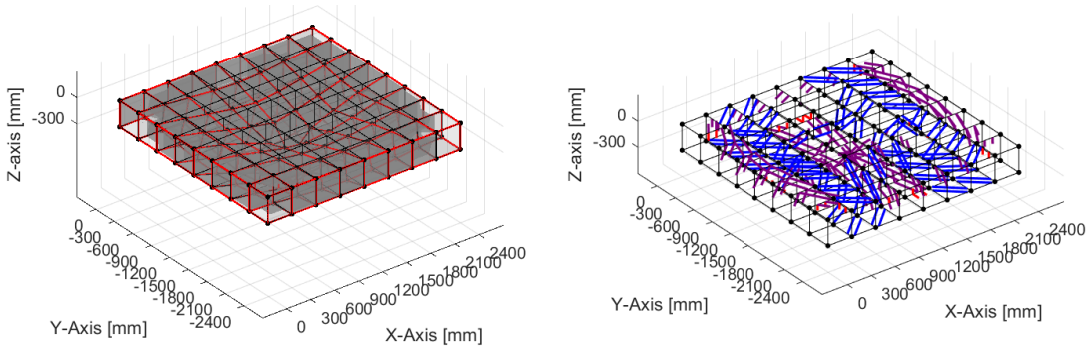


Figure 6.26: *Deformation and Cracking Output at Load Stage for Fixed Slab Model*

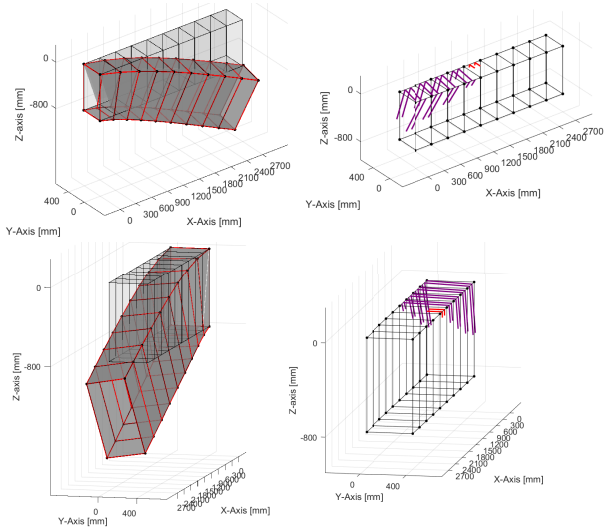


Figure 6.27: *Deformation and Cracking Output at Load Stage for Cantilevered Beam Model*

The program also outputs two text files at each load stage. The "Load Stage Iteration" file is created at the beginning of the load stage and records all the important calculations throughout. The "Load Stage Summary" file on the other hand is created at the end of the load stage and records the high-level behaviour of the model - this is the file that is accessed for post-processing purposes. Examples of these files, for the analysis model of torsional shell specimen ES2, can be found in Appendix E.3.

6.5 Element Verification

As a preliminary verification of the 3d-HyPT element, the two torsion tests that constituted the experimental component of this thesis were modelled using the program described in the previous section. Figure 6.28 shows the finite element mesh generated by the program, which is the same for both tests since the loading and geometry were identical. The test region of the specimens is represented by a 5x5 grid of 3d-HyPT elements, and is globally restrained in three in-plane and three out-of-plane DOFs to provide the necessary stability but still remain statically determinate. Torsion in the model is represented as equal and opposite nodal forces acting along the top and bottom faces (North and South in the experiment), where the resultant moment is taken as the applied torsion. Both models use the same element geometry (230 x 230 x 285 mm), except that ES2 has steel in the Z-direction to represent the T-head reinforcement. The sections are shown in Figure 6.29, and the text files used to generate all the structural inputs are found in Appendix E.1.

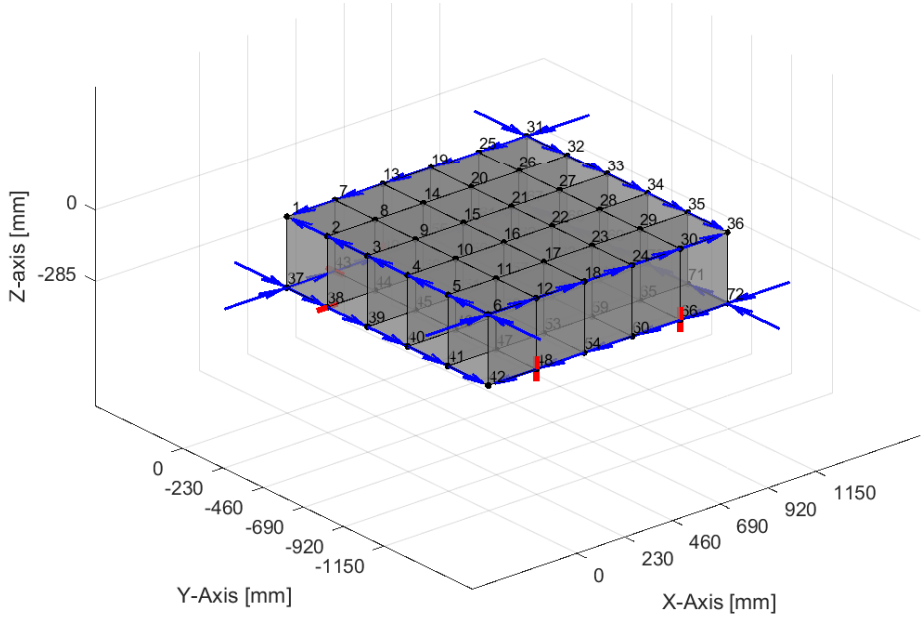


Figure 6.28: *Finite Element Mesh for Torsion Shell Experiments (ES1 & ES2)*

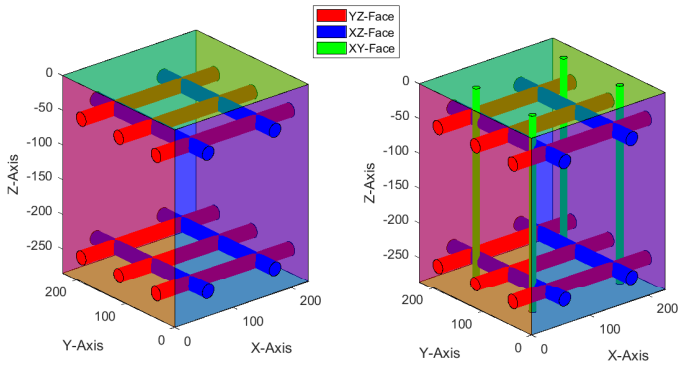


Figure 6.29: *Analysis Element Geometry: ES1 (Left) & ES2 (Right)*

6.5.1 Deformations

Figure 6.30 shows the deformed shape during the analysis of specimen ES2, which closely resembles the double curvature shape associated with pure torsion. The deformations in these images have been magnified to clearly display the progression of deformations, which are similar to the surface deformed shape captured by the LED targets.

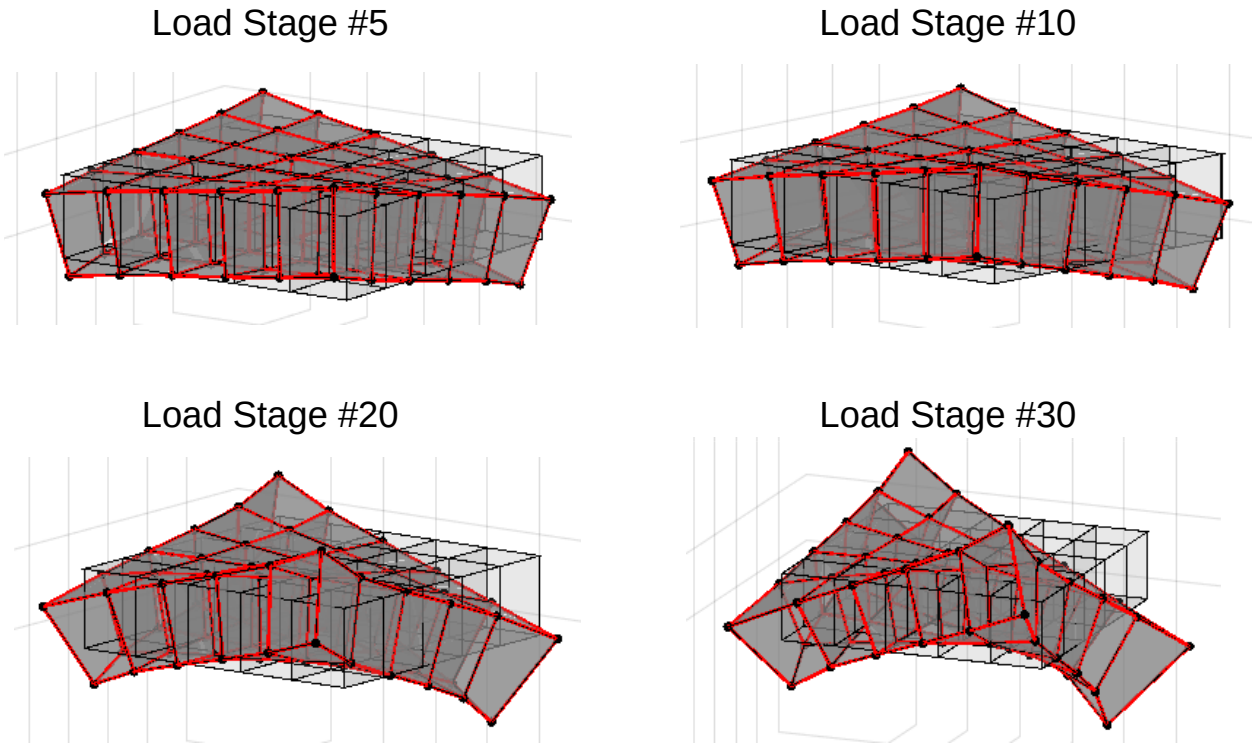


Figure 6.30: *Typical Deformed Shape During the Analysis of a Torsion Shell (Magnified)*

6.5.2 Analysis Comparison

As a preliminary verification study of the element, and to test the functionality of the program, the analysis results for both specimens were post-processed and then compared to their respective experimental data. The following section will discuss the analytical results for the following relationships: torque-twist (Figure 6.31), and out-of-plane shear strain (Figure 6.32). The post-processor is still in development, and hence a detailed look at all the different variables is not currently possible without a significant amount of work beyond the scope of the current project. Another limitation of the program is the fact that it is force-based, meaning that in its current state it does not calculate the post-peak region of a structural analysis problem. Therefore, the comparison plots in this section are only up to the peak response for both the experimental and analytical results.

The torque-twist comparison for both specimens is shown in Figure 6.31. To improve the reliability of the results, the "Program" line is taken as the average of all 25 elements used in each individual model - the top and bottom shear strains are calculated based on the nodal displacements, and are then used to find the twist strain across the element.

The analytical model does an excellent job of predicting the peak torsion, with an Exp./Pred. ratio of 1.09 and 1.04 for ES1 and ES2 respectively. Yet the prediction of the twist strain at the peak torsion is significantly underpredicted, with Exp./Pred. ratios of 1.68 and 1.49. In general, the model matches the pre-cracking behaviour perfectly but is stiffer in the cracked linear portion. Despite the differences in the strength and ductility, it appears that the model captures the shape of the curve before failure - ES1 failing fails in a more sudden manner, while ES2 has a more ductile response up to its peak due to the T-head reinforcement.

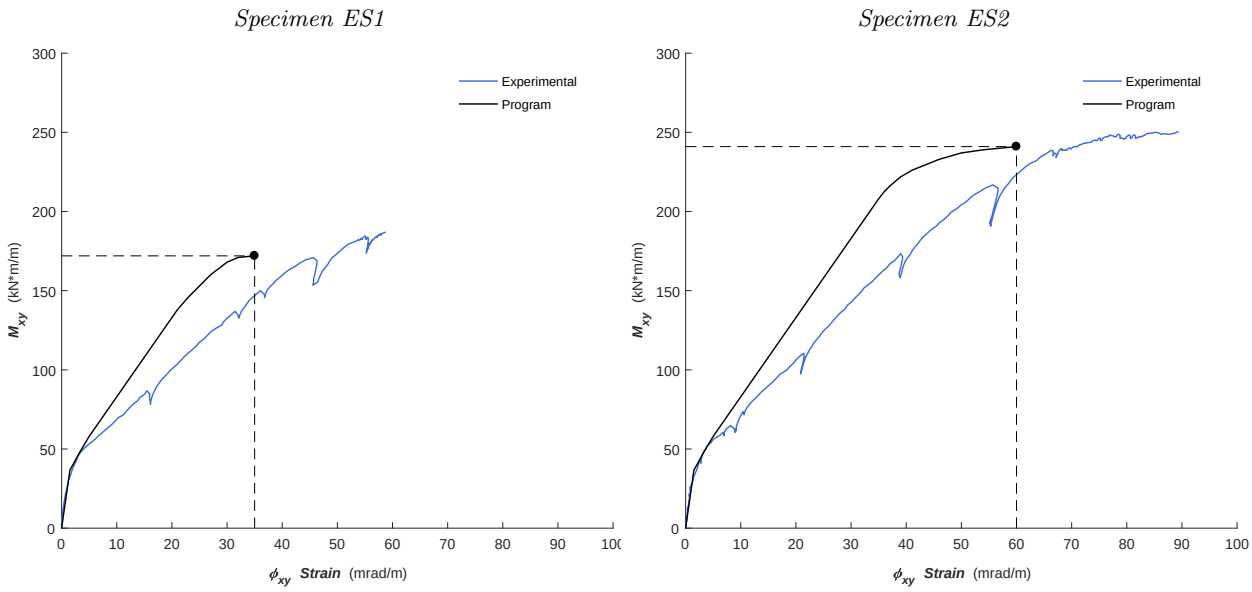


Figure 6.31: *Analysis Program Results: Torque-Twist*

The out-of-plane shear strain comparison for both specimens is shown in Figure 6.32. There were some inconsistencies in the program results for the elements that were adjacent to the supports, so these outliers were removed from the calculations by only taking the average of the out-of-plane strains for the central elements in both specimens. This was considered a reasonable assumption since the experimental instrumentation being compared to was also located away from the edges of the specimen to avoid disturbed region effects. The relative nodal displacements, read from the "Load Stage Summary" files, between the top and bottom faces of each element were used to calculate the strains in both the XZ and YZ planes.

The analytical model once again shows good agreement with the experimental results, although the values of strain at failure are over and under-predicted for specimens ES1 and ES2 respectively. Yet in both specimens the rapid increase in the out-of-plane shear strains indicates that the peak torsion value is approaching, although the actual strain values calculated are questionable since the convergence of the solution was more difficult during the final load stages (especially for specimen ES1). It was found that the final strain values could vary by up to 20% depending on the magnitude of the load step (increments ranging from 1 kN to 10 kN per load stage were used). Aside from these convergence issues, the cracked linear region of the program results were stable and match the experimental results closely right up to the failure. Specimen ES2, with the T-head shear reinforcement, also exhibited a slightly stiffer response in the cracked linear region than specimen ES1. The rapid increase in the out-of-plane shear strains that precedes the peak torsion is consistent with the failure mode, and observations of significant cover spalling and concrete crushing made during the experiments. It is important to note that only the experimental LP data is used in this comparison, since surface-to-surface strains are consistent with the nodal data generated by the program (as opposed to using the internal strains measured by the EGs). The imposed strain in the Z-direction is also assumed based on the experimental results.

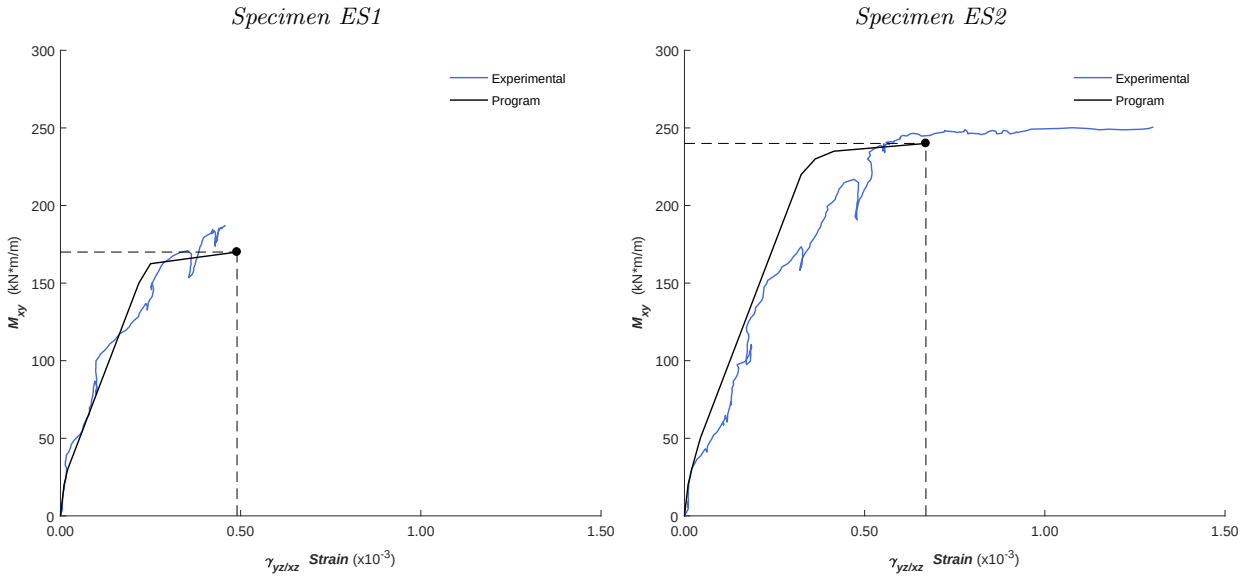


Figure 6.32: *Analysis Program Results: Out-of-Plane Shear Strain*

Overall, the analysis program that was written to implement the 3d-HyPT element is able to predict some of the main results from the two torsion experiments. An important caveat is that this exercise is only intended as a preliminary proof of concept, and should therefore not be taken as definitive proof that the element is appropriate for all types of shell analyses. The only statement that can be made with confidence at this point is that the 3d-HyPT element is a promising tool for the analysis of shells subjected to torsion. As the post-processor is developed, and more shell experiments are performed, a more in-depth verification study will eventually be conducted.

Chapter 7

Conclusions and Recommendations

The following chapter will restate the research objectives and summarize how they were accomplished. This is followed by a list of the main conclusions divided between the experimental and analytical work, and recommendations for future research work that would build upon the research foundation laid in this thesis.

7.1 Summary of Thesis Objectives

The purpose of this thesis was to develop and present a new rational, and mathematically rigorous, finite element for the nonlinear analysis of reinforced concrete beams and shells. This research was born from the necessity to overcome the computational limitations that exist when working with current analysis paradigms. For example, a typical finite element analysis is formulated by using either several low-powered element or fewer high-powered elements to model a structure. The challenge is that the number of low-powered elements needed for a detailed analysis of a large structure will significantly slow the calculations, while on the other hand relying on complex elements with difficult numerical integration schemes will also lead to a significant computational burden.

The Hybrid Panel-Truss (HyPT) element presents a new approach by relying on the combined actions of simpler subcomponents to represent the complex nonlinearity and deformation patterns inherent in reinforced concrete. The one-dimensional trusses capture the axial and flexural deformations, while the two-dimensional panels capture the shear deformations. Not only is calculating the stiffness matrix explicitly from these subcomponents much less challenging from a computational standpoint, the element itself has also been formulated so that only one is necessary through the depth of a member. Together these two factors lead to a significant numerical simplification, in the context of a stiffness matrix structural analysis solution, by reducing the number of global degrees of freedom necessary in a problem.

The two-dimensional version of the element (2d-HyPT) can be used for the analysis of prismatic reinforced concrete beams and columns subjected to in-plane loads. The three-dimensional version of the element (3d-HyPT) extends this simpler derivation so that the element can be used for the analysis of beams and shells subjected to complex combinations of in-plane and out-of-plane loads. In the process of deriving both versions of the element an experimental program was deemed necessary to gather data on the challenging behaviour associated with pure torsion in shells. Overall, this thesis was structured around accomplishing the following goals:

1. To consolidate the work done to date on the two-dimensional version of the element, and to expand the derivation to include a rigorous membrane formulation based on the MCFT.

2. To validate the two-dimensional element against a series of experimental results.

3. To construct two shell specimens, with and without shear reinforcement, and to load them under pure torsion with a displacement-controlled loading protocol.

4. To derive and validate the three-dimensional version of the element against the torsion experiments.

7.2 Summary of Results and Conclusions

For clarity, the main results and conclusions from the thesis are divided between the physical experiments, and the analytical derivation and verification work.

7.2.1 Experimental

With respect to the experimental program, which consisted of constructing and testing two shell specimens in pure torsion, the following conclusions can be made:

1. A pure torsion loading condition can be recreated in a central test region of a shell by applying equal and opposite moments along the edges of the specimen while orienting the flexural reinforcement at 45° to the loading axis.
2. The displacement-controlled loading protocol established for these tests is a viable means of obtaining useful post-peak data from an experiment.
3. The addition of out-of-plane reinforcement, in the form of T-head bars, significantly improved the strength and ductility of the second shell tested.
4. Out-of-plane strains and through-the-thickness expansion of the specimens are important factors to take into account when modelling torsion in shells.
5. The specimens experienced crushing of the outermost layers of concrete, due to equal and opposite in-plane shear stresses on the front and back faces. Cover spalling initiated the failure and continued in the post-peak region of both tests.

7.2.2 Analytical

With respect to the analytical work, which consisted of deriving and verifying the HyPT element, the following conclusions can be made:

1. The HyPT formulation and derivation has resulted in a robust and accurate tool that can be used to quickly analyze the nonlinear response of large reinforced concrete structures.
2. The 2d-HyPT element can be used to safely predict the failure load of shear critical beams.
3. The 2d-HyPT element can be used to determine the load-deflection response of frames, and can be paired with membrane elements to model joint regions.
4. The 3d-HyPT element can be used to model structures subjected to complex loading conditions.
5. The 3d-HyPT element can be used to predict the torque-twist behaviour of reinforced concrete shells.

7.3 Recommendations for Future Work

The downside of undertaking a research project with tremendous breadth is that the depth of discussion and analysis of certain topics must be sacrificed to allow for the overall completion of the thesis within a reasonable page length. The following section will present a list of topics, which given more time and resources should be explored in detail in the future. For clarity, these recommendations are divided between the experimental and analytical work.

7.3.1 Experimental

The following are a list of ways to build upon the experimental component of this research:

1. The pure torsion experimental program should be expanded to determine the influence that different variables have on the strength and ductility of a shell. A series of specimens should be constructed with variable ratios of longitudinal reinforcement, concrete thicknesses, and concrete strengths.

2. The minimum ratio of transverse reinforcement necessary to guarantee superior strength and ductility should be explicitly determined with an experimental program where several identical shells with variable out-of-plane reinforcement ratios are tested in pure torsion.

3. More information on the out-of-plane deformations associated with reinforced concrete shells should be gathered in the future. The quality of the data gained from the embedded gauges suggests that more should be used to better understand the out-of-plane strains at the center of a shell.

7.3.2 Analytical

The following are a list of ways to build upon the analytical component of this research:

1. Although the 2d-HyPT element was well verified with respect to shear critical reinforced concrete beams, further verification studies should be performed with a focus on flexural failures.

2. Further analysis of large-scale structures and experimental test frames should be performed with the 2d-HyPT element, in conjunction with membranes elements. This procedure should be explicitly explained and the method of linking the different types of elements together should be carefully analyzed.

3. A pre and post-processor should be written to implement the 3d-HyPT element.

4. The derivation of the out-of-plane truss terms used in the 3d-HyPT element should be expressed in a more rigorous manner, rather than relying on experimental curves.

5. To determine its general applicability, the 3d-HyPT element should be used in a detailed verification study similar to what was done with the two-dimensional element in this thesis.

References

[1] F. J. Vecchio and M. P. Collins, "The Modified Compression-Field Theory for Reinforced Concrete Elements Subjected to Shear," *ACI Journal*, vol. 83, no. 2, pp. 219–231, Mar. 1986.

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[3] CSA, "Design of Concrete Structures - Clause 11 - Shear and Torsion," in *CSA A23.3*, 2004th ed. Canadian Standards Association, 2004, pp. 53–66.

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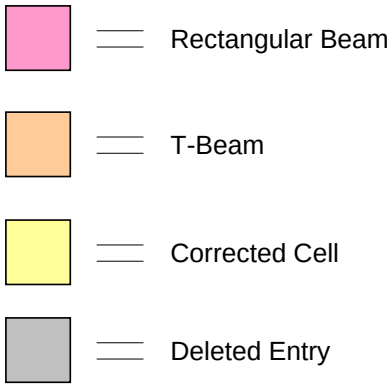
A. Shear Critical Beam Databases

The following appendix presents the shear critical beam databases (as published by Reineck et. al.) used in the verification study of the 2d-HyPT element. These data tables presented have been simplified from their original form to show only the columns of data that are necessary to create an appropriate Augustus-II and Response-2000 model.

Certain cells have been highlighted, the legend is shown below:



A.1 No Stirrups - Point Loads

Notation	Nr.	Literature	ID	Modelling		Section Properties					Loading and Geometry					Tension Reinf.						Compression Reinf.				Conc. Comp.		Conc. Tens.		Test Results				
				Load Step	Ele. Size	b	b_w	h	A_c	z_{c2}	a_F	L	c	a	a/d	d_s	Φ_{st}	A_s	r_s	r_w	f_{sy}	d_{s2}	Φ_{st2}	A_{s2}	f_{sy2}	Φ_a	f'c	$f_{ct,test}$	$f_{ct,m,cal}$	F	$V_{u,F+gRep}$	$V_{u,Rep}$	$V_{u,g+F}$	x_r
				kN	mm	mm	mm	mm	mm²	mm	mm	mm	mm	mm	-	mm	mm	mm²	%	%	MPa	mm	mm	mm²	MPa	mm	MPa	MPa	MPa	kN	kN	kN	kN	mm
Adebar_1989_001_ST1	21	Adebar (1989) +	ST1	10	200	360	360	310	111,600	155		1,625	0	813	2.92	278	20	1,570	1.569	1.569	536	32	20	1,570	536	19	50.1	3.87	4.02			128	129	406
Adebar_1989_002_ST2	22	Adebar;	ST2	10	200	360	360	310	111,600	155		1,625	0	813	2.92	278	20	1,570	1.569	1.569	536	32	20	1,570	536	19	50.1	3.87	4.02			119	120	406
Adebar_1989_003_ST3	23	Collins (1994) +	ST3	10	200	290	290	310	89,900	155		1,625	0	813	2.92	278	20	1,570	1.947	1.947	536	32	20	1,570	536	19	46.9	4.05	3.84			108	109	406
Adebar_1989_005_ST16	25	Adebar;	ST16	10	200	290	290	210	60,900	105		1,625	0	813	4.56	178	20	1,570	3.041	3.041	536	30	20	1,570	536	19	49.1	3.33	3.96			75	76	406
Adebar_1989_007_ST23	27	Collins (1996)	ST23	10	200	290	290	310	89,900	155		1,625	0	813	2.92	278	15	800	0.992	0.992	484	32	15	800	484	19	56.5	5.04	4.24			90	91	406
AhmadKhaloo_1986_001_A1	28	Ahmad;	A1	5	200	127	127	254	32,258	127		2,032	406	813	4.00	203	25	1,013	3.927	3.927	414					13	60.0		4.33	58	58	58	58	406
AhmadKhaloo_1986_002_A2	29	Kahloo	A2	5	200	127	127	254	32,258	127		1,626	406	610	3.00	203	25	1,013	3.927	3.927	414					13	60.0		4.33	69	69	69	69	305
AhmadKhaloo_1986_003_A3	30	Poveda (1986)	A3	5	200	127	127	254	32,258	127		1,504	406	549	2.70	203	25	1,013	3.927	3.927	414					13	60.0		4.33	69	69	69	69	274
AhmadKhaloo_1986_007_A7	34		A7	5	200	127	127	254	32,258	127		2,071	406	832	4.00	208	16	467	1.768	1.768	414					13	60.0		4.33	47	47	47	47	416
AhmadKhaloo_1986_008_A8	35		A8	5	200	127	127	254	32,258	127		1,655	406	624	3.00	208	16	467	1.768	1.768	414					13	60.0		4.33	49	49	49	49	312
AhmadKhaloo_1986_013_B1	40		B1	5	200	127	127	254	32,258	127		2,020	406	807	4.00	202	29	1,289	5.034	5.034	414					13	66.3		4.48	51	52	52	403
AhmadKhaloo_1986_014_B2	41		B2	5	200	127	127	254	32,258	127		1,616	406	605	3.00	202	29	1,289	5.034	5.034	414					13	66.3		4.48	69	69	69	69	303
AhmadKhaloo_1986_015_B3	42		B3	5	200	127	127	254	32,258	127		1,495	406	545	2.70	202	29	1,289	5.034	5.034	414					13	66.3		4.48	100	100	100	100	272
AhmadKhaloo_1986_019_B7	46		B7	5	200	127	127	254	32,258	127		2,071	406	832	4.00	208	16	594	2.248	2.248	414					13	66.3		4.48	44	45	45	45	416
AhmadKhaloo_1986_020_B8	47		B8	5	200	127	127	254	32,258	127		1,655	406	624	3.00	208	16	594	2.248	2.248	414					13	66.3		4.48	47	47	47	47	312
AhmadKhaloo_1986_021_B9	48		B9	5	200	127	127	254	32,258	127		1,530	406	562	2.70	208	16	594	2.248	2.248	414					13	66.3		4.48	80	80	80	80	281
AhmadKhaloo_1986_025_C1	52	Ahmad;	C1	5	150	127	127	254	32,258	127		1,880	406	737	4.00	184	22	1,552	6.635	6.635	414					13	63.6		4.41	54	55	55	368
AhmadKhaloo_1986_026_C2	53	Kahloo	C2	5	150	127	127	254	32,258	127		1,511	406	552	3.00	184	22	1,552	6.635	6.635	414					13	63.6		4.41	76	76	76	276
AhmadKhaloo_1986_027_C3	54	Poveda (1986)	C3	5	150	127	127	254	32,258	127		1,401	406	497	2.70	184	22	1,552	6.635	6.635	414					13	63.6		4.41	69	69	69	249
AhmadKhaloo_1986_031_C7	58		C7	5	150	127	127	254	32,258	127		2,058	406	826	4.00	207	19	855	3.260	3.260	414					13	63.6		4.41	45	46	46	413
AhmadKhaloo_1986_032_C8	59		C8	5	100	127	127	254	32,258	127		1,645	406	620	3.00	207	19	855	3.260	3.260	414					13	63.6		4.41	44	45	45	310
AhmadKhaloo_1986_033_C9	60		C9	5	150	127	127	254	32,258	127		1,522	406	558	2.70	207	19	855	3.260	3.260	414					13	63.6		4.41	45	46	46	279
AhmadPark_1995_007_B7N	88	Ahmad;	B7N	2	150	102	102	204	20,808	102		1,774	457	659	3.70	178	13	253	1.395	1.395	413	3	6	63	413	13	41.2		3.51			27	27	329
AhmadPark_1995_015_B7H	96	Park;	B7H	2	150	102	102	204	20,808	102		1,774	457	659	3.70	178	13	253	1.395	1.395	413	3	6	63	413	13	75.7		4.68			27	27	329
AhmadPark_1995_016_B8H	97	El-Dash (1995)	B8H	2	150	102	102	204	20,808	102		1,774	457	659	3.70	178	13	253	1.395	1.395	413	3	6	63	413	13	78.4		4.74			27	27	329
AlAlusi_1957_002_12	99	Al-Alusi (1957)	12	1	100	330	76	146	19,194	49	64	1,041	406	318	2.50	127	13	253	0.604	2.618	366					6	22.8	1.89	2.31			27	27	159
AlAlusi_1957_003_11	100		11	1	100	330	76	146	19,194	49	64	1,270	406	432	3.40	127	13	253	0.604	2.618	366					6	26.2	2.50	2.56			17	18	227
AlAlusi_1957_004_2	101		2	1	100	330	76	146	19,194	49	64	1,270	406	432	3.40	127	10	143	0.340	1.473	366					6	25.5	2.23	2.50			14	15	216
AlAlusi_1957_005_21	102		21	1	100	330	76	151	20,871	50	64	1,270	406	432	3.40	127	13	253	0.604	2.618	366	19	13	253	366	6	26.8	2.49	2.60			24	24	216
AlAlusi_1957_006_15	103		15	1	100	330	76	151	20,871	50	64	1,422	406	508	4.00	127	13	253	0.604	2.618	366	19	13	253	366	6	22.8	2.30	2.32			17	17	254
AlAlusi_1957_008_10	105		10	1	100	330	76	146	19,194	49	64	1,422	406	508	4.00	127	13	253	0.604	2.618	366					6	26.2	2.30	2.56			15	15	254
AlAlusi_1957_009_4	106		4	1	100	330	76	146	19,194	49	64	1,422	406	508	4.00	127	10	143	0.340	1.473	366					6	24.2	2.31	2.41			14	14	254
AlAlusi_1957_010_13	107		13	1	100	330	76	146	19,194	49	64	1,422	406	508	4.00	127	13	253	0.604	2.618	366					6	26.3	2.27	2.56			17	17	254
AlAlusi_1957_012_18	109		18	1	100	330	76	146	19,194	49	64	1,549	406	572	4.50	127	13	253	0.604	2.618	366					6	24.5	2.37	2.44			14	14	286
AlAlusi_1957_015_7	112		7	1	100	330	76	146	19,194	49	64	1,549	406	572	4.50	127	13	253	0.604	2.618	366					6	23.0	2.17	2.33			14	14	286
AlAlusi_1957_016_24	113		24	1	100	330	76	146	19,194	49	64	1,549	406	572	4.50	127	13	253	0.604	2.618	366	24	13	253	366	6	26.1	2.44	2.55			15	16	286
AlAlusi_1957_017_16	114		16	1	100	330	76	151	20,871	50	64	1,549	406	572	4.50	127	13	253	0.604	2.618	366	19	13	253	366	6	25.7	2.34	2.52			15	15	286
AlAlusi_1957_018_17	115		17	1	100	330	76	146	19,194	49	64	1,803	406	699	5.50	127	13	253	0.604	2.618	366					6	27.2	2.50	2.62			14	14	349
AlAlusi_1957_019_8	116		8	1	100	330	76	146	19,194	49	64	1,803	406	699	5.50	127	13	253	0.604	2.618	366					6	23.9	2.27	2.39			13	14	349
AlAlusi_1957_020_19	117		19	1	100	330	76	146	19,194	49	64	1,803	406	699	5.50	127	16	396	0.944	4.091	366					6	28.2	2.47	2.69			14	14	349
AlAlusi_1957_021_25	118		25	1	100	330	76	146	19,194	49	64	1,803	406	699	5.50	127	13	253	0.604	2.618	366	24	13	253	366	6	23.6	2.16	2.37			14	14	349
AlAlusi_1957_022_9	119		9	1	100	330	76	146	19,194	49	64	2,057	406	826	6.50	127	13	253	0.604	2.618	366					6	29.3	2.40	2.77			14	14	413
AlAlusi_1957_023_20	120		20	1	100	330	76	146	19,194	49	64	2,057	406	826	6.50	127	16	396	0.944	4.091	366					6	24.9	2.46	2.46			15	15	413
AlAlusi_1957_025_23	122		23	1	100	330	76	146	19,194	49	64	2,286	406	940	7.40	127	16	396	0.944	4.091	366					6	25.8	2.31	2.53			14	14	470
Angelakos_2000_001_DB0530	123	Angelakos;	DB0530	20	650	300	300	1,000	300,000	500	76	5,400	76	2,662	2.88	925	30	1,400	0.505	0.505	550					10	29.6		2.78	158	165	168	168	1,331
Angelakos_2000_002_DB120	124	Bentz;	DB120	20	650	300	300	1,000	300,000	500	76	5,400	76	2,662	2.88	925	30	2,800	1.009	1.009	550					10	18.6		2.00	172	179	182	182	1,331
Angelakos_2000_003_DB130	125	Collins (2000)	DB130	20	650	300	300	1,000	300,000	500	76	5,400	76	2,662	2.88	925	30	2,800	1.009	1.009	550					10	29.6		2.78	178	185	188	188	1,331
Angelakos_2000_004_DB140	126		DB140	20	650	300	300	1,000	300,000	500	76	5,400	76	2,662	2.88	925	30	2,800	1.009	1.009	550					10	35.6		3.17	173	180	183	183	1,331
Angelakos_2000_005_DB165	127		DB165	20	650	300	300	1,000	300,000	500	76	5,400	76	2,662	2.88	925	30	2,800	1.009	1.009	550					10	62.6		4.39	178	185	188	188	1,331
Angelakos_2000_006_DB180	128		DB180	20	650	300	300	1,000	300,000	500	76	5,400	76	2,662	2.88	925	30	2,800	1.009	1.009	550					10	77.6		4.72	165	172	175	175	1,331
Angelakos_2000_007_DB230	129		DB230	20	650	300	300	1,000	300,000	500	76	5,400	76	2,662	2.97	895	30	5,600	2.086	2.086	550					10	29.6		2.78	250	257	260	260	1,331
Aster_1974_002_2	131	Aster;	2	10	140	1000	1,000	278	277,500	139	60	2,500	660	920	3.68	250	14	1,600	0.640	0.640	543					30	24.5	2.41	2.44	216		222	222	460
Aster_1974_003_3	132	Koch (1974)	3	10	140	1000	1,000	284	284,250	142	60	2,500	660	920	3.68	250	20	2,280	0.912	0.912	525					30	24.9	2.71	2.47	221		226	226	460
Aster_1974_005_11	134		11	15	300	1000	1,000	534	534,250	267	60	4,750	1,100	1,825	3.65	500	20	2,280	0.456	0.456	525					30	22.2	2.12	2.27	261		280	280	913
Aster_1974_006_12	135		12	15	300	1000	1,000	535	535,000	268	60	4,750	1,100	1,825	3.65	500	20	3,260	0.652	0.652	525					30	24.9	2.71	2.47	324		343	343	913
Aster_1974_007_16	136		16	20	700	1000	1,000	789	789,000	395	100	7,000	1,500	2,750	3.67	750	24	3,140	0.419	0.419	526					30	28.0	2.41	2.67	392		433	433	1,375
Lubell_2004_001_AT-1 - East	161	Lubell, Sherwood, Bentz	AT-1 - East	120	440	2016	2,016	1,005	2,026,080	503	76	5,400		2,662	2.91	916	30	9,800	0.760	0.760	465					10	61.7	6.21	4.37	1,133		1,194	1,194	1,399
Lubell_2004_002_AT-1 West	162	Collins (2004)	AT-1 West	120	440	2016	2,016	1,005	2,026,080	503	76	5,400		2,662	2.91	916	30	9,800	0.760	0.760	465					10	62.2	6.21	4.37	1,221		1,288	1,288	1,273
Lubell_2004_003_AT-2 / 250N	163		AT-2 / 250N	10	250	250	250	469	117,250	235	76	2,600		1,262	2.89	437	25	1,000	0.915	0.915	465					10	35.3	3.66	3.15	115		117	117	459
Lubell_2004_004_AT-2/ 250W	164	Sherwood (2008)	AT-2/ 250W	10	250	252	252	471	118,692	236	76	2,600		1,262	2.87	439	25	1,000	0.904	0.904	465					10	36.1	3.66	3.20	112		114	114	674
Lubell_2004_005_AT-2 /1000W	165		AT-2 /1000W	30	250	1002	1,002	471	471,942	236	76	2,600		1,262	2.87	439	25	4,000	0.909	0.909	465					10	36.6	3.66	3.23	471		479	479	527
Lubell_2004_006_AT-2/1000N	166		AT-2/1000N	40	250	1002	1,002	470	470,940	235	76	2,600		1,262	2.88	438	25	4,000	0.911	0.911	465					10	35.5	3.66	3.16	440		448	448	555
Lubell_2004_007_AT-2/3000	167		AT-2/3000	100	250	3005	3,005	472	1,418,360	236	76	2,600		1,262	2.87	439	25	12,000	0.910	0.910	465					10	38.2	3.66	3.33	1,282		1,308	1,308	486
Lubell_2004_008_AT-3/N1	168		AT-3/N1	20	200	697	697	339	236,283	170	76	2,080		1,002	3.26	307	25	2,000	0.935	0.935	465					20	35.1	3.66	3.14	238		240	240	533
Lubell_2004_009_AT-3/N2	169		AT-3/N2	20	200	706	706	339	239,334	170	76	2,080		1,002	3.27	306	25	2,000	0.926	0.926	465					20	34.7	3.66	3.11	259		261	261	509
Lubell_2004_010_AT-3/T1	170		AT-3/T1	20	200	700	700	338	236,600	169	76	2,080		1,002	3.27	306	25	2,000	0.934	0.934	465					20	35.4	3.66	3.16	253		256	256	400
Lubell_2004_011_AT-3/T2	171		AT-3/T2	20	200	706	706	339	239,334	170	76	2,080		1,002	3.26	307	25	2,000	0.923	0.923	465					20	34.7	3.66	3.11	249		252	252	345
Bernander_1957_001_A1	172	Bernander (1957)	A1	2	175	100	100	200	20,000	100	75	2,100	700	700	4.17	168	15	186	1.109	1.109	667					14	26.7	2.54	2.59			21	22	350
Bernander_1957_002_A2	173		A2	2	175	100	100	200	20,000	100	75	2,100	700	700	4.17	168	16	196	1.167	1.167	905					14	26.7	2.54	2.59			24	24	350
Bernander_1957_003_A3	174		A3	2	175	100	100	200	20,000	100	75	2,100	700	700	4.17	168	8	162	0.966	0.966	910					14	25.2	2.54	2.48			20	20	350
Bernander_1957_004_A4	175		A4	2	175	100	100	200	20,000	100	75	2,100	700	700	4.17	168	15	186	1.109	1.109	667					14	26.7	2.54	2.59			22	22	350
Bernander_1957_005_A5	176		A5	2	175	100	100	200	20,000	100	75	2,100	700	700	4.17	168	16	196	1.167	1.167	905					14	26.7	2.54	2.59			21	21	350
Bernander_1957_006_A6	177		A6	2	175	100	100	200	20,000	100	75	2,100	700	700	4.17	168	8	162	0.966	0.966	910					14	25.2	2.54	2.48			17	18	350
Bernhardt_1986_001_S6A	178	Bernhardt;	S6A	5	100	150	150	200	30,000	100		2,550	1,750	400	2.52	159	20	628	2.634	2.634	510						79.7		4.77	95		96	96	200

Figure A.1: *Shear Critical Beam Database (No Stirrups - Part 1/11)*

Notation	Nr.	Literature	ID	Modelling		Section Properties					Loading and Geometry					Tension Reinf.						Compression Reinf.				Conc. Comp.		Conc. Tens.		Test Results				
				Load Step	Ele. Size	b	b_w	h	A_c	z_{c2}	a_F	L	c	a	a/d	d_s	Φ_{st}	A_s	r_s	r_w	f_{sy}	d_{s2}	Φ_{st2}	A_{s2}	f_{sy2}	Φ_a	f'c	$f_{ct,test}$	$f_{ct,m,cal}$	F	$V_{u,F}+g_{Rep}$	$V_{u,Rep}$	$V_{u,g}+F$	x_r
-	-	-	-	kN	mm	mm	mm	mm	mm²	mm	mm	mm	mm	mm	-	mm	mm	mm²	%	%	MPa	mm	mm	mm²	MPa	mm	MPa	MPa	MPa	kN	kN	kN	kN	mm
Bernhardt_1986_003_S6C	180	Fynboe (1986)	S6C	5	100	150	150	200	30,000	100		2,550	1,750	400	2.52	159	20	628	2.634	2.634	510						79.7		4.77	115		116	116	200
Bernhardt_1986_004_S9A	181		S9A	5	100	150	150	200	30,000	100		2,550	1,450	550	3.46	159	20	1,257	5.269	5.269	510						79.7		4.77	80		81	81	275
Bernhardt_1986_005_S9B	182		S9B	5	100	150	150	200	30,000	100		2,550	1,450	550	3.46	159	20	1,257	5.269	5.269	510						79.7		4.77	65		66	66	275
Bernhardt_1986_006_S9C	183		S9C	5	100	150	150	200	30,000	100		2,550	1,450	550	3.46	159	20	1,257	5.269	5.269	510						94.7		5.05	68		69	69	275
Bhal_1968_001_B1	184	Bhal (1968)	B1	5	200	240	240	350	84,000	175	38	1,800	38	881	2.94	300	24	905	1.257	1.257	426					30	20.8	2.44	2.16	70		71	71	480
Bhal_1968_002_B2	185		B2	5	300	240	240	650	156,000	325	75	3,600	75	1,763	2.94	600	24	1,810	1.257	1.257	426					30	27.2	2.71	2.62	117		119	119	1,200
Bhal_1968_003_B3	186		B3	5	400	240	240	950	228,000	475	113	5,400	113	2,644	2.94	900	24	2,714	1.257	1.257	426					30	25.1	3.02	2.48	162		166	166	1,875
Bhal_1968_004_B4	187		B4	5	440	240	240	1,250	300,000	625	150	7,200	150	3,525	2.94	1,200	24	3,619	1.257	1.257	426					30	22.8	2.38	2.31	177		187	187	2,138
Bhal_1968_005_B5	188		B5	5	300	240	240	650	156,000	325	75	3,600	75	1,763	2.94	600	24	905	0.628	0.628	426					30	24.2	2.40	2.41	104		107	107	1,022
Bhal_1968_006_B6	189		B6	5	300	240	240	650	156,000	325	75	3,600	75	1,763	2.94	600	12	905	0.628	0.628	422					30	22.3	2.94	2.28	112		115	115	853
Bhal_1968_007_B7	190		B7	5	400	240	240	950	228,000	475	113	5,400	113	2,644	2.94	900	24	1,357	0.628	0.628	426					30	24.8	2.95	2.46	135		140	140	1,757
Bhal_1968_008_B8	191		B8	5	400	240	240	950	228,000	475	113	5,400	113	2,644	2.94	900	12	1,357	0.628	0.628	422					30	25.3	2.28	2.49	123		128	128	1,785
Bresler_1963_001_0A-1	192	Bresler;	0A-1	10	300	310	310	556	172,374	278	152	3,658	152	1,753	3.80	461	29	2,579	1.805	1.805	555					19	20.2	2.64	2.12	167		171	171	876
Bresler_1963_002_0A-2	193	Scordelis (1963)	0A-2	10	370	305	305	561	171,096	281	152	4,572	152	2,210	4.74	466	29	3,224	2.269	2.269	555					19	21.3	2.89	2.20	178		184	184	716
Bresler_1963_003_0A-3	194		0A-3	10	520	307	307	556	170,961	278	152	6,401	152	3,124	6.77	462	29	3,868	2.727	2.727	552					19	35.2	2.76	3.14	189		196	196	1,562
Cladera_2002_001_H 50/1	195	Cladera;	H 50/1	10	170	200	200	400	80,000	200	75	2,160	75	1,043	2.90	360	32	1,608	2.234	2.234	500					12	47.5		3.87			100	101	521
Cladera_2002_003_H 60/1	196		H 60/1	10	170	200	200	400	80,000	200	75	2,160	75	1,043	2.90	360	32	1,608	2.234	2.234	500					12	58.4		4.29			108	109	521
Cladera_2002_004_H 75/1	197	Cladera (2002)	H 75/1	10	170	200	200	400	80,000	200	75	2,160	75	1,043	2.90	360	32	1,608	2.234	2.234	500					12	66.5		4.48			100	101	521
Cladera_2002_005_H 100/1	198		H 100/1	10	170	200	200	400	80,000	200	75	2,160	75	1,043	2.90	360	32	1,608	2.234	2.234	500					12	84.6		4.86			118	119	521
Cao_2000_001_SB 2003/0	199	Cao (2000)	SB 2012/0	25	900	300	300	2,000	600,000	1000	150	10,800	150	5,325	2.89	1,845	30	8,400	1.518	1.518	436	150	20	1,493	433	10	25.1		2.47	379		418	418	2,663
Cao_2000_002_SB 2012/0	200		SB 2003/0	25	900	300	300	2,000	600,000	1000	150	10,800	150	5,325	2.77	1,925	30	2,100	0.364	0.364	436	150	20	1,493	433	10	27.7		2.65	200		239	239	2,663
Cederwall_1974_001_734-34	201	Cederwall; Hedman; Losberg (1974)	734-34	5	100	135	135	260	35,100	130		3,000	1,400	800	3.42	234	12	339	1.074	1.074	818		8	101	487		26.9		2.60	41		42	42	400
Chana_1981_001_2.1a	203	Chana (1981)	2.1a	5	200	203	203	406	82,418	203	40	2,136	40	1,048	3.00	356	20	1,257	1.739	1.739	478					20	36.5	3.02	3.23	96		96	96	534
Chana_1981_001_2.1b	204		2.1b	5	200	203	203	406	82,418	203	40	2,136	40	1,048	3.00	356	20	1,257	1.739	1.739	478					20	36.5	3.02	3.23	97		97	97	534
Chana_1981_002_2.2a	205		2.2a	5	200	203	203	406	82,418	203	40	2,136	40	1,048	3.00	356	20	1,257	1.739	1.739	478					10	30.4	2.57	2.84	87		87	87	534
Chana_1981_002_2.2b	206		2.2b	5	200	203	203	406	82,418	203	40	2,136	40	1,048	3.00	356	20	1,257	1.739	1.739	478					10	30.4	2.57	2.84	94		94	94	534
Chana_1981_003_2.3a	207		2.3a	5	200	203	203	406	82,418	203	40	2,136	40	1,048	3.00	356	20	1,257	1.739	1.739	478					20	33.3	2.75	3.02	99		99	99	534
Chana_1981_003_2.3b	208		2.3b	5	200	203	203	406	82,418	203	40	2,136	40	1,048	3.00	356	20	1,257	1.739	1.739	478					20	33.3	2.75	3.02	96		96	96	534
Chana_1981_004_3.1a	209		3.1a	2	100	100	100	202	20,200	101	24	1,062	24	519	3.00	177	10	314	1.775	1.775	421					10	22.1	2.63	2.26	24		24	24	266
Chana_1981_004_3.1b	210		3.1b	2	100	100	100	202	20,200	101	24	1,062	24	519	3.00	177	10	314	1.775	1.775	421					10	22.1	2.63	2.26	24		24	24	266
Chana_1981_005_3.2a	211		3.2a	2	100	100	100	202	20,200	101	24	1,062	24	519	3.00	177	10	314	1.775	1.775	421					10	23.7	2.67	2.38	25		25	25	266
Chana_1981_005_3.2b	212		3.2b	2	100	100	100	202	20,200	101	24	1,062	24	519	3.00	177	10	314	1.775	1.775	421					10	23.7	2.67	2.38	26		26	26	266
Chana_1981_006_3.3a	213		3.3a	2	100	100	100	202	20,200	101	24	1,062	24	519	3.00	177	10	314	1.775	1.775	421					10	26.1	2.40	2.55	27		27	27	266
Chana_1981_006_3.3b	214		3.3b	2	100	100	100	202	20,200	101	24	1,062	24	519	3.00	177	10	314	1.775	1.775	421					10	26.1	2.40	2.55	23		23	23	266
Chana_1981_007_D1	215		D1	2	100	100	100	202	20,200	101	24	1,062	24	519	3.00	177	10	314	1.775	1.775	421					10	20.1	2.31	2.11	22		22	22	266
Chana_1981_008_D2	216		D2	2	100	100	100	202	20,200	101	24	1,062	24	519	3.00	177	10	314	1.775	1.775	421					10	20.6	2.48	2.15	23		23	23	266
Chana_1981_009_D3	217		D3	2	100	100	100	202	20,200	101	24	1,062	24	519	3.00	177	10	314	1.775	1.775	421					10	29.4	3.11	2.77	21		21	21	266
Chana_1981_010_4.1a	218		4.1a	1	60	60	60	121	7,260	61	24	636	24	306	3.00	106	6	113	1.778	1.778	504					5	18.4	2.90	1.98	10		10	10	159
Chana_1981_010_4.1b	219		4.1b	1	60	60	60	121	7,260	61	24	636	24	306	3.00	106	6	113	1.778	1.778	504					5	18.4	2.90	1.98	9		9	9	159
Chana_1981_011_4.2a	220		4.2a	1	60	60	60	121	7,260	61	24	636	24	306	3.00	106	6	113	1.778	1.778	504					5	18.4	2.90	1.98	9		9	9	159
Chana_1981_011_4.2b	221		4.2b	1	60	60	60	121	7,260	61	24	636	24	306	3.00	106	6	113	1.778	1.778	504					5	18.4	2.90	1.98	10		10	10	159
Chana_1981_012_4.3a	222		4.3a	1	60	60	60	121	7,260	61	24	636	24	306	3.00	106	6	113	1.778	1.778	504					5	32.8	3.29	2.99	12		12	12	159
Chana_1981_012_4.3b	223		4.3b	1	60	60	60	121	7,260	61	24	636	24	306	3.00	106	6	113	1.778	1.778	504					5	32.8	3.29	2.99	12		12	12	159
Chana_1981_013_4.4a	224		4.4a	1	60	60	60	121	7,260	61	24	636	24	306	3.00	106	6	113	1.778	1.778	504					5	32.8	3.29	2.99	10		10	10	159
Chana_1981_013_4.4b	225		4.4b	1	60	60	60	121	7,260	61	24	636	24	306	3.00	106	6	113	1.778	1.778	504					5	32.8	3.29	2.99	10		10	10	159
Chang_1958_001_IA1	239	Chang;	IA1	2	120	102	102	152	15,484	76	51	1,168	51	559	4.09	137	16	401	2.890	2.890	328					25	25.2		2.48			20	20	279
Chang_1958_003_IB1	241	Kesler (1958)	IB1	2	100	102	102	152	15,484	76	51	762	51	356	2.60	137	13	258	1.860	1.860	328					25	25.2		2.48			20	20	178
Chang_1958_005_IC1	243		IC1	2	100	102	102	152	15,484	76	51	965	51	457	3.35	137	10	329	2.370	2.370	328					25	25.2		2.48			20	20	229
Chang_1958_006_IC2	244		IC2	2	100	102	102	152	15,484	76	51	965	51	457	3.35	137	10	329	2.370	2.370	328					25	25.2		2.48			18	18	229
Chang_1958_009_IIB1	247		IIB1	2	120	102	102	152	15,484	76	51	1,168	51	559	4.09	137	10	329	2.370	2.370	328					25	15.3		1.73			17	17	279
Chang_1958_011_IIC1	249		IIC1	2	100	102	102	152	15,484	76	51	762	51	356	2.60	137	16	401	2.890	2.890	328					25	15.3		1.73			18	18	178
Chang_1958_027_4-21a	265		4-21a	2	120	102	102	152	15,484	76	51	1,067	51	508	3.72	137	13	258	1.860	1.860	328					25	36.2		3.21			21	21	254
Chang_1958_029_4-22a	267		4-22a	2	120	102	102	152	15,484	76	51	1,067	51	508	3.72	137	13	258	1.860	1.860	328					25	29.5		2.78			21	22	254
Chang_1958_031_4-23a	269		4-23a	2	120	102	102	152	15,484	76	51	1,067	51	508	3.72	137	13	258	1.860	1.860	328					25	29.8		2.80			22	22	254
Chang_1958_037_5-21a	275		5-21a	2	120	102	102	152	15,484	76	51	1,067	51	508	3.72	137	16	401	2.890	2.890	328					25	29.8		2.80			29	29	254
Chang_1958_038_5-21b	276		5-21b	2	120	102	102	152	15,484	76	51	1,067	51	508	3.72	137	16	401	2.890	2.890	328					25	29.8		2.80			27	28	254
Chang_1958_039_5-22a	277		5-22a	2	120	102	102	152	15,484	76	51	1,067	51	508	3.72	137	16	401	2.890	2.890	328					25	28.8		2.73			22	23	254
Chang_1958_040_5-22b	278		5-22b	2	120	102	102	152	15,484	76	51	1,067	51	508	3.72	137	16	401	2.890	2.890	328					25	28.8		2.73			26	26	254
Chang_1958_041_5-23a	279		5-23a	2	120	102	102	152	15,484	76	51	1,067	51	508	3.72	137	16	401	2.890	2.890	328					25	29.7		2.79			25	25	254
Chang_1958_042_5-23b	280		5-23b	2	120	102	102	152	15,484	76	51	1,067	51	508	3.72	137	16	401	2.890	2.890	328					25	29.7		2.79			23	23	254
Collins_1999_001_B100	293	Collins;	B100	15	440	300	300	1,000	300,000	500	76	5,400	76	2,662	2.88	925	30	2,800	1.009	1.009	550					10	33.6		3.04	218		228	228	1,331
Collins_1999_002_B100H	294	Kuchma (1999)	B100H	15	440	300	300	1,000	300,000	500	76	5,400	76	2,662	2.88	925	30	2,800	1.009	1.009	550					10	95.6		5.07	186		193	193	1,727
Collins_1999_003_B100B	295		B100B	15	440	300	300	1,000	300,000	500	76	5,400	76	2,662	2.88	925	30	2,800	1.009	1.009	550					10	36.6		3.23	197		207	207	1,331
Collins_1999_004_B100L	296		B100L	15	440	300	300	1,000	300,000	500	76	5,400	76	2,662	2.88	925	16	2,800	1.009	1.009	483					10	36.6		3.23	216		226	226	1,331
Collins_1999_005_B100-R	297		B100-R	15	440	300	300	1,000	300,000	500	76	5,400	76	2,662	2.88	925	30	2,800	1.009	1.009	550					10	33.6		3.04	242		252	252	1,331
Collins_1999_006_B100HE	298		B100HE	15	440	300	300	1,000	300,000	500	76	5,400	76	2,662	2.88	925	30	2,800	1.009	1.009	550					10	95.6		5.07	210		220	220	1,331
Collins_1999_007_B100L-R	299		B100L-R	15	440	300	300	1,000	300,000	500	76	5,400	76	2,662	2.88	925	16	2,800	1.009	1.009	483					10	36.6		3.23	228		238	238	1,331
DiazdeCossio_1960_002_A-2	301	Diaz de Cossio;	A-2	5	150	152	152	305	46,452	152	152	1,829	152	838	3.30	254	13	380	0.982	0.982	469					25	29.1	2.53	2.75	42		42	42	419
DiazdeCossio_1960_003_A-3	302	Siess (1960)	A-3	5	180	152	152	305	46,452	152	152	2,337	152	1,092	4.30	254	13	380	0.982	0.982	452					25	17.0	2.14	1.87	34		35	35	546
DiazdeCossio_1960_007_A-12	306		A-12	5	150	152	152	305	46,452	152	152	1,829	152	838	3.30	254	29	1,289	3.331	3.331	314					25	24.3	2.22	2.42	59		59	59	419
DiazdeCossio_1960_008_A-13	307		A-13	5	180	152	152	305	46,452	152	152	2,337	152	1,092	4.30	254	29	1,289	3.331	3.331	393					25	19.7	1.95	2.08	47		48	48	546
DiazdeCossio_1960_009_A-14	308		A-14	5	220	152	152	305	46,452	152	152	2,845	152	1,346	5.30	254	29	1,289	3.331	3.331	364					25	25.1	2.10	2.48	55		56	56	673
Drangsholt_1990_001_B11	310	Drangsholt;	B11	5	150	150	150	250	37,500	125	40	2,300	974	663	3.00	221	16	603	1.820	1.820	485		10	157		16	51.6	3.39	4.10			58	59	332
Drangsholt_1990_003_B13	312	Thorenfeld (1992)	B13	5	200	150	150	250	37,500	125	40	2,300	644	828	4.00	207	16	1,005	3.238	3.238	485		10	157		16	51.6	3.39	4.10			70	71	414

Figure A.2: *Shear Critical Beam Database (No Stirrups - Part 2/11)*

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Notation	**Nr.**	**Literature**	**ID**	**Modelling**		**Section Properties**					**Loading and Geometry**					**Tension Reinf.**						**Compression Reinf.**				**Conc. Comp.**		**Conc. Tens.**		**Test Results**				
				Load Step	Ele. Size	b	b_w	h	A_c	z_{c2}	a_F	L	c	a	a/d	d_s	Φ_{st}	A_s	r_s	r_w	f_{sy}	d_{s2}	Φ_{st2}	A_{s2}	f_{sy2}	Φ_a	f'c	$f_{ct,test}$	$f_{ct,m,cal}$	F	$V_{u,F}+g_{Rep}$	$V_{u,Rep}$	$V_{u,g}+F$	x_r
-	-	-	-	kN	mm	mm	mm	mm	mm²	mm	mm	mm	mm	mm	-	mm	mm	mm²	%	%	MPa	mm	mm	mm²	MPa	mm	MPa	MPa	MPa	kN	kN	kN	kN	mm
Drangsholt_1990_004_B14	313		B14	5	150	150	150	250	37,500	125	40	2,300	1,058	621	3.00	207	16	1,005	3.238	3.238	485		10	157		16	51.6	3.39	4.10			83	83	311
Drangsholt_1990_006_B21	315		B21	5	150	150	150	250	37,500	125	40	2,300	974	663	3.00	221	16	603	1.820	1.820	485		10	157		16	75.4	3.94	4.68			68	69	332
Drangsholt_1990_008_B23	317		B23	5	200	150	150	250	37,500	125	40	2,300	644	828	4.00	207	16	1,005	3.238	3.238	485		10	157		16	75.4	3.94	4.68			78	78	414
Drangsholt_1990_009_B24	318		B24	5	150	150	150	250	37,500	125	40	2,300	1,058	621	3.00	207	16	1,005	3.238	3.238	485		10	157		16	75.4	3.94	4.68			83	83	311
Drangsholt_1990_016_B43	320	Drangsholt;	B43	5	200	150	150	250	37,500	125	40	2,300	644	828	4.00	207	16	1,005	3.238	3.238	485		10	157		16	84.0	4.19	4.85			86	87	414
Drangsholt_1990_017_B44	321	Thorenfeld (1992)	B44	5	150	150	150	250	37,500	125	40	2,300	1,058	621	3.00	207	16	1,005	3.238	3.238	485		10	157		16	84.0	4.19	4.85			107	108	311
Drangsholt_1990_019_B51	323		B51	5	150	150	150	250	37,500	125	40	2,300	974	663	3.00	221	16	603	1.820	1.820	485		10	157		16	95.3	4.38	5.06			56	57	332
Drangsholt_1990_021_B53	325		B53	5	200	150	150	250	37,500	125	40	2,300	644	828	4.00	207	16	1,005	3.238	3.238	485		10	157		16	95.3	4.38	5.06			77	78	414
Drangsholt_1990_022_B54	326		B54	5	150	150	150	250	37,500	125	40	2,300	1,058	621	3.00	207	16	1,005	3.238	3.238	485		10	157		16	95.3	4.38	5.06			78	78	311
Drangsholt_1990_024_B61	328		B61	5	220	300	300	500	150,000	250	80	4,600	1,948	1,326	3.00	442	32	2,413	1.820	1.820	485		20	628		16	75.4	4.24	4.68			180	186	663
Drangsholt_1990_026_B63	330		B63	5	270	300	300	500	150,000	250	80	4,600	1,288	1,656	4.00	414	32	4,021	3.238	3.238	485		20	628		16	75.4	4.24	4.68			229	235	828
Drangsholt_1990_027_B64	331		B64	5	220	300	300	500	150,000	250	80	4,600	2,116	1,242	3.00	414	32	4,021	3.238	3.238	485		20	628		16	75.4	4.24	4.68			281	287	621
Elzanaty_1986_002_F11	334	Elzanaty;	F11	5	250	178	178	305	54,193	152		3,239	1,080	1,080	4.00	270	19	570	1.188	1.188	434					13	18.3		1.97			44	45	540
Elzanaty_1986_003_F12	335	Nilson;	F12	5	250	178	178	305	54,193	152		3,219	1,073	1,073	4.00	268	22	1,164	2.440	2.440	434					13	18.3		1.97			53	54	707
Elzanaty_1986_004_F8	336	Slate (1986)	F8	5	250	178	178	305	54,193	152		3,277	1,092	1,092	4.00	273	13	451	0.930	0.930	434					13	37.6		3.29			45	46	546
Elzanaty_1986_005_F13	337		F13	5	250	178	178	305	54,193	152		3,239	1,080	1,080	4.00	270	19	570	1.188	1.188	434					13	37.6		3.29			48	49	540
Elzanaty_1986_006_F14	338		F14	5	250	178	178	305	54,193	152		3,219	1,073	1,073	4.00	268	22	1,164	2.440	2.440	434					13	37.6		3.29			63	65	537
Elzanaty_1986_007_F1	339		F1	5	250	178	178	305	54,193	152		3,239	1,080	1,080	4.00	270	19	570	1.188	1.188	434					13	63.1		4.40			57	59	564
Elzanaty_1986_008_F2	340		F2	5	250	178	178	305	54,193	152		3,219	1,073	1,073	4.00	268	22	1,164	2.440	2.440	434					13	63.1		4.40			66	67	547
Elzanaty_1986_009_F10	341		F10	5	250	178	178	305	54,193	152		3,200	1,067	1,067	4.00	267	25	1,520	3.206	3.206	434					13	63.1		4.40			75	76	533
Elzanaty_1986_010_F9	342		F9	5	250	178	178	305	54,193	152		3,219	1,073	1,073	4.00	268	22	776	1.627	1.627	434					13	76.9		4.71			62	64	537
Elzanaty_1986_011_F15	343		F15	5	250	178	178	305	54,193	152		3,219	1,073	1,073	4.00	268	22	1,164	2.440	2.440	434					13	76.9		4.71			66	68	537
Elzanaty_1986_015_F6	347		F6	5	400	178	178	305	54,193	152		4,829	1,610	1,610	6.00	268	22	1,164	2.440	2.440	434					13	61.0		4.35			60	62	805
Feldman_1955_002_ L-2	349	Feldman;	L-2	5	150	152	152	305	46,452	152	152	2,438	914	762	3.02	252	29	1,290	3.353	3.353	310					25	19.1	1.61	2.04	76		76	76	544
Feldman_1955_003_ L-2A	350	Siess (1955)	L-2A	5	150	152	152	305	46,452	152	152	2,438	914	762	3.02	252	29	1,290	3.353	3.353	283					25	34.3	2.64	3.09	80		81	81	497
Feldman_1955_004_ L-3	351		L-3	5	150	152	152	305	46,452	152	152	2,946	914	1,016	4.02	252	29	1,290	3.353	3.353	310					25	25.6	2.14	2.51	53		54	54	648
Feldman_1955_005_L-4	352		L-4	5	200	152	152	305	46,452	152	152	3,454	914	1,270	5.03	252	29	1,290	3.353	3.353	303					25	23.4	2.14	2.36	51		52	52	940
Feldman_1955_006_ L-5	353		L-5	5	250	152	152	305	46,452	152	152	3,962	914	1,524	6.04	252	29	1,290	3.353	3.353	331					25	25.5	2.39	2.51	51		52	52	1,029
Feldman_1955_009_L2R	356		L2R	5	150	152	152	305	46,452	152	76	1,524	76	724	2.87	252	29	1,290	3.353	3.353	310					25	19.1	1.61	2.04	75		75	75	686
Feldman_1955_010_L2aR	357		L2aR	5	150	152	152	305	46,452	152	76	1,524	76	724	2.87	252	29	1,290	3.353	3.353	283					25	34.3	2.64	3.09	93		93	93	362
Feldman_1955_011_L3R	358		L3R	5	150	152	152	305	46,452	152	76	2,032	76	978	3.87	252	29	1,290	3.353	3.353	310					25	25.6	2.14	2.51	62		62	62	489
Ferguson_1953_001_A1	359	Ferguson;	A1	2	100	432	102	241	37,097	86	102	1,626	203	711	3.39	210	25	1,013	1.120	4.760	276					6	27.3		2.63			29	29	356
Ferguson_1953_002_A2	360	Thompson (1953)	A2	2	100	432	102	241	37,097	86	102	1,626	203	711	3.39	210	25	1,013	1.120	4.760	276					6	24.9		2.46			27	27	356
Ferguson_1953_003_A3	361		A3	2	100	432	102	241	37,097	86	102	1,626	203	711	3.39	210	25	1,013	1.120	4.760	276					6	32.7		2.99			34	34	356
Ferguson_1953_004_A4	362		A4	2	100	432	102	241	37,097	86	102	1,626	203	711	3.39	210	25	1,013	1.120	4.760	276					6	32.6		2.98			32	32	356
Ferguson_1953_005_A5	363		A5	2	100	432	102	241	37,097	86	102	1,626	203	711	3.39	210	25	1,013	1.120	4.760	276					6	43.0		3.61			34	34	356
Ferguson_1953_006_A6	364		A6	2	100	432	102	241	37,097	86	102	1,626	203	711	3.39	210	25	1,013	1.120	4.760	276					6	36.3		3.21			36	36	356
Ferguson_1953_007_D1	365		D1	2	100	432	178	241	52,581	102	102	1,626	203	711	3.39	210	25	1,013	1.120	2.720	276					6	28.9		2.74			49	49	356
Ferguson_1953_008_D2	366		D2	2	100	432	178	241	52,581	102	102	1,626	203	711	3.39	210	25	1,013	1.120	2.720	276					6	27.2		2.62			52	53	356
Ferguson_1953_009_N1	367		N1	2	100	483	108	191	34,839	64	102	2,134	711	711	4.00	178	19	570	0.664	2.970	276					16	18.3		1.97			24	24	356
Ferguson_1953_010_N2	368		N2	2	100	483	108	191	34,839	64	102	2,134	711	711	4.00	178	19	570	0.664	2.970	276					16	18.2		1.97			24	25	356
Ferguson_1953_011_N3	369		N3	2	100	483	108	191	34,839	64	102	2,134	711	711	4.00	178	19	570	0.664	2.970	276					16	15.1		1.71			21	22	356
Ferguson_1953_012_G4	370		G4	2	100	559	108	140	32,258	43	102	2,134	711	711	6.22	114	19	570	0.892	4.620	276					16	20.5		2.14			14	15	356
Ferguson_1953_013_G5	371	Ferguson;	G5	2	100	559	108	140	32,258	43	102	2,134	711	711	6.22	114	19	570	0.892	4.620	276					16	19.3		2.05			16	16	356
Ferguson_1953_014_G6	372	Thompson (1953)	G6	2	100	559	108	140	32,258	43	102	2,134	711	711	6.22	114	19	570	0.892	4.620	276					16	19.5		2.06			18	18	356
Ferguson_1953_015_B1	373		B1	2	100	432	102	241	41,290	82	102	1,626	203	711	3.39	210	25	1,013	1.120	4.760	276					6	33.3		3.02			35	35	356
Ferguson_1953_016_B2	374		B2	2	100	432	102	241	41,290	82	102	1,626	203	711	3.39	210	25	1,013	1.120	4.760	276					6	31.1		2.88			32	32	356
Ferguson_1953_017_B3	375		B3	2	100	432	102	241	41,290	82	102	1,626	203	711	3.39	210	25	1,013	1.120	4.760	276					6	37.6		3.29			39	39	356
Ferguson_1953_018_B4	376		B4	2	100	432	102	241	41,290	82	102	1,626	203	711	3.39	210	25	1,013	1.120	4.760	276					6	41.0		3.50			44	44	356
Ferguson_1953_019_B5	377		B5	2	100	432	102	241	41,290	82	102	1,626	203	711	3.39	210	25	1,013	1.120	4.760	276					6	38.6		3.36			38	38	356
Ferguson_1953_020_C1	378		C1	2	100	432	102	241	43,806	80	102	1,626	203	711	3.39	210	25	1,013	1.120	4.760	276					6	31.1		2.88			50	50	356
Ferguson_1953_021_C2	379		C2	2	100	432	102	241	43,387	81	102	1,626	203	711	3.39	210	25	1,013	1.120	4.760	276					6	31.1		2.88			39	39	356
Ferguson_1953_022_L1	380		L1	2	100	483	108	191	65,766	71	102	2,134	711	711	4.48	159	19	570	0.744	3.326	276					16	19.3		2.05			27	28	356
Ferguson_1953_023_L2	381		L2	2	100	483	108	191	65,766	71	102	2,134	711	711	4.48	159	19	570	0.744	3.326	276					16	20.2		2.12			30	30	356
Ferguson_1953_024_L3	382		L3	2	100	483	108	191	65,766	71	102	2,134	711	711	4.48	159	19	570	0.744	3.326	276					16	19.8		2.09			27	28	356
Ferguson1_1956_001_F2	383	Ferguson (1956)	F2	2	100	101	101	210	21,131	105		1,524	305	610	3.23	189	16	396	2.077	2.077	310					6	26.9		2.60			22	22	305
Gabrielsson_1993_002_SAR3	388	Gabrielsson (1993)	SAR3	5	150	200	200	298	59,600	149		2,500	300	1,100	4.23	260	16	1,608	3.093	3.093	652						134.6	3.26	5.69	107		108	108	550
Gabrielsson_1993_003_HP1	389		HP1	5	150	200	200	238	47,600	119		1,900	300	800	4.00	200	16	1,206	3.016	3.016	686						136.6	3.53	5.72	109		109	109	400
Gabrielsson_1993_004_HP3	390		HP3	5	150	200	200	238	47,600	119		1,900	300	800	4.00	200	16	1,608	4.021	4.021	661						122.6	3.53	5.51	102		102	102	400
Gabrielsson_1993_005_HP5	391		HP5	5	150	200	200	238	47,600	119		1,900	300	800	4.00	200	16	1,608	4.021	4.021	661						105.6	3.06	5.24	109		110	110	400
Ghannoum_1998_003_N155 (N)	397	Ghannoum (1998)	N155 (N)	5	100	400	400	155	62,000	78	100	1,138	500	319	2.50	128	16	1,000	1.961	1.961	444					20	31.8	2.77	2.93			112	113	159
Ghannoum_1998_004_N155 (S)	398		N155 (S)	5	100	400	400	155	62,000	78	100	1,138	500	319	2.50	128	16	600	1.176	1.176	444					20	31.8	2.77	2.93			85	85	159
Ghannoum_1998_005_N220 (N)	399		N220 (N)	5	100	400	400	220	88,000	110	100	1,450	500	475	2.50	190	20	1,500	1.974	1.974	433					20	31.8	2.77	2.93			123	124	238
Ghannoum_1998_006_N220 (S)	400		N220 (S)	5	100	400	400	220	88,000	110	100	1,450	500	475	2.50	190	20	900	1.184	1.184	433					20	31.8	2.77	2.93			104	105	238
Ghannoum_1998_007_N350 (N)	401		N350 (N)	10	200	400	400	350	140,000	175	100	2,063	500	781	2.50	313	25	2,500	2.000	2.000	436	40	11	200	477	20	31.8	2.77	2.93			179	181	391
Ghannoum_1998_008_N350 (S)	402		N350 (S)	10	200	400	400	350	140,000	175	100	2,063	500	781	2.50	313	25	1,500	1.200	1.200	436	40	11	200	477	20	31.8	2.77	2.93			158	160	391
Ghannoum_1998_009_N485 (N)	403		N485 (N)	10	250	400	400	485	194,000	243	100	2,700	500	1,100	2.50	440	30	3,500	1.989	1.989	385	40	11	200	477	20	31.8	2.77	2.93			215	219	550
Ghannoum_1998_010_N485 (S)	404		N485 (S)	10	250	400	400	485	194,000	243	100	2,700	500	1,100	2.50	440	30	2,100	1.193	1.193	385	40	11	200	477	20	31.8	2.77	2.93			188	191	550
Ghannoum_1998_011_N960 (N)	405		N960 (N)	20	350	400	400	960	384,000	480	100	4,945	500	2,223	2.50	889	30	7,000	1.969	1.969	385	40	16	400	444	20	31.8	2.77	2.93			386	399	1,111
Ghannoum_1998_012_N960 (S)	406		N960 (S)	20	350	400	400	960	384,000	480	100	4,945	500	2,223	2.50	889	30	4,200	1.181	1.181	385	40	16	400	444	20	31.8	2.77	2.93			367	379	1,111
Ghannoum_1998_013_H90 (N)	407		H90 (N)	5	50	400	400	90	36,000	45	100	825	500	163	2.50	65	11	500	1.923	1.923	648					10	56.2	3.14	4.23			77	78	81
Ghannoum_1998_014_H90 (S)	408		H90 (S)	5	50	400	400	90	36,000	45	100	825	500	163	2.50	65	11	300	1.154	1.154	648					10	56.2	3.14	4.23			52	52	81
Ghannoum_1998_015_H155 (N)	409		H155 (N)	5	100	400	400	155	62,000	78	100	1,138	500	319	2.50	128	16	1,000	1.961	1.961	444					10	56.2	3.14	4.23			105	106	159
Ghannoum_1998_016_H155 (S)	410		H155 (S)	5	100	400	400	155	62,000	78	100	1,138	500	319	2.50	128	16	600	1.176	1.176	444					10	56.2	3.14	4.23			77	77	159
Ghannoum_1998_017_H220 (N)	411		H220 (N)	10	100	400	400	220	88,000	110	100	1,450	500	475	2.50	190	20	1,500	1.974	1.974	433					10	56.2	3.14	4.23			135	136	238

Figure A.3: *Shear Critical Beam Database (No Stirrups - Part 3/11)*

Notation	Nr.	Literature	ID	Modelling		Section Properties					Loading and Geometry					Tension Reinf.						Compression Reinf.				Conc. Comp.		Conc. Tens.		Test Results				
				Load Step	Ele. Size	b	b_w	h	A_c	z_{c2}	a_F	L	c	a	a/d	d_s	Φ_{st}	A_s	r_s	r_w	f_{sy}	d_{s2}	Φ_{st2}	A_{s2}	f_{sy2}	Φ_a	f'c	$f_{ct,test}$	$f_{ct,m,cal}$	F	$V_{u,F}+g_{Rep}$	$V_{u,Rep}$	$V_{u,g}+F$	x_r
-	-	-	-	kN	mm	mm	mm	mm	mm²	mm	mm	mm	mm	mm	-	mm	mm	mm²	%	%	MPa	mm	mm	mm²	MPa	mm	MPa	MPa	MPa	kN	kN	kN	kN	mm
Ghannoum_1998_018_H220 (S)	412		H220 (S)	10	100	400	400	220	88,000	110	100	1,450	500	475	2.50	190	20	900	1.184	1.184	433					10	56.2	3.14	4.23			106	107	238
Ghannoum_1998_019_H350 (N)	413		H350 (N)	20	200	400	400	350	140,000	175	100	2,063	500	781	2.50	313	25	2,500	2.000	2.000	436	40	11	200	477	10	56.2	3.14	4.23			190	192	391
Ghannoum_1998_020_H350 (S)	414		H350 (S)	15	200	400	400	350	140,000	175	100	2,063	500	781	2.50	313	25	1,500	1.200	1.200	436	40	11	200	477	10	56.2	3.14	4.23			157	159	391
Ghannoum_1998_021_H485 (N)	415		H485 (N)	20	250	400	400	485	194,000	243	100	2,700	500	1,100	2.50	440	30	3,500	1.989	1.989	385	40	11	200	477	10	56.2	3.14	4.23			199	203	550
Ghannoum_1998_022_H485 (S)	416		H485 (S)	20	250	400	400	485	194,000	243	100	2,700	500	1,100	2.50	440	30	2,100	1.193	1.193	385	40	11	200	477	10	56.2	3.14	4.23			199	202	550
Ghannoum_1998_023_H960 (N)	417		H960 (N)	20	350	400	400	960	384,000	480	100	4,945	500	2,223	2.50	889	30	7,000	1.969	1.969	385	40	16	400	444	10	56.2	3.14	4.23			337	350	1,111
Ghannoum_1998_024_H960 (S)	418		H960 (S)	20	350	400	400	960	384,000	480	100	4,945	500	2,223	2.50	889	30	4,200	1.181	1.181	385	40	16	400	444	10	56.2	3.14	4.23			317	329	1,111
Grimm_1997_001_S 1.1	419	Grimm, R. (1997)	S 1.1	5	100	300	300	200	60,000	100	50	1,540	400	570	3.73	153	14	616	1.342	1.342	660					16	87.7	5.80	4.92			70	71	273
Grimm_1997_002_S 1.2	420		S 1.2	5	100	300	300	200	60,000	100	50	1,540	400	570	3.75	152	16	1,005	2.205	2.205	517					16	88.8	3.80	4.94			75	76	293
Grimm_1997_003_S 1.3	421		S 1.3	5	100	300	300	200	60,000	100	50	1,540	400	570	3.90	146	28	1,847	4.217	4.217	487					16	91.3	4.26	4.99			99	99	277
Grimm_1997_004_S 2.2	422	Grimm, R. (1997)	S 2.2	15	200	300	300	400	120,000	200	120	3,260	800	1,230	3.53	348	25	1,963	1.881	1.881	469					16	88.9	3.80	4.95			191	194	615
Grimm_1997_005_S 2.4	423		S 2.4	15	200	300	300	400	120,000	200	120	3,260	800	1,230	3.75	328	28	3,695	3.755	3.755	487					16	91.7	4.33	5.00			230	233	625
Grimm_1997_006_S 3.2	424		S 3.2	20	400	300	300	800	240,000	400	250	6,860	1,600	2,630	3.66	718	28	3,695	1.715	1.715	487					16	91.3	4.26	4.99			258	270	1,387
Grimm_1997_007_S 3.3	425		S 3.3	15	400	300	300	800	240,000	400	250	6,860	1,600	2,630	3.53	746	28	1,847	0.825	0.825	487					16	92.0	5.01	5.00			201	215	1,063
Grimm_1997_008_S 3.4	426		S 3.4	20	400	300	300	800	240,000	400	250	6,860	1,600	2,630	3.81	690	28	7,389	3.570	3.570	487					16	91.7	4.33	5.00			381	393	1,315
Grimm_1997_009_S 4.1	427		S 4.1	5	100	300	300	200	60,000	100	50	1,540	400	570	3.73	153	14	616	1.342	1.342	660					16	108.5	5.39	5.29			74	75	309
Grimm_1997_010_S 4.2	428		S 4.2	10	100	300	300	200	60,000	100	50	1,540	400	570	3.75	152	16	1,005	2.205	2.205	517					16	108.5	5.39	5.29			90	91	293
Grimm_1997_011_S 4.3	429		S 4.3	10	100	300	300	200	60,000	100	50	1,540	400	570	3.90	146	28	1,847	4.217	4.217	487					16	108.5	5.39	5.29			122	123	208
Haddadin_1971_001_A1	430	Haddadin; Hong;	A1	10	150	610	178	470	127,419	172		1,905		953	2.50	381	29	2,579	1.110	3.807	517		10	143	517		27.1	2.14	2.62			117	118	476
Haddadin_1971_002_C1	431	Mattock (1971)	C1	10	250	610	178	470	127,419	172		3,239		1,619	4.25	381	29	2,579	1.110	3.807	517		10	143	517		23.5	2.48	2.37			87	90	810
Haddadin_1971_003_E1	432		E1	10	150	610	178	470	127,419	172		1,905		953	2.50	381	29	2,579	1.110	3.807	517		10	143	517		11.5	1.30	1.40			99	101	476
Haddadin_1971_004_J1	433		J1	10	150	610	178	470	127,419	172		1,905		953	2.50	381	29	2,579	1.110	3.807	517		10	143	517		23.3	2.23	2.35			122	124	476
Hallgreen1_1994_001_B90SB5-2-33	434	Hallgren (1994)	B90SB5-2-33	5	100	156	156	232	36,192	116	100	2,000	600	700	3.66	191	12	678	2.272	2.272	651					18	30.4	3.06	2.84	56	57	57	350	
Hallgreen1_1994_002_B90SB6-2-33	435		B90SB6-2-33	5	100	156	156	235	36,660	118	100	2,000	600	700	3.61	194	12	678	2.241	2.241	651					18	30.4	3.06	2.84	54	54	54	350	
Hallgreen1_1994_003_B90SB9-2-31	436		B90SB9-2-31	5	100	156	156	233	36,348	117	100	2,000	600	700	3.65	192	12	678	2.266	2.266	651					18	28.7	2.88	2.72	49	50	50	350	
Hallgreen1_1994_004_B90SB10-2-31	437		B90SB10-2-31	5	100	157	157	234	36,738	117	100	2,000	600	700	3.63	193	12	667	2.202	2.202	651					18	28.7	2.88	2.72	54	54	54	350	
Hallgreen1_1994_005_B90SB13-2-86	438		B90SB13-2-86	5	100	163	163	233	37,979	117	100	2,000	600	700	3.65	192	12	678	2.169	2.169	630					18	83.8	6.03	4.85	83	83	83	350	
Hallgreen1_1994_006_B90SB14-2-86	439		B90SB14-2-86	5	100	158	158	235	37,130	118	100	2,000	600	700	3.61	194	12	678	2.213	2.213	630					18	83.8	6.03	4.85	77	77	77	350	
Hallgreen1_1994_007_B90SB17-2-45	440		B90SB17-2-45	5	100	157	157	232	36,424	116	100	2,000	600	700	3.66	191	12	678	2.258	2.258	630					18	42.5	3.24	3.58	59	60	60	350	
Hallgreen1_1994_008_B90SB18-2-45	441		B90SB18-2-45	5	100	155	155	235	36,425	118	100	2,000	600	700	3.61	194	12	678	2.256	2.256	630					18	42.5	3.24	3.58	63	64	64	350	
Hallgreen1_1994_009_B90SB21-2-85	442		B90SB21-2-85	5	100	155	155	235	36,425	118	100	2,000	600	700	3.61	194	12	678	2.256	2.256	630					18	82.2	5.40	4.82	69	70	70	350	
Hallgreen1_1994_010_B90SB22-2-85	443		B90SB22-2-85	5	100	158	158	234	36,972	117	100	2,000	600	700	3.63	193	12	678	2.225	2.225	630					18	82.2	5.40	4.82	76	76	76	350	
Hallgreen1_1994_011_B91SC1-2-62	444		B91SC1-2-62	5	100	156	156	234	36,504	117	100	2,000	600	700	3.63	193	12	678	2.254	2.254	443					18	59.4	4.95	4.31	71	72	72	350	
Hallgreen1_1994_012_B91SC2-2-62	445		B91SC2-2-62	5	100	155	155	237	36,735	119	100	2,000	600	700	3.57	196	12	678	2.231	2.231	443					18	59.4	4.95	4.31	70	70	70	350	
Hallgreen1_1994_013_B91SC3-2-69	446		B91SC3-2-69	5	100	155	155	235	36,425	118	100	2,000	600	700	3.61	194	12	678	2.256	2.256	443					18	66.7	4.68	4.49	77	77	77	350	
Hallgreen1_1994_014_B91SC4-2-69	447		B91SC4-2-69	5	100	156	156	236	36,816	118	100	2,000	600	700	3.59	195	12	678	2.229	2.229	443					18	66.7	4.68	4.49	74	75	75	350	
Hallgreen1_1994_015_B91SD1-4-61	448		B91SD1-4-61	5	100	156	156	247	38,532	124	100	2,000	600	700	3.61	194	16	1,206	3.987	3.987	494					18	58.4	4.32	4.29	89	89	89	350	
Hallgreen1_1994_016_B91SD2-4-61	449		B91SD2-4-61	5	100	156	156	248	38,688	124	100	2,000	600	700	3.59	195	16	1,206	3.965	3.965	494					18	58.4	4.32	4.29	90	91	91	438	
Hallgreen1_1994_017_B91SD3-4-66	450		B91SD3-4-66	5	100	156	156	248	38,688	124	100	2,000	600	700	3.59	195	16	1,206	3.965	3.965	494					18	63.3	4.41	4.41	82	82	82	350	
Hallgreen1_1994_018_B91SD4-4-66	451		B91SD4-4-66	5	100	155	155	248	38,440	124	100	2,000	600	700	3.59	195	16	1,206	3.990	3.990	494					18	63.3	4.41	4.41	79	80	80	350	
Hallgreen1_1994_019_B91SD5-4-58	452		B91SD5-4-58	5	100	156	156	249	38,844	125	100	2,000	600	700	3.58	196	16	1,206	3.954	3.954	494					18	55.9	4.59	4.22	78	79	79	429	
Hallgreen1_1994_020_B91SD6-4-58	453		B91SD6-4-58	5	100	150	150	249	37,350	125	100	2,000	600	700	3.58	196	16	1,206	4.112	4.112	494					18	55.9	4.59	4.22	83	83	83	375	
Hallgreen2_1996_003_B3	456	Hallgren (1996)	B3	10	100	262	262	240	62,880	120		1,350	250	550	2.64	208	16	402	0.738	0.738	632					18	90.0	5.85	4.97	76	76	76	275	
Hallgreen2_1996_005_B5	458		B5	10	100	283	283	240	67,920	120		1,350	250	550	2.61	211	20	628	1.052	1.052	604					18	88.9	6.30	4.95	104	104	104	275	
Hallgreen2_1996_007_B7	460		B7	10	100	337	337	240	80,880	120		1,350	250	550	2.64	208	16	402	0.574	0.574	630					18	82.6	6.66	4.82	89	89	89	275	
Hamadi_1976_001_G1	461	Hamadi (1976)	G1	5	200	100	100	400	40,000	200	50	2,560	50	1,255	3.39	370	20	628	1.698	1.698	400					20	27.9		2.67	45	45	45	795	
Hamadi_1976_002_G2	462		G2	5	200	100	100	400	40,000	200	50	2,560	50	1,255	3.37	372	16	402	1.081	1.081	460					20	21.1		2.19	41	41	41	843	
Hamadi_1976_004_G4a	464		G4a	5	350	100	100	400	40,000	200	50	4,440	50	2,195	5.90	372	16	402	1.081	1.081	800					20	19.6		2.07	30	31	31	1,520	
Hamadi_1976_005_G4b	465		G4b	5	200	100	100	400	40,000	200	50	4,440	1,880	1,280	3.44	372	16	402	1.081	1.081	800					20	18.6		1.99	37	39	39	640	
Hanson1_1958_001_8A-X	466	Hanson (1958)	8A-X	5	110	152	152	305	46,452	152	102	1,981	660	660	2.48	267	25	1,013	2.493	2.493	333						23.1		2.34	80	81	81	330	
Hanson1_1958_002_8A	467		8A	5	110	152	152	305	46,452	152	102	1,981	660	660	2.48	267	25	1,013	2.493	2.493	333						25.3		2.49	58	58	58	330	
Hanson1_1958_003_8B	468		8B	5	110	152	152	305	46,452	152	102	1,981	660	660	2.48	267	25	1,013	2.493	2.493	333						34.7		3.11	90	91	91	330	
Hanson1_1958_004_8C	469		8C	5	110	152	152	305	46,452	152	102	1,981	660	660	2.48	267	25	2,027	4.987	4.987	333						55.6		4.21	127	128	128	330	
Hanson1_1958_005_8D	470		8D	5	110	152	152	305	46,452	152	102	1,981	660	660	2.48	267	25	2,027	4.987	4.987	333						71.3		4.59	165	166	166	330	
Hanson2_1961_001_8A4	471	Hanson (1961)	8A4	2	200	152	152	305	46,452	152	102	3,048	406	1,321	4.95	267	13	507	1.247	1.247	611						18.5		1.99	34	35	35	660	
Hanson2_1961_002_8B4	472		8B4	2	200	152	152	305	46,452	152	102	3,048	406	1,321	4.95	267	13	507	1.247	1.247	611						28.6		2.72	43	44	44	660	
Hanson2_1961_003_8BW4	473		8BW4	2	200	152	152	305	46,452	152	102	3,048	406	1,321	4.95	267	13	507	1.247	1.247	611						27.3		2.63	40	41	41	660	
Hanson2_1961_004_8B2	474		8B2	2	200	152	152	305	46,452	152	102	3,048	406	1,321	4.95	267	22	1,424	3.505	3.505	636						28.4		2.71	52	53	53	660	
Hanson2_1961_005_8B3	475		8B3	2	100	152	152	305	46,452	152	102	1,981	660	660	2.48	267	13	507	1.247	1.247	334						27.7		2.66	46	47	47	330	
Hedmann_1978_001_A4	476	Hedmann; Losberg (1978)	A4	2	200	152	152	297	45,093	148				1,321	4.95	267	13	507	1.249	1.249	611					13	17.5		1.91		34	35	661	
Hedmann_1978_002_B4	477		B4	2	200	152	152	297	45,093	148				1,321	4.95	267	13	507	1.249	1.249	611					13	27.0		2.61		43	44	661	
Hedmann_1978_003_BW4	478		BW4	2	200	152	152	297	45,093	148				1,321	4.95	267	13	507	1.249	1.249	611					13	25.8		2.53		40	41	661	
Hedmann_1978_004_B2	479		B2	2	200	152	152	297	45,093	148				1,321	4.95	267	22	901	2.220	2.220	645					13	26.9		2.60		52	53	661	
Islam_1998_001_M100-S0	480	Islam;	M100-S0	5	120	150	150	250	37,500	125	100	2,200	600	800	3.94	203	25	982	3.224	3.224	532	47	25	982	532	10	80.9		4.79		65	66	400	
Islam_1998_002_M80-S0	481	Pam;	M80-S0	5	120	150	150	250	37,500	125	100	2,200	600	800	3.94	203	25	982	3.224	3.224	532	47	25	982	532	10	69.8		4.56		58	59	400	
Islam_1998_003_M60-S0	482	Kwan (1998)	M60-S0	5	120	150	150	250	37,500	125	100	2,200	600	800	3.86	207	20	628	2.024	2.024	554	43	20	628	554	10	48.4		3.92		46	46	400	
Islam_1998_004_M40-S0	483		M40-S0	5	120	150	150	250	37,500	125	100	2,200	600	800	3.90	205	25	982	3.193	3.193	320	45	25	982	320	10	32.0		2.94		55	56	400	
Islam_1998_005_M25-S0	484		M25-S0	5	120	150	150	250	37,500	125	100	2,200	600	800	3.86	207	20	628	2.024	2.024	350	43	20	628	350	10	24.2		2.41		48	48	400	
Johnson_1989_001_6	485	Johnson; Ramirez (1989)	6	20	400	305	305	610	185,806	305	229	4,255	914	1,670	3.10	539	32	4,086	2.489	2.489	525	46	29	1,289	540	19	53.5		4.16	191	197	197	835	
Kani_1967_001_40	486	Kani (1967)	40	2	100	152	152	152	23,110	76	89	1,952	457	747	5.35	140	19	548	2.589	2.589	388					19	24.0		2.40		32	0	374	
Kani_1967_002_41	487		41	2	50	152	152	152	23,226	76	89	1,137	457	340	2.41	141	19	561	2.608	2.608	381					19	24.8		2.46		51	0	170	
Kani_1967_003_43	488		43	2	100	151	151	152	23,071	76	89	2,083	457	813	5.93	137	19	568	2.734	2.734	392					19	25.6		2.51		29	0	406	
Kani_1967_007_47	492		47	2	100	151	151	152	23,032	76	89	1,814	457	678	5.13	132	19	568	2.844	2.844	392					19	22.4		2.28		28	0	339	
Kani_1967_008_48	493		48	2	100	151	151	152	23,032	76	89	1,814	457	678	5.09	133	19	568	2.817	2.817	392					19	22.4		2.28		27	0	339	

Figure A.4: *Shear Critical Beam Database (No Stirrups - Part 4/11)*

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Notation	**Nr.**	**Literature**	**ID**	**Modelling**		**Section Properties**					**Loading and Geometry**					**Tension Reinf.**						**Compression Reinf.**				**Conc. Comp.**		**Conc. Tens.**		**Test Results**				
				Load Step	Ele. Size	b	b_w	h	A_c	z_{c2}	a_F	L	c	a	a/d	d_s	Φ_{st}	A_s	r_s	r_w	f_{sy}	d_{s2}	Φ_{st2}	A_{s2}	f_{sy2}	Φ_a	f'c	$f_{ct,test}$	$f_{ct,m,cal}$	F	$V_{u,F}+g_{Rep}$	$V_{u,Rep}$	$V_{u,g}+F$	x_r
-	-	-	-	kN	mm	mm	mm	mm	mm²	mm	mm	mm	mm	mm	-	mm	mm	mm²	%	%	MPa	mm	mm	mm²	MPa	mm	MPa	MPa	MPa	kN	kN	kN	kN	mm
Kani_1967_009_52	494		52	2	100	152	152	152	23,226	76	89	1,544	457	544	3.93	138	19	568	2.691	2.691	392					19	22.4	2.29			29	0	272
Kani_1967_012_55	497		55	2	100	150	150	152	22,916	76	89	1,270	457	406	3.02	135	19	568	2.805	2.805	392					19	22.7	2.31			33	0	203
Kani_1967_013_56	498		56	2	100	153	153	152	23,342	76	89	1,409	457	476	3.46	137	19	561	2.667	2.667	403					19	24.8	2.46			28	0	238
Kani_1967_014_57	499		57	2	100	153	153	152	23,342	76	89	1,952	457	747	5.39	139	19	555	2.612	2.612	375					19	24.0	2.40			32	0	374
Kani_1967_015_58	500		58	2	100	152	152	152	23,226	76	89	1,409	457	476	3.44	138	19	561	2.661	2.661	417					19	24.8	2.46			29	0	238
Kani_1967_016_59	501		59	2	100	154	154	152	23,535	76	89	1,203	457	373	2.67	140	19	568	2.632	2.632	392					19	24.2	2.42			50	0	186
Kani_1967_017_60	502		60	2	100	155	155	152	23,613	76	89	1,271	457	407	2.93	139	19	568	2.642	2.642	392					19	24.4	2.43			39	0	203
Kani_1967_018_81	503		81	5	250	153	153	305	46,761	152		4,170	914	1,628	5.93	274	25	1,161	2.759	2.759	343					19	25.1	2.48			51	0	814
Kani_1967_020_83	505		83	5	100	156	156	305	47,535	152		2,542	914	814	3.00	271	25	1,161	2.745	2.745	343					19	25.0	2.47			65	0	407
Kani_1967_021_84	506		84	5	200	151	151	305	46,064	152		3,085	914	1,085	4.00	271	25	1,161	2.835	2.835	342					19	25.0	2.47			55	0	706
Kani_1967_023_91	508		91	5	250	154	154	305	47,071	152		4,170	914	1,628	6.06	269	25	1,123	2.705	2.705	364					19	25.0	2.47			51	0	814
Kani_1967_025_93	510		93	5	300	155	155	305	47,226	152		4,441	914	1,763	6.46	273	25	1,123	2.656	2.656	372					19	27.9	2.67			54	0	882
Kani_1967_027_95	512		95	5	100	153	153	305	46,761	152		2,271	914	678	2.47	275	25	1,161	2.752	2.752	338					19	22.9	2.32			73	0	339
Kani_1967_028_96	513		96	5	200	153	153	305	46,684	152		3,085	914	1,085	3.94	275	25	1,161	2.756	2.756	335					19	22.9	2.32			56	0	543
Kani_1967_029_97	514		97	5	200	152	152	305	46,452	152		2,545	914	815	2.95	276	25	1,129	2.681	2.681	366					19	24.8	2.46			62	0	408
Kani_1967_030_98	515		98	5	100	153	153	305	46,684	152		2,273	914	679	2.47	275	25	1,129	2.685	2.685	366					19	23.8	2.39			76	0	340
Kani_1967_031_99	516		99	5	100	152	152	305	46,452	152		2,273	914	679	2.50	272	25	1,129	2.726	2.726	366					19	23.8	2.39			77	0	340
Kani_1967_034_63	519		63	5	400	154	154	610	94,142	305	89	5,356	1,016	2,170	4.00	543	29	2,323	2.771	2.771	352					19	23.8	2.39			93	0	1,085
Kani_1967_035_64	520		64	5	900	156	156	610	95,226	305	89	9,697	1,016	4,340	8.03	541	29	2,323	2.751	2.751	352					19	23.3	2.35			79	0	2,170
Kani_1967_036_65	521		65	5	200	150	150	610	91,200	305	89	3,734	1,016	1,359	2.46	552	29	2,329	2.818	2.818	374					19	24.6	2.44			112	0	679
Kani_1967_037_66	522	Kani (1967)	66	10	750	156	156	610	95,226	305	89	7,527	1,016	3,255	6.01	541	29	2,323	2.747	2.747	352					19	24.0	2.40			91	0	1,628
Kani_1967_041_71	526		71	10	400	155	155	610	94,451	305		4,271	1,016	1,628	2.99	544	29	2,245	2.663	2.663	373					19	25.0	2.47			102	0	814
Kani_1967_043_74	528		74	10	400	152	152	610	92,903	305		4,277	1,016	1,631	3.12	523	29	2,265	2.840	2.840	366					19	24.8	2.46			108	0	815
Kani_1967_044_75	529		75	10	400	152	152	610	92,903	305		4,277	1,016	1,631	3.11	524	29	2,265	2.836	2.836	367					19	24.9	2.46			108	0	815
Kani_1967_045_76	530		76	10	200	152	152	610	92,903	305		3,734	1,016	1,359	2.63	518	29	2,265	2.870	2.870	372					19	28.4	2.70			115	0	679
Kani_1967_046_79	531		79	10	700	153	153	610	93,368	305		8,626	1,016	3,805	6.84	556	29	2,316	2.719	2.719	381					19	23.7	2.38			84	0	1,902
Kani_1967_048_3042	533		3042	10	400	154	154	1,219	187,664	610	305	7,506	2,032	2,737	2.50	1,095	32	4,555	2.703	2.703	375					19	24.0	2.40			237	0	1,368
Kani_1967_049_3043	534		3043	10	600	154	154	1,219	187,354	610	254	8,585	2,032	3,277	3.00	1,092	32	4,555	2.714	2.714	376					19	24.6	2.44			165	0	1,638
Kani_1967_050_3044	535		3044	10	900	152	152	1,219	185,806	610	254	10,759	2,032	4,364	3.98	1,097	32	4,555	2.724	2.724	376					19	27.1	2.62			159	0	2,842
Kani_1967_051_3045	536		3045	10	900	155	155	1,219	188,903	610	254	12,954	2,032	5,461	5.00	1,092	32	4,568	2.699	2.699	381					19	25.9	2.53			152	0	2,731
Kani_1967_052_3046	537		3046	10	1200	155	155	1,219	188,903	610	254	17,394	2,032	7,681	7.00	1,097	32	4,594	2.702	2.702	360					19	24.3	2.42			154	0	3,840
Kani_1967_053_3047	538		3047	10	1400	155	155	1,219	188,903	610	254	19,548	2,032	8,758	8.00	1,095	32	4,555	2.685	2.685	376					19	24.3	2.42			147	0	4,379
Kani_1967_054_271	539		271	10	400	611	611	305	186,271	152		4,176	914	1,631	6.07	269	32	4,510	2.746	2.746	377					19	24.6	2.44			217	0	815
Kani_1967_055_272	540		272	10	300	611	611	305	186,193	152		3,632	914	1,359	5.02	271	32	4,510	2.726	2.726	377					19	24.6	2.44			228	0	679
Kani_1967_056_273	541		273	10	200	612	612	305	186,580	152		3,089	914	1,087	4.01	271	32	4,510	2.716	2.716	377					19	24.8	2.45			206	0	544
Kani_1967_057_274	542		274	10	200	612	612	305	186,580	152		2,545	914	815	3.02	270	32	4,510	2.726	2.726	377					19	24.8	2.45			250	0	408
KaniHuggins_1979_002_266	544	Kani; Huggins;	266	2	100	153	153	305	46,684	152		2,261	914	673	2.48	272	8	207	0.498	0.498	396					19	15.7	1.76			32	0	337
KaniHuggins_1979_003_267	545	Wittkopp (1979)	267	2	150	153	153	305	46,761	152		2,813	914	949	3.53	269	8	213	0.515	0.515	400					19	18.3	1.97			24	0	475
KaniHuggins_1979_004_268	546		268	2	150	153	153	305	46,684	152		2,546	914	816	2.96	275	8	207	0.491	0.491	396					19	17.7	1.92			27	0	408
KaniHuggins_1979_007_246	549		246	2	150	153	153	305	46,684	152		2,819	914	952	3.47	274	8	213	0.507	0.507	400					19	25.2	2.48			25	0	476
KaniHuggins_1979_008_248	550		248	2	100	153	153	305	46,684	152		2,271	914	678	2.41	282	8	213	0.493	0.493	400					19	25.2	2.48			37	0	339
KaniHuggins_1979_015_179	557		179	2	100	153	153	305	46,684	152		2,271	914	678	2.57	264	8	213	0.526	0.526	400					19	29.9	2.81			34	0	339
KaniHuggins_1979_016_180	558		180	2	150	153	153	305	46,761	152		2,813	914	949	3.53	269	8	213	0.515	0.515	400					19	32.1	2.95			25	0	475
KaniHuggins_1979_019_143	561		143	2	150	154	154	305	46,839	152		3,085	914	1,085	3.96	274	10	314	0.744	0.744	428					19	15.3	1.73			30	0	543
KaniHuggins_1979_025_149	567		149	2	100	153	153	305	46,529	152		2,271	914	678	2.50	272	10	323	0.778	0.778	380					19	15.6	1.75			44	0	339
KaniHuggins_1979_026_150	568		150	2	100	153	153	305	46,761	152		2,271	914	678	2.48	273	10	323	0.770	0.770	380					19	15.6	1.75			46	0	339
KaniHuggins_1979_027_151	569		151	2	100	154	154	305	46,916	152		2,273	914	679	2.49	273	10	326	0.777	0.777	382					19	16.9	1.86			36	0	340
KaniHuggins_1979_028_152	570		152	2	150	149	149	305	45,522	152		2,545	914	815	3.02	270	10	319	0.790	0.790	384					19	17.3	1.89			32	0	408
KaniHuggins_1979_029_153	571		153	2	150	152	152	305	46,452	152		2,545	914	815	2.99	273	10	317	0.763	0.763	384					19	17.3	1.89			33	0	408
KaniHuggins_1979_031_103	573	Kani; Huggins;	103	2	150	155	155	305	47,303	152		2,542	914	814	2.97	274	10	314	0.738	0.738	423					19	27.0	2.61			39	0	407
KaniHuggins_1979_033_105	575	Wittkopp (1979)	105	2	100	152	152	305	46,452	152		2,273	914	679	2.50	272	10	320	0.773	0.773	383					19	23.8	2.39			42	0	340
KaniHuggins_1979_034_106	576		106	2	100	154	154	305	46,839	152		2,271	914	678	2.53	268	10	314	0.762	0.762	422					19	26.4	2.57			45	0	339
KaniHuggins_1979_035_107	577		107	2	200	154	154	305	47,071	152		3,627	914	1,356	5.08	267	10	314	0.761	0.761	422					19	24.2	2.41			26	0	678
KaniHuggins_1979_039_111	581		111	2	150	154	154	305	46,916	152		2,271	914	678	2.49	272	10	317	0.757	0.757	368					19	24.6	2.44			43	0	339
KaniHuggins_1979_040_112	582		112	2	100	153	153	305	46,606	152		2,271	914	678	2.48	273	10	317	0.759	0.759	368					19	24.6	2.44			39	0	339
KaniHuggins_1979_043_115	585		115	2	100	152	152	305	46,452	152		2,273	914	679	2.50	272	10	319	0.770	0.770	383					19	23.8	2.39			45	0	340
KaniHuggins_1979_044_116	586		116	2	150	152	152	305	46,452	152		2,545	914	815	3.01	271	10	321	0.776	0.776	384					19	24.0	2.40			39	0	408
KaniHuggins_1979_048_163	590		163	2	100	156	156	305	47,535	152		2,271	914	678	2.49	273	10	321	0.756	0.756	378					19	33.0	3.00			40	0	339
KaniHuggins_1979_049_163'	591		163'	2	100	152	152	305	46,219	152		2,271	914	678	2.50	272	10	321	0.780	0.780	378					19	33.0	3.00			38	0	339
KaniHuggins_1979_052_166	594		166	2	150	152	152	305	46,297	152		2,545	914	815	3.01	271	10	322	0.781	0.781	377					19	33.0	3.00			40	0	408
KaniHuggins_1979_053_166'	595		166'	2	150	154	154	305	46,839	152		2,545	914	815	2.97	274	10	320	0.759	0.759	379					19	33.0	3.00			38	0	408
KaniHuggins_1979_058_121	600		121	2	150	152	152	305	46,452	152		2,545	914	815	2.99	272	16	768	1.850	1.850	330					19	17.9	1.95			49	0	408
KaniHuggins_1979_059_122	601		122	2	150	150	150	305	45,677	152		3,089	914	1,087	3.94	276	16	761	1.843	1.843	343					19	17.5	1.91			39	0	544
KaniHuggins_1979_060_123	602		123	2	150	155	155	305	47,381	152		3,085	914	1,085	4.00	271	16	755	1.790	1.790	346					19	13.0	1.53			38	0	543
KaniHuggins_1979_061_124	603		124	2	200	154	154	305	47,071	152		3,627	914	1,356	5.00	271	16	755	1.802	1.802	345					19	13.0	1.53			32	0	678
KaniHuggins_1979_062_126	604		126	2	150	155	155	305	47,381	152		2,542	914	814	2.99	272	16	755	1.783	1.783	346					19	13.9	1.61			43	0	407
KaniHuggins_1979_066_130	608		130	2	200	153	153	305	46,761	152		3,898	914	1,492	5.41	276	16	755	1.785	1.785	346					19	15.6	1.75			40	0	746
KaniHuggins_1979_067_131	609		131	2	150	151	151	305	46,064	152		2,273	914	679	2.48	274	16	768	1.854	1.854	401					19	15.7	1.77			50	0	340
KaniHuggins_1979_068_132	610		132	2	150	154	154	305	46,839	152		2,273	914	679	2.51	271	16	755	1.814	1.814	417					19	16.1	1.79			52	0	340
KaniHuggins_1979_069_133	611		133	2	200	154	154	305	46,916	152		3,632	914	1,359	4.97	273	16	761	1.810	1.810	508					19	17.5	1.91			39	0	679
KaniHuggins_1979_076_27	618		27	2	150	152	152	305	46,452	152	89	2,271	914	678	2.50	271	16	774	1.873	1.873	396					19	27.4	2.64			51	0	339
KaniHuggins_1979_077_28	619		28	2	150	152	152	305	46,452	152	89	2,271	914	678	2.50	271	16	774	1.873	1.873	396					19	26.8	2.59			54	0	339
KaniHuggins_1979_078_29	620		29	2	200	152	152	305	46,452	152	89	3,356	914	1,221	4.50	271	16	774	1.873	1.873	350					19	22.2	2.27			43	0	610
KaniHuggins_1979_079_30	621		30	2	200	152	152	305	46,452	152	89	3,356	914	1,221	4.50	271	16	774	1.873	1.873	350					19	22.8	2.31			46	0	610
KaniHuggins_1979_084_35	626	Kani; Huggins;	35	2	150	155	155	305	47,303	152	89	2,819	914	953	3.53	269	16	761	1.820	1.820	491					19	23.7	2.38			45	0	476

Figure A.5: *Shear Critical Beam Database (No Stirrups - Part 5/11)*

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Notation	**Nr.**	**Literature**	**ID**	**Modelling**		**Section Properties**					**Loading and Geometry**					**Tension Reinf.**						**Compression Reinf.**				**Conc. Comp.**		**Conc. Tens.**		**Test Results**				
				Load Step	Ele. Size	b	b_w	h	A_c	z_{c2}	a_F	L	c	a	a/d	d_s	Φ_{st}	A_s	r_s	r_w	f_{sy}	d_{s2}	Φ_{st2}	A_{s2}	f_{sy2}	Φ_a	f'c	$f_{ct,test}$	$f_{ct,m,cal}$	F	$V_{u,F}+g_{Rep}$	$V_{u,Rep}$	$V_{u,g}+F$	x_r
-	-	-	-	kN	mm	mm	mm	mm	mm²	mm	mm	mm	mm	mm	-	mm	mm	mm²	%	%	MPa	mm	mm	mm²	MPa	mm	MPa	MPa	MPa	kN	kN	kN	kN	mm
KaniHuggins_1979_085_36	627	Wittkopp (1979)	36	2	150	153	153	305	46,606	152	89	2,819	914	953	3.49	273	16	761	1.823	1.823	491					19	23.7		2.38			52	0	476
KaniHuggins_1979_087_182	629		182	2	200	155	155	305	47,148	152		3,627	914	1,356	5.05	268	15	748	1.802	1.802	386					19	31.5		2.91			49	0	678
KaniHuggins_1979_090_186	632		186	2	150	155	155	305	47,148	152		3,085	914	1,085	3.99	272	15	748	1.780	1.780	394					19	32.7		2.99			55	0	543
KaniHuggins_1979_093_191	635		191	2	150	154	154	305	46,839	152		2,545	914	815	2.96	275	16	761	1.801	1.801	497					19	31.6		2.92			53	0	408
KaniHuggins_1979_095_193	637		193	2	150	153	153	305	46,761	152		2,271	914	678	2.44	278	16	768	1.803	1.803	352					19	32.2		2.96			57	0	339
KaniHuggins_1979_096_194	638		194	2	150	154	154	305	46,916	152		2,542	914	814	2.93	278	16	768	1.797	1.797	352					19	32.2		2.96			51	0	407
KaniHuggins_1979_097_195	639		195	2	150	153	153	305	46,684	152		3,085	914	1,085	3.94	275	16	768	1.821	1.821	352					19	32.2		2.96			47	0	543
KaniHuggins_1979_099_197	641		197	2	150	150	150	305	45,832	152		2,273	914	679	2.48	274	16	755	1.835	1.835	376					19	33.6		3.04			53	0	340
KaniHuggins_1979_104_202	646		202	2	150	154	154	305	46,839	152		4,170	914	1,628	5.97	273	19	1,123	2.680	2.680	377					19	31.5		2.91			50	0	814
KaniHuggins_1979_108_206	650		206	2	150	152	152	305	46,452	152		2,273	914	679	2.51	270	19	1,123	2.726	2.726	381					19	32.8		2.99			100	0	340
KaniHuggins_1979_110_208	652		208	2	200	157	157	305	47,768	152		3,356	914	1,221	4.44	275	19	1,155	2.679	2.679	379					19	33.3		3.03			60	0	610
KaniHuggins_1979_112_210	654	Kani; Huggins;	210	2	150	154	154	305	47,071	152		2,273	914	679	2.50	272	19	1,123	2.675	2.675	381					19	32.8		2.99			79	0	340
KaniHuggins_1979_113_211	655	Wittkopp (1979)	211	2	150	153	153	305	46,684	152		2,545	914	815	3.02	270	19	1,129	2.733	2.733	381					19	32.8		2.99			57	0	408
KaniHuggins_1979_114_212	656		212	2	150	155	155	305	47,303	152		2,545	914	815	2.98	273	19	1,129	2.662	2.662	381					19	32.8		2.99			60	0	408
KaniHuggins_1979_115_213	657		213	2	200	154	154	305	46,993	152		3,360	914	1,223	4.44	276	19	1,129	2.657	2.657	381					19	34.3		3.09			57	0	612
KaniHuggins_1979_116_214	658		214	2	150	153	153	305	46,761	152		2,273	914	679	2.50	272	19	1,129	2.708	2.708	412					19	33.6		3.04			82	0	340
KaniHuggins_1979_117_215	659		215	2	150	154	154	305	47,071	152		2,273	914	679	2.48	274	19	1,129	2.673	2.673	412					19	33.6		3.04			66	0	340
KaniHuggins_1979_119_709	661		709	2	200	152	152	305	46,452	152	64	3,633	914	1,359	4.87	279	25	1,156	2.717	2.717	379					19	24.4		2.43			52	0	680
KaniHuggins_1979_120_666	662		666	2	150	155	155	305	47,226	152	64	2,546	914	816	2.95	277	25	1,156	2.697	2.697	348					19	26.9		2.60			63	0	408
KaniHuggins_1979_121_675	663		675	2	150	152	152	305	46,452	152	64	2,548	914	817	2.95	277	25	1,156	2.740	2.740	378					19	24.2		2.42			57	0	408
KaniHuggins_1979_122_718	664		718	2	200	152	152	305	46,219	152	64	3,632	914	1,359	4.85	280	25	1,156	2.721	2.721	392					19	24.2		2.41			54	0	679
KaniHuggins_1979_123_742	665		742	2	200	152	152	305	46,452	152		3,633	914	1,359	5.02	271	25	1,156	2.801	2.801	507					19	32.5		2.97			54	0	680
KaniHuggins_1979_124_744	666		744	2	200	152	152	305	46,452	152		3,631	914	1,358	5.05	269	25	1,156	2.820	2.820	465					19	34.2		3.08			52	0	679
KaniHuggins_1979_125_746	667		746	2	200	152	152	305	46,452	152		3,629	914	1,357	5.06	268	25	1,156	2.828	2.828	474					19	28.6		2.72			53	0	679
KaniHuggins_1979_127_502	669		502	2	150	152	152	305	46,452	152		2,539	914	812	2.83	287	25	1,156	2.643	2.643	373					19	23.0		2.33			50	0	406
KaniHuggins_1979_129_504	671		504	2	150	151	151	305	45,987	152		2,542	914	814	2.98	273	25	1,156	2.806	2.806	346					19	23.8		2.39			62	0	407
Kawano_1998_001_A-1a	673	Kawano; Watanabe (1998)	A-1a	2	150	105	105	330	34,650	165		2,200	400	900	3.00	300	16	402	1.277	1.277	370	16	402	370		20	22.4		2.28	34	34	34	34	450
Kawano_1998_002_A-1b	674		A-1b	2	150	105	105	330	34,650	165		2,200	400	900	3.00	300	16	402	1.277	1.277	370	16	402	370		20	22.4		2.28	30	30	30	30	450
Kawano_1998_003_A-2a	675		A-2a	5	250	176	176	570	100,320	285		3,600	600	1,500	3.00	500	16	1,206	1.371	1.371	370					20	24.9		2.46	83	85	85	85	750
Kawano_1998_004_A-2b	676		A-2b	5	250	176	176	570	100,320	285		3,600	600	1,500	3.00	500	16	1,206	1.371	1.371	370					20	24.9		2.46	102	104	104	104	750
Kawano_1998_005_A-3a	677		A-3a	20	500	350	350	1,050	367,500	525		6,500	800	2,850	3.00	950	25	3,927	1.181	1.181	360	25	1,963	360		20	18.3		1.97	216	232	232	232	1,425
Kawano_1998_006_A-3b	678		A-3b	20	500	350	350	1,050	367,500	525		6,500	800	2,850	3.00	950	25	3,927	1.181	1.181	360	25	1,963	360		20	18.2		1.97	238	254	254	254	1,425
Kawano_1998_007_A-4a	679		A-4a	60	1000	600	600	2,200	1,320,000	1100		13,000	1,000	6,000	3.00	2,000	35	14,432	1.203	1.203	360	35	4,811	360		40	19.8		2.09	611	721	721	721	3,000
Kawano_1998_008_A-4b	680		A-4b	60	1000	600	600	2,200	1,320,000	1100		13,000	1,000	6,000	3.00	2,000	35	14,432	1.203	1.203	360	35	4,811	360		40	20.7		2.16	560	671	671	671	3,000
KimPark_1994_001_CTL-1	681	Kim,	CTL-1	5	150	170	170	300	51,000	150	100	1,890	270	810	3.00	270	19	860	1.874	1.874	477					25	49.6		3.99			71	71	405
KimPark_1994_002_CTL-2	682	Park (1994)	CTL-2	5	150	170	170	300	51,000	150	100	1,890	270	810	3.00	270	19	860	1.874	1.874	477					25	49.6		3.99			72	72	405
KimPark_1994_003_P1.0-1	683		P1.0-1	5	150	170	170	300	51,000	150	100	1,904	272	816	3.00	272	14	468	1.012	1.012	477					25	49.6		3.99			58	59	408
KimPark_1994_004_P1.0-2	684		P1.0-2	5	150	170	170	300	51,000	150	100	1,904	272	816	3.00	272	14	468	1.012	1.012	477					25	49.6		3.99			56	57	408
KimPark_1994_005_P3.4-1	685		P3.4-1	5	150	170	170	300	51,000	150	100	1,869	267	801	3.00	267	25	1,520	3.349	3.349	477					25	49.6		3.99			78	79	401
KimPark_1994_006_P3.4-2	686		P3.4-2	5	150	170	170	300	51,000	150	100	1,869	267	801	3.00	267	25	1,520	3.349	3.349	477					25	49.6		3.99			79	79	401
KimPark_1994_007_P4.6-1	687		P4.6-1	5	150	170	170	300	51,000	150	100	1,785	255	765	3.00	255	25	2,027	4.676	4.676	477					25	49.6		3.99			90	90	383
KimPark_1994_008_P4.6-2	688		P4.6-2	5	150	170	170	300	51,000	150	100	1,785	255	765	3.00	255	25	2,027	4.676	4.676	477					25	49.6		3.99			95	96	383
KimPark_1994_011_A4.5-1	691	Kim,	A4.5-1	5	200	170	170	300	51,000	150	100	2,700	270	1,215	4.50	270	19	860	1.874	1.874	477					25	49.6		3.99			67	67	608
KimPark_1994_012_A4.5-2	692	Park (1994)	A4.5-2	5	200	170	170	300	51,000	150	100	2,700	270	1,215	4.50	270	19	860	1.874	1.874	477					25	49.6		3.99			64	65	608
KimPark_1994_013_A6.0-1	693		A6.0-1	5	250	170	170	300	51,000	150	100	3,510	270	1,620	6.00	270	19	860	1.874	1.874	477					25	49.6		3.99			59	60	810
KimPark_1994_014_A6.0-2	694		A6.0-2	5	250	170	170	300	51,000	150	100	3,510	270	1,620	6.00	270	19	860	1.874	1.874	477					25	49.6		3.99			61	62	810
KimPark_1994_015_D142-1	695		D142-1	5	100	170	170	170	28,900	85	100	994	142	426	3.00	142	14	452	1.872	1.872	477					25	49.6		3.99			41	41	213
KimPark_1994_016_D142-2	696		D142-2	5	100	170	170	170	28,900	85	100	994	142	426	3.00	142	14	452	1.872	1.872	477					25	49.6		3.99			39	40	213
KimPark_1994_017_D550-1	697		D550-1	20	250	300	300	620	186,000	310	100	3,850	550	1,650	3.00	550	22	3,097	1.877	1.877	477					25	49.6		3.99			226	231	825
KimPark_1994_018_D550-2	698		D550-2	20	250	300	300	620	186,000	310	100	3,850	550	1,650	3.00	550	22	3,097	1.877	1.877	477					25	49.6		3.99			215	219	825
KimPark_1994_019_D915-1	699		D915-1	20	450	300	300	1,000	300,000	500	100	6,405	915	2,745	3.00	915	29	5,139	1.872	1.872	477					25	49.6		3.99			272	285	1,373
KimPark_1994_020_D915-2	700		D915-2	20	450	300	300	1,000	300,000	500	100	6,405	915	2,745	3.00	915	29	5,139	1.872	1.872	477					25	49.6		3.99			332	345	1,373
Krefeld_1966_003_11A2	711	Krefeld;	11A2	5	150	152	152	381	58,064	191	127	1,829	127	851	2.71	314	32	1,583	3.310	3.310	366						27.8		2.66			73	74	203
Krefeld_1966_004_12A2	712	Thurston (1966)	12A2	5	150	152	152	305	46,452	152	127	1,829	127	851	3.58	238	32	1,583	4.370	4.370	366						27.7		2.66			64	65	318
Krefeld_1966_005_18A2	713		III-18A2	5	150	152	152	381	58,064	191	127	1,829	127	851	2.69	316	29	1,283	2.664	2.664	386						16.9		1.86			63	64	330
Krefeld_1966_006_18B2	714		18B2	5	150	152	152	381	58,064	191	127	1,829	127	851	2.69	316	29	1,283	2.664	2.664	386						17.5		1.91			72	73	254
Krefeld_1966_007_18C2	715		18C2	5	150	152	152	381	58,064	191	127	1,829	127	851	2.69	316	29	1,283	2.664	2.664	386						20.2		2.12			73	74	546
Krefeld_1966_008_18D2	716		18D2	5	150	152	152	381	58,064	191	127	1,829	127	851	2.69	316	29	1,283	2.664	2.664	386						19.7		2.08			60	61	318
Krefeld_1966_009_13A2	717		IV-13A2	5	150	152	152	381	58,064	191	127	1,829	127	851	2.67	319	22	388	0.798	0.798	366						17.5		1.91			48	49	381
Krefeld_1966_010_14A2	718		14A2	5	150	152	152	305	46,452	152	127	1,829	127	851	3.50	243	22	388	1.048	1.048	366						18.3		1.97			35	36	343
Krefeld_1966_011_15A2	719		15A2	5	150	152	152	381	58,064	191	127	1,829	127	851	2.69	316	29	641	1.332	1.332	386						17.7		1.93			46	46	445
Krefeld_1966_012_15B2	720		15B2	5	150	152	152	381	58,064	191	127	1,829	127	851	2.69	316	29	641	1.332	1.332	386						18.3		1.97			52	53	406
Krefeld_1966_013_16A2	721		16A2	5	150	152	152	305	46,452	152	127	1,829	127	851	3.55	240	29	641	1.755	1.755	386						19.8		2.09			42	43	279
Krefeld_1966_014_17A2	722		17A2	5	150	152	152	305	46,452	152	127	1,829	127	851	3.50	243	22	776	2.097	2.097	366						19.6		2.07			44	45	381
Krefeld_1966_015_18E2	723		18E2	5	150	152	152	381	58,064	191	127	1,829	127	851	2.69	316	29	1,283	2.664	2.664	386						17.4		1.90			82	83	343
Krefeld_1966_016_19A2	724	Krefeld;	19A2	5	150	152	152	305	46,452	152	127	1,829	127	851	3.55	240	29	1,283	3.510	3.510	386						18.2		1.96			46	47	419
Krefeld_1966_017_20A2	725	Thurston (1966)	20A2	5	150	152	152	305	46,452	152	127	1,829	127	851	3.58	238	32	1,583	4.370	4.370	366						18.6		2.00			51	51	356
Krefeld_1966_018_21A2	726		21A2	5	150	203	203	305	61,935	152	127	1,829	127	851	3.58	238	32	2,375	4.917	4.917	366						17.5		1.91			77	77	445
Krefeld_1966_020_2AC	728		2AC	5	200	152	152	305	46,452	152	127	2,438	127	1,156	4.55	254	25	507	1.309	1.309	394						20.6		2.15			38	38	737
Krefeld_1966_021_3AC	729		3AC	5	200	152	152	305	46,452	152	127	2,438	127	1,156	4.52	256	22	776	1.992	1.992	366						18.4		1.98			44	45	267
Krefeld_1966_022_4AC	730		4AC	5	200	152	152	305	46,452	152	127	2,438	127	1,156	4.55	254	25	1,013	2.618	2.618	394						14.1		1.63			38	38	724
Krefeld_1966_023_5AC	731		5AC	5	200	152	152	305	46,452	152	127	2,438	127	1,156	4.58	252	29	1,283	3.333	3.333	386						15.9		1.78			42	43	381
Krefeld_1966_024_6AC	732		6AC	5	200	152	152	305	46,452	152	127	2,438	127	1,156	4.61	250	32	1,583	4.149	4.149	366						20.4		2.14			53	54	343
Krefeld_1966_027_3CC	735		3CC	5	250	152	152	305	46,452	152	127	3,048	127	1,461	5.72	256	22	776	1.992	1.992	366						18.1		1.96			36	37	686
Krefeld_1966_028_4CC	736		4CC	5	250	152	152	305	46,452	152	127	3,048	127	1,461	5.75	254	25	1,013	2.618	2.618	394						18.2		1.96			40	41	699

Figure A.6: *Shear Critical Beam Database (No Stirrups - Part 6/11)*

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Notation	**Nr.**	**Literature**	**ID**	**Modelling**		**Section Properties**					**Loading and Geometry**					**Tension Reinf.**						**Compression Reinf.**				**Conc. Comp.**		**Conc. Tens.**		**Test Results**				
				Load Step	Ele. Size	b	b_w	h	A_c	z_{c2}	a_F	L	c	a	a/d	d_s	Φ_{st}	A_s	r_s	r_w	f_{sy}	d_{s2}	Φ_{st2}	A_{s2}	f_{sy2}	Φ_a	f'c	$f_{ct,test}$	$f_{ct,m,cal}$	F	$V_{u,F}+g_{Rep}$	$V_{u,Rep}$	$V_{u,g}+F$	x_r
-	-	-	-	kN	mm	mm	mm	mm	mm²	mm	mm	mm	mm	mm	-	mm	mm	mm²	%	%	MPa	mm	mm	mm²	MPa	mm	MPa	MPa	MPa	kN	kN	kN	kN	mm
Krefeld_1966_029_5CC	737		5CC	5	250	152	152	305	46,452	152	127	3,048	127	1,461	5.78	252	29	1,283	3.333	3.333	386						17.9		1.95			44	46	330
Krefeld_1966_035_3GC	743		V-3GC	5	350	152	152	305	46,452	152	127	4,267	127	2,070	8.10	256	22	776	1.992	1.992	379						20.0		2.11			32	33	330
Krefeld_1966_043_6C	751		VII-6C	5	350	152	152	305	46,452	152	127	1,829	127	851	3.37	252	29	1,283	3.333	3.333	386						17.7		1.93			51	52	254
Krefeld_1966_044_3AAC	752		VIII- 3AAC	5	150	152	152	305	46,452	152	127	1,829	127	851	3.33	256	22	776	1.992	1.992	366						32.2		2.95			56	56	191
Krefeld_1966_045_4AAC	753		4AAC	5	150	152	152	305	46,452	152	127	1,829	127	851	3.35	254	25	1,013	2.618	2.618	394						26.8		2.60			58	59	292
Krefeld_1966_046_5AAC	754		5AAC	5	150	152	152	305	46,452	152	127	1,829	127	851	3.37	252	29	1,283	3.333	3.333	386						30.4		2.84			57	58	330
Krefeld_1966_047_6AAC	755		6AAC	5	150	152	152	305	46,452	152	127	1,829	127	851	3.40	250	32	1,583	4.149	4.149	366						32.0		2.94			60	61	330
Krefeld_1966_048_3AC	756		3AC	5	150	152	152	305	46,452	152	127	2,438	127	1,156	4.52	256	22	776	1.992	1.992	366						29.5		2.78			53	54	533
Krefeld_1966_049_4AC	757		4AC	5	200	152	152	305	46,452	152	127	2,438	127	1,156	4.55	254	25	1,013	2.618	2.618	394						28.1		2.68			54	55	330
Krefeld_1966_050_5AC	758		5AC	5	200	152	152	305	46,452	152	127	2,438	127	1,156	4.58	252	29	1,283	3.333	3.333	386						30.4		2.84			54	55	305
Krefeld_1966_051_6AC	759		6AC	5	200	152	152	305	46,452	152	127	2,438	127	1,156	4.61	250	32	1,583	4.149	4.149	366						31.7		2.92			59	60	533
Krefeld_1966_052_4CC	760		4CC	5	250	152	152	305	46,452	152	127	3,048	127	1,461	5.75	254	25	1,013	2.618	2.618	394						36.0		3.20			52	54	432
Krefeld_1966_053_5CC	761		5CC	5	250	152	152	305	46,452	152	127	3,048	127	1,461	5.78	252	29	1,283	3.333	3.333	386						35.0		3.14			57	58	838
Krefeld_1966_054_6CC	762		6CC	5	250	152	152	305	46,452	152	127	3,048	127	1,461	5.83	250	32	1,583	4.149	4.149	366						36.0		3.20			63	64	991
Krefeld_1966_056_5EC	764		5EC	5	350	152	152	305	46,452	152	127	3,658	127	1,765	6.99	252	29	1,283	3.333	3.333	386						35.0		3.14			53	54	1,384
Krefeld_1966_057_6EC	765		6EC	5	350	152	152	305	46,452	152	127	3,658	127	1,765	7.05	250	32	1,583	4.149	4.149	366						31.4		2.90			49	50	889
Krefeld_1966_059_4AAC	767		4AAC	5	150	152	152	305	46,452	152	127	1,829	127	851	3.35	254	25	1,013	2.618	2.618	394						10.5		1.30			43	43	483
Krefeld_1966_060_5AAC	768		5AAC	5	150	152	152	305	46,452	152	127	1,829	127	851	3.37	252	29	1,283	3.333	3.333	386						13.0		1.53			50	51	229
Krefeld_1966_062_3AC	770		3AC	5	200	152	152	305	46,452	152	127	2,438	127	1,156	4.52	256	22	776	1.992	1.992	366						11.3		1.38			37	37	724
Krefeld_1966_067_4CC	775	Krefeld;	4CC	5	250	152	152	305	46,452	152	127	3,048	127	1,461	5.75	254	25	1,013	2.618	2.618	394						14.7		1.68			35	36	940
Krefeld_1966_072_C	780	Thurston (1966)	X-C	5	250	203	203	533	108,387	267	127	3,048	127	1,461	3.03	483	25	1,520	1.550	1.550	394						14.4		1.65			85	87	635
Krefeld_1966_073_PCA	781		XI-PCA	5	350	152	152	305	46,452	152	127	3,658	127	1,765	7.05	250	32	1,583	4.149	4.149	366						33.9		3.06			53	54	1,321
Krefeld_1966_074_PCB	782		PCB	5	350	152	152	305	46,452	152	127	3,658	127	1,765	7.05	250	32	1,583	4.149	4.149	366						33.9		3.06			53	54	1,321
Krefeld_1966_075_OCA	783		s-I-OCa	5	250	152	152	305	46,452	152	127	3,048	127	1,461	5.75	254	25	1,013	2.618	2.618	394						33.3		3.03			48	49	991
Krefeld_1966_076_OCB	784		OCb	5	250	152	152	305	46,452	152	127	3,048	127	1,461	5.75	254	25	1,013	2.618	2.618	394						36.6		3.23			52	53	1,016
Krefeld_1966_077_OCA	785		s-II- Oca	10	350	254	254	508	129,032	254	127	3,658	127	1,765	3.87	456	29	2,565	2.216	2.216	386						35.9		3.19			147	150	800
Krefeld_1966_078_OCB	786		OCb	10	350	254	254	508	129,032	254	127	3,658	127	1,765	3.87	456	29	2,565	2.216	2.216	386						35.9		3.19			133	137	584
Kung_1985_002_B	788	Küng (1985)	B	2	120	140	140	230	32,200	115		1,500	500	500	2.50	200	8	101	0.359	0.359	502					30	17.4		1.90			20	21	250
Kung_1985_003_C	789		C	2	120	140	140	230	32,200	115		1,500	500	500	2.50	200	10	157	0.561	0.561	504					30	17.2		1.89			26	27	250
Kung_1985_004_D	790		D	2	120	140	140	230	32,200	115		1,500	500	500	2.50	200	12	226	0.808	0.808	497					30	16.7		1.85			30	31	250
Kung_1985_005_E	791		E	2	120	140	140	230	32,200	115		1,500	500	500	2.50	200	14	308	1.100	1.100	492					30	16.5		1.83			43	43	250
Kung_1985_006_F	792		F	2	120	140	140	230	32,200	115		1,500	500	500	2.50	200	18	509	1.818	1.818	507					30	16.0		1.79			54	54	250
Kung_1985_007_D-1	793		D-1	2	120	140	140	230	32,200	115		1,500	500	500	2.50	200	12	226	0.808	0.808	497	30	6	57	491	30	19.3		2.05			43	43	250
Kung_1985_008_E-1	794		E-1	2	120	140	140	230	32,200	115		1,500	500	500	2.50	200	14	308	1.100	1.100	492	30	6	57	491	30	17.5		1.91			40	41	250
KuhlmannEhmann_2001_001_A6-L	797	Kuhlmann; Ehmann (2001)	A6-L	15	120	402	402	303	121,806	152	70	1,500	70	715	2.86	250	20	1,571	1.563	1.563	579		20	1,571	579	16	47.2	2.86	3.85			199	200	358
KuhlmannEhmann_2001_002_A6-R	798		A6-R	15	200	402	402	303	121,806	152	70	2,500	70	1,215	4.86	250	20	1,571	1.563	1.563	579		20	1,571	579	16	47.2	2.86	3.85			146	148	608
KuhlmannZilch_2002_001_B1/l	799	Kuhlmann; Zilch;	B1/l	15	120	400	400	302	120,800	151	70	1,500	70	715	2.86	250	25	1,924	1.924	1.924	554		25	1,924	554	16	45.2	3.61	3.74			187	188	358
KuhlmannZilch_2002_002_B1/r	800	Ehmann et al. (2002)	B1/r	15	200	400	400	302	120,800	151	70	2,500	70	1,215	4.86	250	25	1,924	1.924	1.924	554		25	1,924	554	16	45.2	3.61	3.74			150	152	608
KuhlmannZilch_2002_003_C3	801		C3	15	150	400	400	301	120,400	151	70	2,000	70	965	3.86	250	20	1,571	1.571	1.571	559		20	1,571	559	16	41.0	3.47	3.50			138	140	483
KuhlmannZilch_2002_004_C6	802		C6	15	150	400	400	302	120,800	151	70	2,000	70	965	3.86	250	20	1,571	1.571	1.571	559		20	1,571	559	16	41.9	3.52	3.55			138	140	483
Kulkarni_1998_005_B4JL20-S	807	Kulkarni;	B4JL20-S	2	100	102	102	178	18,156	89		1,672	152	760	5.00	152	10	214	1.379	1.379	518					10	38.2		3.33			20	20	380
Kulkarni_1998_007_B3SE03-S	809	Shah (1998)	B3SE03-S	2	100	102	102	178	18,156	89		1,673	305	684	4.50	152	10	214	1.379	1.379	518					10	41.2		3.51			23	23	342
Kulkarni_1998_011_B3NO15-S	813		B3NO15-S	2	100	102	102	178	18,156	89		1,368	152	608	4.00	152	10	214	1.379	1.379	518					10	39.2		3.39			23	23	304
Kulkarni_1998_013_B3NO30-S	815		B3NO30-S	2	100	102	102	178	18,156	89		1,216	152	532	3.50	152	10	214	1.379	1.379	518					10	41.2		3.51			24	24	266
Laupa_1953_002_S2	818	Laupa;	S2	5	200	152	152	305	46,452	152	152	2,743		1,295	4.82	269	19	855	2.088	2.088	284					25	24.5		2.44	42		43	43	648
Laupa_1953_003_S3	819	Siess (1953)	S3	5	200	152	152	305	46,452	152	152	2,743		1,295	4.89	265	25	1,013	2.508	2.508	410					25	29.9		2.81	53		54	54	648
Laupa_1953_004_S4	820		S4	5	200	152	152	305	46,452	152	152	2,743		1,295	4.92	263	29	1,283	3.195	3.195	309					25	28.4		2.71	56		56	56	648
Laupa_1953_005_S5	821		S5	5	200	152	152	305	46,452	152	152	2,743		1,295	4.95	262	32	1,583	3.968	3.968	315					25	27.5		2.64	50		51	51	648
Laupa_1953_008_S11	824		S11	5	200	152	152	305	46,452	152	152	2,743		1,295	4.85	267	22	776	1.907	1.907	328					25	12.4		1.47	34		35	35	648
Laupa_1953_009_S13	825		S13	5	200	152	152	305	46,452	152	152	2,743		1,295	4.95	262	32	1,583	3.968	3.968	304					25	23.8		2.39	50		51	51	648
Leonhardt_1962_004_P4	829	Leonhardt; Walther (1962)	P4	5	100	500	500	165	82,500	83	80	1,500	520	490	3.38	145	12	1,018	1.404	1.404	427					30	10.9		1.34	98		99	99	245
Leonhardt_1962_018_4l	843		4l	5	100	190	190	320	60,800	160	75	1,700	360	670	2.48	270	26	1,062	2.070	2.070	465					30	28.0		2.68	80		81	81	355
Leonhardt_1962_019_4r	844		4r	5	100	190	190	320	60,800	160	130	1,700	360	670	2.48	270	26	1,062	2.070	2.070	465					30	28.0		2.68	86		87	87	355
Leonhardt_1962_020_5l	845		5l	5	150	190	190	320	60,800	160	75	1,950	330	810	3.00	270	26	1,062	2.070	2.070	465					30	28.0		2.68	59		60	60	355
Leonhardt_1962_021_5r	846		5r	5	150	190	190	320	60,800	160	130	1,950	330	810	3.00	270	26	1,062	2.070	2.070	465					30	28.0		2.68	75		76	76	454
Leonhardt_1962_022_6l	847		6l	5	200	190	190	320	60,800	160	75	2,350	150	1,100	4.07	270	26	1,062	2.070	2.070	465					30	28.0		2.68	59		60	60	707
Leonhardt_1962_023_6r	848		6r	5	200	190	190	320	60,800	160	130	2,350	150	1,100	4.07	270	26	1,062	2.070	2.070	465					30	28.0		2.68	66		67	67	580
Leonhardt_1962_024_7-1	849		7-1	5	200	190	190	320	60,800	160	75	3,100	400	1,350	4.86	278	26	1,062	2.010	2.010	465					30	27.7		2.66	60		61	61	856
Leonhardt_1962_025_7-2	850		7-2	5	200	190	190	320	60,800	160	130	3,100	400	1,350	4.86	278	26	1,062	2.010	2.010	465					30	27.7		2.66	66		67	67	675
Leonhardt_1962_026_8-1	851		8-1	5	250	190	190	320	60,800	160	75	3,600	360	1,620	5.83	278	26	1,062	2.010	2.010	465					30	31.2		2.89	63		64	64	972
Leonhardt_1962_027_8-2	852		8-2	5	250	190	190	320	60,800	160	130	3,600	360	1,620	5.91	274	26	1,062	2.040	2.040	465					30	31.2		2.89	63		64	64	810
Leonhardt_1962_028_EA1	857		EA1	5	100	190	190	320	60,800	160	70	2,000	500	750	2.78	270	24	1,106	2.156	2.156	440					30	18.0		1.95	58		59	59	415
Leonhardt_1962_029_EA2	858		EA2	5	100	190	190	320	60,800	160	70	2,000	500	750	2.78	270	16	911	1.776	1.776	430					30	18.0		1.95	75		75	75	380
Leonhardt_1962_030_D1/1	859		D1/1	1	50	50	50	80	4,000	40	25	520	100	210	3.00	70	6	57	1.616	1.616	451					15	27.1		2.62	7		7	7	140
Leonhardt_1962_031_D1/2	860		D1/2	1	50	50	50	80	4,000	40	25	520	100	210	3.00	70	6	57	1.616	1.616	451					15	27.1		2.62	7		7	7	105
Leonhardt_1962_032_D2/1	861		D2/1	2	100	100	100	160	16,000	80	50	1,040	200	420	3.00	140	12	226	1.616	1.616	427					15	28.9		2.74	21		21	21	210
Leonhardt_1962_033_D2/2	862		D2/2	2	100	100	100	160	16,000	80	50	1,040	200	420	3.00	140	12	226	1.616	1.616	427					15	28.9		2.74	23		23	23	241
Leonhardt_1962_034_D3/1	863		D3/1	5	100	150	150	240	36,000	120	75	1,560	300	630	3.00	210	18	509	1.616	1.616	413					15	31.4		2.90	46		47	47	315
Leonhardt_1962_035_D3/2l	864		D3/2l	5	100	150	150	240	36,000	120	75	1,560	300	630	3.00	210	18	509	1.616	1.616	413					15	31.4		2.90	41		42	42	315
Leonhardt_1962_036_D3/2r	865		D3/2r	5	100	150	150	240	36,000	120	75	1,560	300	630	3.00	210	18	509	1.616	1.616	413					15	31.4		2.90	45		45	45	346
Leonhardt_1962_037_D4/1	866		D4/1	5	150	200	200	320	64,000	160	100	2,080	400	840	3.00	280	24	938	1.675	1.675	439					15	32.2		2.95	74		75	75	382
Leonhardt_1962_038_D4/2l	867		D4/2l	5	150	200	200	320	64,000	160	100	2,080	400	840	3.00	280	24	938	1.675	1.675	439					15	32.2		2.95	74		75	75	420
Leonhardt_1962_039_D4/2r	868		D4/2r	5	150	200	200	320	64,000	160	100	2,080	400	840	3.00	280	24	938	1.675	1.675	439					15	32.2		2.95	69		70	70	420
Leonhardt_1962_040_C1	869		C1	5	100	100	100	180	18,000	90	25	1,000	100	450	3.00	150	16	199	1.327	1.327	425					30	35.9		3.19	22		22	22	238
Leonhardt_1962_041_C2	870		C2	5	150	150	150	330	49,500	165	50	2,000	200	900	3.00	300	16	603	1.340	1.340	425					30	35.9		3.19	65		65	65	403

Figure A.7: *Shear Critical Beam Database (No Stirrups - Part 7/11)*

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Notation	**Nr.**	**Literature**	**ID**	**Modelling**		**Section Properties**					**Loading and Geometry**					**Tension Reinf.**						**Compression Reinf.**				**Conc. Comp.**		**Conc. Tens.**		**Test Results**				
				Load Step	Ele. Size	b	b_w	h	A_c	z_{c2}	a_F	L	c	a	a/d	d_s	Φ_{st}	A_s	r_s	r_w	f_{sy}	d_{s2}	Φ_{st2}	A_{s2}	f_{sy2}	Φ_a	f'c	$f_{ct,test}$	$f_{ct,m,cal}$	F	$V_{u,F}+g_{Rep}$	$V_{u,Rep}$	$V_{u,g}+F$	x_r
-	-	-	-	kN	mm	mm	mm	mm	mm²	mm	mm	mm	mm	mm	-	mm	mm	mm²	%	%	MPa	mm	mm	mm²	MPa	mm	MPa	MPa	MPa	kN	kN	kN	kN	mm
Leonhardt_1962_042_C3	871		C3	10	200	200	200	500	100,000	250	75	3,000	300	1,350	3.00	450	16	1,206	1.340	1.340	425					30	35.9		3.19	99		100	100	917
Leonhardt_1962_043_C4	872		C4	10	400	225	225	670	150,750	335	100	4,000	400	1,800	3.00	600	16	1,810	1.340	1.340	425					30	35.9		3.19	147		151	151	1,000
Leonhardt_1962_044_E6	873		E6	10	100	190	190	320	60,800	160	100	2,000	500	750	2.78	270	20	1,232	2.401	2.401	425					30	25.9		2.53	91		92	92	466
Marti_1977_001_PS6	886	Marti; Pralong;	PS6	10	100	400	400	180	72,000	90	150	2,380	1,120	640	3.83	167	14	1,232	1.844	1.844	542					16	26.9	3.53	2.60	112		113	113	320
Marti_1977_003_PS11	888	Thürlimann (1977)	PS11	10	100	400	400	180	72,000	90	150	2,380	1,120	640	3.83	167	14	924	1.383	1.383	542					16	27.1	3.80	2.62	97		99	99	320
Mathey_1963_017_IIIa- 17	905	Mathey;	IIIa- 17	5	400	203	203	457	92,903	229	89	3,658	610	1,524	3.78	403	32	2,083	2.545	2.545	505					25	26.8		2.60			88	90	762
Mathey_1963_018_IIIa-18	906	Watstein (1963)	IIIa-18	5	400	203	203	457	92,903	229	89	3,658	610	1,524	3.78	403	32	2,083	2.545	2.545	505					25	22.8		2.31			81	83	762
Mathey_1963_019_Va-19	907		Va-19	5	400	203	203	457	92,903	229	89	3,658	610	1,524	3.78	403	19	763	0.932	0.932	690					25	21.1		2.19			63	66	762
Mathey_1963_020_Va-20	908		Va-20	5	400	203	203	457	92,903	229	89	3,658	610	1,524	3.78	403	19	763	0.932	0.932	690					25	23.2		2.34			66	68	762
Mathey_1963_021_ Vlb-21	909	Mathey;	Vlb-21	5	400	203	203	457	92,903	229	89	2,896	610	1,143	2.84	403	19	688	0.841	0.841	707					25	23.7		2.38			71	73	572
Mathey_1963_022_ Vlb-22	910	Watstein (1963)	Vlb-22	5	400	203	203	457	92,903	229	89	2,896	610	1,143	2.84	403	19	688	0.841	0.841	707					25	23.4		2.36			62	64	572
Mathey_1963_023_ Vlb-23	911		Vlb-23	5	400	203	203	457	92,903	229	89	2,896	610	1,143	2.84	403	19	688	0.841	0.841	707					25	28.2		2.69			75	77	572
Mathey_1963_024_ Vla-24	912		Vla-24	5	400	203	203	457	92,903	229	89	3,658	610	1,524	3.78	403	13	383	0.468	0.468	696					25	23.9		2.40			54	57	762
Mathey_1963_025_ Vla-25	913		Vla-25	5	400	203	203	457	92,903	229	89	3,658	610	1,524	3.78	403	13	383	0.468	0.468	696					25	23.4		2.36			50	52	762
Moayer2_1974_001_P41	914	Moayer; Regan (1974)	P41	5	150	599	150	320	84,503	108	27	1,981	27	977	3.50	279	16	792	0.473	1.891	641					19	41.6		3.53			70	71	489
Moody_1954_013_A1	927	Moody;	A1	5	100	178	178	305	54,193	152	51	1,600	51	775	2.96	262	36	1,007	2.166	2.166	310					25	27.9		2.67	60		61	61	387
Moody_1954_014_A2	928	Viest; Elstner;	A2	5	100	178	178	305	54,193	152	51	1,600	51	775	2.90	267	25	1,013	2.137	2.137	310					25	28.6		2.72	67		67	67	387
Moody_1954_015_A3	929	Hognestad (1954)	A3	5	100	178	178	305	54,193	152	51	1,600	51	775	2.89	268	22	1,061	2.227	2.227	310					25	28.6		2.72	76		76	76	387
Moody_1954_016_A4	930		A4	5	100	178	178	305	54,193	152	51	1,600	51	775	2.87	270	19	1,140	2.375	2.375	310					25	29.1		2.75	71		72	72	387
Moody_1954_017_B1	931		B1	5	100	178	178	305	54,193	152	51	1,600	51	775	2.90	267	25	760	1.603	1.603	310					25	18.8		2.01	56		57	57	387
Moody_1954_018_B2	932		B2	5	100	178	178	305	54,193	152	51	1,600	51	775	2.89	268	22	776	1.628	1.628	310					25	19.2		2.04	60		61	61	387
Moody_1954_019_B3	933		B3	5	100	178	178	305	54,193	152	51	1,600	51	775	2.87	270	19	768	1.600	1.600	310					25	16.8		1.86	56		56	56	387
Moody_1954_020_B4	934		B4	5	100	178	178	305	54,193	152	51	1,600	51	775	2.85	272	16	792	1.640	1.640	310					25	14.4		1.65	56		56	56	387
Moody_1954_025_1	939		1	5	150	152	152	305	46,452	152	102	2,743	914	914	3.41	268	22	776	1.898	1.898	310					25	34.3		3.09	58		59	59	457
Moody_1954_026_2	940		2	5	150	152	152	305	46,452	152	102	2,743	914	914	3.41	268	22	776	1.898	1.898	310					25	14.3		1.64	36		37	37	457
Moody_1954_027_3	941		3	5	150	152	152	305	46,452	152	102	2,743	914	914	3.41	268	22	776	1.898	1.898	310					25	23.4		2.36	52		53	53	457
Moody_1954_028_4	942		4	5	150	152	152	305	46,452	152	102	2,743	914	914	3.41	268	22	776	1.898	1.898	310					25	13.0		1.53	40		41	41	457
Moody_1954_029_5	943		5	5	150	152	152	305	46,452	152	102	2,743	914	914	3.41	268	22	776	1.898	1.898	310					25	28.3		2.70	52		53	53	457
Moody_1954_030_6	944		6	5	150	152	152	305	46,452	152	102	2,743	914	914	3.41	268	22	776	1.898	1.898	310					25	13.4		1.56	34		35	35	457
Moody_1954_031_7	945		7	5	150	152	152	305	46,452	152	102	2,743	914	914	3.41	268	22	776	1.898	1.898	310					25	28.5		2.71	51		52	52	457
Moody_1954_033_9	947		9	5	150	152	152	305	46,452	152	102	2,743	914	914	3.41	268	22	776	1.898	1.898	310					25	38.8		3.36	53		54	54	457
Moody_1954_034_10	948		10	5	150	152	152	305	46,452	152	102	2,743	914	914	3.41	268	22	776	1.898	1.898	310					25	21.5		2.22	49		50	50	457
Moody_1954_035_11	949		11	5	150	152	152	305	46,452	152	102	2,743	914	914	3.41	268	22	776	1.898	1.898	310					25	35.7		3.18	60		61	61	457
Moody_1954_036_12	950		12	5	150	152	152	305	46,452	152	102	2,743	914	914	3.41	268	22	776	1.898	1.898	310					25	17.8		1.93	47		48	48	457
Moody_1954_037_13	951		13	5	150	152	152	305	46,452	152	102	2,743	914	914	3.41	268	22	776	1.898	1.898	310					25	35.4		3.16	56		57	57	457
Moody_1954_038_14	952		14	5	150	152	152	305	46,452	152	102	2,743	914	914	3.41	268	22	776	1.898	1.898	310					25	20.2		2.12	43		44	44	457
Moody_1954_039_15	953		15	5	150	152	152	305	46,452	152	102	2,743	914	914	3.41	268	22	776	1.898	1.898	310					25	35.0		3.13	51		52	52	457
Moody_1954_040_16	954		16	5	150	152	152	305	46,452	152	102	2,743	914	914	3.41	268	22	776	1.898	1.898	310					25	13.9		1.61	38		39	39	457
Morrow_1957_025_ B40 B4	981	Morrow;	B40 B4	10	200	305	305	406	123,871	203	178	2,388	178	1,105	3.00	368	22	2,122	1.890	1.890	378					25	32.4		2.96	156		158	158	552
Morrow_1957_026_ B56 B2	982	Viest (1957)	B56 B2	10	250	305	305	406	123,871	203	178	3,200	178	1,511	4.10	368	22	2,122	1.890	1.890	471					25	12.3		1.47	100		103	103	756
Morrow_1957_028_ B56 A4	984		B56 A4	10	250	305	305	406	123,871	203	178	3,200	178	1,511	4.03	375	25	2,803	2.454	2.454	330					25	22.6		2.30	138		140	140	756
Morrow_1957_029_ B56 B4	985		B56 B4	10	250	305	305	406	123,871	203	178	3,200	178	1,511	4.10	368	22	2,122	1.890	1.890	441					25	24.8		2.46	122		125	125	756
Morrow_1957_030_ B56 E4	986		B56 E4	10	250	305	305	406	123,871	203	178	3,200	178	1,511	4.10	368	19	1,425	1.270	1.270	429					25	26.0		2.54	109		111	111	756
Morrow_1957_031_ B56 A6	987		B56 A6	10	250	308	308	406	125,213	203	178	3,200	178	1,511	4.25	356	29	4,237	3.867	3.867	439					25	37.5		3.28	178		180	180	756
Morrow_1957_032_ B56 B6	988		B56 B6	10	250	305	305	406	123,871	203	178	3,200	178	1,511	4.07	372	22	2,122	1.873	1.873	466					25	43.3		3.63	137		139	139	756
Morrow_1957_033_ B70 B2	989		B70 B2	10	400	305	305	406	123,871	203	178	3,912	178	1,867	5.11	365	22	2,122	1.906	1.906	462					25	13.9		1.61	89		92	92	933
Morrow_1957_034_ B70 A4	990		B70 A4	10	400	305	305	406	123,871	203	178	3,912	178	1,867	5.07	368	25	2,803	2.497	2.497	436					25	24.8		2.46	132		135	135	933
Morrow_1957_035_ B70 A6	991		B70 A6	10	400	305	305	406	123,871	203	178	3,912	178	1,867	5.25	356	29	4,237	3.909	3.909	435					25	42.6		3.59	178		181	181	933
Morrow_1957_036_ B84 B4	992		B84 B4	10	500	305	305	406	123,871	203	178	4,623	178	2,223	6.11	363	22	2,122	1.915	1.915	465					25	24.8		2.46	111		115	115	1,111
Morrow_1957_037_ B113 B4	993		B113 B4	10	500	305	305	406	123,871	203	178	6,096	178	2,959	8.10	365	22	2,122	1.906	1.906	469					25	30.2		2.83	104		109	109	1,480
Mphonde_1984_001_AO-3-3b	995	Mphonde;	AO-3-3b	5	150	152	152	337	51,290	168	51	2,134	51	1,041	3.49	298	25	1,520	3.342	3.342	414					10	18.9		2.02			65	65	521
Mphonde_1984_002_AO-3-3c	996	Frantz (1984)	AO-3-3c	5	150	152	152	337	51,290	168	51	2,134	51	1,041	3.49	298	22	1,061	2.333	2.333	414					10	25.4		2.50			67	67	521
Mphonde_1984_003_AO-7-3a	997		AO-7-3a	5	150	152	152	337	51,290	168	51	2,134	51	1,041	3.49	298	25	1,520	3.342	3.342	414					10	36.2		3.21			82	83	521
Mphonde_1984_004_AO-7-3b	998		AO-7-3b	5	150	152	152	337	51,290	168	51	2,134	51	1,041	3.49	298	25	1,520	3.342	3.342	414					10	40.3		3.45			83	83	521
Mphonde_1984_005_AO-11-3a	999		AO-11-3a	5	150	152	152	337	51,290	168	51	2,134	51	1,041	3.49	298	25	1,520	3.342	3.342	414					10	74.5		4.66			90	90	521
Mphonde_1984_006_AO-11-3b	1000		AO-11-3b	5	150	152	152	337	51,290	168	51	2,134	51	1,041	3.49	298	25	1,520	3.342	3.342	414					10	74.2		4.65			89	90	521
Mphonde_1984_007_AO-15-3a	1001		AO-15-3a	5	150	152	152	337	51,290	168	51	2,134	51	1,041	3.49	298	25	1,520	3.342	3.342	414					10	81.0		4.79			93	94	521
Mphonde_1984_008_AO-15-3b	1002		AO-15-3b	5	150	152	152	337	51,290	168	51	2,134	51	1,041	3.49	298	25	1,520	3.342	3.342	414					10	93.7		5.04			100	101	521
Mphonde_1984_009_AO-15-3c	1003		AO-15-3c	5	150	152	152	337	51,290	168	51	2,134	51	1,041	3.49	298	25	1,520	3.342	3.342	414					10	91.8		5.00			98	99	521
Mphonde_1984_010_AO-3-2	1004		AO-3-2	5	100	152	152	337	51,290	168	51	1,492	51	721	2.41	298	25	1,520	3.342	3.342	414					10	18.7		2.01			78	78	360
Mphonde_1984_011_AO-7-2	1005		AO-7-2	5	100	152	152	337	51,290	168	51	1,492	51	721	2.41	298	25	1,520	3.342	3.342	414					10	43.9		3.67			118	118	360
Mphonde_1984_012_AO-11-2	1006		AO-11-2	5	100	152	152	337	51,290	168	51	1,492	51	721	2.41	298	25	1,520	3.342	3.342	414					10	78.9		4.75			111	112	360
Mphonde_1984_013_AO-15-2a	1007		AO-15-2a	5	100	152	152	337	51,290	168	51	1,492	51	721	2.41	298	25	1,520	3.342	3.342	414					10	83.5		4.84			178	178	360
Mphonde_1984_014_AO-15-2b	1008		AO-15-2b	5	100	152	152	337	51,290	168	51	1,492	51	721	2.41	298	25	1,520	3.342	3.342	414					10	68.8		4.53			206	206	360
Niwa_1987_001_1	1014	Niwa;	1	25	1000	600	600	2,100	1,260,000	1050	65	12,000	65	5,968	2.98	2,000	23	3,324	0.277	0.277	999					25	24.7	2.17	2.45			402	493	2,984
Niwa_1987_002_2	1015	Yamada et al. (1987)	2	25	1000	600	600	2,100	1,260,000	1050	65	12,000	65	5,968	2.98	2,000	23	1,662	0.139	0.139	999					25	23.8	2.05	2.39			382	473	2,984
Niwa_1987_003_3	1016		3	10	500	300	300	1,100	330,000	550	33	6,000	33	2,984	2.98	1,000	23	416	0.139	0.139	999					25	22.2	1.93	2.27			114	125	1,492
Podgorniak_1998_001_BRL100	1023	Podgorniak-Stanik (1998)	BRL100	10	650	300	300	1,000	300,000	500	75	5,400	75	2,663	2.88	925	30	1,404	0.506	0.506	550					10	91.6		5.00	157		166	166	1,503
Podgorniak_1998_001_BRH100	1024		BRH100	20	650	300	300	1,000	300,000	500	75	5,400	75	2,663	2.97	895	30	8,426	3.138	3.138	550					10	91.6		5.00	683		690	690	1,670
Podgorniak_1998_002_BN100	1025		BN100	20	650	300	300	1,000	300,000	500	75	5,400	75	2,663	2.88	925	30	2,106	0.759	0.759	550					10	34.6		3.11	185		194	194	1,504
Podgorniak_1998_003_BH100	1026		BH100	20	650	300	300	1,000	300,000	500	75	5,400	75	2,663	2.88	925	30	2,106	0.759	0.759	550					10	96.6		5.09	186		195	195	1,444
Podgorniak_1998_004_BN50	1027		BN50	10	200	300	300	500	150,000	250	75	2,700	75	1,313	2.92	450	25	1,096	0.812	0.812	486					10	34.6		3.11	130		132	132	690
Podgorniak_1998_005_BH50	1028		BH50	10	200	300	300	500	150,000	250	75	2,700	75	1,313	2.92	450	25	1,096	0.812	0.812	486					10	96.6		5.09	130		132	132	785
Podgorniak_1998_006_BN25	1029		BN25	5	100	300	300	250	75,000	125	25	1,352	25	664	2.95	225	16	603	0.894	0.894	437					10	34.6		3.11	73		73	73	392

Figure A.8: *Shear Critical Beam Database (No Stirrups - Part 8/11)*

Notation	Nr.	Literature	ID	Modelling		Section Properties					Loading and Geometry						Tension Reinf.						Compression Reinf.				Conc. Comp.		Conc. Tens.		Test Results					
				Load Step	Ele. Size	b	b_w	h	A_c	z_{c2}	a_F	L	c	a	a/d	-	d_s	Φ_{st}	A_s	r_s	r_w	f_{sy}	d_{s2}	Φ_{st2}	A_{s2}	f_{sy2}	Φ_a	f'_c	$f_{t,ct,test}$	$f_{t,ct,m,cal}$	F	$V_{u,F}+g_{Rep}$	$V_{u,Rep}$	$V_{u,g}+F$	x_r	
-	-	-	-	kN	mm	mm	mm	mm	mm^2	mm	mm	mm	mm	mm	-	-	mm	mm	mm^2	%	%	MPa	mm	mm	mm^2	MPa	mm	MPa	MPa	MPa	kN	kN	kN	kN	mm	
Podgomiak_1998_007_BH25	1030		BH25	5	100	300	300	250	75,000	125	25	1,352	25	664	2.95		225	16	603	0.894	0.894	437					10	96.6		5.09	84		85	85	249	
Rajagopalan_1968_001_S-13	1032	Rajagopalan;	S-13	5	200	152	152	311	47,340	156		2,540	305	1,118	4.22		265	17	697	1.729	1.729	655					13	21.3	2.57	2.20			40	41	559	
Rajagopalan_1968_002_S-1	1033	Ferguson (1968)	S-1	5	150	154	154	311	47,893	156		2,337	305	1,016	3.93		259	16	568	1.426	1.426	655					13	34.2	2.82	3.08			36	36	508	
Rajagopalan_1968_003_S-2	1034		S-2	5	150	154	154	311	47,893	156		2,337	305	1,016	3.83		265	13	400	0.980	0.980	655					13	30.7	2.87	2.86			37	38	508	
Rajagopalan_1968_004_S-3	1035		S-3	5	150	152	152	311	47,419	156		2,540	305	1,118	4.19		267	12	329	0.810	0.810	524					13	26.6	2.56	2.58			31	32	559	
Rajagopalan_1968_005_S-4	1036		S-4	5	150	152	152	311	47,419	156		2,540	305	1,118	4.17		268	10	258	0.631	0.631	524					13	30.7	2.46	2.86			28	29	559	
Rajagopalan_1968_006_S-5	1037		S-5	5	150	152	152	311	47,419	156		2,540	305	1,118	4.27		262	9	211	0.529	0.529	1779					13	25.5	2.37	2.51			34	34	559	
Rajagopalan_1968_007_S-9	1038		S-9	5	150	152	152	311	47,261	156		2,540	305	1,118	4.27		262	9	211	0.531	0.531	1779					13	22.7	2.29	2.31			24	25	559	
Rajagopalan_1968_008_S-6	1039		S-6	5	150	151	151	311	46,945	156		2,540	305	1,118	4.18		267	8	141	0.349	0.349	1779					13	28.6	2.57	2.72			27	28	559	
Rajagopalan_1968_009_S-7	1040		S-7	5	150	152	152	311	47,419	156		2,540	305	1,118	4.17		268	7	103	0.253	0.253	1779					13	26.2	2.77	2.56			30	31	559	
Rajagopalan_1968_010_S-12	1041		S-12	5	150	153	153	311	47,656	156		2,540	305	1,118	4.16		268	7	103	0.251	0.251	1779					13	27.3	2.59	2.63			25	25	559	
Regan_1971_001_R1	1042	Regan (1971)	R1	5	150	152	152	304	46,208	152	50	1,828	50	889	3.27		272	16	603	1.459	1.459	630					19	23.5		2.36			46	47	444	
Regan_1971_002_R2	1043		R2	5	150	152	152	304	46,208	152	50	1,828	50	889	3.27		272	16	603	1.459	1.459	630	10	142	270		19	23.5		2.36			48	49	444	
Regan_1971_003_R3	1044		R3	5	150	152	152	304	46,208	152	50	1,828	50	889	3.27		272	16	603	1.459	1.459	630					19	22.1		2.26			46	47	444	
Regan_1971_007_R7	1048		R7	5	150	152	152	304	46,208	152	50	1,828	50	889	3.27		272	16	603	1.459	1.459	630					19	25.4		2.50			56	57	444	
Regan_1971_008_R29	1049		R29	5	150	152	152	304	46,208	152	50	1,828	50	889	3.27		272	16	603	1.459	1.459	630					19	27.5		2.65			54	55	444	
Regan_1971_009_K3	1050		K3	5	400	610	152	305	81,168	103	50	3,655	50	1,803	6.63		272	16	1,608	0.969	3.891	630	8	196	280		19	30.3		2.83			62	64	901	
Rehm_1978_001_P 1	1052	Rehm; Eligehausen; Neubert (1978)	P 1	25	150	900	900	340	306,000	170	200	3,000	1,000	1,000	3.19		313	11	3,421	1.214	1.214	564					30	21.3	2.60	2.20	327		333	333	690	
Reinneck_1978_002_N6	1054	Reineck; Koch;	N6	5	100	500	500	250	125,000	125		2,500	1,370	565	2.50		226	12	887	0.785	0.785	501	24	12	905	501	16	23.4	2.45	2.36	118		120	120	283	
Reinneck_1978_003_N7	1055	Schlaich (1978)	N7	5	100	500	500	250	125,000	125		2,500	1,375	563	2.50		225	14	1,569	1.395	1.395	441	25	14	1,539	441	16	22.2	2.81	2.27	140		142	142	281	
Reinneck_1978_004_N8	1056		N8	5	100	500	500	250	125,000	125		2,500	918	791	3.50		226	12	887	0.785	0.785	501	24	12	905	501	16	23.4	2.45	2.36	102		104	104	396	
Remmel_1991_002_2	1058	Remmel (1991)	2	5	100	150	150	200	30,000	100	84	1,026	16	505	3.06		165	14	462	1.866	1.866	523					16	82.7	4.77	4.83			48	48	252	
Remmel_1991_003_3	1059		3	5	100	150	150	200	30,000	100	84	1,840	520	660	4.00		165	14	462	1.866	1.866	523					16	82.7	4.77	4.83			46	47	330	
Remmel_1991_005_5	1061		5	5	100	150	150	200	30,000	100	83	995	16	490	3.06		160	25	982	4.091	4.091	554					16	82.1	4.73	4.81			60	60	245	
Remmel_1991_006_6	1062		6	5	100	150	150	200	30,000	100	81	1,750	470	640	4.00		160	25	982	4.091	4.091	554					16	82.1	4.73	4.81			58	58	320	
Rosenbusch_2002_001_1.2 / 1	1067	Rosenbusch;	1.2 / 1	5	150	200	200	300	60,000	150	50	1,800	50	875	3.37		260	28	1,847	3.552	3.552	550						41.0	3.07	3.50	91		91	91	438	
Rosenbusch_2002_003_2.3 / 1	1069		2.3 / 1	5	100	200	200	300	60,000	150	50	2,300	1,000	650	2.48		262	16	603	1.151	1.151	550						37.2	2.68	3.27	79		80	80	325	
Rosenbusch_2002_004_2.4 / 1	1070		2.4 / 1	5	100	200	200	300	60,000	150	50	2,250	1,000	625	2.40		260	20	942	1.812	1.812	550						37.2	2.68	3.27	120		121	121	313	
Rosenbusch_2002_005_2.6 / 1	1071		2.6 / 1	5	150	200	200	300	60,000	150	50	2,250	200	1,025	3.94		260	20	942	1.812	1.812	550						37.9	2.57	3.31	75		76	76	513	
Ruesch_1962_001_X	1072	Ruesch;	X	2	100	90	90	134	12,060	67	57	1,250	450	400	3.60		111	11	265	2.650	2.650	481					30	20.6	2.04	2.15	15		15	15	200	
Ruesch_1962_002_Y	1073	Haugli (1962)	Y	5	100	120	120	229	27,480	115	102	2,240	806	717	3.60		199	16	634	2.654	2.654	407					30	20.6	2.04	2.15	30		31	31	358	
Ruesch_1962_003_Z	1074		Z	5	150	180	180	301	54,180	151	135	2,960	1,066	947	3.62		262	23	1,246	2.643	2.643	412					30	21.8	2.53	2.24	55		56	56	474	
Salandra_1989_003_LR-2.59-NS	1077	Salandra;	LR-2.59-NS	2	100	102	102	203	20,645	102		1,345	457	444	2.59		171	13	253	1.454	1.454	414					13	52.4		4.13			27	27	222	
Salandra_1989_004_LR-3.63-NS	1078	Ahmad (1989)	LR-3.63-NS	2	100	102	102	203	20,645	102		1,702	457	622	3.63		171	13	253	1.454	1.454	414					13	50.6		4.05			22	22	311	
Salandra_1989_007_HR-2.59-NS	1081		HR-2.59-NS	2	100	102	102	203	20,645	102		1,345	457	444	2.59		171	13	253	1.454	1.454	414					13	65.7		4.46			30	30	222	
Salandra_1989_008_HR-3.63-NS	1082		HR-3.63-NS	2	100	102	102	203	20,645	102		1,702	457	622	3.63		171	13	253	1.454	1.454	414					13	67.7		4.51			20	20	311	
Scholz_1994_002_A-2	1084	Scholz (1994)	A-2	5	200	200	200	400	80,000	200	100	3,500	1,268	1,116	3.00		372	16	603	0.811	0.811	500					16	78.2	4.91	4.74	83		85	85	558	
Scholz_1994_005_B-2	1087		B-2	5	200	200	200	400	80,000	200	100	3,500	1,292	1,104	3.00		368	25	1,473	2.001	2.001	500					16	82.1	4.87	4.81	125		127	127	552	
Scholz_1994_006_B-3	1088		B-3	5	250	200	200	400	80,000	200	100	3,500	556	1,472	4.00		368	25	1,473	2.001	2.001	500					16	82.1	4.87	4.81	110		112	112	736	
Scholz_1994_008_C-2	1090		C-2	5	200	200	200	400	80,000	200	100	3,500	1,304	1,098	3.00		366	28	2,463	3.365	3.365	500					16	81.5	4.91	4.80	121		123	123	549	
Scholz_1994_009_C-3	1091		C-3	5	250	200	200	400	80,000	200	100	3,500	572	1,464	4.00		366	28	2,463	3.365	3.365	500					16	81.5	4.91	4.80	106		108	108	732	
Scholz_1994_011_D-2	1093		D-2	5	200	200	200	400	80,000	200	100	3,500	1,328	1,086	3.00		362	16	1,407	1.944	1.944	500					16	94.4	5.37	5.05	121		123	123	543	
Scholz_1994_012_D-3	1094		D-3	5	250	200	200	400	80,000	200	100	3,500	604	1,448	4.00		362	16	1,407	1.944	1.944	500					16	94.4	5.37	5.05	121		123	123	724	
Shin_1999_003_MHB 2.5-0	1097	Shin; Lee;	MHB 2.5-0	5	100	125	125	250	31,250	125	23	1,075	23	526	2.45		215	25	1,013	3.771	3.771	410	10	143	392		19	49.6		3.99	56		57	57	285	
Shin_1999_006_HB 2.5-0	1100	Moon; Ghosh (1999)	HB 2.5-0	5	100	125	125	250	31,250	125	23	1,075	23	526	2.45		215	25	1,013	3.771	3.771	410	10	143	392		13	70.6		4.57	85		85	85	297	
Swamy_1971_001_M1N3D	1121	Swamy;	M1N3D	5	100	381	152	229	87,097	114		3,124	2,096	514	3.00		171	19	1,140	1.745	4.363	414					38	19.7	2.63	2.08			82	0	257	
Swamy_1971_002_M1N3	1122	Qureshi (1971)	M1N3	5	100	381	152	229	87,097	114		3,124	2,096	514	3.00		171	19	1,140	1.745	4.363	414					19	27.0	2.58	2.61			87	0	257	
Swamy_1971_003_M1N3A	1123		M1N3A	5	100	381	152	229	87,097	114		3,124	2,096	514	3.00		171	19	1,140	1.745	4.363	414					19	28.2	2.67	2.69			79	0	257	
Swamy_1971_004_M1N3B	1124		M1N3B	5	100	381	152	229	87,097	114		3,124	2,096	514	3.00		171	19	1,140	1.745	4.363	414					10	25.4	2.43	2.50			82	0	257	
Swamy_1971_005_M2N3A	1125		M2N3A	1	40	191	76	114	21,774	57		1,562	1,047	257	3.01		86	10	285	1.748	4.370	414					19	28.2	2.67	2.69			26	0	129	
Swamy_1971_006_M2N3	1126		M2N3	1	40	191	76	114	21,774	57		1,562	1,047	257	3.01		86	10	285	1.748	4.370	414					10	29.3	2.81	2.76			22	0	129	
Swamy_1971_007_M2N3B	1127		M2N3B	1	40	191	76	114	21,774	57		1,562	1,047	257	3.01		86	10	285	1.748	4.370	414					10	28.5	2.86	2.71			23	0	129	
Swamy_1971_008_M2N3C	1128		M2N3C	1	40	191	76	114	21,774	57		1,562	1,047	257	3.01		86	10	285	1.748	4.370	414					6	26.8	2.61	2.59			23	0	129	
Swamy_1971_009_M3N3B	1129		M3N3B	1	40	127	51	76	9,677	38		1,041	699	171	3.00		57	6	127	1.745	4.363	414					10	28.5	2.86	2.71			13	0	86	
Swamy_1971_010_M3N3	1130		M3N3	1	40	127	51	76	9,677	38		1,041	699	171	3.00		57	6	127	1.745	4.363	414					6	27.5	2.72	2.64			11	0	86	
Swamy_1971_011_M3N3C	1131		M3N3C	1	40	127	51	76	9,677	38		1,041	699	171	3.00		57	6	127	1.745	4.363	414					6	26.8	2.61	2.59			9	0	86	
Swamy_1971_012_M1N8	1132		M1N8	5	200	381	152	229	87,097	114		3,124	381	1,372	8.00		171	19	1,140	1.745	4.363	414					19	29.9	2.76	2.81			49	0	686	
Swamy_1971_015_M3N4	1135		M1N4	5	100	381	152	229	87,097	114		3,124	1,753	686	4.00		171	19	1,140	1.745	4.363	414					19	28.2	2.89	2.69			66	0	343	
Swamy_1971_016_M2N4	1136		M2N4	1	40	191	76	114	21,774	57		1,562	876	343	4.01		86	10	285	1.748	4.370	414					10	27.0	2.67	2.61			18	0	171	
Swamy_1971_017_M3N4	1137		M3N4	1	40	127	51	76	9,677	38		1,041	584	229	4.00		57	6	127	1.745	4.363	414					6	27.2	2.67	2.63			8	0	114	
Taylor1_1968_001_1A	1144	Taylor (1968)	1A	5	150	203	203	406	82,580	203	51	4,572	2,337	1,118	3.02		370	22	776	1.032	1.032	350					10	26.5		2.57			62	65	559	
Taylor1_1968_002_2A	1145		2A	5	150	203	203	406	82,580	203	51	4,572	2,337	1,118	3.02		370	22	1,164	1.548	1.548	350					10	30.8		2.86			92	95	559	
Taylor1_1968_005_5A	1148		5A	5	150	203	203	406	82,580	203	51	4,572	2,743	914	2.47		370	22	776	1.032	1.032	350					10	27.5		2.65			81	84	457	
Taylor1_1968_007_1B	1150		1B	5	150	203	203	406	82,580	203	51	4,572	2,337	1,118	3.02		370	22	776	1.032	1.032	350					10	26.5		2.57			76	79	559	
Taylor1_1968_008_2B	1151		2B	5	150	203	203	406	82,580	203	51	4,572	2,337	1,118	3.02		370	22	1,164	1.548	1.548	350					10	30.8		2.86			101	104	559	
Taylor1_1968_009_3B	1152		3B	5	150	203	203	406	82,580	203	51	4,572	2,337	1,118	3.02		370	22	776	1.032	1.032	350					10	29.2		2.76			76	79	559	
Taylor1_1968_011_5B	1154		5B	5	150	203	203	406	82,580	203	51	4,572	2,743	914	2.47		370	22	776	1.032	1.032	350					10	27.5		2.65			81	84	457	
Taylor1_1968_012_6B	1155		6B	5	150	203	203	406	82,580	203	51	4,572	1,981	1,295	3.50		370	22	776	1.032	1.032	350					10	25.4		2.50			78	81	648	
Taylor2_1972_001_A1	1156	Taylor (1972)	A1	20	450	400	400	1,000	400,000	500		6,500	900	2,800	3.01		930	40	5,027	1.351	1.351	420					38	26.3		2.56	341		358	358	1,400	
Taylor2_1972_002_A2	1157		A2	20	450	400	400	1,000	400,000	500		6,500	900	2,800	3.01		930	40	5,027	1.351	1.351	420					19	20.2		2.12	311		328	328	1,400	
Taylor2_1972_003_B1	1158		B1	10	250	200	200	500	100,000	250		3,250	450	1,400	3.01		465	20	1,257	1.351	1.351	420					38	24.4		2.43	102		104	104	700	
Taylor2_1972_004_B2	1159		B2	5	250	200	200	500	100,000	250		3,250	450	1,400	3.01		465	20	1,257	1.351	1.351	420					19	19.6		2.08	85		87	87	700	
Taylor2_1972_005_B3	1160		B3	5	250	200	200	500	100,000	250		3,250	450	1,400	3.01		465	20	1,257	1.351	1.351	420					9	26.0		2.54	83		85	85	700	
Walraven_1978_001_A1	1210	Walraven (1978)	A1	2	50	200	200	150	30,000	75		1,750	1,000	375	3.00		125	10	207	0.829	0.829	440					16	21.7	2.24	2.23			30	30	188	

Figure A.9: *Shear Critical Beam Database (No Stirrups - Part 9/11)*

Notation	Nr.	Literature	ID	Modelling		Section Properties					Loading and Geometry					Tension Reinf.						Compression Reinf.				Conc. Comp.		Conc. Tens.		Test Results				
				Load Step	Ele. Size	b	b_w	h	A_c	z_{c2}	a_F	L	c	a	a/d	d_s	Φ_{st}	A_s	r_s	r_w	f_{sy}	d_{s2}	Φ_{st2}	A_{s2}	f_{sy2}	Φ_a	f'c	$f_{t,ct,test}$	$f_{t,ct,m,cal}$	F	$V_{u,F}+g_{Rep}$	$V_{u,Rep}$	$V_{u,g}+F$	x_r
-	-	-	-	kN	mm	mm	mm	mm	mm²	mm	mm	mm	mm	mm	-	mm	mm	mm²	%	%	MPa	mm	mm	mm²	MPa	mm	MPa	MPa	MPa	kN	kN	kN	kN	mm
Walraven_1978_002_A2	1211		A2	5	200	200	200	450	90,000	225		3,520	1,000	1,260	3.00	420	20	622	0.741	0.741	440					16	21.7	2.24	2.23			71	73	751
Walraven_1978_003_A3	1212		A3	5	350	200	200	750	150,000	375		5,320	1,000	2,160	3.00	720	22	1,140	0.792	0.792	440					16	22.0	2.39	2.26			101	106	1,281
Xie_1994_003_NNN-3	1224	Xie; Ahmad; Yu (1994)	NNN-3	5	100	127	127	254	32,258	127	32	1,295	32	632	2.93	216	19	570	2.079	2.079	421					19	36.1		3.20	37	37	37	37	316
Xie_1994_006_NHN-3	1227		NHN-3	5	100	127	127	254	32,258	127	32	1,295	32	632	2.93	216	19	570	2.079	2.079	421					19	98.5		5.12	46	46	46	46	316
Yoon_1996_001_N1-S	1228	Yoon;	N1-S	25	500	375	375	750	281,250	375	75	4,300	75	2,113	3.23	655	30	7,069	2.878	2.878	400		10	142		20	33.6	2.79	3.04		249	256	1,056
Yoon_1996_002_M1-S	1229	Cook;	M1-S	25	500	375	375	750	281,250	375	75	4,300	75	2,113	3.23	655	30	7,069	2.878	2.878	400		10	142		10	64.6	4.14	4.44		296	303	1,056
Yoon_1996_003_H1-S	1230	Mitchell (1996)	H1-S	25	500	375	375	750	281,250	375	75	4,300	75	2,113	3.23	655	30	7,069	2.878	2.878	400		10	142		10	84.6	5.49	4.86		327	334	1,056
Yoshida_2000_001_YB2000/0	1231	Yoshida; Bentz; Collins (2000)	YB2000/0	25	900	300	300	2,000	600,000	1000	146	10,800	146	5,327	2.82	1,890	30	4,200	0.741	0.741	457	70	20	900	433	10	31.2		2.89		255	289	3,013
Lubell_2006_001_AW1	1232	Lubell (2006)	AW1	60	400	1170	1,170	590	690,300	295	153	3,700		1,774	3.30	538	25	5,000	0.794	0.794	467					10	34.5		3.10	585	605	605	607	
Lubell_2006_002_AW4	1233		AW4	60	400	1168	1,168	590	689,120	295	153	3,700		1,774	3.51	506	25	10,000	1.692	1.692	467					10	37.5		3.29	706	727	727	590	
Lubell_2006_003_AW8	1234		AW8	60	400	1169	1,169	591	690,879	296	76	3,700		1,812	3.57	507	25	10,000	1.687	1.687	467					10	37.0		3.26	771	790	790	649	
Lubell_2006_004_AX6	1235		AX6	20	200	703	703	338	237,614	169	76	2,080		1,002	3.48	288	25	3,500	1.729	1.729	467					10	38.6		3.35	279	283	283	387	
Lubell_2006_005_AX7	1236		AX7	20	200	704	704	335	235,840	168	76	2,080		1,002	3.49	287	20	2,100	1.039	1.039	413					10	38.6		3.35	247	251	251	375	
Lubell_2006_006_AX8	1237		AX8	20	200	705	705	339	238,995	170	76	2,080		1,002	3.47	289	25	3,500	1.718	1.718	467					10	38.6		3.35	271	272	272	732	
Lubell_2006_007_AY1	1238		AY1	10	200	249	249	467	116,283	234	76	2,600		1,262	2.91	434	15	354	0.328	0.328	900					10	38.3		3.34	84	85	85	814	
Sherwood_2008_001_L-10N1	1239	Sherwood (2008)	L-10N1	20	1000	300	300	1,510	453,000	755	76	8,100		4,012	2.87	1,400	30	3,500	0.833	0.833	452	75	20	600	487	10	36.0		3.19	250	271	271	2,073	
Sherwood_2008_002_L-10N2	1240	Sherwood;Bentz;	L-10N2	20	1000	300	300	1,510	453,000	755	76	8,100		4,012	2.87	1,400	30	3,500	0.833	0.833	452	75	20	600	487	10	37.9		3.31	227	248	248	2,092	
Sherwood_2008_003_L-10H	1241	Collins (2007)	L-10H	20	1000	300	300	1,510	453,000	755	76	8,100		4,012	2.87	1,400	30	3,500	0.833	0.833	452	75	20	600	487	10	71.2		4.59	225	240	240	2,552	
Sherwood_2008_004_L-20N1	1242		L-20N1	20	1000	300	300	1,510	453,000	755	76	8,100		4,012	2.87	1,400	30	3,500	0.833	0.833	452	75	20	600	487	19	29.0		2.74	250	268	268	2,270	
Sherwood_2008_005_L-20N2	1243		L-20N2	20	1000	300	300	1,510	453,000	755	76	8,100		4,012	2.87	1,400	30	3,500	0.833	0.833	452	75	20	600	487	19	30.8		2.86	250	273	273	1,939	
Sherwood_2008_006_L-40N1	1244		L-40N1	20	1000	300	300	1,510	453,000	755	76	8,100		4,012	2.87	1,400	30	3,500	0.833	0.833	452	75	20	600	487	38	25.7		2.52	227	245	245	2,314	
Sherwood_2008_007_L-40N2	1245		L-40N2	20	1000	300	300	1,510	453,000	755	76	8,100		4,012	2.87	1,400	30	3,500	0.833	0.833	452	75	20	600	487	38	26.1		2.55	273	291	291	2,342	
Sherwood_2008_008_L-50N1	1246		L-50N1	20	1000	300	300	1,510	453,000	755	76	8,100		4,012	2.87	1,400	30	3,500	0.833	0.833	452	75	20	600	487	51	38.6		3.35	256	274	274	2,331	
Sherwood_2008_009_L-50N2	1247		L-50N2	20	1000	300	300	1,510	453,000	755	76	8,100		4,012	2.87	1,400	30	3,500	0.833	0.833	452	75	20	600	487	51	37.7		3.30	283	299	299	2,483	
Sherwood_2008_010_L-50N2R	1248		L-50N2R	20	1000	300	300	1,510	453,000	755	76	8,100		4,012	2.87	1,400	30	3,500	0.833	0.833	452	75	20	600	487	51	37.7		3.30	307	331	331	1,782	
Sherwood_2008_011_S-10N1	1249		S-10N1	5	100	122	122	330	40,260	165	61	1,620		780	2.78	280	10	285	0.835	0.835	494					10	39.5		3.41	36	37	37	396	
Sherwood_2008_012_S-10N2	1250		S-10N2	5	100	122	122	330	40,260	165	61	1,620		780	2.78	280	10	285	0.835	0.835	494					10	39.5		3.41	38	38	38	478	
Sherwood_2008_013_S-10H	1251		S-10H	5	100	122	122	330	40,260	165	61	1,620		780	2.78	280	10	285	0.835	0.835	494					10	74.9		4.67	37	38	38	489	
Sherwood_2008_014_S-20N1	1252		S-20N1	5	100	122	122	330	40,260	165	61	1,620		780	2.78	280	10	285	0.835	0.835	494					19	36.8		3.24	39	39	39	458	
Sherwood_2008_015_S-20N2	1253		S-20N2	5	100	122	122	330	40,260	165	61	1,620		780	2.78	280	10	285	0.835	0.835	494					19	35.7		3.18	38	38	38	458	
Sherwood_2008_016_S-40N1	1254		S-40N1	5	100	122	122	330	40,260	165	61	1,620		780	2.78	280	10	285	0.835	0.835	494					38	26.7		2.59	42	42	42	528	
Sherwood_2008_017_S-40N2	1255		S-40N2	5	100	122	122	330	40,260	165	61	1,620		780	2.78	280	10	285	0.835	0.835	494					38	26.7		2.59	35	35	35	408	
Sherwood_2008_018_S-50N1	1256		S-50N1	5	100	122	122	330	40,260	165	61	1,620		780	2.78	280	10	285	0.835	0.835	494					51	41.1		3.50	38	38	38	524	
Sherwood_2008_019_S-50N2	1257		S-50N2	5	100	122	122	330	40,260	165	61	1,620		780	2.78	280	10	285	0.835	0.835	494					51	41.1		3.50	40	41	41	486	
Sherwood_2008_020_L-20L	1258		L-20L	10	1000	295	295	1,510	445,450	755	76	8,100		4,012	2.77	1,450	26	1,088	0.254	0.254	880	75	20			19	33.0		3.01	172	188	188	2,428	
Sherwood_2008_021_L-20LR	1259		L-20LR	10	1000	295	295	1,510	445,450	755	76	8,100		4,012	2.77	1,450	26	1,088	0.254	0.254	880	75	20			19	33.0		3.01	209	226	226	2,396	
Thiele_2010_001_T1-ohne	1260	Thiele (2010)	T1_ohne	5	150	400	400	300	120,000	150	40	2,100	40	1,030	4.15	248	14	924	0.931	0.931	581					16	23.2	0.00	2.34	107	107	107	740	
Thiele_2010_002_T7_70_oben	1261		T7_70_oben	5	150	400	400	350	140,000	175	40	2,100	40	1,030	3.47	297	16	1,608	1.354	1.354	580					16	22.2	0.00	2.27	129	131	131	496	
Thiele_2010_003_T9-ohne	1262		T9_ohne	5	150	400	400	200	80,000	100	40	1,700	40	830	4.97	167	16	1,608	2.408	2.408	632					16	39.4	0.00	3.40	112	112	112	470	
Thiele_2010_004_T13-ohne	1263		T13_ohne	5	150	400	400	250	100,000	125	40	1,700	40	830	3.82	217	16	1,608	1.853	1.853	632					16	40.1	0.00	3.44	127	128	128	500	
Thiele_2010_005_T10_40_oben	1264		T10_40_oben	5	150	400	400	250	100,000	125	40	1,700	40	830	4.97	167	16	1,608	2.408	2.408	632					16	39.4	0.00	3.40	102	102	102	495	
Injaganeri_2007_001_H20-0-0	1265	Injaganeri (2007)	H20-0-0	5	100	150	150	200	30,000	100	38	966	38	464	2.88	161	16	603	2.498	2.498	521		8	101			48.0	0.00	3.90	56	56	56	232	
Injaganeri_2007_002_H40-0-0	1266		H40-0-0	5	150	150	150	400	60,000	200	38	2,070	38	1,016	2.95	345	16	1,206	2.331	2.331	521		8	101			56.1	0.00	4.23	120	121	121	508	
Injaganeri_2007_003_H60-0-0	1267		H60-0-0	5	400	150	150	600	90,000	300	38	3,216	38	1,589	2.97	536	20	2,513	3.126	3.126	595		8	101			56.1	0.00	4.23	170	172	172	795	
Winkler_2011_001_SB2	1268	Winkler (2011)	SB 2	5	100	150	150	240	36,000	120	38	1,601	38	782	3.91	200	10	358	1.194	1.194	573					16	32.7	2.61	2.99	42	42	42	305	
Winkler_2011_002_SB3	1269		SB 3	5	200	150	150	345	51,750	173	50	2,400	50	1,175	3.92	300	12	531	1.180	1.180	566					16	32.7	2.61	2.99	52	52	52	830	
Winkler_2011_003_SB4	1270		SB 4	5	300	225	225	495	111,375	248	63	3,600	63	1,769	3.93	450	12	1,219	1.204	1.204	567					16	32.7	2.61	2.99	91	93	93	965	
Winkler_2011_004_SB5	1271		SB 5	10	400	300	300	647	194,100	324	75	4,800	75	2,363	3.94	600	16	2,158	1.199	1.199	590					16	32.7	2.61	2.99	159	166	166	980	
Winkler_2011_005_SB6	1272		SB 6	10	800	450	450	950	427,500	475	100	7,200	100	3,550	3.94	900	20	4,860	1.200	1.200	571					16	32.7	2.61	2.99	279	304	304	1,190	
Rosenbusch_2003_001_1.1-1	1279	Rosenbusch (2003)	1.1-1	5	150	200	200	300	60,000	150	50	1,800		875	3.37	260	12	339	0.652	0.652	550	40	10	157	550	16	41.0		3.50	50	51	51	435	
Rosenbusch_2003_002_1.2-1	1280		2.1-1	5	150	200	200	300	60,000	150	50	1,800		875	3.37	260	28	1,847	3.552	3.552	550	40	10	157	550	16	41.0		3.50	91	91	91	480	
Tureyen_2002_001_V-S-1	1281	Tureyen; Frosch (2002)	V-S-1	10	200	457	457	406	185,806	203	76	2,438		1,181	3.28	360	16	1,583	0.961	0.961	524					19	38.5	3.13	3.35	177	179	179	650	
Tureyen_2002_002_V-S-2	1282	Tureyen (2001)	V-S-2	20	200	457	457	427	195,096	213	76	2,438		1,181	3.28	360	16	3,167	1.922	1.922	524					19	39.0	3.53	3.38	200	203	203	623	
Tureyen_2002_003_V-D-2	1283		V-D-2	10	200	457	457	406	185,806	203	76	2,438		1,181	3.28	360	16	594	0.360	0.360	745					19	41.3	3.37	3.51	132	134	134	596	
bentz_2005_001_SBB1.1	1284	Bentz; Buckley (2005)	SBB1.1	2	60	104	104	103	10,712	52	25	495		235	2.80	84	10	142	1.625	1.625	400					10	33.2		3.02	14	14	14	131	
bentz_2005_002_SBB1.2	1285		SBB1.2	2	60	105	105	103	10,815	52	25	495		235	2.80	84	10	142	1.610	1.610	400					10	33.2		3.02	19	19	19	131	
bentz_2005_003_SBB1.3	1286		SBB1.3	2	60	104	104	103	10,712	52	25	495		235	2.80	84	10	142	1.625	1.625	400					10	33.2		3.02	15	15	15	121	
bentz_2005_004_SBB2.1	1287		SBB2.1	2	100	106	106	206	21,836	103	25	990		483	2.87	168	10	284	1.595	1.595	400					10	31.9		2.94	29	29	29	224	
bentz_2005_005_SBB2.2	1288		SBB2.2	2	100	105	105	206	21,630	103	25	990		483	2.87	168	10	284	1.610	1.610	400					10	31.9		2.94	30	31	31	241	
bentz_2005_006_SBB2.3	1289		SBB2.3	2	100	106	106	204	21,624	102	25	990		483	2.91	166	10	284	1.614	1.614	400					10	31.9		2.94	30	30	30	207	
bentz_2005_007_SBB3.1	1290		SBB3.1	5	150	105	105	378	39,690	189	25	1,980		978	2.94	333	15	542	1.550	1.550	400					10	33.7		3.05	42	43	43	592	
bentz_2005_008_SBB3.2	1291		SBB3.2	5	150	101	101	378	38,178	189	25	1,980		978	2.94	333	15	542	1.612	1.612	400					10	33.7		3.05	41	41	41	468	
bentz_2005_009_SBB3.3	1292		SBB3.3	5	150	101	101	378	38,178	189	25	1,980		978	2.94	333	15	542	1.612	1.612	400					10	33.7		3.05	43	43	43	499	
Tanimura_2005_011_45	1355	Tanimura; Sato (2005)	45	20	150	300	300	450	135,000	225	100	2,400	400	1,000	2.50	400	29	2,642	2.202	2.202	750		16	402			94.8		5.06		345	347	500	
Sneed_2007_001_1-1	1356	Sneed (2007);	1-1	10	100	305	305	306	93,368	153	38	1,397	38	679	2.91	233	19	855	1.202	1.202	431					10	63.7	4.28	4.41	130	131	131	330	
Sneed_2007_002_1-2	1357	Sneed, Ramirez (2008);	1-2	10	250	306	306	611	187,202	306	89	3,162	89	1,537	2.89	532	25	2,027	1.244	1.244	453					10	63.7	4.07	4.41	136	139	139	739	
Sneed_2007_003_1-3	1358	Sneed, Ramirez (2010)	1-3	10	350	305	305	762	232,258	381	133	4,064	133	1,965	2.89	681	29	2,579	1.242	1.242	474					10	62.6	4.03	4.39	141	147	147	1,118	
Sneed_2007_004_1-4	1359		1-4	10	400	306	306	914	280,103	457	178	4,928	178	2,375	2.89	822	36	4,030	1.600	1.600	475					10	72.4	4.50	4.61	158	165	165	1,361	
Sneed_2007_005_2-1	1360		2-1	5	100	203	203	306	62,245	153	38	1,397	38	679	2.89	235	16	594	1.244	1.244	483					10	66.2	3.76	4.47	57	57	57	366	
Sneed_2007_006_2-2	1361		2-2	10	300	408	408	608	248,049	304	89	3,162	89	1,537	2.92	527	29	2,579	1.199	1.199	474					10	62.4	4.10	4.39	150	155	155	815	
Sneed_2007_007_2-3	1362		2-3	20	400	508	508	762	387,096	381	133	4,064	133	1,965	2.87	684	29	4,513	1.299	1.299	474					10	65.7	4.16	4.46	250	261	261	889	
Sneed_2007_008_2-4	1363		2-4	20	400	613	613	914	560,438	457	178	4,928	178	2,375	2.90	820	36	8,059	1.603	1.603	475					10	70.5	3.97	4.57	333	344	344	1,608	
Padilla_2009_001	1364	Padilla Lavaselli (2009)	25-3.4-1-2P	10	100	500	500	250	125,000	125	155	4,000	3,000	500	2.50	200	12	339	0.339	0.339	500					20	41.4	3.42	3.51	74	80	80	250	
Padilla_2009_002	1365		40-3.2-1-2P	15	250	500	500	400	200,000	200	155	4,000	2,250	875	2.50	350	12	565	0.323	0.323	500					20	38.7	3.15	3.34	146	153	153	438	

Figure A.10: *Shear Critical Beam Database (No Stirrups - Part 10/11)*

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Notation	**Nr.**	**Literature**	**ID**	**Modelling**		**Section Properties**					**Loading and Geometry**					**Tension Reinf.**						**Compression Reinf.**				**Conc. Comp.**		**Conc. Tens.**		**Test Results**				
				Load Step	Ele. Size	b	b_w	h	A_c	z_{c2}	a_F	L	c	a	a/d	d_s	Φ_{st}	A_s	r_s	r_w	f_{sy}	d_{s2}	Φ_{st2}	A_{s2}	f_{sy2}	Φ_a	f'c	$f_{ct,test}$	$f_{ct,m,cal}$	F	$V_{u,F}+g_{Rep}$	$V_{u,Rep}$	$V_{u,g}+F$	x_r
-	-	-	-	kN	mm	mm	mm	mm	mm²	mm	mm	mm	mm	mm	-	mm	mm	mm²	%	%	MPa	mm	mm	mm²	MPa	mm	MPa	MPa	MPa	kN	kN	kN	kN	mm
Padilla_2009_003	1366		70-3.1-I-2P	25	400	500	500	700	350,000	350	155	4,000	750	1,625	2.50	650	16	1,005	0.309	0.309	560					20	41.3	3.42	3.50	230		238	238	1,050
Padilla_2009_004	1367		70-4.8-I-2P	25	400	500	500	700	350,000	350	155	4,000	750	1,625	2.50	650	20	1,571	0.483	0.483	532					20	40.9	3.42	3.48	249		257	257	1,000
Padilla_2009_005	1368		70-7.6-I-2P	35	400	500	500	700	350,000	350	155	4,000	750	1,625	2.50	650	25	2,454	0.755	0.755	500					20	40.6	3.56	3.46	343		351	351	1,000
Tompos_2002_001_V18-0	1376	Tompos; Frosch (2002)	V18-0	10	200	229	229	486	111,048	243	76	2,553	76	1,238	2.91	425	25	1,013	1.042	1.042	552					19	34.1	3.17	3.04	95		97	97	510
Brown_2006_001_III-1	1378	Brown; Sankovic; Bayrak; Jirsa;	III-1	10	200	203	203	486	98,709	243	76	2,438	76	1,181	2.91	406	25	2,534	3.068	3.068	469					19	25.4		2.42			91	91	665
Sagaseta_2008_04_BG-02	1385		BG-01	10	250	135	135	500	67,500	250	100	3,200	100	1,550	3.33	465	20	628	1.001	1.001	580					10	77.0	5.10	4.74	61		63	63	800
Sagaseta_2008_05_BL-01	1386		BG-02	10	250	135	135	500	67,500	250	100	3,200	100	1,550	3.33	465	20	628	1.001	1.001	580					10	77.0	5.10	4.74	63		64	64	900
Sagaseta_2008_06_BL-02	1387		BL-01	5	250	135	135	500	67,500	250	100	3,200	100	1,550	3.33	465	20	628	1.001	1.001	580					10	65.7	4.37	4.49	47		48	48	990
Sagaseta_2008_07_A0	1388		BL-02	5	250	135	135	500	67,500	250	100	3,200	100	1,550	3.33	465	20	628	1.001	1.001	580					10	65.7	4.37	4.49	54		55	55	800
Karayiannis_1999_02_B0	1389	Karayiannis; Chalioris (1999)	A0	10	150	200	200	300	60,000	150	100	1,640	200	720	2.77	260	18	763	1.468	1.468	550	22	14	308	550	32	24.7	1.80	2.37	60		61	61	440
Karayiannis_1999_03_A0	1390		B0	10	200	200	200	300	60,000	150	100	2,000	200	900	3.46	260	18	1,018	1.957	1.957	550	22	14	308	550	32	24.7	1.80	2.37	72		72	72	450
Zararis_1999_01_A0	1391	Zararis; Papadakis (1999)	A0	4	150	140	140	260	36,400	130		2,692	1,000	846	3.60	235	12	452	1.375	1.375	588	21	8	101	624		23.7		2.29			32	33	457
Zararis_1999_02_A0.33	1392		A0.33	4	150	140	140	260	36,400	130		2,692	1,000	846	3.60	235	12	452	1.375	1.375	588	21	8	101	624		21.3		2.10			40	41	705
Zararis_1999_03_B0.33	1393		B0.33	4	150	140	140	260	36,400	130		2,692	1,000	846	3.60	235	12	452	1.375	1.375	588	21	8	101	624		21.3		2.10			36	37	569
Swamy_1974_010_M3	1402		M2	2	50	76	76	114	8,710	57	0	570		285	3.00	95	6	63	0.875	0.875	426		3	16			14.9		1.56			19	19	142
Swamy_1974_11_M4	1403		M3	1	50	76	76	114	8,710	57	0	569		284	3.00	95	6	63	0.875	0.875	426		3	16			14.9		1.56			10	10	142
Swamy_1974_12_T2	1404		M4	1	50	76	76	114	8,710	57	0	570		285	3.00	95	6	63	0.875	0.875	426		3	16			14.9		1.56			7	7	142
Swamy_1974_13_T3	1405		T2	5	50	76	76	152	11,613	76	0	789		395	3.00	132	16	396	3.948	3.948	434		3	16			23.7		2.29			51	51	197
Swamy_1974_14_T4	1406		T3	2	50	76	76	152	11,613	76	0	1,053		526	4.00	132	16	396	3.948	3.948	434		3	16			23.7		2.29			23	23	263
Swamy_1974_15_T5	1407		T4	2	50	76	76	152	11,613	76	0	1,053		526	4.00	132	16	396	3.948	3.948	434		3	16			23.7		2.29			17	17	263
Swamy_1974_16_T6	1408		T5	2	50	76	76	152	11,613	76	0	1,053		526	4.00	132	16	396	3.948	3.948	434		3	16			23.7		2.29			18	18	263
Swamy_1974_17_L1-A	1409		T6	2	50	76	76	152	11,613	76	0	1,053		526	4.00	132	16	396	3.948	3.948	434		3	16			23.7		2.29			18	18	263
Lee_2008_01_L1-A	1410	Lee; Kim (2008)	L1-A	20	200	350	350	450	157,500	225	50	2,460	50	1,205	2.94	410	29	2,570	1.791	1.791	525	40	22	774	385	25	37.5	3.06	3.26	193		195	195	603
Lee_2008_02_L2-A	1411		L2-A	20	200	350	350	450	157,500	225	50	2,400	50	1,175	3.01	390	29	4,497	3.294	3.294	525	40	22	774	385	25	37.5	3.06	3.26	221		223	223	588
Lee_2008_03_L3-A	1412		L3-A	20	200	350	350	450	157,500	225	50	2,330	50	1,140	2.96	385	29	6,424	4.768	4.768	525	40	22	774	385	25	37.5	3.06	3.26	221		223	223	570
Lee_2008_06_L6-A	1415		L6-A	10	100	350	350	320	112,000	160	50	1,280	50	615	2.37	260	19	1,719	1.889	1.889	550	40	22	774	385	25	28.1	2.43	2.62	101		102	102	308
Lee_2008_08_S2-A	1417		S2-A	20	200	350	350	450	157,500	225	50	2,460	50	1,205	2.94	410	29	3,212	2.238	2.238	525	40	22	774	385	25	37.5	3.06	3.26	177		179	179	603
Lee_2008_09_S3-A	1418		S3-A	20	400	350	350	450	157,500	225	50	3,280	50	1,615	3.94	410	29	3,212	2.238	2.238	525	40	22	774	385	25	37.5	3.06	3.26	167		170	170	808
Lee_2008_11_S5-A	1420		S5-A	10	200	350	350	320	112,000	160	50	2,240	50	1,095	3.91	280	19	860	0.877	0.877	550	40	22	774	385	25	28.1	2.43	2.62	82		84	84	548
Lee_2008_12_S6-A	1421		S6-A	10	250	350	350	320	112,000	160	50	2,800	50	1,375	4.91	280	19	860	0.877	0.877	550	40	22	774	385	25	28.1	2.43	2.62	75		76	76	688
Lee_2008_13_C1-A	1422		C1-A	20	200	350	350	450	157,500	225	50	2,460	50	1,205	2.94	410	29	3,212	2.238	2.238	525	40	22	774	385	25	18.1	1.35	1.84	161		163	163	603
Gonzalez-Fonteboa_2006_01_V0CCS	1423	Gonzalez-Fonteboa;	V0CC	10	200	200	200	350	70,000	175	150	2,600	600	1,000	3.29	304	28	1,810	2.977	2.977	621	47	16	402	586	25	38.2	2.66	3.30	89		90	90	398
Gonzalez-Fonteboa_2006_02_V0RC	1424	Martinez-Abella (2007)	V0CCS	10	200	200	200	350	70,000	175	150	2,600	600	1,000	3.29	304	28	1,810	2.977	2.977	621	47	16	402	586	25	44.4	2.34	3.69	101		102	102	638
Gonzalez-Fonteboa_2006_03_V0RCS	1425		V0RC	10	200	200	200	350	70,000	175	150	2,600	600	1,000	3.29	304	28	1,810	2.977	2.977	621	47	16	402	586	25	37.7	2.61	3.27	91		92	92	500
Gonzalez-Fonteboa_2006_04_BO01	1426		V0RCS	10	200	200	200	350	70,000	175	150	2,600	600	1,000	3.29	304	28	1,810	2.977	2.977	621	47	16	402	586	25	39.4	2.36	3.38	84		85	85	430
Schacht_2014_01_BO01	1427	Schacht (2010)	BO01	5	150	200	200	300	60,000	150	150	2,100	500	800	2.96	270	16	804	1.489	1.489	525					16	32.2		2.91	60		61	61	400
Schacht_2014_02_BO02	1428		BO02	5	200	200	200	300	60,000	150	150	2,400	500	950	3.52	270	16	804	1.489	1.489	525					16	32.2		2.91	60		61	61	475
Schacht_2014_03_BO03	1429		BO03	5	200	200	200	300	60,000	150	150	2,700	500	1,100	4.07	270	16	804	1.489	1.489	525					16	32.2		2.91	55		56	56	550
Schacht_2014_04_BO04	1430		BO04	5	250	200	200	300	60,000	150	150	3,300	500	1,400	5.19	270	16	804	1.489	1.489	525					16	32.2		2.91	50		51	51	700
Rahal_2004_01_A65-NTR	1431	Rahal; Al-Shaleh (2004)	A65-NTR	10	200	200	200	370	74,000	185	160	2,200	400	900	2.73	330	25	1,425	2.159	2.159	440					12	58.2		4.30	125		126	126	450
Rahal_2004_02_B65-NTR	1432		B65-NTR	15	200	200	200	370	74,000	185	160	2,200	400	900	2.95	305	25	2,375	3.893	3.893	440					12	58.8	5.30	4.31	170		171	171	450
Vecchio_2004_01_OA1	1433	Vecchio; Shim (2004)	OA1	15	300	305	305	552	172,360	276	75	3,660	75	1,793	3.92	457	28	2,400	1.694	1.694	694					20	21.5	2.13	2.12	166		169	169	896
Vecchio_2004_02_OA2	1434	Sim (2002)	OA2	15	400	305	305	552	171,105	276	75	4,570	75	2,248	4.92	457	28	3,100	2.224	2.224	636					20	24.6	3.03	2.36	160		165	165	1,124
Vecchio_2004_03_OA3	1435		OA3	20	500	305	305	552	170,692	276	75	6,400	75	3,163	6.92	457	28	3,800	2.709	2.709	599					20	41.3	2.82	3.50	193		199	199	1,581
Collins_2015_01_East	1438	Collins; Bentz; Quach; Proestos (2015)	East	40	2000	250	250	4,000	1,000,000	2000	200	24,000	200	11,900	3.09	3,840	30	6,300	0.656	0.656	573	70	20	900	522	14	38.0		3.29	252		405	405	5,500
Collins_2015_02_Trad	1439		Traditional	5	150	175	175	305	53,342	152	19	1,651	19	816	3.09	264	11	294	0.636	0.636	458					14	42.6		3.58	47		48	48	408

Figure A.11: *Shear Critical Beam Database (No Stirrups - Part 11/11)*

A.2 No Stirrups - Distributed Load

Notation	Nr.	Literature	ID	Modelling		Section Properties					Loading and Geometry					Tension Reinf.						Compression Reinf.				Conc. Comp.		Conc. Tens.		Test Results				
				Load Step	Ele. Size	b	b_w	h	A_c	z_{c2}	a_F	L	c	a	a/d	d_s	Φ_{st}	A_s	r_s	r_w	f_{sy}	d_{s2}	Φ_{st2}	A_{s2}	f_{sy2}	Φ_a	f'c	$f_{ct,test}$	$f_{ct,m,cal}$	F	$V_{u,F}+g_{Rep}$	$V_{u,Rep}$	$V_{u,g}+F$	x_r
-	-	-	-	kN	mm	mm	mm	mm	mm^2	mm	mm	mm	mm	mm	-	mm	mm	mm^2	%	%	MPa	mm	mm	mm^2	MPa	mm	MPa	MPa	MPa	kN	kN	kN	kN	mm
Feldman_1955_001_D-1	1600	Feldman; Siess (1955)	D-1	20	200	152	152	305	46,452	152		2,794		699	2.77	252	29	1,289	3.351	3.351	295					25	28.4	2.29	2.71	93		60	60	432
Feldman_1955_002_D-2	1601		D-2	20	200	152	152	305	46,452	152		2,794		699	2.77	252	29	1,289	3.351	3.351	307					25	36.2	2.39	3.20	110		71	71	381
Feldman_1955_003_D-3	1602		D-3	20	200	152	152	305	46,452	152		3,353		838	3.32	252	29	1,289	3.351	3.351	314					25	30.8	2.66	2.87	94		57	57	457
Feldman_1955_006_D-6	1603		D-6	20	200	152	152	305	46,452	152		2,794		699	2.77	252	29	1,289	3.351	3.351	310					25	21.4	2.07	2.21	104		62	62	381
Krefeld_1996_020_2AU	1604	Krefeld;	2AU	20	200	152	152	305	46,452	152		2,438		610	2.40	254	25	507	1.309	1.309	394						18.8		2.01		76	43	44	325
Krefeld_1996_022_4AU	1605	Thurston (1966)	4AU	20	200	152	152	305	46,452	152		2,438		610	2.40	254	25	1,013	2.618	2.618	273						15.5		1.74		91	52	52	353
Krefeld_1996_023_5AU	1606		5AU	20	200	152	152	305	46,452	152		2,438		610	2.41	252	29	1,289	3.351	3.351	268						18.2		1.97		110	63	64	352
Krefeld_1996_026_2CU	1607		2CU	20	200	152	152	305	46,452	152		3,048		762	3.00	254	25	507	1.309	1.309	370						18.4		1.98		54	33	34	302
Krefeld_1996_027_3CU	1608		3CU	20	200	152	152	305	46,452	152		3,048		762	2.98	256	22	776	1.992	1.992	319						18.1		1.96		72	43	44	607
Krefeld_1996_028_4CU	1609		4CU	20	200	152	152	305	46,452	152		3,048		762	3.00	254	25	1,013	2.618	2.618	276						18.2		1.96		80	48	49	251
Krefeld_1996_029_5CU	1610		5CU	20	200	152	152	305	46,452	152		3,048		762	3.02	252	29	1,289	3.351	3.351	224						18.0		1.95		83	50	51	492
Krefeld_1996_030_6CU	1611		6CU	20	200	152	152	305	46,452	152		3,048		762	3.04	250	32	1,635	4.283	4.283	174						18.2		1.96		78	47	48	466
Krefeld_1996_031_3EU	1612		3EU	20	200	152	152	305	46,452	152		3,658		914	3.58	256	22	776	1.992	1.992	349						15.2		1.72		62	41	43	409
Krefeld_1996_032_4EU	1613		4EU	20	200	152	152	305	46,452	152		3,658		914	3.60	254	25	1,013	2.618	2.618	327						17.8		1.94		73	49	50	238
Krefeld_1996_035_3GU	1614		3GU	20	200	152	152	305	46,452	152		4,267		1,067	4.17	256	22	776	1.992	1.992	379						20.2		2.12		59	42	44	409
Krefeld_1996_037_5GU	1615		5GU	20	200	152	152	305	46,452	152		4,267		1,067	4.23	252	29	1,289	3.351	3.351	260						18.9		2.02		66	47	49	314
Krefeld_1996_039_3JU	1616		3JU	20	200	152	152	305	46,452	152		4,877		1,219	4.77	256	22	776	1.992	1.992	379						19.8		2.09		48	37	39	409
Krefeld_1996_048_4AU	1617		4AU	20	200	152	152	305	46,452	152		2,438		610	2.40	254	25	1,013	2.618	2.618	298						29.3		2.76		117	67	68	276
Krefeld_1996_049_5AU	1618		5AU	20	200	152	152	305	46,452	152		2,438		610	2.41	252	29	1,289	3.351	3.351	306						29.3		2.76		133	75	76	314
Krefeld_1996_050_6AU	1619		6AU	20	200	152	152	305	46,452	152		2,438		610	2.43	250	32	1,635	4.283	4.283	278						31.7		2.92		155	88	89	377
Krefeld_1996_051_4CU	1620		4CU	20	200	152	152	305	46,452	152		3,048		762	3.00	254	25	1,013	2.618	2.618	314						29.9		2.80		97	59	60	213
Krefeld_1996_052_5CU	1621		5CU	20	200	152	152	305	46,452	152		3,048		762	3.02	252	29	1,289	3.351	3.351	254						29.9		2.80		95	58	59	314
Krefeld_1996_053_6CU	1622		6CU	20	200	152	152	305	46,452	152		3,048		762	3.04	251	32	1,635	4.278	4.278	249						34.4		3.10		108	65	67	288
Krefeld_1996_063_4CU	1623		4CU	20	200	152	152	305	46,452	152		3,048		762	3.00	254	25	1,013	2.618	2.618	251						14.7		1.68		71	42	43	569
Krefeld_1996_067_4EU	1624		4EU	20	200	152	152	305	46,452	152		3,658		914	3.60	254	25	1,013	2.618	2.618	231						11.9		1.43		50	34	35	315
Leonhardt_1962_007_14/1	1625	Leonhardt;	14/1	20	200	190	190	320	60,800	160		3,000		750	2.75	273	26	1,062	2.047	2.047	465					30	29.9	2.97	2.80	101		64	64	375
Leonhardt_1962_008_14/2	1626	Walther (1962)	14/2	20	200	190	190	320	60,800	160		3,000		750	2.75	273	26	1,062	2.047	2.047	465					30	29.9	2.97	2.80	101		63	63	400
Leonhardt_1962_009_15/1	1627		15/1	20	200	190	190	320	60,800	160		4,000		1,000	3.68	272	26	1,062	2.055	2.055	465					30	34.4	3.30	3.09	88		61	61	405
Leonhardt_1962_010_15/2	1628		15/2	20	200	189	189	320	60,480	160		4,000		1,000	3.66	273	26	1,062	2.058	2.058	465					30	34.4	3.30	3.09	94		68	68	437
Leonhardt_1962_011_16/1	1629		16/1	20	200	190	190	320	60,800	160		5,000		1,250	4.58	273	26	1,062	2.047	2.047	465					30	31.9	2.59	2.94	88		68	68	416
Leonhardt_1962_012_16/2	1630		16/2	20	200	189	189	320	60,480	160		5,000		1,250	4.56	274	26	1,062	2.050	2.050	465					30	31.9	2.59	2.94	88		70	70	438
Regan_1971_001_UL1	1631	Regan (1971)	UL1	20	200	152	152	305	46,360	153		3,366		841	3.18	265	16	1,206	2.995	2.995	630	16		397	427	19	32.6	0.00	2.98	110		64	64	508
Shioya_1989_005_UB-10-1.3-0	1632	Shioya (1989)	UB-10-1.3-0	20	200	300	300	240	72,000	120		2,000		500	2.50	200	16	804	1.340	1.340	353					5	17.7	1.89	1.93	79		47	47	282
Shioya_1985_003_2-3	1633	Shioya (1989);	2-3	20	200	300	300	655	196,500	328		7,200		1,800	3.00	600	6	679	0.377	0.377	440					10	18.7	1.63	2.00	94		72	72	1,000
Shioya_1985_004_2-4	1634	Shioya, Nojiri,	2-4	20	200	500	500	1,200	600,000	600		12,000		3,000	3.00	1,000	10	2,199	0.440	0.440	370					10	24.8	1.85	2.46	151		157	157	1,600
Shioya_1985_005_2-5	1635	Akiyama (1985)	2-5	20	200	500	500	1,200	600,000	600		12,000		3,000	3.00	1,000	10	2,199	0.440	0.440	370					25	19.5	2.01	2.07	178		170	170	1,800
Shioya_1985_006_2-6	1636		2-6	20	200	1000	1,000	2,100	2,100,000	1050		24,000		6,000	3.00	2,000	16	8,042	0.402	0.402	370					25	26.1	2.46	2.55	924		539	539	4,133
Shioya_1985_007_2-7	1637		2-7	20	200	1500	1,500	3,140	4,710,000	1570		36,000		9,000	3.00	3,000	25	17,671	0.393	0.393	360					25	21.9	1.97	2.25	1,890		1,103	1,103	6,000
Shioya_1989_004_3-4	1638	Shioya (1989)	3-4	20	200	300	300	655	196,500	328		7,200		1,800	3.00	600	6	679	0.377	0.377	440					3	24.9	1.70	2.46	75		59	59	1,070
Shioya_1989_006_3-6	1639		3-6	20	200	500	500	1,200	600,000	600		12,000		3,000	3.00	1,000	10	2,199	0.440	0.440	370					5	25.8	1.58	2.53	112		120	120	1,850
SP1	1640	Perkins	SP1	20	200	307	307	1,000	307,000	500		4,800		500	2.63	914	30	2,100	0.748	0.748	460	75	20	600	429		64.0	2.64					150	
BF4	1641	Acevedo	BF4	20	200	300	300	1,000	300,000	500		7,200		500	3.89	925	30	2,100	0.757	0.757	400						53.4	2.41					74	
BF6	1642		BF6	20	200	299	299	1,000	299,000	500		4,800		500	2.59	925	30	2,100	0.759	0.759	400						55.4	2.46					134	

Figure A.12: *Shear Critical Beam Database (No Stirrups & Distributed Load)*

A.3 Stirrups - Point Loads

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Notation	**Nr.**	**Literature**	**ID**	**Modelling**		**Section properties**					**Loading and Geometry**					**Tension Reinf.**						**Compression Reinf.**				**Stirrups**				**Conc. Comp.**		**Conc. Tens.**		**Test Results**			
				Load Step	Ele. Size	b	b_w	h	A_c	z_{c2}	a_F	L	c	a	a/d	d_s	Φ_{sl}	A_s	r_s	r_w	f_{sy}	d_{s2}	Φ_{sl2}	A_{s2}	f_{sy2}	Φ_w	A_{sw}	r_w	f_{syw}	Φ_a	f'c	$f_{ct,test}$	$f_{ct,m,cal}$	F	$V_{u,F}+g_{R\Phi}$	$V_{u,Rep}$	$V_{u,R}+F$
	-	-	-	kN	mm	mm	mm	mm	mm²	mm	mm	mm	mm	mm	-	mm	mm	mm²	%	%	MPa	mm	mm	mm²	MPa	mm	mm²	%	MPa	mm	MPa	MPa	MPa	kN	kN	kN	kN
Ahmad_1996_003_NNW-3	19	Ahmad;	NNW-3	2	200	127	127	254	32,258	127	32	1,219	32	594	2.92	203	19	823	3.191	3.191	421	38	13	253	421	6	63	0.491	324	19	39		3.39		87		87	87
Ahmad_1996_006_NHW-3	22	Xie;	NHW-3	2	200	127	127	254	32,258	127	32	1,189	32	578	2.92	198	19	1,140	4.531	4.531	421	38	13	253	421	6	63	0.503	324	19	95		5.11	102		103	103
Ahmad_1996_007_NHW-3a	23	Yu (1996)	NHW-3a	2	200	127	127	254	32,258	127	32	1,189	32	578	2.92	198	19	1,140	4.531	4.531	421	38	13	253	421	6	63	0.654	324	19	87		4.96	108		108	108
Ahmad_1996_008_NHW-3b	24		NHW-3b	2	200	127	127	254	32,258	127	32	1,189	32	578	2.92	198	19	1,140	4.531	4.531	421	38	13	253	421	6	63	0.785	324	19	100		5.20	123		123	123
Ahmad_1996_009_NHW-4	25		NHW-4	2	200	127	127	254	32,258	127	32	1,585	32	777	3.92	198	19	1,140	4.531	4.531	421	38	13	253	421	6	63	0.503	324	19	96		5.12	94		94	94
Angelakos_1999_001_DB0.530M	40	Angelakos D.;	DB0.530M	2	200	300	300	1,000	300,000	500	76	5,400	76	2,662	2.88	925	30	1,400	0.505	0.505	550	75	15	400	483	10	71	0.079	508	10	30		2.78	256		266	266
Angelakos_1999_004_DB140M	42	Collins P. (1999)	DB140M	2	200	300	300	1,000	300,000	500	76	5,400	76	2,662	2.88	925	30	2,800	1.009	1.009	550	75	15	400	483	10	71	0.079	508	10	36		3.17	270		280	280
Aparicio_1997_001_VHA	45	Aparicio; Calavera	VHA	2	200	585	75	800	277,821	421		12,000	0	2,400	3.41	704	20	7,640	1.855	14.470	500		12	653	500	12	226	1.774	500		42		3.56		887		895
Aparicio_1997_002_HA-45	46	del Pozo (1997)	HA-45	2	200	1,450	150	1,450	830,000	550	320	21,850	320	4,190	3.06	1,369	32	19,302	0.972	9.400	520		10	1,030	500	12	226	1.676	582		41	4.21	3.49		3384		3429
Bernhardt_1986_002_S7 A	58	Bernhardt;	S7 A	2	200	150	150	200	30,000	100		2,550	1,450	550	3.42	161	20	1,257	5.203	5.203	500		8	101	427	8	101	0.670	427		78		4.77	140		141	141
Bernhardt_1986_003_S7 B	59	Fynboe (1986)	S7 B	2	200	150	150	200	30,000	100		2,550	1,450	550	3.42	161	20	1,257	5.203	5.203	500		8	101	427	8	101	0.670	427		78		4.77	150		151	151
Bernhardt_1986_004_S8 A	60		S8 A	2	200	150	150	200	30,000	100		2,550	1,450	550	3.42	161	20	1,257	5.203	5.203	500		8	101	427	7	67	0.447	427		78		4.77	125		126	126
Bernhardt_1986_005_S8 B	61		S8 B	2	200	150	150	200	30,000	100		2,550	1,450	550	3.42	161	20	1,257	5.203	5.203	500		8	101	427	7	67	0.447	427		78		4.77	135		136	136
Bhal_1968_001_B1S	62	Bhal (1968)	B1S	2	200	240	240	350	84,000	175	180	1,800	180	810	2.70	300	24	905	1.257	1.257	426	25	10	157	443	6	57	0.147	441	30	26	2.26	2.46	128		129	129
Bhal_1968_002_B2S	63		B2S	2	200	240	240	650	156,000	325	240	3,600	240	1,680	2.80	600	24	1,810	1.257	1.257	426	25	10	157	443	6	57	0.147	441	30	24	2.39	2.33	248		250	250
Bhal_1968_003_B3S	64		B3S	2	200	240	240	950	228,000	475	270	5,400	270	2,565	2.85	900	24	2,714	1.257	1.257	426	25	10	157	443	6	57	0.147	441	30	25	2.67	2.42	365		369	369
Bhal_1968_004_B4S	65		B4S	2	200	240	240	1,250	300,000	625	300	7,200	300	3,450	2.88	1,200	24	3,619	1.257	1.257	426	25	10	157	443	6	57	0.147	441	30	24	2.14	2.36	459		473	473
Bresler_1963_001_A-1	111	Bresler;	A-1	2	200	307	307	561	172,522	281	152	3,658	152	1,753	3.76	466	29	2,579	1.800	1.800	555	51	13	253	346	6	63	0.098	326	19	23	2.57	2.23	234		237	237
Bresler_1963_007_C-1	117	Scordelis (1963)	C-1	2	200	155	155	559	86,580	279	152	3,658	152	1,753	3.78	464	29	1,289	1.795	1.795	555	51	13	253	346	6	63	0.195	326	19	28	2.81	2.62	156		158	158
Caldera_2002_001_H 50/2	123	Cladera;	H 50/2	2	200	200	200	400	80,000	200	75	2,160	75	1,043	2.95	353	32	1,608	2.278	2.278	500	35	8	101	540	6	57	0.109	530	12	47		3.87		178		179
Caldera_2002_002_H 50/3	124	Mari (2002)	H 50/3	2	200	200	200	400	80,000	200	75	2,160	75	1,043	2.97	351	32	1,608	2.291	2.291	500	37	8	101	540	8	101	0.239	540	12	47		3.87		242		243
Caldera_2002_003_H 50/4	125		H 50/4	2	200	200	200	400	80,000	200	75	2,160	75	1,043	2.97	351	32	2,099	2.991	2.991	500	37	8	101	540	8	101	0.239	540	12	47		3.87		246		247
Caldera_2002_004_H 60/2	126		H 60/2	2	200	200	200	400	80,000	200	75	2,160	75	1,043	2.95	353	32	1,608	2.278	2.278	500	35	8	101	530	6	57	0.141	530	12	58		4.29		180		181
Caldera_2002_007_H 75/2	129		H 75/2	2	200	200	200	400	80,000	200	75	2,160	75	1,043	2.95	353	32	1,608	2.278	2.278	500	35	8	101	530	6	57	0.141	530	12	65		4.48		204		205
Caldera_2002_010_H 100/2	132		H 100/2	2	200	200	200	400	80,000	200	75	2,160	75	1,043	2.95	353	32	1,608	2.278	2.278	500	35	8	101	540	6	57	0.171	530	12	83		4.86		226		227
Cederwall_1974_003_734-46	137	Cederwall; Hedman; Losberg (1974)	734-46	2	200	139	139	260	36,140	169		3,000	1,800	900	2.56	234	12	339	1.043	1.043	818		8	101		6	57	0.407	437		29		2.66		96		97
Gabrielsson_1993_006_HS1	208	Gabrielsson (1993)	HS1	1	200	200	200	322	64,400	161		2,050	450	800	3.08	260	16	1,608	3.093	3.093	666					8	101	0.430	522		77	2.60	4.73		250		251
Gabrielsson_1993_007_HS2	209		HS2	2	200	200	200	322	64,400	161		2,800	600	1,100	4.23	260	16	1,608	3.093	3.093	666					8	101	0.265	522		77	2.60	4.73		200		201
Gabrielsson_1993_008_HPS1	210		HPS1	2	200	200	200	287	57,400	144		1,300	200	550	2.44	225	16	1,608	3.574	3.574	666					8	101	0.335	522		92	3.20	5.05		324		325
Gabrielsson_1993_009_HPS2	211		HPS2	2	200	200	200	287	57,400	144		1,300	200	550	2.44	225	16	1,608	3.574	3.574	666					8	101	0.335	522		97	3.20	5.14		305		306
Guidi_1963_001_V	213	Guidi; Radogna (1963)	V	2	200	250	80	400	59,200	200				1,500	3.95	380	12	1,018	1.071	3.348	491	20	6	113	491	6	57	0.707	491	15	32		2.92		123		124
Guralnik_1960_004_IB-2R	217	Guralnik (1960)	IB-2R	2	200	584	178	387	110,161	140	76	2,464	635	914	2.97	308	22	776	0.431	1.418	584		22	776	584	6	63	0.244	529	16	16	1.42	1.65		140		142
Guralnik_1960_005_IC-1R	218		IC-1R	2	200	584	178	387	110,161	140	76	2,438	610	914	3.06	299	32	2,410	1.379	4.531	577		32	2,410	577	13	253	1.603	341	16	32	2.16	2.92		412		414
Guralnik_1960_006_IC-2R	219		IC-2R	2	200	584	178	387	110,161	140	76	2,489	660	914	2.95	310	32	2,410	1.333	4.379	577		32	2,410	577	6	63	0.244	529	16	32	2.16	2.92		225		227
Guralnik_1960_008_ID-2R	221		ID-2R	2	200	584	178	387	110,161	140	76	2,515	686	914	2.99	306	22	1,346	0.753	2.473	602		22	1,346	602	6	63	0.244	529	16	32	2.16	2.92		218		220
Hamadi_1976_002_GT-2	243	Hamadi (1976); Hamadi, Regan (1980)	GT-2	2	200	500	120	400	86,000	134	75	2,500	75	1,213	3.46	350	20	1,257	0.718	2.992	400		12	452	350	6	57	0.377	320	20	24		2.29		149		150
Hegger_2001_001_SVB 3b	247	Hegger, J.; Görtz, S.; Will, N.(2001)	SVB 3b	2	200	220	180	500	100,000	242		3,000		1,500	3.33	450	25	2,945	2.975	3.636	532					8	101	0.559	514		67		4.51		427		429
Hegger_2003_001_NSC 3L	248	Hegger, J; Görtz, S. (2003)	NSC 3L	2	200	400	80	500	104,000	250	100	4,500	1,500	1,500	3.19	470	20	3,581	1.905	9.525	500					6	57	0.707	550		28		2.58		334		338
Hegger_2003_002_NSC 3R	249		NSC 3R	2	200	400	80	500	104,000	250	100	3,000	100	1,450	3.09	470	20	3,581	1.905	9.525	500					6	57	0.707	550		28		2.58		349		351
Johnston_1939_002_B2-II	250	Johnston; Cox (1939)	B2-II	2	200	305	305	338	103,064	169		2,743	914	914	3.00	305	16	764	0.822	0.822	416					6	63	0.102	276	19	21		2.09	100		103	103
Johnston_1939_009_T3-I	257		T3-I	2	200	305	305	337	102,718	169		2,743	914	914	3.00	305	19	726	0.781	0.781	444					6	63	0.102	276	19	21		2.09	102		104	104
Johnston_1939_010_T3-II	258		T3-II	2	200	305	305	337	102,718	169		2,743	914	914	3.00	305	19	726	0.781	0.781	444					6	63	0.102	276	19	21		2.09	95		97	97
Johnson_1989_001_1	259	Johnson;	1	2	200	305	305	610	185,806	305	229	4,255	914	1,670	3.10	539	32	4,086	2.489	2.489	525	46	29	1,289	540	6	63	0.156	479	19	35		3.07	338		344	344
Johnson_1989_002_2	260	Ramirez (1989)	2	2	200	305	305	610	185,806	305	229	4,255	914	1,670	3.10	539	32	4,086	2.489	2.489	525	46	29	1,289	540	6	63	0.078	479	19	35		3.07	222		228	228
Johnson_1989_005_5	263		5	2	200	305	305	610	185,806	305	229	4,255	914	1,670	3.10	539	32	4,086	2.489	2.489	525	46	29	1,289	540	6	63	0.156	479	19	53		4.16	383		388	388
Kong_1997_001_S1-1	358	Kong;	S1-1	2	200	250	250	350	87,500	175	100	1,960	500	730	2.50	292	36	2,046	2.803	2.803	452	41	12	224	462	5	38	0.153	569	7	59		4.31		228		230
Kong_1997_002_S1-2	359	Rangan (1997)	S1-2	2	200	250	250	350	87,500	175	100	1,960	500	730	2.50	292	36	2,046	2.803	2.803	452	41	12	224	462	5	38	0.153	569	7	59		4.31		208		210
Kong_1997_003_S1-3	360		S1-3	2	200	250	250	350	87,500	175	100	1,960	500	730	2.50	292	36	2,046	2.803	2.803	452	41	12	224	462	5	38	0.153	569	7	59		4.31		206		207
Kong_1997_004_S1-4	361		S1-4	2	200	250	250	350	87,500	175	100	1,960	500	730	2.50	292	36	2,046	2.803	2.803	452	41	12	224	462	5	38	0.153	569	7	59		4.31		278		279
Kong_1997_005_S1-5	362		S1-5	2	200	250	250	350	87,500	175	100	1,960	500	730	2.50	292	36	2,046	2.803	2.803	452	41	12	224	462	5	38	0.153	569	7	59		4.31		253		255
Kong_1997_006_S1-6	363		S1-6	2	200	250	250	350	87,500	175	100	1,960	500	730	2.50	292	36	2,046	2.803	2.803	452	41	12	224	462	5	38	0.153	569	7	59		4.31		224		225
Kong_1997_007_S2-1	364		S2-1	2	200	250	250	350	87,500	175	100	1,960	500	730	2.50	292	36	2,046	2.803	2.803	452	41	12	224	462	5	38	0.102	569	7	67	3.25	4.51		260		261
Kong_1997_008_S2-2	365		S2-2	2	200	250	250	350	87,500	175	100	1,960	500	730	2.50	292	36	2,046	2.803	2.803	452	41	12	224	462	5	38	0.123	569	7	67	3.25	4.51		233		234
Kong_1997_009_S2-3	366		S2-3	2	200	250	250	350	87,500	175	100	1,960	500	730	2.50	292	36	2,046	2.803	2.803	452	41	12	224	462	5	38	0.153	569	7	67	3.25	4.51		253		255
Kong_1997_010_S2-4	367		S2-4	2	200	250	250	350	87,500	175	100	1,960	500	730	2.50	292	36	2,046	2.803	2.803	452	41	12	224	462	5	38	0.153	569	7	67	3.25	4.51		219		221
Kong_1997_011_S2-5	368		S2-5	2	200	250	250	350	87,500	175	100	1,960	500	730	2.50	292	36	2,046	2.803	2.803	452	41	12	224	462	5	38	0.204	569	7	67	3.25	4.51		282		284
Kong_1997_013_S3-1	370		S3-1	2	200	250	250	350	87,500	175	100	1,980	500	740	2.49	297	28	1,232	1.659	1.659	450	41	12	224	462	4	25	0.099	632	7	62	3.28	4.40		209		211
Kong_1997_014_S3-2	371		S3-2	2	200	250	250	350	87,500	175	100	1,980	500	740	2.49	297	28	1,232	1.659	1.659	450	41	12	224	462	4	25	0.099	632	7	62	3.28	4.40		178		179
Kong_1997_015_S3-3	372		S3-3	2	200	250	250	350	87,500	175	100	1,960	500	730	2.49	293	36	2,046	2.793	2.793	452	41	12	224	462	4	25	0.099	632	7	62	3.28	4.40		229		230
Kong_1997_016_S3-4	373		S3-4	2	200	250	250	350	87,500	175	100	1,960	500	730	2.49	293	36	2,046	2.793	2.793	452	41	12	224	462	4	25	0.099	632	7	62	3.28	4.40		175		176
Kong_1997_017_S3-5	374		S3-5	2	200	250	250	350	87,500	175	100	1,940	500	720	2.51	287	24	2,760	3.847	3.847	442	41	12	224	462	4	25	0.099	632	7	62	3.28	4.40		297		298
Kong_1997_018_S3-6	375		S3-6	2	200	250	250	350	87,500	175	100	1,940	500	720	2.51	287	24	2,760	3.847	3.847	442	41	12	224	462	4	25	0.099	632	7	62	3.28	4.40		283		284
Kong_1997_019_S4-1	376	Kong;	S4-1	2	200	250	250	600	150,000	300	100	3,100	500	1,300	2.48	524	36	4,092	3.124	3.124	452	41	12	224	462	5	38	0.153	569	7	80	3.72	4.82		354		356
Kong_1997_021_S4-3	378	Rangan (1997)	S4-3	2	200	250	250	400	100,000	200	100	2,160	500	830	2.50	332	28	2,464	2.969	2.969	450	41	12	224	462	5	38	0.153	569	7	80	3.72	4.82		243		245
Kong_1997_022_S4-4	379		S4-4	2	200	250	250	350	87,500	175	100	1,960	500	730	2.50	292	36	2,046	2.803	2.803	452	41	12	224	462	5	38	0.153	569	7	80	3.72	4.82		258		259
Kong_1997_024_S4-6	381		S4-6	2	200	250	250	250	62,500	125	100	1,500	500	500	2.53	198	24	1,380	2.788	2.788	442	41	12	224	462	5	38	0.153	569	7	80	3.72	4.82		203		204
Kong_1997_025_S5-1	382		S5-1	2	200	250	250	350	87,500	175	100	2,260	500	880	3.01	292	36	2,046	2.803	2.803	452	41	12	224	452	5	38	0.153	569	7	82	4.80	4.86		242		243
Kong_1997_026_S5-2	383		S5-2	2	200	250	250	350	87,500	175	100	2,100	500	800	2.74	292	36	2,046	2.803	2.803	452	41	12	224	452	5	38	0.153	569	7	82	4.80	4.86		260		261
Kong_1997_027_S5-3	384		S5-3	2	200	250	250	350	87,500	175	100	1,960	500	730	2.50	292	36	2,046	2.803	2.803	452	41	12	224	462	5	38	0.153	569	7	82	4.80	4.86		244		245
Kong_1997_031_S7-1	388		S7-1	2	200	250	250	350	87,500	175	50	1,940	50	945	3.40	278	32	3,284	4.725	4.725	433	47	24	920	442	5	38	0.102	569	7	69	3.68	4.56		217		218
Kong_1997_032_S7-2	389		S7-2	2	200	250	250	350	87,500	175	50	1,940	50	945	3.40	278	32	3,284	4.725	4.725	433	47	24	920	442	5	38	0.123	569	7	69	3.68	4.56		205		206
Kong_1997_033_S7-3	390		S7-3	2	200	250	250	350	87,500	175	50	1,940	50	945	3.40	278	32	3,284	4.725	4.725	433	47	24	920	442	5	38	0.153	569	7	69	3.68	4.56		247		248
Kong_1997_034_S7-4	391		S7-4	2	200	250	250	350	87,500	175	50	1,940	50	945	3.40	278	32	3,284	4.725	4.725	433	47	24	920	442	5	38	0.192	569	7	69	3.68	4.56		274		275
Kong_1997_035_S7-5	392		S7-5	2	200	250	250	350	87,500	175	50	1,940	50	945	3.40	278	32	3,284	4.725	4.725	433	47	24	920	442	5	38	0.219	569	7	69	3.68	4.56		304		305
Kong_1997_036_S7-6	393		S7-6	2	200	250	250	350	87,500	175	50	1,940	50	945	3.40	278	32	3,284	4.725	4.725	433	47	24	920	442	5	38	0.256	569	7	69	3.68	4.56		311		312
Kong_1997_037_S8-1	394		S8-1	2	200	250	250	350	87,500	175	100	1,960	500	730	2.50	292	36	2,046	2.803	2.803	452	41	12	224	462	5	38	0.102	569	7	69	3.38	4.56		272		273
Kong_1997_038_S8-2	395		S8-2	2	200	250	250	350	87,500	175	100	1,960	500	730	2.50	292	36	2,046	2.803	2.803	452	41	12	224	462	5	38	0.123	569	7	69	3.38	4.56		251		252
Kong_1997_039_S8-3	396		S8-3	2	200	250	250	350	87,500	175	100	1,960	500	730	2.50	292	36	2,046	2.803	2.803	452	41	12	224	462	5	38	0.153	569	7	69	3.38	4.56		310		311
Kong_1997_040_S8-4	397		S8-4	2	200	250	250	350	87,500	175	100	1,960	500	730	2.50	292	36	2,046	2.803	2.803	452	41	12	224	462	5	38	0.153	569	7	69	3.38	4.56		266		267
Kong_1997_041_S8-5	398		S8-5	2	200	250	250	350	87,500	175	100	1,960	500	730	2.50	292	36	2,046	2.803	2.803	452	41	12	224	462	5	38	0.192	569	7	69	3.38	4.56		289		290
Kong_1997_042_S8-6	399		S8-6	2	200	250	250	350	87,500	175	100	1,960	500	730	2.50	292	36	2,046	2.803	2.803	452	41	12	224	462	5	38	0.219	569	7	69	3.38	4.56		284		285
Krefeld_1966_010_26-1	419	Krefeld; Thurston (1966)	26-1	2	200	254	254	508	129,032	254	127	3,658	127	1,765	3.87	456	29	2,579	2.228	2.228	352					6	63	0.164	341		38		3.30		207		210
Krefeld_1966_012_29b-1	421		29b-1	2	200	254	254	508	129,032	254	127	3,658	127	1,765	3.87	456	29	2,579	2.228	2.228	339					6	63	0.109	341		36		3.15		160		163
Krefeld_1966_015_29a-2	424		29a-2	2	200	254	254	508	129,032	254	127	3,658	127	1,765	3.87	456	29	2,579	2.228	2.228	383					6	63	0.109	372		35		3.12		217		220
Krefeld_1966_016_29b-2	425		29b-2	2	200	254	254	508	129,032	254	127	3,658	127	1,765	3.87	456	29	2,579	2.228	2.228	364					6	63	0.109	372		39		3.38		202		205
Krefeld_1966_017_29c-2	426		29c-2	2	200	254	254	508	129,032	254	127	3,658	127	1,765	3.87	456	29	2,579	2.228	2.228	271					6	63	0.109	372		23		2.24		161		164
Krefeld_1966_018_29d-2	427		29d-2	2	200	254	254	508	129,032	254

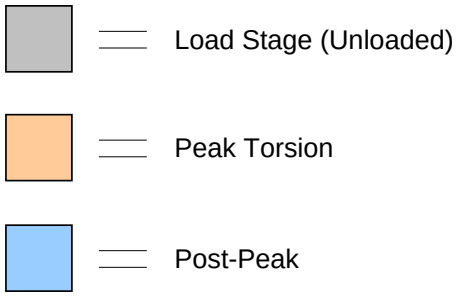
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Notation	**Nr.**	**Literature**	**ID**	**Modelling**		**Section properties**					**Loading and Geometry**					**Tension Reinf.**						**Compression Reinf.**				**Stirrups**				**Conc. Comp.**		**Conc. Tens.**		**Test Results**			
				Load Step	Ele. Size	b	b_w	h	A_c	z_{c2}	a_E	L	c	a	a/d	d_s	Φ_{st}	A_s	r_s	r_w	f_{sy}	d_{s2}	Φ_{st2}	A_{s2}	f_{sy2}	Φ_w	A_{sw}	r_w	f_{syw}	Φ_a	f'c	$f_{ct,test}$	$f_{ct,m,cal}$	F	$V_{u,F}+\gamma_{Rep}$	$V_{u,Rep}$	$V_{u,R}+F$
	-	-	-	kN	mm	mm	mm	mm	mm²	mm	mm	mm	mm	mm	-	mm	mm	mm²	%	%	MPa	mm	mm	mm²	MPa	mm	mm²	%	MPa	mm	MPa	MPa	MPa	kN	kN	kN	kN
Krefeld_1966_024_24.5-3	**433**		24.5-3	2	200	254	254	508	129,032	254	127	3,658	127	1,765	3.87	456	29	2.579	2.228	2.228	406					6	63	0.218	237		34		3.01			233	236
Krefeld_1966_034_39-3	**443**		39-3	2	200	254	254	508	129,032	254	127	3,658	127	1,765	3.87	456	29	2.579	2.228	2.228	406					10	142	0.244	276		41		3.45			240	243
Leonhardt_1962_002_ET2	**482**	Leonhardt; Walther (1962);	ET2	2	200	300	150	350	63,750	151	100	3,000	900	1,050	3.50	300	20	1,257	1.396	2.793	420	8	101	456		6	57	0.343	314	30	23	2.47	2.21	129	132	131	131
Leonhardt_1962_002_T1 (r)	**489**	Leonhardt; Walther; DAfStb152 (1962)	T1 (r)	2	200	1,500	100	900	362,500	292	200	6,000	1,000	2,500	3.03	825	26	8,464	0.684	10.259	465	10	864			12	232	2.900	427	30	23	2.38	2.24	785		800	800
Leonhardt_1963_010_TA12	**497**	Leonhardt; Walther (1963)	TA12	2	200	960	160	440	134,400	134	120	3,000	500	1,250	3.33	375	24	2,714	0.754	4.524	409	10	314	426		6	57	0.313	440	30	25	2.41	2.39	265	270	268	268
Levi_1989/1993_001_RC 30 A1	**503**	Levi;	RC 30 A1	2	200	900	120	1,050	278,000	433		9,600	2,000	3,800	4.04	940	24	9,048	1.069	8.021	500					12	226	0.838	480		24		2.30			676	695
Levi_1989/1993_002_RC 30 A2	**504**	Marro	RC 30 A2	2	200	900	120	1,050	278,000	433		9,600	2,000	3,800	4.04	940	24	9,048	1.069	8.021	500					12	226	0.838	480		24		2.30			688	707
Levi_1989/1993_003_RC 60 A1	**505**	(1989/1993)	RC 60 A1	2	200	900	120	1,050	278,000	433		9,600	2,000	3,800	4.04	940	26	10,619	1.255	9.414	450					12	226	0.838	480		45		3.71			990	1009
Levi_1989/1993_004_RC 60 A2	**506**		RC 60 A2	2	200	900	120	1,050	278,000	433		9,600	2,000	3,800	4.04	940	26	10,619	1.255	9.414	450					12	226	0.838	480		45		3.71			938	957
Levi_1989/1993_005_RC 60 B1	**507**		RC 60 B1	2	200	900	120	1,050	278,000	433		9,600	2,000	3,800	4.04	940	30	14,137	1.671	12.533	470					12	226	1.257	480		48		3.88			1181	1200
Levi_1989/1993_006_RC 60 B2	**508**		RC 60 B2	2	200	900	120	1,050	278,000	433		9,600	2,000	3,800	4.04	940	30	14,137	1.671	12.533	470					12	226	1.257	480		48		3.88			1239	1258
Levi_1989/1993_007_RC 70 B1	**509**		RC 70 B1	2	200	900	120	1,050	278,000	433		9,600	2,000	3,800	4.04	940	30	14,137	1.671	12.533	470					12	226	1.257	480		57		4.27			1330	1349
Maruyama_1988_001_RS2-WD	**522**	Maruyama K., Rizkalla S. H. (1988)	RS2-WD	2	200	650	86	490	90,550	168		3,000	700	1,150	2.89	450	16	402	0.137	1.035	400	10	143			6	30	0.230	645		38		3.30			126	128
Moayer_1974_002_P20	**524**	Moayer; Regan (1974)	P20	2	200	599	150	320	84,503	108	27	1,981	27	977	3.50	279	16	792	0.473	1.891	641					6	48	0.212	310	19	39		3.33			120	121
Özden_1967_002_T6	**533**	Özden (1967)	T6	2	200	400	110	355	62,250	126	130	3,000	900	1,050	3.52	298	20	1,257	1.054	3.834	441					8	101	0.609	273	16	32		2.87			137	139
Özden_1967_003_T7	**534**		T7	2	200	400	110	355	62,250	126	130	3,000	900	1,050	3.52	298	20	1,257	1.054	3.834	447					8	101	0.609	273	16	29		2.68			141	143
Özden_1967_004_T9	**535**		T9	2	200	400	110	355	62,250	126	130	3,000	900	1,050	3.52	298	20	1,257	1.054	3.834	444					8	101	0.609	273	16	29		2.68			154	155
Ozcebe_1999_003_TS56	**552**	Ozcebe; Ersoy; Tankut (1999)	TS56	2	200	150	150	360	54,000	180		3,500	400	1,550	5.00	310	16	1,608	3.459	3.459	450	10	157	410		4	25	0.239	255	15	58		4.29			129	130
Ozcebe_1999_006_TS59	**555**		TS59	2	200	150	150	360	54,000	180		3,500	400	1,550	5.00	310	20	2,061	4.432	4.432	435	10	157	410		4	25	0.279	255	15	78		4.76			125	127
Ozcebe_1999_009_TS36	**558**		TS36	2	200	150	150	360	54,000	180		2,260	400	930	3.00	310	16	1,206	2.594	2.594	450	10	157	410		4	25	0.239	255	15	71		4.62			156	157
Ozcebe_1999_011_TH39	**560**		TH39	2	200	150	150	360	54,000	180		2,260	400	930	3.00	310	20	1,433	3.081	3.081	439	10	157	410		4	25	0.209	255	15	69		4.57			143	144
Ozcebe_1999_012_TS39	**561**		TS39	2	200	150	150	360	54,000	180		2,260	400	930	3.00	310	20	1,433	3.081	3.081	439	10	157	410		4	25	0.279	255	15	69		4.57			179	180
Petersson_1972_001_V1	**563**	Petersson (1972)	V1	2	200	175	175	353	61,775	177	100	2,600	100	1,150	3.57	322	16	603	1.070	1.070	977	10	157	463		6	57	0.215	323	16	36		3.17	100		101	101
Petersson_1972_002_VL1	**564**		VL1	2	200	301	120	307	60,732	152	100	2,200	100	900	3.24	278	16	1,005	1.201	3.014	990	16	402	635		8	101	0.838	366	16	41		3.47	190		191	191
Quast_1999_001_1/1	**565**	Quast (1999); Los (2000)	1/1	2	200	260	260	401	104,260	263	75	2,400	75	1,163	3.27	355	28	1,232	1.334	1.334	563	44	20	628	556	6	57	0.091	641	16	45		3.72	153		154	154
Regan_1971_001_R8	**581**	Regan (1971)	R8	2	200	152	152	305	46,360	153	75	1,828	75	876	3.22	272	16	603	1.459	1.459	630	10	142	270		6	49	0.213	270	19	25		2.40			81	82
Regan_1971_004_R11	**584**		R11	2	200	152	152	305	46,360	153	75	1,828	75	876	3.22	272	16	804	1.945	1.945	630	10	142	270		6	49	0.213	270	19	25		2.36			91	92
Regan_1971_005_R12	**585**		R12	2	200	152	152	305	46,360	153	75	1,829	75	877	3.45	254	16	1,608	4.166	4.166	630	10	142	270		6	49	0.213	270	19	32		2.88			112	113
Regan_1971_011_R20	**591**		R20	2	200	152	152	305	46,360	153	75	1,828	75	876	3.22	272	16	603	1.459	1.459	630	10	142	270		6	49	0.213	270	19	40		3.43			92	93
Regan_1971_012_R21	**592**		R21	2	200	152	152	305	46,360	153	75	1,829	75	877	3.45	254	16	1,608	4.166	4.166	630	10	142	270		6	62	0.402	280	19	45		3.73			153	154
Regan_1971_013_R22	**593**		R22	2	200	152	152	305	46,360	153	75	2,448	75	1,187	4.36	272	16	1,608	3.891	3.891	630	10	142	270		6	49	0.213	270	19	28		2.59			81	82
Regan_1971_016_R25	**596**		R25	2	200	152	152	305	46,360	153	75	1,829	75	877	3.45	254	16	1,608	4.166	4.166	630	25	1,013	427		6	49	0.213	270	19	29		2.68			107	108
Regan_1971_021_T3	**601**		T3	2	200	610	152	305	81,168	103	50	1,833	50	892	3.28	272	16	603	0.364	1.459	630	10	443	270		6	49	0.213	270	19	27		2.57			105	106
Regan_1971_022_T4	**602**		T4	2	200	610	152	305	81,168	103	50	1,833	50	892	3.28	272	16	804	0.485	1.945	630	10	443	270		6	49	0.213	270	19	33		2.93			110	111
Regan_1971_025_T7	**605**		T7	2	200	610	152	305	81,168	103	50	1,827	50	888	3.37	264	16	1,206	0.749	3.006	630	10	443	270		6	49	0.213	280	19	27		2.51			109	110
Regan_1971_026_T8	**606**	Regan (1971)	T8	2	200	610	152	305	81,168	103	50	1,829	50	889	3.50	254	16	1,608	1.038	4.166	630	10	443	270		6	49	0.213	280	19	30		2.77			124	125
Regan_1971_029_T13	**609**		T13	2	200	610	152	305	81,168	103	50	1,833	50	892	3.28	272	16	603	0.364	1.459	630	10	443	270		6	49	0.213	270	19	13		1.35			90	91
Regan_1971_030_T15	**610**		T15	2	200	610	152	305	81,168	103	50	3,658	50	1,804	7.10	254	16	1,608	1.038	4.166	630	10	443	270		6	49	0.213	270	19	31		2.86			104	106
Regan_1971_032_T17	**612**		T17	2	200	610	152	305	81,168	103	50	3,658	50	1,804	7.10	254	16	1,608	1.038	4.166	630	10	443	270		6	62	0.402	280	19	34		3.00			134	136
Regan_1971_033_T19	**613**		T19	2	200	610	152	305	81,168	103	50	2,743	50	1,347	5.30	254	16	1,608	1.038	4.166	630	10	443	270		6	49	0.213	270	19	29		2.67			106	107
Regan_1971_034_T20	**614**		T20	2	200	610	152	305	81,168	103	50	2,743	50	1,347	5.30	254	16	1,608	1.038	4.166	630	10	443	270		6	62	0.402	280	19	30		2.76			138	139
Regan_1971_038_T25	**618**		T25	2	200	610	152	305	81,168	103	50	1,833	50	892	3.28	272	16	603	0.364	1.459	630	10	443	270		6	49	0.213	270	19	50		4.03			114	115
Regan_1971_039_T26	**619**		T26	2	200	610	152	305	81,168	103	50	1,829	50	889	3.50	254	16	1,608	1.038	4.166	630	10	443	270		6	62	0.402	280	19	49		3.98			179	180
Regan_1971_046_T34	**626**		T34	2	200	305	152	305	57,988	130	50	2,743	50	1,347	5.30	254	16	1,608	2.076	4.166	630	10	443	270		6	49	0.213	270	19	30		2.74			112	113
Regan_1971_047_T35	**627**		T35	2	200	1,066	152	305	115,824	84	50	2,743	50	1,347	5.30	254	16	1,608	0.594	4.166	630	10	443	270		6	49	0.213	270	19	30		2.74			115	117
Regan_1971_059_W5	**639**		W5	2	200	610	64	305	76,786	113	50	1,830	50	890	3.33	267	16	1,608	0.988	9.413	630	10	314	275		10	157	0.259	190	19	33		2.94			190	191
Regan_1971_061_W7	**641**		W7	2	200	610	64	305	76,786	113	50	1,830	50	890	3.33	267	16	1,608	0.988	9.413	630	10	314	275		8	101	2.067	691	19	33		2.94			162	163
Rehm_1978_001_RsIS / BQ II 0	**642**	Rehm; Eligehausen; Neubert (1978)	RsIS / BQ II 0	2	200	900	250	510	208,750	180		3,870	1,290	1,290	3.00	430	26	4.247	1.098	3.951	469	8	201			11	190	0.760	560	32	23		2.26			595	601
Rehm_1978_004_RnIIS	**645**		RnIIS	2	200	950	450	600	345,000	251		4,932	1,644	1,644	3.00	548	26	3,355	0.644	1.361	746					9	113	0.336	557	32	21		2.08			745	758
Reineck_1991_001_Stb III	**646**	Reineck (2001)	Stb III	2	200	838	77	648	207,323	318	160	5,200	160	2,520	4.27	590	28	6,158	1.245	13.554	515	28	7,081	514		8	99	1.195	515	8	58	4.32	4.28	530		537	537
Reineck_1991_002_Stb I	**647**		Stb I	2	200	837	77	650	209,760	333	160	5,190	160	2,515	4.27	589	28	7,081	1.436	15.613	514	28	6,158	515		10	163	1.678	549	8	58	4.32	4.28	675		682	682
Roller_1990_007_7	**657**	Roller; Russel (1990)	7	2	200	457	457	870	397,741	435	133	4,572	133	2,219	2.91	762	32	6,538	1.877	1.877	472					10	143	0.158	445	13	69	3.79	4.56			788	799
Roller_1990_009_9	**659**		9	2	200	457	457	870	397,741	435	133	4,572	133	2,219	2.91	762	32	8,173	2.346	2.346	472					10	143	0.158	445	13	119	5.07	5.52			749	761
Roller_1990_010_10	**660**		10	2	200	457	457	870	397,741	435	133	4,572	133	2,219	2.91	762	36	10,074	2.892	2.892	431					10	143	0.234	445	13	119	5.07	5.52			1172	1183
Sarsam_1992_007_BL2-H	**667**	Sarsam; Al-Musawi (1992)	BL2-H	2	200	180	180	270	48,600	135	100	2,264	400	932	4.00	233	25	1,183	2.820	2.820	502	34	10	157	450	4	25	0.093	820	12	72		4.63			138	139
Sarsam_1992_008_BS2-H	**668**		BS2-H	2	200	180	180	270	48,600	135	100	1,565	400	583	2.50	233	25	1,183	2.820	2.820	502	34	10	157	450	4	25	0.093	820	12	70		4.59			224	224
Sarsam_1992_010_BS4-H	**670**		BS4-H	2	200	180	180	270	48,600	135	100	1,565	400	583	2.50	233	25	1,183	2.820	2.820	502	34	10	157	450	4	25	0.186	820	12	76		4.73			207	207
Sarsam_1992_011_CL2-H	**671**		CL2-H	2	200	180	180	270	48,600	135	100	2,264	400	932	4.00	233	25	1,470	3.505	3.505	543	34	10	157	450	4	25	0.093	820	12	67		4.51			147	148
Sarsam_1992_013_CS3-H	**673**		CS3-H	2	200	180	180	270	48,600	135	100	1,565	400	583	2.50	233	25	1,470	3.505	3.505	543	34	10	157	450	4	25	0.140	820	12	70		4.60			247	248
Sarsam_1992_014_CS4-H	**674**		CS4-H	2	200	180	180	270	48,600	135	100	1,565	400	583	2.50	233	25	1,470	3.505	3.505	543	34	10	157	450	4	25	0.186	820	12	72		4.63			221	221
Shin_1999_009_MHB 2.5-25	**683**	Shin; Lee; Moon; Gosh (1999)	MHB 2.5-25	2	200	125	125	250	31,250	125	23	1,075	23	526	2.45	215	25	1,013	3.771	3.771	410	10	143	392		6	63	0.295	366	19	49		3.99	99		99	99
Shin_1999_010_MHB 2.5-50	**684**		MHB 2.5-50	2	200	125	125	250	31,250	125	23	1,075	23	526	2.45	215	25	1,013	3.771	3.771	410	10	143	392		6	63	0.589	366	19	49		3.99	149		149	149
Shin_1999_021_HB 2.5-25	**695**		HB 2.5-25	2	200	125	125	250	31,250	125	23	1,075	23	526	2.45	215	25	1,013	3.771	3.771	410	10	143	392		6	63	0.295	366	13	69		4.57	116		116	116
Shin_1999_022_HB 2.5-50	**696**		HB 2.5-50	2	200	125	125	250	31,250	125	23	1,075	23	526	2.45	215	25	1,013	3.771	3.771	410	10	143	392		6	63	0.589	366	13	69		4.57	149		149	149
Soerensen_1974_001_T-21	**699**	Soerensen (1974)	T-21	2	200	400	110	355	62,250	126	100	3,000	900	1,050	3.52	298	20	1,257	1.054	3.834	420					8	101	0.522	229	32	31		2.82	129		131	131
Soerensen_1974_003_T-23	**701**		T-23	2	200	400	110	355	62,250	126	100	3,000	900	1,050	3.52	298	20	1,257	1.054	3.834	420					6	57	0.343	349	32	33		2.93	139		141	141
Soerensen_1974_007_T-2-B	**705**		T-2-B	2	200	400	110	355	62,250	126	100	3,000	900	1,050	3.52	298	20	1,257	1.054	3.834	457	36	8	201	262	5	39	0.305	397	32	24		2.29	129		131	131
Soerensen_1974_009_T-4-B	**707**		T-4-B	2	200	400	110	355	62,250	126	100	3,000	900	1,050	3.52	298	20	1,257	1.054	3.834	457	36	8	201	262	5	39	0.204	397	32	23		2.28	107		108	108
Stroband_1997_002_2	**710**	Stroband (1997)	2	2	200	500	90	700	165,500	336	91	5,000	69	1,654	2.56	647	25	3,574	1.104	6.136	600		10	314		8	101	0.677	600	16	83	6.12	4.87			528	531
Stroband_1997_003_3	**711**		3	2	200	500	90	700	165,500	336	91	5,000	69	1,654	2.56	647	32	5,228	1.616	8.976	560		10	314		12	226	1.523	630	16	84	6.30	4.89			886	890
Stroband_1997_004_4	**712**		4	2	200	500	90	700	165,500	336	91	5,000	69	1,654	2.50	662	32	6,434	1.945	10.806	560		10	314		12	226	2.646	630	16	85	6.75	4.91			1141	1145
Stroband_1997_005_5	**713**		5	2	200	500	90	700	165,500	336	91	5,000	69	1,654	2.55	650	32	6,836	2.103	11.686	560		10	314		12	226	3.867	630	16	85	6.21	4.91			1216	1219
Tan_1995_019_G-2.70-5.38	**759**	Tan, K.H.; Kong, F.K.; Teng, S.; Guan, L. (	G-2.70-5.38	2	200	110	110	500	55,000	250		2,500	0	1,250	2.70	463	20	628	1.234	1.234	505		6	57		10	157	0.476	375	10	34		3.05	105		106	106
Taylor_1966_004_HSS-1-B	**785**	Taylor, R. (1966)	HSS-1-B	2	200	305	114	305	49,355	119		2,591	305	1,143	4.44	257	16	990	1.263	3.367	441		22	776	278	5	42	0.326	438	19	19		1.88	86		87	87
Yoon_1996_009_H2-N	**805**	Yoon; Cook; Mitchell (1996)	H2-N	2	200	375	375	750	281,250	375	75	4,300	75	2,113	3.23	655	30	7,022	2.859	2.859	400		10	157		10	142	0.236	430	10	83	5.49	4.86			721	728
Rosenbusch_2003_001_1.3-1	**806**	Rosenbusch (2003)	1.3/1	2	200	200	200	300	60,000	150	50	1,800		875	3.37	260	28	1,847	3.552	3.552	550	40	6	57	550	4	25	0.070	680	16	47		3.83	120		121	121
Rosenbusch_2003_002_1.4-1	**807**		1.4/1	2	200	200	200	300	60,000	150	50	1,800		875	3.37	260	28	1,847	3.552	3.552	550	40	6	57	550	4	25	0.140	680	16	46		3.76	170		171	171
Rosenbusch_2003_004_1.7-1	**809**		1.7/1	2	200	200	200	300	60,000	150	50	1,800		875	3.37	260	28	1,847	3.552	3.552	550	40	6	57	550	8	101	0.559	550	16	48		3.90	190		190	190
Kautsch_2010_001_A2	**810**	Kautsch (2010)	A2	2	200	655	155	820	207,100	283	150	4,000		1,925	2.68	719	28	3,195	0.678	2.865	468	75	12	1,357	585	8	101	0.432	605	16	29	2.51	2.71	653		657	657
Kautsch_2010_002_B2	**811**		B2	2	200	655	155	820	207,100	283	150	4,000		1,925	2.68	719	28	3,195	0.678	2.865	468	75	12	1,357	585	8	101	0.324	605	16	30	2.48	2.74	566		571	571
Tanimura_2005_031_41	**865**	Tanimura; Sato (2005)	41	2	200	300	300	450	135,000	225	100	2,400	400	1,000	2.50	400	29	2,642	2.202	2.202	750		16	402		10	157	0.524	388		20		1.97			324	326

Figure A.14: *Shear Critical Beam Database (Stirrups - Part 2/2)*

B. AeroPro Experimental Data

The following appendix presents the data recorded by the various types of instrumentation, processed through the AeroPro software, during the pure torsion shell experiments. Since the data was sampled at 10 Hz, the initial unfiltered number of data rows per test was unwieldly (approx. 200,000 rows). To make the analysis tasks more manageable this was reduced to the approximately 800 data rows per test presented here. In the interest of keeping the appendix compact, the excel sheets have been stitched together with columns across the page, to be read from top to bottom and from left to right.

Certain cells have been highlighted, the legend is shown below:



B.1 Specimen ES1

Actuators

NAME	N_{fact}	N_{Top}	N_{Lcast}	N_{Mwire}	S_{fact}	S_{Top}	S_{Lcast}	S_{Swire}	T_{avg}
UNIT	[kN]	[kN]	[kN]	[kN]	[kN]	[kN]	[kN]	[kN]	[kN*m/m]
ROW #									
3	-6.9	-16.8	-4.1	-6.3	-10.4	-8.1	-8.2	-4.4	1.6
3790	-4.2	-14.0	-8.4	3.4	-5.7	26.4	-6.0	-13.2	2.0
3806	-6.5	-12.6	-1.7	28.6	13.3	60.0	1.2	-24.3	3.7
3822	-20.1	-17.0	13.2	43.8	25.1	78.1	-4.4	-30.2	5.8
3961	-22.1	-10.9	14.9	34.8	1.4	65.8	-4.3	-22.9	4.5
4118	-23.1	-14.4	10.3	21.5	-5.5	35.7	-3.0	-14.6	3.2
27328	-18.6	-19.2	-1.2	3.1	-14.6	26.5	5.5	1.6	2.3
59268	-31.9	9.8	10.6	12.6	-6.4	31.1	-7.8	-9.5	3.0
65462	-42.4	-0.2	21.5	21.6	3.7	40.3	-20.4	-21.3	4.3
65601	-53.9	-10.3	33.0	33.1	16.2	50.7	-31.0	-33.2	2.0
65686	-64.4	-21.9	43.8	43.8	26.6	62.5	-40.5	-43.7	8.7
65839	-75.1	-33.8	54.6	54.5	37.4	74.5	-50.1	-54.5	10.9
66240	-86.3	-44.3	65.7	65.7	48.5	85.3	-59.4	-65.6	13.0
68683	-97.5	-55.4	76.7	76.7	59.6	95.6	-69.8	-76.7	15.3
68967	-108.4	-66.3	87.7	87.7	70.5	106.2	-79.4	-87.7	17.4
69104	-119.3	-77.4	98.6	98.7	81.6	117.0	-89.1	-98.7	19.6
69200	-130.5	-88.5	109.9	109.8	92.7	127.7	-98.8	-109.9	21.8
69489	-141.4	-99.3	120.7	120.6	103.5	138.0	-108.2	-120.6	23.9
69713	-152.6	-110.3	131.7	131.8	114.5	148.9	-118.2	-131.6	26.1
69825	-163.3	-121.2	142.6	142.6	125.4	159.7	-127.4	-142.6	28.3
69921	-174.5	-132.4	153.8	153.9	136.6	170.6	-137.5	-153.8	30.5
70128	-185.5	-143.4	164.8	164.9	147.6	181.3	-146.9	-164.8	32.7
70320	-196.5	-154.3	175.7	175.8	158.5	192.1	-156.3	-175.7	34.8
70444	-207.3	-165.2	186.7	186.8	169.4	202.7	-166.6	-186.7	37.0
70669	-218.2	-176.1	197.6	197.8	180.3	213.6	-177.3	-197.6	39.0
70997	-229.6	-187.4	208.9	209.0	191.7	224.4	-187.9	-208.9	41.4
71243	-240.9	-198.8	220.3	220.3	203.0	235.4	-198.3	-220.3	43.7
71373	-251.7	-209.6	231.1	231.2	213.8	246.0	-208.6	-231.1	45.8
71557	-262.5	-220.3	241.9	242.0	224.5	257.0	-216.6	-242.0	47.9
71860	-273.3	-231.2	252.8	252.8	235.4	267.9	-228.5	-252.8	50.1
72184	-284.2	-242.1	263.7	263.7	246.2	278.5	-239.0	-263.6	52.3
72500	-295.1	-253.1	274.6	274.6	257.2	289.6	-250.0	-274.6	54.5
72910	-305.8	-263.7	285.3	285.4	267.8	299.4	-258.8	-285.4	56.6
73144	-316.7	-274.6	296.2	296.2	278.8	310.4	-268.3	-296.2	58.7
73445	-327.5	-285.5	307.1	307.1	289.6	321.1	-278.5	-307.2	60.9
73769	-338.6	-296.5	318.0	318.1	300.7	331.8	-289.1	-318.1	63.1
74090	-349.5	-307.3	329.0	329.1	311.5	342.1	-299.1	-329.0	65.3
74506	-360.5	-318.4	340.1	340.2	322.6	352.7	-309.8	-340.1	67.5
74713	-371.0	-329.0	350.8	350.8	333.3	363.4	-320.2	-350.8	69.6
75658	-382.0	-339.8	361.5	361.6	343.9	373.9	-328.2	-361.5	71.7
76799	-392.6	-350.5	372.3	372.3	354.7	383.9	-338.6	-372.3	73.8
77056	-403.7	-361.6	383.4	383.4	365.7	394.5	-348.9	-383.3	76.0
77272	-414.6	-372.6	394.2	394.3	376.7	405.3	-358.7	-394.2	78.2
77775	-425.7	-383.5	405.2	405.2	387.7	415.8	-368.5	-405.2	80.3
77909	-436.4	-394.4	416.2	416.2	398.6	426.6	-378.5	-416.2	82.5
78492	-447.5	-405.4	427.1	427.2	409.6	437.3	-388.8	-427.2	84.7
78613	-458.5	-416.3	438.1	438.1	420.5	447.7	-397.4	-438.1	86.8
79516	-447.6	-405.6	427.4	427.5	409.8	437.3	-386.5	-427.4	84.7
80118	-436.8	-394.9	416.6	416.6	399.0	427.0	-378.9	-416.6	82.6
83849	-425.7	-383.7	405.6	405.5	387.9	416.2	-369.9	-405.5	80.4
99294	-414.8	-372.8	394.7	394.7	377.0	405.7	-359.4	-394.7	78.3
103450	-426.1	-383.8	405.4	405.5	388.0	416.3	-369.0	-405.2	80.4
103579	-437.3	-395.0	416.7	416.7	399.2	426.9	-378.3	-416.7	82.6
103664	-448.3	-406.0	427.7	427.9	410.2	437.6	-388.3	-427.8	84.8
103892	-459.2	-417.1	438.8	438.8	421.2	448.1	-398.6	-438.7	87.0
104001	-470.0	-428.0	449.9	449.9	432.2	458.9	-408.6	-449.8	89.2
104187	-480.9	-438.9	460.8	460.8	443.1	469.6	-419.0	-460.8	91.3
104377	-492.2	-450.0	471.8	471.9	454.2	480.3	-428.0	-471.8	93.5
104630	-503.1	-461.0	482.7	482.8	465.0	491.6	-437.6	-482.7	95.6
104830	-514.1	-472.0	493.8	493.9	476.2	501.1	-448.0	-493.8	97.8
105039	-524.9	-482.8	504.7	504.7	487.0	511.2	-458.1	-504.7	100.0
105400	-536.0	-493.8	515.7	515.8	498.0	521.0	-467.9	-515.6	102.1
105715	-547.1	-504.8	526.8	526.8	509.0	531.4	-478.0	-526.8	104.3
105946	-558.1	-515.9	537.8	537.8	520.0	542.1	-489.3	-537.8	106.5
106220	-568.6	-526.5	548.5	548.5	530.7	552.7	-500.4	-548.5	108.7
106538	-579.6	-537.4	559.4	559.5	541.6	562.9	-510.4	-559.4	110.8
106918	-590.7	-548.5	570.4	570.6	552.6	573.5	-520.8	-570.4	113.0
107216	-601.7	-559.5	581.5	581.6	563.7	583.9	-530.5	-581.4	115.2
107427	-612.7	-570.6	592.6	592.7	574.8	594.6	-540.9	-592.6	117.4
107736	-623.7	-581.5	603.4	603.6	585.6	605.0	-551.0	-603.4	119.6
107929	-634.7	-592.6	614.6	614.6	596.8	615.6	-561.2	-614.6	121.8
108193	-645.5	-603.4	625.4	625.5	607.6	626.0	-571.4	-625.4	123.9
108620	-656.8	-614.6	636.5	636.5	618.7	636.1	-581.0	-636.5	126.1
108784	-667.6	-625.4	647.2	647.3	629.5	646.7	-591.4	-647.2	128.2
109910	-678.6	-636.5	658.4	658.5	640.6	657.3	-600.4	-658.4	130.4
110098	-689.5	-647.3	669.4	669.4	651.5	667.9	-610.1	-669.3	132.6
110425	-700.3	-658.4	680.4	680.5	662.6	677.9	-621.0	-680.3	134.7
110725	-711.3	-669.2	691.3	691.3	673.5	687.7	-631.8	-691.3	136.9
111677	-700.5	-658.5	680.6	680.6	662.7	678.2	-621.9	-680.6	134.8
113390	-689.5	-647.4	669.4	669.5	651.7	668.4	-612.4	-669.5	132.6
114004	-700.9	-658.6	680.6	680.6	662.8	678.2	-621.9	-680.6	134.8
114107	-711.8	-669.6	691.6	691.6	673.8	688.7	-632.7	-691.6	137.0
114287	-722.6	-680.5	702.4	702.5	684.6	699.3	-642.9	-702.4	139.2
114460	-733.9	-691.8	713.7	713.8	695.8	709.9	-653.0	-713.7	141.4
114560	-744.5	-702.5	724.5	724.6	706.6	720.0	-662.8	-724.5	143.5
114740	-755.4	-713.3	735.3	735.3	717.4	730.7	-673.4	-735.3	145.7
115034	-766.2	-724.1	746.1	746.3	728.2	740.7	-682.8	-746.1	147.8
115365	-777.3	-735.2	757.3	757.4	739.3	751.6	-693.0	-757.2	150.0
116420	-766.3	-724.3	746.4	746.4	728.5	741.7	-682.0	-746.3	147.8
117644	-755.4	-713.5	735.5	735.5	717.7	732.2	-673.9	-735.5	145.6
117764	-766.4	-724.2	746.2	746.4	728.4	741.8	-683.3	-746.1	147.8
117864	-777.3	-735.2	757.3	757.4	739.4	752.1	-693.1	-757.3	150.0
118042	-788.3	-746.2	768.3	768.4	750.4	762.2	-703.4	-768.3	152.2
118364	-799.4	-757.3	779.3	779.3	761.4	772.7	-714.7	-779.3	154.4
118542	-810.2	-768.0	790.1	790.2	772.1	782.9	-724.5	-790.0	156.5
118822	-821.3	-779.1	801.2	801.3	783.3	793.9	-735.2	-801.2	158.7
119033	-832.0	-789.8	812.1	812.2	794.0	804.6	-745.4	-812.1	160.9
119308	-843.0	-801.0	823.1	823.3	805.1	815.6	-756.5	-823.1	163.1
119769	-854.1	-811.9	834.1	834.1	816.1	825.8	-766.0	-834.0	165.3
120100	-865.0	-823.0	845.2	845.2	827.2	836.5	-776.1	-845.1	167.5
120508	-875.8	-833.7	855.8	855.9	837.8	846.9	-786.7	-855.9	169.6
120956	-881.9	-839.9	862.2	862.2	844.1	853.7	-792.7	-862.3	170.9
121410	-871.0	-829.2	851.5	851.3	833.4	844.3	-783.2	-851.5	168.8
121496	-859.6	-817.7	840.2	840.1	822.0	834.2	-772.8	-840.2	166.5
121598	-848.6	-806.7	829.0	829.0	811.0	824.2	-762.8	-829.2	164.3
121629	-838.0	-796.0	818.1	818.1	800.1	814.1	-752.9	-818.2	162.2
121874	-826.3	-784.5	806.9	806.7	788.9	803.8	-741.3	-807.0	160.0
121961	-815.4	-773.6	795.9	795.8	777.9	793.4	-730.7	-795.9	157.8
122068	-804.7	-762.7	784.9	784.9	766.9	783.1	-720.1	-784.9	155.6
124120	-793.7	-751.8	774.1	774.1	756.0	771.9	-711.1	-774.1	153.5
147223	-804.8	-762.7	784.7	784.8	766.9	781.4	-717.6	-784.7	155.5
147423	-815.6	-773.7	795.7	795.9	777.9	791.5	-727.8	-795.7	157.7
147457	-826.7	-784.5	806.6	806.7	788.6	801.6	-738.0	-806.5	159.8
147551	-837.7	-795.6	817.7	817.8	799.7	811.9	-748.7	-817.7	162.0
147733	-848.5	-806.4	828.5	828.6	810.5	822.0	-759.7	-828.5	164.2
147987	-859.6	-817.5	839.6	839.7	821.6	832.0	-770.5	-839.6	166.4
148115	-870.3	-828.4	850.5	850.6	832.5	842.3	-780.8	-850.5	168.5
148225	-881.4	-839.3	861.6	861.7	843.5	853.0	-791.0	-861.5	170.7
148533	-892.4	-850.3	872.4	872.5	854.4	863.8	-802.2	-872.3	172.9
148790	-903.2	-861.1	883.4	883.5	865.2	874.3	-811.2	-883.3	175.1
149126	-914.1	-872.1	894.4	894.4	876.4	885.1	-823.2	-894.4	177.3
149435	-925.0	-882.9	905.2	905.3	887.2	895.6	-833.4	-905.2	179.4
149989	-934.4	-892.2	914.4	914.4	896.4	904.9	-842.7	-914.3	181.3
150102	-936.8	-894.7	916.9	916.9	898.8	907.4	-844.9	-916.9	181.8
150119	-939.1	-897.0	919.2	919.3	901.1	909.5	-847.4	-919.2	182.3
150236	-936.8	-894.9	917.3	917.3	899.1	908.5	-845.3	-917.3	181.9
150254	-939.2	-896.9	919.1	919.3	901.0	910.1	-846.6	-919.2	182.3
150364	-941.5	-899.2	921.3	921.3	903.3	912.2	-848.6	-921.4	182.7
150378	-943.5	-901.3	923.7	923.9	905.5	914.4	-850.7	-923.7	183.1
150431	-941.3	-899.4	921.9	921.8	903.6	912.8	-849.0	-921.9	182.8
150470	-939.1	-897.2	919.6	919.6	901.4	910.7	-846.9	-919.6	182.3
150497	-941.7	-899.5	921.7	921.8	903.6	912.4	-848.6	-921.7	182.7
150510	-944.0	-901.8	924.1	924.3	905.9	914.6	-850.8	-924.1	183.2
150533	-946.1	-904.1	926.5	926.5	908.3	916.9	-853.0	-926.4	183.7
150594	-948.7	-906.5	928.7	928.7	910.6	919.2	-855.1	-928.7	184.2
150609	-950.9	-908.8	931.1	931.2	912.9	921.2	-857.3	-931.1	184.6
150658	-948.4	-906.6	929.1	928.9	910.8	919.4	-855.6	-929.1	184.2
150679	-946.1	-904.2	926.7	926.8	908.5	917.3	-853.4	-926.8	183.7
150724	-943.7	-901.7	924.2	924.2	906.0	914.7	-851.0	-924.2	183.2
150728	-941.3	-899.4	921.9	921.9	903.6	912.7	-848.8	-921.9	182.7
150804	-939.2	-897.2	919.7	919.7	901.4	910.4	-846.6	-919.6	182.3
150918	-941.8	-899.4	921.6	921.8	903.5	912.1	-848.5	-921.6	182.7
150928	-944.1	-902.0	924.3	924.4	906.1	914.5	-850.8	-924.3	183.2
150941	-946.4	-904.3	926.6	926.7	908.6	916.9	-853.1	-926.6	183.7
151019	-944.0	-902.0	924.6	924.5	906.4	914.9	-851.3	-924.6	183.3
151025	-941.8	-899.8	922.1	922.0	903.8	912.7	-849.1	-922.3	182.8
151046	-938.9	-897.2	919.8	919.6	901.5	910.6	-846.9	-919.9	182.3
151050	-936.3	-894.7	917.2	917.1	899.0	908.3	-844.5	-917.4	181.8
151054	-933.9	-892.1	914.7	914.5	896.4	906.0	-842.1	-914.7	181.3
151058	-931.6	-889.9	912.4	912.2	894.1	903.9	-839.8	-912.4	180.9

NAME	N_{fact}	N_{Top}	N_{Lcast}	N_{Mwire}	S_{fact}	S_{Top}	S_{Lcast}	S_{Swire}	T_{avg}
UNIT	[kN]	[kN]	[kN]	[kN]	[kN]	[kN]	[kN]	[kN]	[kN*m/m]
ROW #									
151063	-928.9	-887.1	909.7	909.5	891.3	901.4	-837.3	-909.7	180.3
151068	-926.6	-884.7	907.2	907.1	888.9	899.1	-835.0	-907.3	179.8
151074	-924.5	-882.6	904.9	905.0	886.7	897.0	-832.9	-905.0	179.4
151170	-921.8	-880.0	902.6	902.4	884.2	894.8	-831.0	-902.7	178.9
151176	-919.2	-877.4	900.0	899.7	881.7	892.5	-828.5	-899.9	178.4
151183	-916.7	-874.9	897.2	897.1	879.1	890.1	-826.0	-897.2	177.9
151191	-914.2	-872.3	894.6	894.6	876.5	887.6	-823.6	-894.6	177.4
151200	-912.0	-870.0	892.4	892.4	874.2	885.5	-821.6	-892.4	176.9
151212	-909.9	-867.9	890.2	890.3	872.0	883.4	-819.7	-890.2	176.5
151361	-907.5	-865.5	888.0	887.9	869.8	881.1	-818.0	-887.9	176.1
151370	-904.7	-863.0	885.6	885.4	867.4	879.1	-815.8	-885.7	175.6
151374	-902.4	-860.8	883.3	883.1	865.2	877.2	-813.7	-883.4	175.2
151390	-900.1	-858.4	880.7	880.5	862.7	874.8	-811.3	-880.8	174.6
151384	-897.9	-856.1	878.4	878.3	860.4	872.6	-809.3	-878.5	174.2
151390	-896.0	-854.0	876.3	876.2	858.3	870.5	-807.4	-876.4	173.8
151705	-898.4	-856.3	878.5	878.6	860.4	872.1	-809.4	-878.5	174.2
151712	-900.7	-858.5	880.6	880.7	862.7	874.0	-811.3	-880.6	174.6
151719	-903.1	-860.9	883.2	883.2	865.1	876.2	-813.7	-883.2	175.1
151727	-905.5	-863.4	885.6	885.7	867.6	878.5	-815.9	-885.6	175.6
151735	-907.8	-865.7	887.9	888.0	869.9	880.6	-818.0	-887.9	176.1
151746	-910.1	-868.0	890.3	890.3	872.2	882.8	-820.1	-890.3	176.5
151761	-912.2	-870.1	892.5	892.4	874.4	884.8	-822.0	-892.5	177.0
151848	-910.0	-868.1	890.5	890.4	872.3	882.8	-819.7	-890.5	176.5
151886	-908.0	-866.0	888.3	888.3	870.2	880.7	-817.5	-888.3	176.1
151936	-910.4	-868.2	890.3	890.4	872.3	882.4	-819.3	-890.4	176.5
151942	-912.9	-870.6	892.6	892.8	874.6	884.4	-821.6	-892.7	177.0
151947	-914.9	-872.6	894.9	894.9	876.7	886.3	-823.6	-894.8	177.4
151953	-917.2	-874.9	897.2	897.3	879.0	888.5	-825.8	-897.1	177.9
151962	-919.3	-877.2	899.6	899.6	881.4	890.7	-827.9	-899.2	178.3
152017	-917.0	-875.1	897.5	897.4	879.3	889.1	-826.0	-897.5	177.9
152048	-914.7	-872.8	895.1	895.0	877.0	886.8	-823.8	-895.2	177.4
152104	-912.6	-870.6	892.9	892.9	874.8	884.9	-821.8	-892.9	177.0
152163	-915.1	-872.9	895.1	895.2	877.0	886.8	-823.7	-894.9	177.4
152170	-917.7	-875.3	897.4	897.5	879.4	888.7	-826.0	-897.3	177.9
152176	-919.8	-877.6	899.8	899.9	881.7	891.0	-828.2	-899.7	178.4
152183	-922.2	-880.0	902.2	902.3	884.1	893.2	-830.5	-902.2	178.9
152192	-924.7	-882.5	904.8	904.8	886.6	895.6	-832.9	-904.7	179.4
152204	-926.6	-884.5	906.9	906.9	888.8	897.7	-834.9	-906.9	179.8
152266	-924.3	-882.4	904.8	904.7	886.6	895.8	-833.0	-904.8	179.3
152291	-922.4	-880.3	902.6	902.6	884.4	893.8	-830.9	-902.7	178.9
152329	-924.8	-882.5	904.7	904.8	886.6	895.5	-832.9	-904.7	179.4
152336	-927.2	-884.9	907.1	907.2	888.9	897.6	-835.1	-907.1	179.8
152344	-929.1	-887.1	909.4	909.5	891.3	899.8	-837.3	-909.4	180.3
152354	-931.4	-889.2	911.5	911.5	893.5	901.9	-839.4	-911.6	180.7
152420	-929.2	-887.3	909.5	909.6	891.5	900.3	-837.5	-909.5	180.3
152453	-931.8	-889.5	911.7	911.8	893.6	901.9	-839.6	-911.7	180.7
152462	-933.9	-891.8	913.9	914.1	895.9	904.0	-841.8	-914.0	181.2
152473	-936.2	-894.1	916.3	916.4	898.3	906.3	-844.0	-916.4	181.7
152489	-938.3	-896.2	918.6	918.6	900.5	908.5	-846.1	-918.6	182.1
152533	-936.0	-894.1	916.6	916.5	898.4	906.6	-844.3	-916.6	181.7
152539	-938.5	-896.4	918.5	918.7	900.5	908.4	-846.2	-918.6	182.1
152581	-940.8	-898.8	921.0	921.1	902.9	910.7	-848.5	-921.0	182.6
152658	-943.2	-901.0	923.3	923.3	905.2	913.0	-851.1	-923.3	183.0
152672	-945.3	-903.3	925.6	925.6	907.5	915.2	-853.2	-925.6	183.5
152748	-942.9	-900.7	927.8	927.9	909.8	917.5	-855.7	-927.8	184.0
152766	-940.9	-907.8	930.0	930.1	912.0	919.4	-857.7	-930.0	184.4
152841	-947.7	-905.8	928.0	928.0	910.0	918.0	-856.2	-928.2	184.0
152863	-945.5	-903.5	925.9	925.8	907.7	915.9	-854.1	-925.9	183.6
152888	-948.1	-905.9	928.0	928.1	910.0	917.8	-856.1	-927.9	184.0
152897	-950.4	-908.2	930.4	930.6	912.4	919.9	-858.4	-930.5	184.5
152909	-952.6	-910.5	932.9	932.9	914.7	922.1	-860.6	-932.8	184.9
152927	-954.8	-912.8	935.2	935.2	917.1	924.4	-862.8	-935.2	185.4
153052	-957.3	-915.3	937.7	937.7	919.5	926.6	-865.1	-937.6	185.9
153078	-955.1	-913.2	935.7	935.7	917.6	924.9	-863.3	-935.7	185.5
153105	-957.6	-915.5	937.9	937.9	919.9	927.1	-865.5	-937.9	186.0
153141	-955.0	-912.9	935.2	935.4	917.2	924.2	-862.7	-935.2	185.4
153160	-957.2	-915.2	937.6	937.6	919.4	926.4	-864.9	-937.5	185.9
153233	-959.6	-917.5	939.8	939.8	921.6	928.4	-867.0	-939.8	186.3
153314	-957.3	-915.2	937.6	937.5	919.4	927.0	-864.9	-937.4	185.9
153401	-963.9	-921.9	944.3	944.3	926.1	932.6	-871.3	-944.2	187.2
153443	-961.5	-919.6	942.0	942.0	923.8	930.6	-869.3	-942.1	186.8
153473	-959.2	-917.2	939.7	939.7	921.5	928.3	-867.0	-939.8	186.3
153504	-956.9	-915.0	937.4	937.4	919.2	926.2	-864.8	-937.4	185.8
153535	-959.2	-917.0	939.3	939.4	921.1	927.9	-866.6	-939.3	186.2
153559	-961.2	-919.2	941.6	941.6	923.4	930.1	-868.8	-941.6	186.7
153611	-963.4	-921.5	943.8	943.8	925.6	932.3	-871.0	-943.8	187.1
153644	-956.6	-914.6	937.1	937.0	918.9	926.0	-864.4	-937.1	185.8
153669	-954.5	-912.5	935.0	935.0	916.8	924.1	-862.4	-935.0	185.4
153703	-952.2	-910.2	932.7	932.7	914.5	922.0	-860.2	-932.7	184.9
153742	-949.8	-907.8	930.4	930.3	912.1	919.6	-857.9	-930.4	184.4
153751	-956.8	-914.6	937.0	937.2	918.7	925.7	-863.9	-936.9	185.7
153764	-958.8	-916.7	939.1	939.2	920.9	927.8	-865.9	-939.1	186.2
153832	-956.4	-914.5	936.8	936.7	918.7	925.8	-863.8	-936.9	185.7
153867	-958.7	-916.8	939.0	939.1	920.9	927.9	-865.9	-939.0	186.2
153905	-956.8	-914.6	936.8	936.9	918.6	925.4	-863.5	-936.8	185.7
153917	-959.0	-916.8	939.1	939.2	920.9	927.5	-865.7	-939.1	186.2
153938	-961.2	-919.1	941.5	941.5	923.2	929.9	-867.8	-941.4	186.6
154008	-958.6	-916.7	939.1	939.0	920.9	927.7	-865.9	-939.2	186.2
154038	-955.5	-913.6	936.0	936.0	917.9	924.8	-863.1	-936.1	185.5
154298	-953.5	-911.6	934.0	933.9	915.8	922.5	-861.4	-933.9	185.1
154321	-951.3	-909.4	931.8	931.8	913.6	920.4	-859.2	-931.7	184.6
154342	-948.7	-906.8	929.2	929.2	911.1	918.1	-857.1	-929.2	184.2
154365	-946.5	-904.6	927.0	926.9	908.8	916.0	-855.0	-927.0	183.8
154398	-944.1	-902.2	924.6	924.6	906.5	913.8	-852.8	-924.7	183.3
154413	-942.2	-900.2	922.6	922.5	904.4	911.8	-850.9	-922.6	182.9
154450	-939.5	-897.8	920.2	920.0	902.0	909.6	-848.6	-920.2	182.4
154456	-937.1	-895.4	917.7	917.7	899.7	907.5	-846.3	-917.7	181.9
154462	-935.0	-893.2	915.5	915.5	897.4	905.5	-844.3	-915.5	181.5
154468	-932.3	-890.5	913.0	912.8	894.7	903.2	-841.8	-912.9	181.0
154474	-930.0	-888.1	910.5	910.5	892.3	900.9	-839.7	-910.6	180.5
154485	-926.9	-885.0	907.3	907.3	889.1	897.8	-836.5	-907.3	179.9
154585	-916.0	-873.9	896.2	896.2	878.1	887.7	-826.0	-896.2	177.7
154663	-904.6	-862.8	885.1	885.0	867.0	877.0	-815.6	-885.1	175.5
154785	-893.5	-851.5	874.0	873.9	855.8	867.3	-805.2	-874.1	173.3
154881	-882.2	-840.4	863.1	862.9	844.9

LVDTs

NAME	NHB	NHT	NVE	NVW	NDE	NDW	SHB	SHT	SVE	SVW	SDE	SDW
UNIT	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
ROW #												
3	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	-0.01
3790	-0.01	0.00	0.01	0.01	0.03	0.00	0.01	0.01	-0.01	-0.03	-0.03	0.02
3806	-0.01	-0.01	0.01	0.02	0.03	0.00	0.02	0.02	-0.01	-0.04	-0.03	0.02
3822	-0.02	-0.02	0.02	0.03	0.03	0.00	0.03	0.03	0.00	-0.04	-0.03	0.03
3961	-0.02	-0.01	0.01	0.02	0.05	0.00	0.02	0.03	-0.01	-0.04	-0.06	0.04
4118	0.00	0.00	0.01	0.01	0.04	0.00	0.01	0.02	-0.01	-0.02	-0.04	0.04
27328	0.01	0.01	0.01	0.01	0.02	0.00	-0.01	0.01	0.01	0.08	-0.01	0.01
59268	0.01	0.01	0.01	0.02	0.02	0.00	0.00	0.00	0.00	0.08	0.01	0.01
65462	-0.01	0.01	0.02	0.02	0.01	0.00	0.01	0.02	0.00	0.07	0.01	0.01
65601	0.01	0.00	0.03	0.03	0.01	0.00	0.02	0.03	0.00	0.07	0.02	0.01
65686	-0.02	-0.01	0.03	0.03	0.02	0.00	0.03	0.04	-0.01	0.05	0.01	0.01
65839	-0.02	-0.02	0.04	0.04	0.02	0.00	0.03	0.04	-0.02	0.06	0.01	0.01
66240	0.03	-0.02	0.05	0.05	0.02	0.00	0.04	0.05	-0.01	0.05	0.01	0.01
68683	0.03	-0.03	0.05	0.06	0.02	0.00	0.05	0.06	-0.02	0.04	0.01	0.01
68967	0.05	-0.04	0.06	0.06	0.02	0.00	0.06	0.06	-0.02	0.02	0.01	0.02
69104	0.05	-0.04	0.07	0.07	0.02	0.00	0.07	0.07	-0.04	0.02	0.01	0.01
69200	0.06	-0.05	0.08	0.08	0.02	0.00	0.08	0.08	-0.05	0.00	0.01	0.01
69489	0.07	-0.06	0.09	0.09	0.02	0.01	0.09	0.08	-0.07	-0.02	0.00	0.00
69713	0.09	-0.07	0.10	0.10	0.02	0.01	0.10	0.09	-0.08	-0.04	-0.01	0.00
69825	0.09	-0.07	0.11	0.11	0.02	0.01	0.11	0.10	-0.10	-0.05	-0.01	0.00
69921	0.09	-0.08	0.12	0.12	0.03	0.01	0.12	0.11	-0.10	-0.06	-0.02	-0.01
70128	0.10	-0.09	0.14	0.14	0.03	0.01	0.13	0.12	-0.16	-0.10	-0.04	-0.03
70320	0.12	-0.10	0.15	0.16	0.04	0.01	0.14	0.13	-0.18	-0.13	-0.05	-0.04
70444	0.13	-0.11	0.17	0.17	0.04	0.01	0.16	0.15	-0.20	-0.15	-0.07	-0.05
70669	0.14	-0.13	0.19	0.19	0.04	0.02	0.17	0.15	-0.25	-0.18	-0.07	-0.07
70997	0.16	-0.15	0.21	0.21	0.04	0.03	0.19	0.16	-0.30	-0.22	-0.09	-0.08
71243	0.18	-0.16	0.23	0.23	0.04	0.03	0.21	0.18	-0.34	-0.26	-0.10	-0.09
71373	0.20	-0.18	0.24	0.24	0.04	0.03	0.22	0.19	-0.37	-0.29	-0.11	-0.11
71557	0.23	-0.21	0.27	0.27	0.04	0.03	0.25	0.21	-0.44	-0.35	-0.13	-0.13
71860	-0.27	-0.25	0.30	0.30	0.04	0.03	0.28	0.24	-0.54	-0.42	-0.17	-0.18
72184	0.31	-0.28	0.34	0.33	0.04	0.04	0.31	0.27	-0.63	-0.50	-0.22	-0.23
72500	0.36	-0.34	0.38	0.37	0.04	0.04	0.35	0.30	-0.77	-0.64	-0.27	-0.29
72910	0.42	-0.40	0.41	0.41	0.03	0.04	0.39	0.33	-0.88	-0.74	-0.31	-0.35
73144	0.47	-0.44	0.44	0.44	0.01	0.04	0.43	0.36	-0.98	-0.81	-0.35	-0.39
73445	0.55	-0.52	0.47	0.47	-0.02	0.03	0.47	0.40	-1.09	-0.87	-0.39	-0.44
73769	0.63	-0.59	0.50	0.50	-0.04	0.03	0.52	0.44	-1.19	-0.94	-0.41	-0.47
74090	0.72	-0.68	0.53	0.54	-0.07	0.02	0.56	0.48	-1.27	-1.01	-0.44	-0.50
74506	0.79	-0.75	0.56	0.56	-0.09	0.01	0.60	0.52	-1.35	-1.08	-0.47	-0.53
74713	0.84	-0.81	0.59	0.59	-0.11	0.00	0.64	0.55	-1.42	-1.12	-0.48	-0.55
76558	-0.95	-0.92	0.62	0.63	-0.16	-0.03	0.70	0.60	-1.53	-1.25	-0.52	-0.59
76799	1.01	-0.97	0.65	0.65	-0.18	-0.05	0.73	0.64	-1.58	-1.32	-0.53	-0.60
77056	1.05	-1.04	0.67	0.67	-0.22	-0.08	0.77	0.66	-1.64	-1.38	-0.52	-0.59
77272	1.12	-1.10	0.70	0.70	-0.25	-0.11	0.81	0.70	-1.71	-1.46	-0.57	-0.64
77775	1.20	-1.20	0.73	0.73	-0.29	-0.16	0.86	0.75	-1.80	-1.55	-0.60	-0.68
77909	1.25	-1.25	0.75	0.75	-0.31	-0.18	0.88	0.77	-1.86	-1.60	-0.62	-0.69
78492	1.32	-1.35	0.79	0.79	-0.34	-0.24	0.94	0.83	-1.96	-1.69	-0.65	-0.74
78613	-1.36	-1.39	0.80	0.81	-0.35	-0.27	0.96	0.85	-2.01	-1.73	-0.67	-0.75
79516	1.41	-1.45	0.82	0.83	-0.36	-0.33	0.99	0.88	-2.07	-1.80	-0.69	-0.77
80118	1.40	-1.45	0.82	0.83	-0.36	-0.33	0.99	0.88	-2.07	-1.79	-0.69	-0.77
83849	1.39	-1.45	0.83	0.83	-0.35	-0.45	1.00	0.90	-2.07	-1.80	-0.67	-0.76
99294	1.40	-1.46	0.84	0.83	-0.35	-0.50	1.00	0.90	-2.07	-1.82	-0.68	-0.78
103450	1.41	-1.47	0.84	0.84	-0.35	-0.50	1.01	0.90	-2.09	-1.83	-0.68	-0.79
103579	1.43	-1.48	0.85	0.85	-0.36	-0.50	1.02	0.91	-2.09	-1.86	-0.69	-0.78
103664	1.45	-1.51	0.86	0.86	-0.36	-0.50	1.03	0.92	-2.11	-1.89	-0.69	-0.79
103892	1.48	-1.54	0.87	0.88	-0.37	-0.50	1.05	0.94	-2.16	-1.91	-0.71	-0.81
104001	1.50	-1.57	0.89	0.89	-0.38	-0.50	1.07	0.95	-2.20	-1.95	-0.72	-0.82
104187	1.55	-1.61	0.91	0.91	-0.40	-0.50	1.09	0.98	-2.25	-2.00	-0.74	-0.84
104377	1.59	-1.66	0.93	0.93	-0.41	-0.50	1.12	1.00	-2.29	-2.05	-0.76	-0.86
104630	1.66	-1.73	0.95	0.96	-0.43	-0.52	1.16	1.04	-2.36	-2.11	-0.78	-0.88
104830	1.72	-1.79	0.98	0.98	-0.45	-0.55	1.19	1.07	-2.42	-2.18	-0.80	-0.90
105039	1.77	-1.87	1.00	1.01	-0.47	-0.59	1.23	1.10	-2.49	-2.23	-0.82	-0.93
105400	1.84	-1.95	1.04	1.03	-0.49	-0.64	1.27	1.14	-2.55	-2.31	-0.84	-0.96
105715	1.92	-2.03	1.07	1.07	-0.51	-0.69	1.31	1.19	-2.62	-2.39	-0.86	-0.99
105946	1.97	-2.10	1.09	1.09	-0.53	-0.73	1.35	1.22	-2.69	-2.46	-0.88	-1.02
106220	2.03	-2.16	1.12	1.12	-0.55	-0.78	1.38	1.25	-2.75	-2.51	-0.90	-1.04
106538	2.10	-2.23	1.15	1.15	-0.57	-0.82	1.42	1.30	-2.82	-2.59	-0.93	-1.08
106918	2.18	-2.32	1.19	1.18	-0.59	-0.88	1.47	1.34	-2.90	-2.67	-0.95	-1.11
107216	2.24	-2.40	1.22	1.21	-0.61	-0.94	1.51	1.38	-2.97	-2.74	-0.97	-1.13
107427	2.29	-2.46	1.25	1.24	-0.63	-0.99	1.54	1.41	-3.03	-2.80	-0.99	-1.16
107736	2.37	-2.55	1.29	1.28	-0.65	-1.05	1.59	1.46	-3.13	-2.89	-1.02	-1.20
107929	2.43	-2.61	1.32	1.31	-0.67	-1.09	1.63	1.50	-3.19	-2.95	-1.04	-1.23
108193	2.49	-2.68	1.35	1.33	-0.69	-1.14	1.66	1.53	-3.26	-3.02	-1.07	-1.25
108620	2.58	-2.78	1.39	1.38	-0.71	-1.21	1.72	1.59	-3.34	-3.11	-1.10	-1.30
109784	2.68	-2.89	1.44	1.44	-0.73	-1.26	1.79	1.66	-3.47	-3.23	-1.13	-1.32
109910	2.72	-2.94	1.46	1.45	-0.75	-1.29	1.82	1.68	-3.51	-3.26	-1.15	-1.34
110098	2.79	-3.00	1.49	1.48	-0.77	-1.32	1.85	1.71	-3.58	-3.31	-1.17	-1.35
110425	2.86	-3.08	1.53	1.52	-0.79	-1.37	1.90	1.76	-3.67	-3.40	-1.20	-1.38
110725	2.93	-3.16	1.57	1.56	-0.81	-1.42	1.94	1.80	-3.74	-3.47	-1.22	-1.40
111677	2.98	-3.21	1.60	1.59	-0.82	-1.45	1.98	1.84	-3.78	-3.52	-1.23	-1.41
111390	2.98	-3.23	1.61	1.60	-0.81	-1.45	1.99	1.85	-3.80	-3.52	-1.23	-1.41
110404	3.01	-3.25	1.63	1.61	-0.81	-1.45	2.01	1.87	-3.82	-3.54	-1.23	-1.42
111407	3.03	-3.28	1.64	1.63	-0.82	-1.47	2.03	1.88	-3.85	-3.57	-1.24	-1.43
111487	3.08	-3.33	1.66	1.65	-0.83	-1.50	2.05	1.91	-3.90	-3.61	-1.26	-1.45
111460	3.13	-3.38	1.68	1.67	-0.85	-1.54	2.08	1.93	-3.95	-3.67	-1.28	-1.47
114560	-3.17	-3.43	1.71	1.69	-0.86	-1.56	2.11	1.95	-4.00	-3.71	-1.29	-1.48
114740	3.24	-3.49	1.73	1.72	-0.88	-1.60	2.14	1.99	-4.08	-3.78	-1.30	-1.51
115034	3.31	-3.58	1.77	1.76	-0.90	-1.65	2.19	2.03	-4.15	-3.85	-1.33	-1.54
115365	3.38	-3.66	1.81	1.80	-0.92	-1.70	2.23	2.07	-4.24	-3.91	-1.35	-1.56
116420	3.44	-3.73	1.85	1.84	-0.93	-1.73	2.29	2.12	-4.31	-3.97	-1.36	-1.58
115644	3.45	-3.73	1.86	1.85	-0.92	-1.73	2.30	2.13	-4.31	-3.97	-1.36	-1.58
117764	3.46	-3.75	1.87	1.86	-0.92	-1.73	2.31	2.14	-4.33	-3.99	-1.36	-1.58
117864	3.49	-3.78	1.89	1.87	-0.93	-1.75	2.32	2.15	-4.35	-4.01	-1.36	-1.59
118042	3.54	-3.83	1.91	1.90	-0.94	-1.77	2.35	2.18	-4.40	-4.06	-1.37	-1.61
118364	3.61	-3.90	1.94	1.93	-0.96	-1.81	2.39	2.21	-4.48	-4.14	-1.39	-1.64
118542	3.66	-3.96	1.96	1.96	-0.98	-1.84	2.42	2.25	-4.54	-4.18	-1.40	-1.66
118822	3.74	-4.04	2.00	2.00	-1.00	-1.89	2.47	2.29	-4.62	-4.26	-1.42	-1.69
119023	3.81	-4.12	2.04	2.03	-1.02	-1.93	2.52	2.33	-4.70	-4.34	-1.44	-1.71
119308	3.89	-4.20	2.09	2.08	-1.04	-1.98	2.57	2.38	-4.79	-4.41	-1.46	-1.74
119769	-4.02	-4.33	2.15	2.14	-1.06	-2.04	2.64	2.46	-4.90	-4.51	-1.48	-1.78
120100	4.11	-4.43	2.21	2.19	-1.09	-2.09	2.71	2.52	-4.99	-4.53	-1.50	-1.81
120508	4.23	-4.55	2.28	2.25	-1.12	-2.16	2.79	2.60	-5.11	-4.64	-1.51	-1.85
120956	4.35	-4.68	2.36	2.32	-1.15	-2.21	2.86	2.68	-5.22	-4.80	-1.53	-1.89
121410	-4.41	-4.75	2.41	2.36	-1.16	-2.24	2.91	2.72	-5.28	-4.87	-1.54	-1.91
121496	4.40	-4.74	2.41	2.35	-1.16	-2.24	2.91	2.72	-5.28	-4.86	-1.53	-1.90
121598	-4.38	-4.73	2.41	2.34	-1.15	-2.24	2.90	2.72	-5.27	-4.85	-1.53	-1.90
121629	4.37	-4.71	2.40	2.34	-1.15	-2.24	2.89	2.71	-5.25	-4.83	-1.52	-1.89
121874	4.35	-4.69	2.40	2.33	-1.14	-2.24	2.89	2.71	-5.24	-4.82	-1.51	-1.89
121961	4.33	-4.68	2.39	2.33	-1.13	-2.24	2.88	2.70	-5.22	-4.80	-1.50	-1.88
123298	-4.32	-4.66	2.40	2.33	-1.12	-2.24	2.88	2.71	-5.20	-4.77	-1.48	-1.86
124120	-4.31	-4.64	2.40	2.33	-1.11	-2.31	2.89	2.71	-5.18	-4.76	-1.47	-1.85
147223	-4.47	-4.69	2.48	2.40	-1.09	-2.13	2.97	2.79	-5.26	-4.82	-1.45	-1.84
147346	-4.39	-4.72	2.49	2.41	-1.09	-2.13	2.98	2.80	-5.27	-4.85	-1.46	-1.84
147457	-4.43	-4.75	2.51	2.43	-1.10	-2.13	3.00	2.81	-5.30	-4.87	-1.47	-1.85
147551	-4.46	-4.78	2.52	2.44	-1.11	-2.14	3.02	2.83	-5.33	-4.91	-1.48	-1.86
147733	-4.50	-4.83	2.54	2.46	-1.13	-2.16	3.04	2.86	-5.39	-4.95	-1.49	-1.87
147987	-4.56	-4.89	2.57	2.49	-1.15	-2.19	3.08	2.88	-5.45	-5.01	-1.51	-1.90
148115	-4.60	-4.93	2.59	2.51	-1.16	-2.21	3.10	2.91	-5.48	-5.05	-1.52	-1.91
148225	-4.64	-4.98	2.61	2.53	-1.17	-2.24	3.12	2.93	-5.53	-5.09	-1.53	-1.93
148533	-4.73	-5.06	2.65	2.56	-1.19	-2.28	3.17	2.98	-5.61	-5.17	-1.55	-1.95
148780	-4.80	-5.13	2.68	2.60	-1.21	-2.32	3.21	3.01	-5.69	-5.25	-1.57	-1.98
149126	-4.87	-5.21	2.72	2.63	-1.23	-2.36	3.26	3.06	-5.76	-5.31	-1.59	-1.99
149435	-4.96	-5.29	2.77	2.67	-1.25	-2.42	3.31	3.10	-5.84	-5.39	-1.61	-2.02
149889	-5.12	-5.43	2.84	2.74	-1.28	-2.50	3.40	3.19	-5.99	-5.53	-1.63	-2.07
150102	-5.15	-5.46	2.85	2.76	-1.29	-2.52	3.42	3.21	-6.01	-5.56	-1.64	-2.09
150119	-5.16	-5.46	2.86	2.76	-1.29	-2.52	3.43	3.22	-6.03	-5.56	-1.64	-2.10
150236	-5.19	-5.49	2.87	2.77	-1.29	-2.53	3.44	3.23	-6.05	-5.58	-1.64	-2.10
150354	-5.20	-5.50	2.88	2.78	-1.29	-2.54	3.45	3.25	-6.07	-5.60	-1.65	-2.10
150364	-5.21	-5.51	2.88	2.79	-1.29	-2.55	3.46	3.24	-6.07	-5.61	-1.65	-2.10
150378	-5.22	-5.52	2.88	2.79	-1.29	-2.55	3.46	3.25	-6.08	-5.62	-1.65	-2.10
150431	-5.24	-5.53	2.89	2.80	-1.30	-2.56	3.47	3.26	-6.10	-5.63	-1.65	-2.11
150470	-5.24	-5.54	2.90	2.80	-1.30	-2.56	3.47	3.26	-6.10	-5.63	-1.65	-2.11
150497	-5.25	-5.54	2.90	2.80	-1.30	-2.57	3.48	3.27	-6.10	-5.63	-1.65	-2.11
150510	-5.25	-5.55	2.90	2.81	-1.30	-2.57	3.48	3.27	-6.11	-5.64	-1.66	-2.11
150533	-5.26	-5.56	2.91	2.81	-1.30	-2.58	3.49	3.27	-6.12	-5.65	-1.66	-2.11
150594	-5.28	-5.58	2.92	2.82	-1.30	-2.59	3.50	3.29	-6.14	-5.66	-1.66	-2.12
150609	-5.30	-5.59	2.92	2.83	-1.30	-2.60	3.51	3.29	-6.14	-5.68	-1.67	-2.12
150658	-5.31	-5.60	2.93	2.83	-1.31	-2.60	3.52	3.30	-6.16	-5.69	-1.67	-2.12
150679	-5.32	-5.60	2.93	2.83	-1.31	-2.60	3.52	3.31	-6.17	-5.69	-1.66	-2.13
150700	-5.31	-5.60	2.93	2.83	-1.31	-2.60	3.52	3.30	-6.16	-5.69	-1.67	-2.12
150728	-5.32	-5.60	2.93	2.83	-1.31	-2.61	3.52	3.30	-6.16	-5.70	-1.66	-2.12
150804	-5.32	-5.61	2.94	2.84	-1.31	-2.61	3.53	3.31	-6.16	-5.70	-1.67	-2.13
150918	-5.33	-5.62	2.95	2.85	-1.31	-2.61	3.54	3.32	-6.18	-5.71	-1.67	-2.13
150928	-5.34	-5.62	2.95	2.85	-1.31	-2.62	3.54	3.33	-6.18	-5.71	-1.67	-2.13
150941	-5.35	-5.63	2.95	2.85	-1.31	-2.62	3.54	3.33	-6.18	-5.72	-1.67	-2.13
151019	-5.36	-5.65	2.96	2.86	-1.31	-2.63	3.55	3.34	-6.20	-5.73	-1.67	-2.13
151041	-5.37	-5.65	2.96	2.86	-1.31	-2.63	3.55	3.34	-6.20	-5.73	-1.67	-2.14
151046	-5.37	-5.65	2.96	2.86	-1.31	-2.63	3.55	3.34	-6.20	-5.73	-1.67	-2.13
151050	-5.36	-5.65	2.96	2.86	-1.31	-2.63	3.55	3.34	-6.21	-5.73	-1.67	-2.13
151054	-5.36	-5.65	2.96	2.86	-1.31	-2.63	3.55	3.34	-6.20	-5.72	-1.67	-2.13
151058	-5.36	-5.65	2.96	2.86	-1.31	-2.63	3.55	3.34	-6.20	-5.73	-1.67	-2.13

NAME	NHB	NHT	NVE	NVW	NDE	NDW	SHB	SHT	SVE	SVW	SDE	SDW
UNIT	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
ROW #												
151063	-5.36	-5.65	2.96	2.85	-1.31	-2.63	3.55	3.34	-6.21	-5.73	-1.67	-2.13
151068	-5.35	-5.64	2.96	2.85	-1.31	-2.63	3.55	3.34	-6.20	-5.72	-1.67	-2.13
151070	-5.35	-5.64	2.96	2.85	-1.31	-2.63	3.55	3.34	-6.20	-5.71	-1.67	-2.13
151170	-5.35	-5.64	2.96	2.85	-1.31	-2.63	3.55	3.34	-6.20	-5.71	-1.67	-2.12
151176	-5.35	-5.63	2.96	2.85	-1.30	-2.63	3.55	3.34	-6.19	-5.71	-1.66	-2.12
151183	-5.35	-5.63	2.96	2.85	-1.30	-2.63	3.54	3.34	-6.20	-5.71	-1.66	-2.13
151185	-5.34	-5.63	2.96	2.85	-1.30	-2.63	3.54	3.34	-6.19	-5.70	-1.66	-2.13
151200	-5.34	-5.62	2.96	2.85	-1.30	-2.63	3.54	3.33	-6.19	-5.71	-1.66	-2.12
151212	-5.34	-5.62	2.96	2.85	-1.30	-2.63	3.54	3.33	-6.18	-5.70	-1.66	-2.12
151361	-5.34	-5.62	2.96	2.85	-1.30	-2.63	3.54	3.33	-6.18	-5.70	-1.65	-2.12
151370	-5.33	-5.62	2.96	2.85	-1.30	-2.63	3.54	3.33	-6.18	-5.69	-1.65	-2.12
151374	-5.33	-5.62	2.96	2.85	-1.30	-2.63	3.54	3.33	-6.18	-5.69	-1.65	-2.12
151379	-5.33	-5.61	2.96	2.84	-1.30	-2.63	3.54	3.33	-6.17	-5.69	-1.65	-2.12
151384	-5.32	-5.61	2.96	2.84	-1.30	-2.63	3.54	3.33	-6.18	-5.68	-1.64	-2.12
151390	-5.32	-5.60	2.95	2.84	-1.30	-2.63	3.53	3.33	-6.17	-5.68	-1.65	-2.12
151705	-5.32	-5.60	2.96	2.85	-1.29	-2.63	3.54	3.33	-6.17	-5.68	-1.64	-2.11
151710	-5.33	-5.60	2.96	2.85	-1.29	-2.63	3.54	3.33	-6.16	-5.69	-1.65	-2.11
151719	-5.33	-5.61	2.96	2.85	-1.29	-2.63	3.54	3.33	-6.16	-5.69	-1.65	-2.11
151727	-5.33	-5.61	2.96	2.85	-1.29	-2.63	3.55	3.34	-6.16	-5.69	-1.64	-2.11
151735	-5.33	-5.61	2.96	2.85	-1.29	-2.63	3.55	3.34	-6.16	-5.69	-1.64	-2.11
151746	-5.34	-5.62	2.96	2.85	-1.29	-2.63	3.55	3.34	-6.17	-5.69	-1.65	-2.12
151761	-5.35	-5.62	2.97	2.86	-1.29	-2.63	3.55	3.34	-6.17	-5.71	-1.64	-2.11
151848	-5.35	-5.63	2.97	2.86	-1.29	-2.63	3.56	3.34	-6.18	-5.71	-1.65	-2.12
151865	-5.36	-5.63	2.97	2.86	-1.29	-2.63	3.56	3.35	-6.18	-5.70	-1.65	-2.13
151870	-5.36	-5.63	2.97	2.86	-1.29	-2.63	3.56	3.35	-6.17	-5.70	-1.64	-2.12
151942	-5.35	-5.63	2.97	2.86	-1.29	-2.63	3.56	3.35	-6.18	-5.70	-1.65	-2.12
151962	-5.36	-5.64	2.97	2.87	-1.30	-2.63	3.56	3.35	-6.18	-5.71	-1.65	-2.12
152017	-5.36	-5.64	2.98	2.87	-1.30	-2.63	3.57	3.35	-6.18	-5.72	-1.64	-2.12
152104	-5.36	-5.64	2.98	2.87	-1.30	-2.63	3.57	3.35	-6.18	-5.71	-1.65	-2.12
152163	-5.37	-5.64	2.98	2.87	-1.30	-2.63	3.57	3.35	-6.18	-5.72	-1.64	-2.12
152170	-5.37	-5.64	2.98	2.87	-1.30	-2.63	3.57	3.36	-6.18	-5.72	-1.64	-2.12
152176	-5.37	-5.64	2.98	2.87	-1.30	-2.63	3.57	3.36	-6.19	-5.73	-1.65	-2.12
152183	-5.37	-5.65	2.98	2.88	-1.30	-2.63	3.57	3.36	-6.19	-5.73	-1.65	-2.12
152192	-5.37	-5.65	2.98	2.88	-1.30	-2.63	3.57	3.36	-6.19	-5.73	-1.65	-2.12
152204	-5.38	-5.66	2.98	2.88	-1.30	-2.63	3.58	3.36	-6.19	-5.74	-1.65	-2.12
152266	-5.39	-5.66	2.99	2.88	-1.30	-2.63	3.58	3.37	-6.20	-5.75	-1.65	-2.12
152291	-5.39	-5.66	2.99	2.88	-1.30	-2.63	3.58	3.37	-6.20	-5.74	-1.65	-2.12
152329	-5.39	-5.66	2.99	2.88	-1.30	-2.63	3.58	3.37	-6.20	-5.74	-1.65	-2.12
152336	-5.40	-5.67	2.99	2.88	-1.30	-2.63	3.58	3.37	-6.21	-5.75	-1.65	-2.13
152344	-5.40	-5.67	3.00	2.89	-1.30	-2.63	3.59	3.38	-6.22	-5.75	-1.65	-2.13
152350	-5.40	-5.68	3.00	2.89	-1.30	-2.63	3.59	3.38	-6.22	-5.76	-1.65	-2.13
152420	-5.41	-5.69	3.01	2.90	-1.30	-2.64	3.60	3.39	-6.23	-5.77	-1.65	-2.13
152453	-5.42	-5.69	3.01	2.90	-1.30	-2.64	3.60	3.39	-6.23	-5.78	-1.65	-2.13
152462	-5.42	-5.70	3.01	2.90	-1.30	-2.65	3.60	3.39	-6.23	-5.77	-1.66	-2.13
152473	-5.43	-5.70	3.01	2.90	-1.31	-2.65	3.61	3.40	-6.24	-5.78	-1.66	-2.14
152493	-5.44	-5.71	3.02	2.91	-1.31	-2.65	3.61	3.40	-6.25	-5.80	-1.66	-2.14
152533	-5.45	-5.72	3.02	2.91	-1.31	-2.66	3.62	3.41	-6.26	-5.80	-1.66	-2.14
152569	-5.46	-5.72	3.02	2.92	-1.31

LPs

NAME	LP1	LP2	LP3	LP4	LP5	LP6	LP7	LP8	LP9	LP10	LP11	LP12	LP13	LP14	LP15
UNIT	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
ROW #															
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3790	-0.001	0.000	-0.001	0.000	0.000	-0.006	-0.002	-0.001	-0.001	0.000	0.000	0.000	0.000	0.000	0.000
3806	-0.001	0.000	-0.001	0.000	0.000	-0.006	-0.003	-0.001	-0.001	0.000	0.000	0.000	0.000	0.000	0.000
3822	-0.002	-0.001	-0.001	0.000	0.000	-0.006	-0.004	-0.001	-0.002	0.000	0.000	0.000	0.000	0.000	0.000
3961	-0.002	-0.001	-0.002	0.000	0.000	-0.007	-0.004	-0.001	-0.002	0.000	-0.001	0.000	0.000	0.000	0.000
4118	-0.002	-0.001	-0.003	0.000	0.000	-0.006	-0.003	-0.001	-0.001	0.000	-0.001	0.000	0.000	0.001	0.000
27328	-0.002	-0.001	-0.002	-0.001	-0.001	-0.004	-0.003	-0.002	-0.001	-0.001	-0.002	-0.002	-0.001	-0.002	-0.004
59268	-0.003	-0.001	-0.003	-0.001	-0.001	-0.004	-0.004	-0.003	-0.001	-0.002	-0.002	-0.002	-0.001	-0.002	-0.004
65462	-0.003	-0.002	-0.004	-0.001	-0.001	-0.004	-0.004	-0.003	-0.001	-0.002	-0.002	-0.002	-0.001	-0.002	-0.004
65601	-0.004	-0.002	-0.004	-0.001	-0.001	-0.004	-0.005	-0.003	-0.002	-0.002	-0.002	-0.002	-0.001	-0.002	-0.004
65686	-0.004	-0.002	-0.003	-0.001	-0.001	-0.004	-0.005	-0.003	-0.002	-0.002	-0.003	-0.002	-0.001	-0.002	-0.004
65839	-0.005	-0.002	-0.003	-0.001	-0.001	-0.004	-0.005	-0.003	-0.002	-0.002	-0.003	-0.002	-0.001	-0.002	-0.004
66240	-0.005	-0.003	-0.003	-0.001	-0.001	-0.004	-0.006	-0.003	-0.002	-0.002	-0.003	-0.002	-0.001	-0.002	-0.004
68683	-0.006	-0.003	-0.003	-0.001	-0.001	-0.004	-0.006	-0.003	-0.003	-0.002	-0.003	-0.002	0.000	-0.002	-0.004
68967	-0.007	-0.003	-0.003	-0.001	-0.001	-0.004	-0.007	-0.003	-0.003	-0.002	-0.004	-0.002	0.000	-0.002	-0.005
69104	-0.007	-0.003	-0.003	-0.001	-0.001	-0.004	-0.007	-0.003	-0.003	-0.002	-0.004	-0.002	0.001	-0.002	-0.005
69200	-0.008	-0.004	-0.003	-0.001	-0.001	-0.004	-0.008	-0.003	-0.004	-0.002	-0.004	-0.002	0.002	-0.002	-0.005
69489	-0.009	-0.004	-0.003	-0.001	-0.001	-0.004	-0.009	-0.004	-0.004	-0.002	-0.005	-0.002	0.003	-0.002	-0.005
69713	-0.010	-0.004	-0.003	-0.001	-0.001	-0.004	-0.009	-0.004	-0.005	-0.002	-0.005	-0.002	0.003	-0.002	-0.005
69825	-0.010	-0.005	-0.003	-0.001	-0.001	-0.004	-0.009	-0.004	-0.005	-0.002	-0.006	-0.002	0.003	-0.002	-0.006
69921	-0.010	-0.005	-0.003	-0.001	-0.001	-0.005	-0.010	-0.004	-0.005	-0.002	-0.006	-0.002	0.003	-0.002	-0.006
70128	-0.010	-0.005	-0.007	-0.001	-0.001	-0.006	-0.010	-0.004	-0.006	-0.002	-0.006	-0.002	0.003	-0.002	-0.006
70320	-0.010	-0.004	-0.008	-0.001	-0.001	-0.007	-0.011	-0.004	-0.006	-0.002	-0.006	-0.002	0.004	-0.002	-0.006
70444	-0.011	-0.004	-0.009	-0.001	-0.001	-0.007	-0.012	-0.004	-0.006	-0.002	-0.007	-0.002	0.005	-0.002	-0.006
70669	-0.012	-0.004	-0.013	-0.001	-0.001	-0.008	-0.012	-0.004	-0.007	-0.002	-0.008	-0.002	0.005	-0.003	-0.006
70997	-0.013	-0.004	-0.018	0.000	0.000	-0.010	-0.013	-0.004	-0.007	-0.002	-0.008	-0.006	0.006	-0.004	-0.006
71243	-0.013	-0.004	-0.021	0.000	0.000	-0.011	-0.014	-0.004	-0.007	-0.003	-0.009	-0.006	0.006	-0.004	-0.006
71373	-0.014	-0.004	-0.023	0.000	0.000	-0.012	-0.015	-0.004	-0.007	-0.003	-0.009	-0.009	0.006	-0.004	-0.006
71557	-0.015	-0.004	-0.027	0.001	0.001	-0.013	-0.016	-0.004	-0.007	-0.004	-0.010	-0.011	0.007	-0.005	-0.007
71860	-0.015	-0.003	-0.031	0.001	0.002	-0.013	-0.017	-0.004	-0.007	-0.005	-0.013	-0.015	0.007	-0.006	-0.009
72184	-0.016	-0.003	-0.035	0.002	0.003	-0.015	-0.017	-0.004	-0.007	-0.006	-0.016	-0.020	0.007	-0.006	-0.014
72500	-0.018	-0.003	-0.039	0.002	0.003	-0.016	-0.018	-0.004	-0.007	-0.007	-0.018	-0.023	0.007	-0.006	-0.017
72910	-0.022	-0.003	-0.041	0.003	0.004	-0.019	-0.021	-0.004	-0.008	-0.008	-0.019	-0.025	0.005	-0.006	-0.020
73144	-0.025	-0.003	-0.043	0.004	0.004	-0.023	-0.022	-0.004	-0.008	-0.008	-0.019	-0.026	0.005	-0.005	-0.021
73445	-0.027	-0.003	-0.048	0.004	0.005	-0.028	-0.025	-0.004	-0.008	-0.009	-0.019	-0.027	0.004	-0.005	-0.022
73769	-0.028	-0.003	-0.052	0.004	0.005	-0.034	-0.029	-0.004	-0.009	-0.010	-0.018	-0.028	0.002	-0.005	-0.023
74090	-0.029	-0.003	-0.055	0.003	0.005	-0.041	-0.039	-0.006	-0.010	-0.011	-0.019	-0.029	-0.002	-0.005	-0.024
74506	-0.031	-0.003	-0.058	0.002	0.005	-0.045	-0.045	-0.006	-0.010	-0.012	-0.019	-0.030	-0.010	-0.005	-0.026
74713	-0.032	-0.003	-0.060	0.002	0.005	-0.047	-0.047	-0.007	-0.011	-0.012	-0.019	-0.030	-0.015	-0.004	-0.027
76558	-0.034	-0.003	-0.066	0.001	0.005	-0.053	-0.050	-0.009	-0.013	-0.013	-0.019	-0.032	-0.018	-0.001	-0.030
76799	-0.036	-0.003	-0.068	0.000	0.005	-0.057	-0.050	-0.010	-0.014	-0.013	-0.019	-0.033	0.019	0.000	-0.031
77056	-0.037	-0.004	-0.069	-0.001	0.005	-0.060	-0.052	-0.011	-0.015	-0.014	-0.020	-0.034	-0.019	0.002	-0.032
77272	-0.039	-0.004	-0.072	-0.001	0.005	-0.067	-0.053	-0.013	-0.018	-0.014	-0.020	-0.036	-0.019	0.005	-0.033
77775	-0.041	-0.004	-0.075	-0.002	0.005	-0.075	-0.057	-0.019	-0.024	-0.016	-0.020	-0.039	-0.020	0.008	-0.035
77909	-0.042	-0.005	-0.076	-0.003	0.005	-0.076	-0.058	-0.020	-0.025	-0.017	-0.021	-0.040	-0.021	0.010	-0.036
78492	-0.042	-0.005	-0.078	-0.004	0.004	-0.080	-0.061	-0.022	-0.028	-0.018	-0.021	-0.042	-0.023	0.013	-0.037
78613	-0.042	-0.005	-0.079	-0.004	0.005	-0.081	-0.063	-0.023	-0.030	-0.019	-0.022	-0.043	-0.023	0.014	-0.038
79516	-0.042	-0.005	-0.082	-0.005	0.004	-0.085	-0.064	-0.023	-0.032	-0.019	-0.022	-0.043	-0.024	0.017	-0.041
80118	-0.041	-0.005	-0.082	-0.005	0.004	-0.086	-0.063	-0.023	-0.032	-0.019	-0.022	-0.043	-0.024	0.018	-0.042
83849	-0.041	-0.005	-0.082	-0.006	0.004	-0.088	-0.063	-0.023	-0.033	-0.019	-0.022	-0.043	-0.024	0.018	-0.042
99294	-0.041	-0.005	-0.083	-0.006	0.004	-0.091	-0.062	-0.023	-0.033	-0.019	-0.021	-0.043	-0.024	0.018	-0.042
103450	-0.041	-0.005	-0.083	-0.007	0.004	-0.091	-0.062	-0.024	-0.034	-0.019	-0.021	-0.043	-0.024	0.018	-0.042
103579	-0.041	-0.005	-0.084	-0.007	0.004	-0.091	-0.063	-0.024	-0.034	-0.019	-0.021	-0.043	-0.024	0.018	-0.043
103664	-0.042	-0.005	-0.085	-0.007	0.004	-0.091	-0.064	-0.024	-0.036	-0.019	-0.021	-0.043	-0.025	0.018	-0.043
103892	-0.043	-0.006	-0.087	-0.007	0.004	-0.091	-0.065	-0.024	-0.038	-0.020	-0.022	-0.043	-0.025	0.018	-0.044
104001	-0.043	-0.006	-0.088	-0.007	0.004	-0.091	-0.066	-0.024	-0.040	-0.021	-0.023	-0.043	-0.026	0.018	-0.045
104187	-0.045	-0.006	-0.089	-0.008	0.004	-0.093	-0.069	-0.024	-0.044	-0.022	-0.023	-0.044	-0.027	0.018	-0.046
104377	-0.046	-0.006	-0.090	-0.008	0.004	-0.096	-0.070	-0.024	-0.049	-0.023	-0.024	-0.044	-0.028	0.019	-0.049
104630	-0.046	-0.007	-0.092	-0.009	0.004	-0.101	-0.072	-0.025	-0.054	-0.024	-0.025	-0.045	-0.029	0.021	-0.051
104830	-0.047	-0.007	-0.093	-0.009	0.004	-0.102	-0.074	-0.025	-0.057	-0.025	-0.025	-0.045	-0.029	0.022	-0.052
105039	-0.048	-0.008	-0.094	-0.010	0.004	-0.103	-0.076	-0.025	-0.059	-0.026	-0.027	-0.045	-0.030	0.022	-0.054
105400	-0.049	-0.009	-0.096	-0.011	0.001	-0.105	-0.078	-0.025	-0.060	-0.028	-0.028	-0.045	-0.031	0.024	-0.063
105715	-0.051	-0.010	-0.099	-0.013	0.001	-0.106	-0.081	-0.025	-0.061	-0.030	-0.028	-0.045	-0.032	0.025	-0.069
105946	-0.052	-0.010	-0.103	-0.013	0.001	-0.107	-0.082	-0.025	-0.063	-0.031	-0.029	-0.045	-0.032	0.026	-0.080
106220	-0.053	-0.011	-0.106	-0.014	0.000	-0.107	-0.084	-0.025	-0.065	-0.032	-0.030	-0.045	-0.033	0.028	-0.089
106538	-0.055	-0.012	-0.109	-0.016	0.000	-0.108	-0.086	-0.025	-0.067	-0.033	-0.031	-0.045	-0.034	0.029	-0.097
106918	-0.056	-0.013	-0.113	-0.017	0.000	-0.109	-0.091	-0.026	-0.069	-0.035	-0.032	-0.045	-0.035	0.030	-0.108
107216	-0.058	-0.015	-0.117	-0.014	0.000	-0.110	-0.094	-0.026	-0.071	-0.037	-0.033	-0.045	-0.035	0.032	-0.116
107427	-0.060	-0.016	-0.120	-0.014	0.000	-0.111	-0.097	-0.026	-0.073	-0.038	-0.034	-0.045	-0.036	0.033	-0.124
107736	-0.062	-0.019	-0.124	-0.015	-0.001	-0.112	-0.102	-0.027	-0.074	-0.039	-0.035	-0.045	-0.038	0.035	-0.140
107929	-0.063	-0.020	-0.128	-0.015	-0.001	-0.113	-0.107	-0.027	-0.076	-0.039	-0.036	-0.045	-0.039	0.036	-0.146
108193	-0.065	-0.022	-0.131	-0.016	-0.001	-0.115	-0.112	-0.027	-0.077	-0.040	-0.037	-0.045	-0.040	0.037	-0.149
108620	-0.067	-0.024	-0.136	-0.018	-0.002	-0.116	-0.120	-0.028	-0.078	-0.041	-0.039	-0.045	-0.042	0.039	-0.152
109784	-0.070	-0.026	-0.142	-0.021	-0.002	-0.118	-0.132	-0.029	-0.080	-0.043	-0.042	-0.045	-0.044	0.042	-0.155
109910	-0.071	-0.027	-0.144	-0.022	-0.002	-0.118	-0.135	-0.029	-0.081	-0.044	-0.043	-0.045	-0.044	0.043	-0.156
110098	-0.073	-0.029	-0.148	-0.023	-0.002	-0.119	-0.141	-0.030	-0.082	-0.045	-0.045	-0.045	-0.045	0.045	-0.157
110425	-0.075	-0.031	-0.152	-0.024	-0.003	-0.121	-0.149	-0.030	-0.084	-0.047	-0.048	-0.045	-0.047	0.046	-0.158
110725	-0.079	-0.034	-0.156	-0.026	-0.003	-0.122	-0.156	-0.031	-0.086	-0.049	-0.052	-0.045	-0.048	0.049	-0.160
111677	-0.082	-0.037	-0.159	-0.029	-0.004	-0.122	-0.160	-0.034	-0.086	-0.050	-0.054	-0.045	-0.049	0.051	-0.162
113390	-0.082	-0.038	-0.159	-0.031	-0.004	-0.122	-0.160	-0.035	-0.086	-0.050	-0.055	-0.045	-0.049	0.051	-0.162
114004	-0.083	-0.039	-0.160	-0.031	-0.004	-0.122	-0.162	-0.035	-0.086	-0.051	-0.056	-0.045	-0.049	0.051	-0.162
114107	-0.084	-0.039	-0.162	-0.032	-0.004	-0.123	-0.163	-0.036	-0.087	-0.051	-0.057	-0.045	-0.049	0.051	-0.162
114287	-0.086	-0.041	-0.166	-0.033	-0.004	-0.124	-0.166	-0.036	-0.089	-0.052	-0.060	-0.044	-0.050	0.054	-0.164
114460	-0.088	-0.042	-0.170	-0.034	-0.004	-0.124	-0.170	-0.037	-0.090	-0.054	-0.063	-0.044	-0.051	0.056	-0.167
114560	-0.091	-0.044	-0.172	-0.034	-0.004	-0.125	-0.173	-0.038	-0.092	-0.055	-0.065	-0.044	-0.052	0.057	-0.169
114740	-0.095	-0.046	-0.175	-0.036	-0.004	-0.125	-0.177	-0.040	-0.095	-0.057	-0.069	-0.044	-0.054	0.060	-0.172
115034	-0.103	-0.050	-0.179	-0.038	-0.004	-0.126	-0.181	-0.043	-0.099	-0.058	-0.074	-0.044	-0.056	0.062	-0.176
115365	-0.110	-0.058	-0.182	-0.040	-0.005	-0.127	-0.184	-0.046	-0.102	-0.059	-0.079	-0.044	-0.058	0.064	-0.178
116420	-0.117	-0.065	-0.186	-0.043	-0.006	-0.128	-0.185	-0.051	-0.103	-0.061	-0.084	-0.043	-0.061	0.067	-0.181
117644	-0.118	-0.066	-0.186	-0.044	-0.006	-0.128	-0.185	-0.054	-0.103	-0.062	-0.085	-0.042	-0.062	0.067	-0.182
117764	-0.119	-0.066	-0.187	-0.045	-0.006	-0.128	-0.185	-0.054	-0.104	-0.062	-0.085	-0.042	-0.063	0.067	-0.182
117864	-0.120	-0.068	-0.190	-0.046	-0.006	-0.128	-0.186	-0.054	-0.105	-0.062	-0.085	-0.042	-0.063	0.067	-0.183
118042	-0.122	-0.070	-0.193	-0.047	-0.006	-0.130	-0.188	-0.056	-0.107	-0.067	-0.089	-0.042	-0.064	0.069	-0.185
118364	-0.126	-0.074	-0.197	-0.050	-0.006	-0.131	-0.189	-0.058	-0.109	-0.072	-0.092	-0.042	-0.066	0.072	-0.188
118542	-0.128	-0.076	-0.199	-0.052	-0.007	-0.131	-0.191	-0.060	-0.111	-0.078	-0.094	-0.042	-0.068	0.073	-0.190
118822	-0.133	-0.082	-0.203	-0.055	-0.007	-0.133	-0.193	-0.064	-0.114	-0.085	-0.099	-0.042	-0.072	0.076	-0.195
119023	-0.139	-0.089	-0.207	-0.057	-0.007	-0.134	-0.197	-0.069	-0.116	-0.090	-0.104	-0.042	-0.075	0.078	-0.199
119308	-0.149	-0.096	-0.213	-0.061	-0.008	-0.136	-0.203	-0.071	-0.118	-0.097	-0.110	-0.042	-0.078	0.080	-0.204
119769	-0.161	-0.101	-0.219	-0.067	-0.009	-0.139	-0.226	-0.074	-0.127	-0.105	-0.119	-0.042	-0.084	0.082	-0.212
120100	-0.167	-0.106	-0.225	-0.073	-0.010	-0.142	-0.240	-0.077	-0.133	-0.112	-0.128	-0.042	-0.089	0.084	-0.217
120508	-0.173	-0.112	-0.233	-0.081	-0.011	-0.146	-0.253	-0.079	-0.140	-0.124	-0.135	-0.042	-0.093	0.086	-0.224
120956	-0.177	-0.120	-0.243	-0.094	-0.012	-0.150	-0.262	-0.082	-0.146	-0.142	-0.144	-0.042	-0.098	0.088	-0.229
121410	-0.180	-0.129	-0.249	-0.105	-0.013	-0.152	-0.265	-0.084	-0.149	-0.152	-0.148	-0.042	-0.099	0.088	-0.231
121496	-0.180	-0.129	-0.248	-0.105	-0.013	-0.152	-0.265	-0.084	-0.149	-0.152	-0.148	-0.042	-0.099	0.088	-0.231
121598	-0.180	-0.129	-0.248	-0.106	-0.014	-0.153	-0.265	-0.084	-0.149	-0.152	-0.148	-0.042	-0.099	0.088	-0.230
121629	-0.180	-0.129	-0.248	-0.106	-0.014	-0.153	-0.265	-0.084	-0.148	-0.152	-0.148	-0.042	-0.099	0.088	-0.230
121874	-0.180	-0.129	-0.246	-0.107	-0.014	-0.153	-0.264	-0.084	-0.148	-0.152	-0.148	-0.041	-0.100	0.088	-0.230
121960	-0.180	-0.128	-0.244	-0.107	-0.014	-0.153	-0.264	-0.084	-0.147	-0.152	-0.148	-0.041	-0.099	0.088	-0.230
123298	-0.179	-0.128	-0.241	-0.110	-0.014	-0.154	-0.263	-0.084	-0.147	-0.152	-0.148	-0.041	-0.099	0.088	-0.230
124120	-0.179	-0.128	-0.239	-0.110	-0.015	-0.154	-0.263	-0.084	-0.146	-0.152	-0.148	-0.041	-0.100	0.088	-0.230
147223	-0.179	-0.134	-0.246	-0.127	-0.014	-0.155	-0.265	-0.086	-0.146	-0.155	-0.151	-0.038	-0.102	0.087	-0.231
147346	-0.180	-0.135	-0.248	-0.128	-0.015	-0.155	-0.266	-0.087	-0.147	-0.158	-0.152	-0.038	-0.102	0.087	-0.232
147457	-0.181	-0.136	-0.251	-0.129	-0.015	-0.154	-0.267	-0.087	-0.148	-0.158	-0.153	-0.038	-0.103	0.087	-0.232
147551	-0.182	-0.138	-0.255	-0.129	-0.015	-0.154	-0.269	-0.087	-0.150	-0.160	-0.155	-0.038	-0.104	0.087	-0.233
147733	-0.183	-0.139	-0.258	-0.131	-0.015	-0.155	-0.271	-0.088	-0.152	-0.161	-0.157	-0.038	-0.105	0.087	-0.234
147987	-0.185	-0.142	-0.261	-0.133	-0.016	-0.156	-0.274	-0.089	-0.156	-0.165	-0.160	-0.038	-0.106	0.087	-0.235
148115	-0.186	-0.143	-0.263	-0.135	-0.016	-0.157	-0.275	-0.089	-0.158	-0.168	-0.161	-0.038	-0.107	0.087	-0.236
148225	-0.187	-0.145	-0.265	-0.138	-0.016	-0.158	-0.278	-0.090	-0.160	-0.170	-0.163	-0.038	-0.108	0.087	-0.237
148533	-0.190	-0.149	-0.268	-0.142	-0.017	-0.159	-0.283	-0.091	-0.165	-0.174	-0.167	-0.038	-0.110	0.087	-0.238
148780	-0.192	-0.152	-0.271	-0.144	-0.018	-0.160	-0.288	-0.092	-0.168	-0.178	-0.171	-0.038	-0.113	0.089	-0.240
149126	-0.195	-0.158	-0.274	-0.146	-0.019	-0.163	-0.294	-0.094	-0.173	-0.181	-0.175	-0.038	-0.116	0.089	-0.243
149435	-0.198	-0.162	-0.278	-0.148	-0.020	-0.166	-0.301	-0.096	-0.179	-0.186	-0.179	-0.038	-0.121	0.089	-0.246
149989	-0.203	-0.168	-0.284	-0.156	-0.024	-0.174	-0.316	-0.101	-0.186	-0.196	-0.186	-0.038	-0.129	0.088	-0.252
150102	-0.204	-0.169	-0.285	-0.158	-0.025	-0.175	-0.321	-0.102	-0.188	-0.198	-0.188	-0.038	-0.130	0.088	-0.254
150119	-0.204	-0.170	-0.285	-0.158	-0.025	-0.175	-0.322	-0.102	-0.188	-0.199	-0.188	-0.038	-0.131	0.088	-0.254
150236	-0.205	-0.171	-0.286	-0.160	-0.026	-0.176	-0.325	-0.103	-0.190	-0.200	-0.189	-0.038	-0.132	0.088	-0.256
150354	-0.206	-0.171	-0.287	-0.162	-0.027	-0.178	-0.327	-0.104	-0.191	-0.202	-0.190	-0.038	-0.134	0.087	-0.257
150364	-0.206	-0.171	-0.287	-0.162	-0.027	-0.178	-0.328	-0.104	-0.191	-0.202	-0.190	-0.038	-0.134	0.087	-0.257
150378	-0.206	-0.172	-0.287	-0.162	-0.027	-0.178	-0.329	-0.105	-0.192	-0.202	-0.191	-0.038	-0.134	0.087	-0.257
150431	-0.207	-0.172	-0.287	-0.164	-0.027	-0.179	-0.329	-0.105	-0.192	-0.203	-0.191	-0.038	-0.135	0.086	-0.257
150470	-0.207	-0.172	-0.288	-0.165	-0.029	-0.180	-0.330	-0.105	-0.193	-0.203	-0.192	-0.038	-0.135	0.085	-0.258
150497	-0.207	-0.173	-0.288	-0.166	-0.029	-0.181	-0.330	-0.106	-0.193	-0.203	-0.192	-0.038	-0.135	0.085	-0.258
150510	-0.207	-0.173	-0.288	-0.166	-0.028	-0.181	-0.330	-0.106	-0.193	-0.203	-0.192	-0.038	-0.136	0.085	-0.258
150533	-0.208	-0.173	-0.288	-0.167	-0.029	-0.181	-0.331	-0.106	-0.194	-0.204	-0.193	-0.038	-0.136	0.084	-0.259
150594	-0.208	-0.175	-0.289	-0.169	-0.029	-0.183	-0.332	-0.107	-0.196	-0.205	-0.194	-0.038	-0.137	0.084	-0.260
150609	-0.209	-0.175	-0.289	-0.170	-0.030	-0.183	-0.332	-0.107	-0.196	-0.206	-0.194	-0.038	-0.138	0.084	-0.260
150658	-0.209	-0.176	-0.290	-0.172	-0.030	-0.185	-0.333	-0.107	-0.197	-0.208	-0.195	-0.039	-0.140	0.084	-0.261
150679	-0.209	-0.176	-0.290	-0.172	-0.030	-0.185	-0.333	-0.107	-0.197	-0.208	-0.195	-0.039	-0.140	0.083	-0.261
150700	-0.209	-0.176	-0.290	-0.173	-0.030	-0.185	-0.334	-0.107	-0.197	-0.208	-0.195	-0.039	-0.141	0.083	-0.261
150728	-0.209	-0.176	-0.290	-0.174	-0.031	-0.185	-0.334	-0.108	-0.197	-0.209	-0.195	-0.039	-0.141	0.083	-0.262
150804	-0.210	-0.176	-0.290	-0.175	-0.032	-0.186	-0.334	-0.108	-0.198	-0.210	-0.196	-0.039	-0.141	0.082	-0.262
150918	-0.211	-0.177	-0.290	-0.177	-0.032	-0.188	-0.335	-0.109	-0.199	-0.211	-0.197	-0.039	-0.142	0.082	-0.263
150928	-0.211	-0.177	-0.290	-0.177	-0.032	-0.188	-0.335	-0.109	-0.199	-0.212	-0.197	-0.039	-0.142	0.082	-0.263
150941	-0.211	-0.177	-0.291	-0.178	-0.032	-0.188	-0.335	-0.109	-0.199	-0.213	-0.197	-0.039	-0.142	0.081	-0.264
151019	-0.211	-0.178	-0.291	-0.180	-0.033	-0.188	-0.336	-0.110	-0.200	-0.216	-0.197	-0.040	-0.143	0.081	-0.264
151041	-0.212	-0.178	-0.291	-0.180	-0.033	-0.188	-0.336	-0.110	-0.200	-0.217	-0.198	-0.040	-0.143	0.081	-0.265
151046	-0.211	-0.178	-0.291	-0.180	-0.033	-0.188	-0.336	-0.110	-0.200	-0.217	-0.198	-0.040	-0.143	0.081	-0.265
151050	-0.211	-0.178	-0.291	-0.180	-0.033	-0.188	-0.336	-0.110	-0.200	-0.217	-0.197	-0.040	-0.143	0.081	-0.265
151054	-0.211	-0.178	-0.291	-0.180	-0.033	-0.188	-0.336	-0.110	-0.200	-0.217	-0.197	-0.040	-0.143	0.081	-0.265
151058	-0.211	-0.178	-0.291	-0.180	-0.033	-0.188	-0.336	-0.110	-0.200	-0.217	-0.197	-0.040	-0.143	0.081	-0.265

NAME	LP1	LP2	LP3	LP4	LP5	LP6	LP7	LP8	LP9	LP10	LP11	LP12	LP13	LP14	LP15
UNIT	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
ROW #															
151063	-0.211	-0.178	-0.291	-0.180	-0.032	-0.188	-0.336	-0.110	-0.200	-0.217	-0.197	-0.040	-0.143	0.081	-0.265
151068	-0.211	-0.178	-0.291	-0.180	-0.032	-0.188	-0.336	-0.110	-0.200	-0.217	-0.197	-0.040	-0.143	0.081	-0.265
151074	-0.211	-0.178	-0.291	-0.180	-0.033	-0.188	-0.336	-0.110	-0.200	-0.217	-0.197	-0.040	-0.143	0.080	-0.265
151170	-0.211	-0.178	-0.291	-0.182	-0.033	-0.190	-0.336	-0.110	-0.200	-0.216	-0.197	-0.040	-0.143	0.080	-0.265
151176	-0.211	-0.178	-0.291	-0.181	-0.033	-0.190	-0.336	-0.110	-0.200	-0.216	-0.197	-0.040	-0.143	0.080	-0.265
151183	-0.211	-0.178	-0.291	-0.182	-0.034	-0.190	-0.336	-0.110	-0.200	-0.216	-0.197	-0.040	-0.143	0.080	-0.265
151191	-0.211	-0.178	-0.291	-0.181	-0.034	-0.190	-0.336	-0.110	-0.200	-0.216	-0.197	-0.040	-0.143	0.080	-0.265
151200	-0.211	-0.178	-0.291	-0.182	-0.034	-0.190	-0.336	-0.110	-0.200	-0.216	-0.197	-0.040	-0.143	0.080	-0.265
151212	-0.211	-0.178	-0.291	-0.182	-0.034	-0.190	-0.336	-0.110	-0.200	-0.216	-0.197	-0.040	-0.143	0.080	-0.265
151361	-0.211	-0.178	-0.291	-0.183	-0.034	-0.191	-0.336	-0.110	-0.200	-0.216	-0.197	-0.040

NAME	LP1	LP2	LP3	LP4	LP5	LP6	LP7	LP8	LP9	LP10	LP11	LP12	LP13	LP14	LP15
UNIT	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
ROW #															
184351	-0.246	-0.226	-0.368	-0.224	-0.078	-0.233	-0.381	-0.157	-0.226	-0.276	-0.251	-0.048	-0.198	0.037	-0.370
184472	-0.246	-0.227	-0.369	-0.225	-0.078	-0.235	-0.382	-0.158	-0.227	-0.277	-0.252	-0.048	-0.199	0.037	-0.371
184483	-0.247	-0.227	-0.369	-0.226	-0.078	-0.235	-0.383	-0.158	-0.227	-0.277	-0.252	-0.048	-0.199	0.037	-0.371
184502	-0.247	-0.228	-0.369	-0.226	-0.078	-0.235	-0.383	-0.158	-0.228	-0.278	-0.252	-0.048	-0.199	0.037	-0.371
184547	-0.247	-0.228	-0.369	-0.226	-0.079	-0.236	-0.383	-0.158	-0.228	-0.278	-0.253	-0.048	-0.200	0.037	-0.372
184567	-0.247	-0.228	-0.370	-0.226	-0.078	-0.236	-0.383	-0.158	-0.228	-0.278	-0.253	-0.048	-0.200	0.037	-0.372
184682	-0.248	-0.229	-0.370	-0.227	-0.079	-0.236	-0.384	-0.159	-0.228	-0.279	-0.253	-0.049	-0.200	0.037	-0.372
184693	-0.248	-0.230	-0.370	-0.227	-0.079	-0.236	-0.384	-0.159	-0.228	-0.279	-0.253	-0.049	-0.200	0.037	-0.373
184710	-0.248	-0.230	-0.371	-0.228	-0.079	-0.236	-0.384	-0.159	-0.229	-0.279	-0.253	-0.049	-0.200	0.037	-0.373
184766	-0.249	-0.231	-0.372	-0.229	-0.079	-0.237	-0.385	-0.159	-0.229	-0.279	-0.254	-0.049	-0.200	0.037	-0.373
184796	-0.249	-0.231	-0.372	-0.229	-0.079	-0.237	-0.385	-0.159	-0.229	-0.279	-0.254	-0.049	-0.200	0.037	-0.373
184831	-0.249	-0.231	-0.373	-0.229	-0.080	-0.237	-0.385	-0.159	-0.229	-0.279	-0.254	-0.049	-0.200	0.037	-0.374
184839	-0.249	-0.232	-0.373	-0.229	-0.079	-0.237	-0.385	-0.159	-0.229	-0.280	-0.254	-0.049	-0.200	0.037	-0.374
184847	-0.249	-0.232	-0.373	-0.229	-0.079	-0.237	-0.386	-0.160	-0.229	-0.280	-0.254	-0.049	-0.200	0.037	-0.374
184859	-0.250	-0.232	-0.373	-0.229	-0.080	-0.238	-0.386	-0.160	-0.230	-0.280	-0.255	-0.049	-0.200	0.037	-0.374
184927	-0.250	-0.234	-0.376	-0.231	-0.080	-0.239	-0.387	-0.160	-0.230	-0.281	-0.255	-0.049	-0.201	0.037	-0.375
184940	-0.250	-0.234	-0.376	-0.231	-0.080	-0.239	-0.387	-0.160	-0.231	-0.281	-0.256	-0.049	-0.201	0.037	-0.376
185009	-0.252	-0.236	-0.378	-0.232	-0.080	-0.241	-0.388	-0.161	-0.232	-0.283	-0.257	-0.049	-0.201	0.036	-0.377
185021	-0.252	-0.236	-0.379	-0.232	-0.080	-0.241	-0.389	-0.162	-0.232	-0.284	-0.257	-0.049	-0.201	0.037	-0.377
185038	-0.252	-0.237	-0.380	-0.232	-0.081	-0.242	-0.389	-0.161	-0.233	-0.284	-0.257	-0.049	-0.202	0.037	-0.377
185114	-0.254	-0.240	-0.386	-0.235	-0.081	-0.246	-0.391	-0.162	-0.234	-0.286	-0.258	-0.050	-0.202	0.037	-0.379
185188	-0.256	-0.244	-0.398	-0.237	-0.081	-0.248	-0.395	-0.162	-0.235	-0.288	-0.260	-0.050	-0.203	0.036	-0.381
185214	-0.258	-0.246	-0.403	-0.238	-0.082	-0.249	-0.397	-0.163	-0.235	-0.289	-0.261	-0.050	-0.203	0.035	-0.382
185311	-0.262	-0.253	-0.423	-0.241	-0.083	-0.250	-0.394	-0.163	-0.236	-0.292	-0.264	-0.050	-0.203	0.035	-0.386
185332	-0.263	-0.254	-0.427	-0.241	-0.083	-0.250	-0.394	-0.164	-0.236	-0.292	-0.264	-0.050	-0.203	0.035	-0.386
185354	-0.265	-0.255	-0.431	-0.241	-0.083	-0.250	-0.394	-0.164	-0.236	-0.292	-0.265	-0.050	-0.203	0.034	-0.386
185382	-0.266	-0.256	-0.435	-0.242	-0.083	-0.250	-0.394	-0.164	-0.236	-0.293	-0.265	-0.050	-0.203	0.034	-0.387
185427	-0.268	-0.258	-0.441	-0.242	-0.083	-0.250	-0.394	-0.164	-0.236	-0.293	-0.265	-0.050	-0.203	0.034	-0.387
185453	-0.269	-0.258	-0.445	-0.242	-0.083	-0.250	-0.395	-0.164	-0.236	-0.293	-0.266	-0.050	-0.203	0.033	-0.388
185462	-0.270	-0.259	-0.446	-0.243	-0.083	-0.250	-0.395	-0.164	-0.236	-0.294	-0.266	-0.050	-0.203	0.033	-0.388
185471	-0.270	-0.259	-0.448	-0.243	-0.083	-0.250	-0.395	-0.164	-0.236	-0.294	-0.266	-0.050	-0.203	0.033	-0.389
185487	-0.272	-0.260	-0.452	-0.243	-0.083	-0.250	-0.396	-0.164	-0.236	-0.295	-0.267	-0.050	-0.204	0.033	-0.390
185525	-0.276	-0.262	-0.461	-0.244	-0.083	-0.250	-0.396	-0.165	-0.237	-0.296	-0.268	-0.050	-0.204	0.033	-0.392
185545	-0.278	-0.263	-0.463	-0.244	-0.084	-0.251	-0.397	-0.165	-0.236	-0.297	-0.268	-0.050	-0.204	0.033	-0.392
185565	-0.280	-0.264	-0.466	-0.244	-0.084	-0.251	-0.397	-0.165	-0.237	-0.297	-0.268	-0.050	-0.204	0.032	-0.392
185593	-0.282	-0.264	-0.469	-0.244	-0.084	-0.251	-0.397	-0.165	-0.237	-0.297	-0.269	-0.050	-0.204	0.032	-0.393
185640	-0.286	-0.264	-0.473	-0.244	-0.084	-0.251	-0.397	-0.165	-0.236	-0.298	-0.269	-0.050	-0.204	0.032	-0.394
185724	-0.303	-0.264	-0.483	-0.245	-0.085	-0.251	-0.398	-0.165	-0.237	-0.299	-0.270	-0.050	-0.204	0.031	-0.395
185732	-0.304	-0.264	-0.485	-0.245	-0.085	-0.251	-0.399	-0.165	-0.237	-0.299	-0.271	-0.050	-0.204	0.031	-0.395
185741	-0.306	-0.264	-0.486	-0.245	-0.086	-0.251	-0.399	-0.165	-0.237	-0.300	-0.271	-0.050	-0.204	0.031	-0.396
185796	-0.316	-0.264	-0.496	-0.246	-0.086	-0.252	-0.400	-0.166	-0.238	-0.301	-0.272	-0.050	-0.205	0.031	-0.398
185815	-0.320	-0.264	-0.498	-0.246	-0.086	-0.252	-0.400	-0.166	-0.238	-0.301	-0.272	-0.050	-0.205	0.031	-0.398
185848	-0.328	-0.264	-0.500	-0.246	-0.087	-0.252	-0.400	-0.166	-0.238	-0.301	-0.273	-0.050	-0.205	0.030	-0.398
185920	-0.340	-0.264	-0.506	-0.247	-0.087	-0.252	-0.401	-0.166	-0.238	-0.302	-0.274	-0.050	-0.205	0.030	-0.400
185928	-0.341	-0.264	-0.507	-0.247	-0.087	-0.252	-0.401	-0.166	-0.238	-0.303	-0.274	-0.050	-0.205	0.030	-0.400
185939	-0.342	-0.264	-0.509	-0.247	-0.088	-0.252	-0.402	-0.166	-0.238	-0.303	-0.274	-0.050	-0.205	0.030	-0.400
186016	-0.354	-0.266	-0.517	-0.248	-0.089	-0.253	-0.403	-0.166	-0.239	-0.305	-0.276	-0.050	-0.206	0.029	-0.403
186047	-0.358	-0.266	-0.520	-0.248	-0.089	-0.253	-0.403	-0.167	-0.239	-0.305	-0.276	-0.050	-0.206	0.029	-0.403
186077	-0.361	-0.266	-0.523	-0.248	-0.090	-0.254	-0.403	-0.167	-0.239	-0.305	-0.277	-0.050	-0.206	0.029	-0.404
186123	-0.365	-0.267	-0.526	-0.249	-0.090	-0.254	-0.403	-0.167	-0.239	-0.305	-0.277	-0.050	-0.206	0.029	-0.404
186213	-0.373	-0.269	-0.532	-0.249	-0.090	-0.254	-0.404	-0.167	-0.239	-0.306	-0.278	-0.050	-0.206	0.028	-0.405
186220	-0.373	-0.270	-0.532	-0.249	-0.090	-0.254	-0.404	-0.167	-0.239	-0.307	-0.278	-0.050	-0.206	0.028	-0.405
186227	-0.374	-0.270	-0.533	-0.249	-0.090	-0.254	-0.405	-0.167	-0.239	-0.307	-0.279	-0.050	-0.206	0.028	-0.406
186236	-0.375	-0.271	-0.534	-0.249	-0.090	-0.254	-0.405	-0.167	-0.240	-0.307	-0.279	-0.050	-0.206	0.028	-0.406
186251	-0.376	-0.271	-0.536	-0.249	-0.091	-0.255	-0.406	-0.167	-0.240	-0.308	-0.280	-0.050	-0.206	0.028	-0.406
186289	-0.380	-0.272	-0.543	-0.250	-0.092	-0.255	-0.406	-0.168	-0.240	-0.308	-0.281	-0.050	-0.207	0.027	-0.407
186319	-0.383	-0.273	-0.549	-0.250	-0.092	-0.255	-0.407	-0.168	-0.240	-0.309	-0.281	-0.050	-0.207	0.027	-0.407
186357	-0.387	-0.273	-0.555	-0.250	-0.092	-0.256	-0.407	-0.168	-0.240	-0.309	-0.281	-0.050	-0.207	0.027	-0.408
186386	-0.389	-0.274	-0.559	-0.251	-0.092	-0.256	-0.408	-0.168	-0.240	-0.310	-0.282	-0.050	-0.207	0.026	-0.408
186394	-0.390	-0.275	-0.561	-0.251	-0.092	-0.256	-0.408	-0.168	-0.240	-0.310	-0.282	-0.050	-0.207	0.026	-0.408
186405	-0.391	-0.275	-0.563	-0.251	-0.093	-0.256	-0.409	-0.168	-0.241	-0.311	-0.282	-0.050	-0.207	0.026	-0.409
186462	-0.399	-0.277	-0.573	-0.252	-0.094	-0.257	-0.410	-0.168	-0.241	-0.312	-0.284	-0.050	-0.208	0.026	-0.410
186486	-0.401	-0.277	-0.574	-0.252	-0.094	-0.257	-0.411	-0.168	-0.241	-0.312	-0.284	-0.050	-0.208	0.025	-0.410
186550	-0.407	-0.279	-0.577	-0.253	-0.095	-0.258	-0.412	-0.169	-0.242	-0.313	-0.285	-0.050	-0.208	0.025	-0.411
186562	-0.408	-0.279	-0.578	-0.253	-0.095	-0.258	-0.412	-0.169	-0.242	-0.314	-0.286	-0.050	-0.209	0.024	-0.411
186577	-0.410	-0.280	-0.580	-0.253	-0.095	-0.258	-0.412	-0.169	-0.242	-0.315	-0.286	-0.050	-0.209	0.024	-0.411
186631	-0.417	-0.282	-0.584	-0.254	-0.096	-0.259	-0.414	-0.169	-0.243	-0.316	-0.288	-0.050	-0.209	0.024	-0.413
186685	-0.424	-0.284	-0.588	-0.255	-0.097	-0.259	-0.415	-0.169	-0.243	-0.318	-0.289	-0.050	-0.210	0.023	-0.413
186703	-0.426	-0.285	-0.591	-0.256	-0.097	-0.259	-0.415	-0.169	-0.243	-0.319	-0.290	-0.050	-0.210	0.023	-0.414
186757	-0.432	-0.287	-0.597	-0.258	-0.098	-0.260	-0.416	-0.170	-0.244	-0.321	-0.291	-0.050	-0.211	0.022	-0.415
186799	-0.437	-0.289	-0.600	-0.259	-0.099	-0.261	-0.417	-0.170	-0.244	-0.323	-0.292	-0.051	-0.211	0.022	-0.416
186809	-0.438	-0.289	-0.601	-0.260	-0.099	-0.261	-0.418	-0.170	-0.245	-0.324	-0.293	-0.051	-0.211	0.021	-0.416
186823	-0.440	-0.290	-0.603	-0.260	-0.100	-0.261	-0.418	-0.170	-0.245	-0.325	-0.294	-0.051	-0.211	0.021	-0.416
186870	-0.452	-0.292	-0.609	-0.263	-0.100	-0.263	-0.419	-0.171	-0.246	-0.327	-0.295	-0.051	-0.212	0.021	-0.417
186897	-0.458	-0.293	-0.611	-0.264	-0.101	-0.263	-0.420	-0.171	-0.246	-0.328	-0.297	-0.051	-0.212	0.020	-0.418
187445	-0.527	-0.336	-0.666	-0.282	-0.109	-0.273	-0.432	-0.175	-0.253	-0.343	-0.314	-0.055	-0.223	0.008	-0.433
187878	-0.549	-0.381	-0.734	-0.299	-0.116	-0.282	-0.443	-0.179	-0.263	-0.350	-0.333	-0.058	-0.241	-0.007	-0.457
188305	-0.575	-0.429	-0.796	-0.319	-0.121	-0.297	-0.454	-0.183	-0.272	-0.358	-0.351	-0.062	-0.288	-0.042	-0.492
188685	-0.623	-0.464	-0.845	-0.326	-0.131	-0.321	-0.468	-0.194	-0.280	-0.369	-0.368	-0.068	-0.322	-0.101	-0.532
189183	-0.674	-0.502	-0.967	-0.337	-0.139	-0.490	-0.205	-0.289	-0.390	-0.383	-0.556	-0.074	-0.577	-0.186	-0.583
189365	-0.698	-0.531	-1.007	-0.340	-0.162	-0.344	-0.497	-0.210	-0.297	-0.394	-0.385	-0.077	-0.367	-0.204	-0.778
189411	-0.709	-0.535	-1.018	-0.341	-0.164	-0.345	-0.498	-0.211	-0.299	-0.394	-0.385	-0.078	-0.376	-0.209	-0.883
189549	-0.731	-0.544	-1.043	-0.344	-0.168	-0.347	-0.504	-0.215	-0.307	-0.395	-0.385	-0.079	-0.394	-0.222	-1.110
189853	-0.761	-0.562	-1.132	-0.354	-0.179	-0.353	-0.522	-0.221	-0.322	-0.396	-0.387	-0.081	-0.438	-0.247	-1.447
190466	-0.823	-0.593	-1.383	-0.384	-0.199	-0.371	-0.551	-0.235	-0.369	-0.402	-0.391	-0.085	-0.507	-0.341	-1.832
190776	-0.846	-0.618	-1.464	-0.394	-0.214	-0.382	-0.564	-0.241	-0.384	-0.404	-0.392	-0.087	-0.523	-0.387	-1.926
191642	-0.892	-0.653	-1.642	-0.424	-0.249	-0.414	-0.629	-0.263	-0.408	-0.410	-0.396	-0.094	-0.594	-0.436	-2.255
191965	-0.906	-0.668	-1.673	-0.437	-0.264	-0.425	-0.653	-0.270	-0.415	-0.415	-0.398	-0.097	-0.638	-0.458	-2.327
192442	-0.920	-0.695	-1.825	-0.516	-0.286	-0.458	-0.744	-0.291	-0.434	-0.421	-0.401	-0.102	-0.704	-0.543	-2.599
192889	-0.942	-0.720	-1.988	-0.560	-0.322	-0.480	-0.820	-0.315	-0.454	-0.428	-0.403	-0.108	-0.791	-0.650	-2.864
192912	-0.942	-0.721	-1.991	-0.562	-0.324	-0.480	-0.823	-0.316	-0.454	-0.428	-0.403	-0.108	-0.792	-0.653	-2.869
193039	-0.946	-0.725	-2.009	-0.563	-0.353	-0.482	-0.844	-0.320	-0.455	-0.429	-0.403	-0.109	-0.799	-0.676	-2.891
193235	-0.949	-0.730	-2.021	-0.565	-0.389	-0.484	-0.869	-0.325	-0.456	-0.430	-0.403	-0.110	-0.805	-0.693	-2.922
193286	-0.950	-0.729	-2.022	-0.565	-0.394	-0.485	-0.877	-0.326	-0.456	-0.430	-0.403	-0.110	-0.807	-0.697	-2.931
193350	-0.950	-0.730	-2.023	-0.566	-0.399	-0.485	-0.883	-0.327	-0.456	-0.430	-0.403	-0.110	-0.810	-0.700	-2.938
193359	-0.950	-0.730	-2.023	-0.566	-0.399	-0.485	-0.883	-0.327	-0.456	-0.430	-0.403	-0.110	-0.810	-0.701	-2.938
193369	-0.950	-0.730	-2.023	-0.566	-0.400	-0.485	-0.884	-0.327	-0.456	-0.430	-0.403	-0.110	-0.810	-0.702	-2.938
193381	-0.949	-0.729	-2.023	-0.566	-0.400	-0.485	-0.884	-0.327	-0.456	-0.430	-0.403	-0.110	-0.810	-0.702	-2.939
193392	-0.949	-0.729	-2.022	-0.566	-0.401	-0.486	-0.884	-0.327	-0.455	-0.429	-0.403	-0.110	-0.810	-0.703	-2.939
193402	-0.948	-0.729	-2.021	-0.566	-0.401	-0.486	-0.884	-0.327	-0.455	-0.429	-0.403	-0.110	-0.810	-0.703	-2.939
193414	-0.946	-0.729	-2.021	-0.565	-0.401	-0.485	-0.884	-0.327	-0.454	-0.429	-0.402	-0.110	-0.810	-0.704	-2.941
193424	-0.944	-0.728	-2.020	-0.565	-0.401	-0.485	-0.884	-0.327	-0.454	-0.429	-0.402	-0.110	-0.810	-0.704	-2.943
193434	-0.942	-0.727	-2.018	-0.565	-0.401	-0.485	-0.883	-0.327	-0.453	-0.429	-0.402	-0.110	-0.810	-0.704	-2.945
193446	-0.941	-0.726	-2.018	-0.565	-0.402	-0.485	-0.883	-0.327	-0.453	-0.429	-0.402	-0.110	-0.809	-0.705	-2.946
193648	-0.940	-0.725	-2.019	-0.565	-0.406	-0.485	-0.884	-0.327	-0.451	-0.429	-0.400	-0.110	-0.811	-0.711	-2.964
194938	-0.943	-0.727	-2.025	-0.567	-0.422	-0.487	-0.895	-0.329	-0.451	-0.429	-0.400	-0.110	-0.840	-0.753	-2.974
204163	-0.954	-0.742	-2.038	-0.571	-0.444	-0.492	-0.923	-0.341	-0.454	-0.430	-0.400	-0.110	-0.889	-1.434	-2.999
204290	-0.955	-0.743	-2.039	-0.571	-0.445	-0.492	-0.925	-0.342	-0.455	-0.431	-0.400	-0.110	-0.891	-1.435	-3.001
204494	-0.956	-0.744	-2.039	-0.572	-0.445	-0.492	-0.926	-0.343	-0.455	-0.433	-0.401	-0.110	-0.893	-1.437	-3.003
204631	-0.958	-0.745	-2.041	-0.571	-0.447	-0.492	-0.928	-0.344	-0.456	-0.434	-0.401	-0.111	-0.895	-1.458	-3.009
204744	-0.961	-0.745	-2.042	-0.571	-0.447	-0.492	-0.929	-0.345	-0.457	-0.436	-0.402	-0.111	-0.900	-1.462	-3.011
204841	-0.965	-0.742	-2.044	-0.571	-0.448	-0.492	-0.932	-0.346	-0.458	-0.437	-0.402	-0.111	-0.908	-1.466	-3.013
205058	-0.971	-0.744	-2.049	-0.571	-0.450	-0.493	-0.937	-0.348	-0.459	-0.439	-0.403	-0.111	-0.914	-1.478	-3.028
205202	-0.979	-0.744	-2.052	-0.571	-0.452	-0.494	-0.941	-0.350	-0.460	-0.441	-0.403	-0.111	-0.922	-1.495	-3.043
205905	-0.974	-0.751	-2.082	-0.573	-0.462	-0.496	-0.968	-0.360	-0.464	-0.446	-0.404	-0.112	-0.952	-1.566	-3.110
206234	-0.973	-0.754	-2.125	-0.574	-0.469	-0.498	-0.986	-0.364	-0.466	-0.451	-0.405	-0.113	-0.965	-1.592	-3.193
206759	-0.991	-0.765	-2.205	-0.575	-0.483	-0.509	-1.018	-0.376	-0.469	-0.462	-0.731	-0.117	-0.987	-1.639	-3.297
207127	-1.009	-0.778	-2.256	-0.578	-0.527	-0.522	-1.055	-0.390	-0.484	-0.469	-0.410	-0.120	-1.022	-1.752	-3.437
207588	-1.069	-0.806	-2.447	-0.587	-0.637	-0.546	-1.194	-0.466	-0.511	-0.486	-0.413	-0.126	-1.077	-1.960	-3.729
207915	-1.086	-0.819	-2.521	-0.611	-0.652	-0.563	-1.308	-0.510	-0.541	-0.496	-0.415	-0.129	-1.138	-2.041	-3.851
208575	-1.110	-0.848	-2.642	-0.667	-0.654	-0.618	-1.579	-0.527	-0.586	-0.512	-0.418	-0.135	-1.236	-2.250	-4.127
209107	-1.137	-0.871	-2.816	-0.727	-0.670	-0.680	-1.884	-0.551	-0.619	-0.533	-0.424	-0.145	-1.337	-2.551	-4.390
209527	-1.157	-0.895	-2.932	-0.750	-0.704	-0.716	-2.151	-0.580	-0.685	-0.546	-0.433	-0.147	-1.467	-2.801	-4.656
209772	-1.172	-0.912	-3.007	-0.759	-0.736	-0.741	-2.349	-0.594	-0.718	-0.552	-0.441	-0.149	-1.525	-3.003	-4.850
210222	-1.197	-0.925	-3.182	-0.781	-0.789	-0.772	-2.596	-0.618	-0.754	-0.573	-0.457	-0.153	-1.661	-3.286	-5.114
210602	-1.241	-0.943	-3.364	-0.798	-0.824	-0.868	-2.837	-0.642	-0.783	-0.604	-0.475	-0.165	-1.824	-3.535	-5.336
210762	-1.251	-0.951	-3.476	-0.806	-0.832	-0.906	-2.908	-0.649	-0.794	-0.629	-0.488	-0.174	-1.841	-3.572	-5.383
211063	-1.277	-0.967	-3.626	-0.827	-0.838	-0.948	-2.981	-0.656	-0.811	-0.669	-0.520	-0.191	-1.875	-3.626	-5.453
211439	-1.295	-0.979	-3.714	-0.847	-0.842	-0.970	-3.025	-0.663	-0.827	-0.694	-0.550	-0.203	-1.906	-3.714	-5.502
212246	-1.315	-0.998	-3.831	-0.855	-0.848	-0.999	-3.148	-0.672	-0.847	-0.721	-0.596	-0.219	-1.958	-3.794	-5.589
213867	-1.329	-1.020	-4.005	-0.885	-0.861	-1.030	-3.335	-0.683	-0.889	-0.748	-0.649	-0.243	-2.108	-4.000	-5.803
214870	-1.356	-1.046	-4.200	-0.934	-0.877	-1.050	-3.531	-0.699	-0.920	-0.823	-0.692	-0.269	-2.217	-4.236	-6.007
215417	-1.402	-1.067	-4.373	-0.974	-0.890	-1.061	-3.698	-0.714	-0.943	-0.884	-0.731	-0.315	-2.340	-4.387	-6.205
215818	-1.431	-1.078	-4.507	-0.990	-0.899	-1.070	-3.845	-0.730	-0.985	-0.914	-0.771	-0.341	-2.467	-4.605	-6.392
215989	-1.445	-1.082	-4.528	-0.993	-0.901	-1.077	-3.870	-0.735	-0.995	-0.926	-0.779	-0.345	-2.491	-4.652	-6.428
216017	-1.445	-1.082	-4.528	-0.993	-0.902	-1.076	-3.872	-0.735	-0.995	-0.926	-0.780	-0.346	-2.492	-4.655	-6.433
216066	-1.445	-1.082	-4.530	-0.994	-0.903	-1.077	-3.876	-0.736	-0.995	-0.926	-0.781	-0.346	-2.495	-4.659	-6.437
216123	-1.445	-1.082	-4.531	-0.994	-0.909	-1.077	-3.879	-0.738	-0.995	-0.928	-0.782	-0.347	-2.497	-4.662	-6.440
216147	-1.444	-1.082	-4.531	-0.994	-0.909	-1.077	-3.880	-0.739	-0.995	-0.928	-0.782	-0.347	-2.498	-4.663	-6.441
216180	-1.443	-1.082	-4.531	-0.994	-0.910	-1.077	-3.882	-0.739	-0.995	-0.928	-0.782	-0.347	-2.498	-4.664	-6.442
216225	-1.441	-1.082	-4.531	-0.994	-0.910	-1.077	-3.884	-0.739	-0.995	-0.928	-0.782	-0.348	-2.499	-4.665	-6.443
216271	-1.438	-1.082	-4.531	-0.994	-0.910	-1.077	-3.886	-0.740	-0.994	-0.928	-0.782	-0.348	-2.500	-4.667	-6.444
216305	-1.437	-1.082	-4.531	-0.994	-0.910	-1.077	-3.886	-0.740	-0.993	-0.928	-0.782	-0.348	-2.500	-4.675	-6.444
216348	-1.434	-1.082	-4.531	-0.993	-0.910	-1.076	-3.887	-0.740	-0.991	-0.928	-0.783	-0.349	-2.500	-4.676	-6.445
216422	-1.431	-1.081	-4.531	-0.993	-0.909	-1.075	-3.887	-0.740	-0.989	-0.928	-0.783	-0.349	-2.501	-4.677	-6.446
216466	-1.429	-1.081	-4.531	-0.993	-0.908	-1.073	-3.888	-0.740	-0.987	-0.928	-0.783	-0.349	-2.501	-4.678	-6.447
216555	-1.425	-1.080	-4.530	-0.992	-0.903	-1.071	-3.888	-0.740	-0.983	-0.928	-0.783	-0.351	-2.502	-4.678	-6.448
216638	-1.421	-1.080	-4.530	-0.992	-0.902	-1.070	-3.888	-0.740	-0.979	-0.928	-0.783	-0.354	-2.502	-4.679	-6.449
216717	-1.415	-1.079	-4.529	-0.991	-0.901	-1.068	-3.887	-0.740	-0.976	-0.928	-0.783	-0.356	-2.502	-4.687	-6.449
216808	-1.410	-1.078	-4.529	-0.990	-0.900	-1.065	-3.886	-0.740	-0.973	-0.928	-0.783	-0.357	-2.502	-4.688	-6.449

NAME	LP1	LP2	LP3	LP4	LP5	LP6	LP7	LP8	LP9	LP10	LP11	LP12	LP13	LP14	LP15
UNIT	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
ROW #															
216858	-1.406	-1.077	-4.528	-0.989	-0.899	-1.064	-3.885	-0.739	-0.971	-0.928	-0.783	-0.358	-2.502	-4.689	-6.449
216949	-1.398	-1.074	-4.526	-0.988	-0.899	-1.060	-3.881	-0.739	-0.965	-0.927	-0.783	-0.359	-2.502	-4.695	-6.449
217037	-1.387	-1.073	-4.524	-0.986	-0.897	-1.058	-3.878	-0.738	-0.958	-0.927	-0.783	-0.360	-2.502	-4.695	-6.449
217162	-1.377	-1.072	-4.521	-0.984	-0.896	-1.054	-3.874	-0.736	-0.953	-0.927	-0.783	-0.361	-2.502	-4.702	-6.449
217224	-1.371	-1.070	-4.518	-0.981	-0.895	-1.051	-3.870	-0.734	-0.950	-0.927	-0.783	-0.362	-2.502	-4.703	-6.449
217294	-1.366	-1.069	-4.514	-0.977	-0.893	-1.046	-3.866	-0.733	-0.946	-0.927	-0.782	-0.363	-2.502	-4.709	-6.449
217375	-1.359	-1.068	-4.509	-0.974	-0.891	-1.039	-3.861	-0.731	-0.941	-0.926	-0.782	-0.363	-2.502	-4.709	-6.448
217463	-1.354	-1.068	-4.506	-0.970	-0.889	-1.034	-3.857	-0.729	-0.938	-0.925	-0.781	-0.364	-2.502	-4.717	-6.446
217549	-1.348	-1.068	-4.502	-0.962	-0.886	-1.030	-3.852	-0.727	-0.932	-0.924	-0.780	-0.365	-2.502	-4.726	-6.443
217611	-1.342	-1.066	-4.498	-0.955	-0.883	-1.025	-3.847	-0.725	-0.932	-0.923	-0.779	-0.365	-2

EGs

NAME	EG_1B	EG_1G	EG_1W	EG_2B	EG_2G	EG_2W	EG_3B	EG_3G	EG_3W	EG_4B	EG_4G	EG_4W
UNIT	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]
ROW #												
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3790	-1	-1	-1	-1	-1	-1	0	-2	18	0	-1	18
3806	-1	-1	-1	-1	-1	-2	1	-3	18	0	-1	18
3822	0	-2	0	-2	-1	-2	1	-3	18	0	-1	18
3961	-1	-2	0	-3	-1	-3	2	-3	18	0	-1	18
4118	0	-2	0	-2	-1	-2	2	-3	18	0	-1	18
27328	0	-3	0	-3	-2	-1	1	-15	18	-1	-1	18
59268	-1	-4	0	-3	-2	-1	1	-51	18	-1	-1	18
65462	-1	-3	0	-4	-2	-1	1	-50	18	-1	-1	18
65601	0	-4	0	-4	-2	-1	1	-50	18	-1	-1	18
65686	-1	-3	-1	-5	-2	-1	1	-50	18	-1	-1	18
65839	0	-2	0	-4	-2	-1	2	-50	18	-1	-1	18
66240	-1	-3	0	-4	-2	0	2	-50	18	-1	-1	18
68683	0	-2	0	-4	-2	0	2	-49	18	-1	-1	18
68967	-1	-4	-1	-5	-2	0	3	-49	18	-1	-2	18
69104	-1	-4	0	-5	-2	0	3	-50	18	-1	-2	18
69200	-1	-4	-1	-4	-2	0	3	-50	18	-1	-2	18
69489	-2	-4	0	-3	-2	0	4	-51	18	-2	-4	18
69713	-3	-5	-1	-3	-3	-1	3	-52	18	-2	-6	18
69825	-3	-5	2	-3	-3	0	4	-52	18	-2	-6	18
69921	-4	-5	5	-3	-3	0	4	-52	18	-2	-8	18
70128	-3	-4	8	0	-2	0	4	-54	18	-1	-10	18
70320	-3	-4	10	1	-2	0	4	-58	18	-1	-12	18
70444	-3	-4	12	1	-2	2	5	-60	18	1	-13	18
70669	-4	-6	14	-1	-1	7	5	-65	18	5	-15	18
70997	-5	-7	19	0	-2	11	4	-71	18	8	-19	18
71243	-5	-9	23	-3	-4	13	3	-77	18	11	-23	18
71373	-5	-10	27	-6	-7	16	2	-81	18	13	-27	18
71557	-6	-15	42	-9	-14	18	0	-88	18	17	-36	18
71860	0	-19	63	-7	-22	18	-3	-98	18	18	-46	18
72184	15	-23	79	-3	-29	19	-6	-105	18	16	-58	18
72500	36	-25	65	9	-34	12	-6	-111	18	10	-66	18
72910	74	-18	51	25	-34	4	5	-113	18	3	-68	18
73144	96	-12	49	32	-34	0	9	-114	18	-1	-67	18
73445	116	-1	47	42	-34	-3	14	-111	18	-2	-55	18
73769	133	2	48	53	-32	-7	15	-110	18	6	-52	18
74090	139	-3	59	72	-23	-12	14	-109	18	26	-52	18
74506	148	-3	69	85	-19	-13	12	-108	18	44	-48	18
74713	155	-2	79	93	-18	-14	12	-105	18	53	-48	18
76558	167	6	102	103	-10	-1	13	-90	18	75	-43	18
76799	174	6	107	106	-8	2	12	-88	18	87	-43	18
77056	180	11	118	110	-7	6	13	-83	18	103	-33	18
77272	190	13	130	114	-5	9	14	-79	18	116	-14	18
77775	205	20	145	118	-5	11	17	-72	18	143	-3	18
77909	211	21	150	121	-5	13	17	-71	18	155	-1	18
78492	227	28	165	126	-3	16	22	-64	18	184	6	18
78613	233	29	170	129	-3	17	24	-63	18	193	8	18
79516	244	36	179	133	1	20	31	-61	18	217	17	18
80118	245	38	181	134	2	20	32	-61	18	218	20	18
83849	248	40	185	135	4	21	35	-63	18	221	25	18
99294	251	43	189	136	6	22	37	-78	18	224	30	18
103450	252	43	190	136	6	22	38	-84	18	225	31	18
103579	253	42	192	137	6	23	38	-84	18	227	30	18
103664	255	42	192	138	5	23	39	-84	18	230	30	18
103892	259	43	194	141	5	24	40	-85	18	236	30	18
104001	262	43	195	142	5	25	41	-85	18	241	29	18
104187	268	45	199	146	5	26	43	-85	18	251	29	18
104377	274	47	203	149	7	27	46	-85	18	262	29	18
104630	283	51	210	156	8	28	50	-85	18	278	30	18
104830	290	53	215	161	10	28	54	-85	18	290	30	18
105039	296	54	220	168	13	29	58	-84	18	302	31	18
105400	306	55	228	176	20	30	63	-81	18	317	33	18
105715	313	57	234	185	27	31	70	-78	18	336	35	18
105946	316	60	242	189	34	31	74	-77	18	352	36	18
106220	317	60	247	196	42	31	78	-75	18	367	38	18
106538	316	60	253	206	51	32	84	-73	18	386	40	18
106918	313	59	259	222	60	36	90	-72	18	419	51	18
107216	309	61	266	237	68	39	95	-69	18	474	72	18
107427	311	62	268	249	74	41	100	-68	18	496	76	18
107736	312	63	272	266	82	46	107	-65	18	525	80	18
107929	312	64	276	278	87	50	112	-63	18	544	82	18
108193	312	65	278	289	91	55	118	-62	18	560	84	18
108620	313	69	285	311	98	65	127	-61	18	586	86	18
109784	314	73	293	335	101	86	140	-62	18	613	91	18
109910	316	73	293	338	101	89	143	-62	18	624	91	18
110098	317	74	295	342	102	96	148	-62	18	641	92	18
110425	320	78	301	350	104	106	155	-61	18	660	94	18
110725	322	81	305	358	107	116	162	-60	18	678	96	18
111677	322	84	310	363	112	128	168	-60	18	686	101	18
113390	320	86	313	364	115	131	169	-64	18	684	105	18
114004	321	86	314	366	115	133	171	-66	18	688	105	18
114107	322	86	314	368	116	135	173	-66	18	695	105	18
114287	325	88	317	373	117	139	177	-66	18	707	105	18
114460	327	88	318	378	120	143	181	-65	18	721	106	18
114560	329	89	321	383	122	147	184	-65	18	732	106	18
114740	331	90	324	390	127	154	190	-64	18	747	108	18
115034	334	92	328	400	133	163	197	-62	18	763	109	18
115365	336	93	332	407	137	171	205	-60	18	777	111	18
116420	338	95	340	416	143	180	213	-59	18	785	116	18
117644	338	96	342	416	144	181	213	-59	18	781	118	18
117764	339	95	342	417	145	182	215	-59	18	784	118	18
117864	341	96	343	419	145	183	217	-59	18	791	118	18
118042	342	96	344	424	147	187	221	-59	18	803	118	18
118364	345	97	349	432	151	193	228	-58	18	818	120	18
118542	347	97	350	438	153	196	232	-58	18	829	121	18
118822	350	99	354	449	158	202	240	-56	18	845	125	18
119023	351	99	357	456	161	207	248	-55	18	857	127	18
119308	356	101	362	470	165	212	257	-52	18	872	132	18
119769	359	102	370	484	169	219	270	-47	18	890	138	18
120100	363	104	375	496	173	223	281	-44	18	906	143	18
120503	368	106	381	510	178	229	295	-39	18	923	149	18
120956	373	108	389	526	183	234	311	-35	18	940	155	18
121410	375	109	393	534	187	237	321	-30	18	942	159	18
121496	373	110	394	533	187	236	320	-30	18	938	160	18
121598	373	110	394	533	188	235	319	-30	18	933	160	18
121629	372	110	393	531	187	234	318	-30	18	929	160	18
121874	372	110	394	530	188	234	318	-29	18	923	161	18
121961	370	111	394	529	188	233	316	-29	18	918	161	18
123298	369	112	395	528	188	232	316	-29	18	907	163	18
124120	367	112	395	527	189	231	315	-28	18	901	163	18
147223	368	114	400	527	192	233	322	-36	18	886	170	18
147346	369	113	400	529	193	235	324	-36	18	891	170	18
147457	371	113	402	531	193	236	327	-36	18	898	170	18
147551	373	114	403	534	194	238	330	-36	18	906	170	18
147733	377	113	405	539	195	241	335	-35	18	918	170	18
147987	379	114	407	546	197	244	342	-34	18	932	171	18
148115	381	115	409	550	198	246	345	-34	18	941	171	18
148225	383	114	410	554	199	248	350	-33	18	953	172	18
148533	387	115	413	563	201	252	361	-30	18	970	173	18
148780	390	117	418	572	203	255	369	-28	18	984	175	18
149126	391	116	420	578	205	258	378	-25	18	998	177	18
149435	394	117	426	585	208	261	389	-22	18	1012	180	18
149989	399	119	436	595	211	265	405	-16	18	1030	184	18
150102	400	120	438	598	212	266	408	-15	18	1034	185	18
150119	400	120	439	598	212	266	409	-14	18	1035	185	18
150236	400	120	440	600	212	267	412	-13	18	1037	186	18
150354	402	120	443	601	212	267	414	-12	18	1039	187	18
150364	402	119	441	600	212	267	415	-12	18	1040	187	18
150378	402	119	443	601	212	268	416	-12	18	1041	187	18
150431	402	119	443	602	213	268	418	-11	18	1043	188	18
150470	402	119	442	602	213	268	418	-11	18	1043	188	18
150497	402	118	444	602	213	268	419	-10	18	1044	188	18
150510	402	119	444	602	213	268	420	-10	18	1045	189	18
150533	403	119	445	603	213	269	421	-10	18	1047	189	18
150594	403	119	446	604	213	269	424	-9	18	1051	190	18
150609	403	119	447	604	214	270	425	-9	18	1052	190	18
150658	404	119	448	606	214	270	427	-8	18	1055	190	18
150679	404	119	448	606	214	270	427	-8	18	1054	191	18
150700	404	119	448	607	214	270	427	-7	18	1054	191	18
150728	404	119	449	606	214	270	427	-7	18	1053	191	18
150804	404	119	450	606	214	269	428	-7	18	1052	192	18
150918	403	120	451	607	214	269	429	-6	18	1052	193	18
150928	404	119	451	606	214	269	430	-6	18	1053	193	18
150941	404	119	451	606	214	270	431	-6	18	1055	193	18
151019	405	120	454	608	214	270	433	-5	18	1058	194	18
151041	405	120	454	608	215	270	433	-5	18	1057	194	18
151046	405	120	454	608	215	270	433	-5	18	1057	194	18
151050	405	120	454	608	215	270	433	-5	18	1056	194	18
151054	405	121	454	608	215	270	433	-4	18	1055	194	18
151058	404	120	454	608	215	270	433	-5	18	1054	194	18

NAME	EG_1B	EG_1G	EG_1W	EG_2B	EG_2G	EG_2W	EG_3B	EG_3G	EG_3W	EG_4B	EG_4G	EG_4W
UNIT	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]
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151068	405	120	454	607	215	269	432	-4	18	1053	194	18
151074	405	120	454	607	215	269	432	-4	18	1052	194	18
151170	404	120	454	607	215	269	432	-4	18	1050	195	18
151176	403	121	454	606	215	269	432	-4	18	1049	195	18
151181	404	120	455	607	215	269	431	-4	18	1048	195	18
151191	402	120	453	605	215	269	431	-4	18	1048	195	18
151200	402	118	453	604	215	268	431	-4	18	1047	195	18
151212	402	120	453	605	215	268	431	-4	18	1046	195	18
151361	402	120	455	605	215	268	431	-3	18	1043	195	18
151370	401	120	455	606	215	268	431	-3	18	1043	195	18
151374	401	120	455	605	215	268	430	-3	18	1042	195	18
151379	401	120	455	605	215	267	430	-3	18	1041	195	18
151384	400	119	454	604	215	267	430	-3	18	1040	195	18
151390	401	119	453	604	215	267	429	-3	18	1039	195	18
151705	400	121	456	604	215	267	430	-3	18	1037	196	18
151712	401	120	455	604	215	267	430	-3	18	1038	196	18
151719	401	120	457	605	215	267	430	-3	18	1038	196	18
151727	401	120	456	604	215	267	431	-3	18	1039	196	18
151735	401	119	456	604	215	268	431	-3	18	1039	196	18
151746	400	119	456	604	215	268	431	-3	18	1040	197	18
151761	401	120	457	605	215	268	432	-3	18	1041	197	18
151848	401	120	457	605	215	268	432	-3	18	1041	197	18
151886	401	120	457	605	215	268	432	-2	18	1040	197	18
151936	401	120	457	606	215	268	432	-2	18	1040	197	18
151942	401	120	458	605	215	268	432	-2	18	1040	197	18
151947	401	120	457	605	215	268	432	-2	18	1041	197	18
151953	401	120	457	605	215	268	433	-2	18	1042	197	18
151962	401	119	457	605	215	268	433	-2	18	1043	197	18
152017	401	119	457	605	215	268	433	-2	18	1043	197	18
152048	401	120	458	606	215	268	433	-2	18	1042	197	18
152104	401	120	458	605	215	268	433	-2	18	1041	197	18
152163	401	120	458	605	215	268	433	-2	18	1041	198	18
152170	402	120	459	606	215	268	434	-2	18	1042	198	18
152176	401	119	459	605	215	268	434	-2	18	1042	198	18
152183	401	120	458	605	215	268	434	-2	18	1043	198	18
152192	401	120	459	606	215	269	435	-2	18	1044	198	18
152204	401	120	460	606	215	269	435	-2	18	1045	198	18
152266	401	119	458	607	215	269	436	-1	18	1046	198	18
152291	402	120	459	607	216	269	436	-1	18	1045	198	18
152329	402	119	460	607	216	269	437	-1	18	1046	198	18
152336	402	119	460	607	215	269	437	-1	18	1046	198	18
152344	402	119	460	607	215	269	437	-1	18	1047	198	18
152354	402	119	460	607	216	270	438	-1	18	1048	198	18
152420	403	120	461	609	216	270	439	-1	18	1050	199	18
152453	402	119	461	608	216	270	440	-1	18	1051	199	18
152462	402	119	460	609	216	270	440	-1	18	1052	199	18
152473	403	118	461	609	216	270	441	-1	18	1053	199	18
152489	404	119	461	609	216	271	441	0	18	1054	199	18
152533	404	119	461	610	216	271	443	0	18	1056	199	18
152569	405	119	463	611	216	271	444	0	18	1057	200	18
152581	405	118	462	610	216	272	444	1	18	1059	200	18
152658	405	118	464	612	216	273	447	1	18	1063	200	18
152672	406	119	464	613	216	273	448	2	18	1064	200	18
152748	408	118	467	615	217	273	451	2	18	1069	201	18
152766	407	119	467	615	217	274	452	3	18	1070	201	18
152841	408	119	468	617	217	274	455	4	18	1074	202	18
152863	407	119	467	617	217	274	455	4	18	1074	202	18
152888	408	118	469	617	217	274	456	4	18	1074	203	18
152897	408	118	469	617	217	274	456	4	18	1075	203	18
152909	409	118	469	618	217	275	457	4	18	1077	203	18
152927	409	118	469	618	218	275	458	5	18	1079	203	18
152979	409	117	470	620	218	276	461	6	18	1081	204	18
153026	410	117	471	620	218	276	462	6	18	1083	204	18
153052	410	116	471	620	218	276	464	7	18	1085	205	18
153078	410	117	471	620	218	276	465	7	18	1086	205	18
153105	409	117	472	622	218	276	465	7	18	1086	205	18
153141	410	117	473	622	218	276	466	8	18	1087	206	18
153168	411	118	473	623	218	276	467	8	18	1088	206	18
153233	410	117	475	624	219	277	471	9	18	1092	207	18
153378	412	117	478	627	220	278	478	12	18	1098	209	18
153401	413	116	479	627	220	278	480	13	18	1101	209	18
153443	412	116	479	628	220	278	482	14	18	1103	210	18
153473	412	115	480	628	220	278	483	14	18	1103	210	18
153504	413	115	481	629	220	278	483	15	18	1102	210	18
153535	412	117	483	630	220	278	484	15	18	1103	211	18
153559	412	115	481	629	220	278	486	16	18	1104	211	18
153611	413	116	483	631	221	279	488	17	18	1106	212	18
153644	412	116	483	630	221	278	489	17	18	1106	212	18
153669	411	115	484	631	221	279	490	18	18	1105	212	18
153703	412	116	484	631	221	278	490	18	18	1105	213	18
153742	412	116	485	631	221	278	491	19	18	1105	213	18
153751	412	115	485	632	221	279	492	19	18	1106	213	18
153764	411	115	485	631	221	279	493	19	18	1107	213	18
153832	413	114	486	632	222	279	496	21	18	1109	214	18
153867	412	115	487	634	222	279	497	21	18	1109	214	18
153905	412	114	487	633	222	279	499	22	18	1110	215	18
153917	413	114	487	632	222	279	500	22	18	1111	215	18
153938	414	115	489	635	222	280	501	23	18	1113	215	18
154008	413	114	489	635	222	280	506	25	18	1116	216	18
154038	414	115	489	637	223	280	507	26	18	1115	216	18
154298	418	114	495	642	225	282	528	36	18	1121	218	18
154321	417	116	495	643	225	282	530	37	18	1121	218	18
154342	418	115	495	643	225	282	531	38	18	1122	218	18
154365	417	115	496	642	225	282	533	39	18	1121	219	18
154398	417	114	496	643	225	281	534	40	18	1121	219	18
154433	418	114	496	643	225	281	536	41	18	1121	219	18
154450	417	115	496	644	225	281	537	41	18	1121	219	18
154456	418	114	496	644	225	281	537	41	18	1120	220	18
154462	418	115	496	643	225	281	537	42	18	1120	220	18
154468	418	115	496	643	226	281	537	42	18	1119	220	18
154474	417	115	495	643	226	281	537	42	18	1119	220	18
154485	416	114	495	643	226	280	536	42	18	1117	220	18
154585	416	115	496	643	226	279	537	43	18	1114	221	18
154662	416	115	496	642	226	278	537	44	18	1111	221	18
154785	415	115	496	641	226	278	537	45	18	1107	222	18
154881	413	114	495	642	226	277	536	45	18	1102	222	18
154983	413	115	496	640	226	276	535	45	18	1097	222	18
154992	412	113	495	639	226	275	534	46	18	1096	222	18
154997	411	113	495	639	226	275	534	45	18	1095	222	18
155003	412	114	495	639	226	275	534	46	18	1094	222	18
155011	412	115	495	639	226	275	533	46	18	1093	222	18
155127	411	115	495	639	226	274	533	46	18	1090	223	18
165553	411	111	494	638	228	270	546	52	18	1076	236	18
171859	412	109	493	636	229	269	549	53	18	1071	239	18
171898	412	110	493	637	229	269	549	53	18	1071	239	18
174034	411	110	494	637	229	268	549	52	18	1070	240	18
176124	412	109	493	637	229	268	550	52	18	1070	241	18
176133	412	109	493	637	229	268	550	52	18	1070	241	18
180778	413	111	494	637	229	268	551	50	18	1068	242	18
183169	413	109	493	636	230	268	552	50	18	1067	243	18
183498	413	109	494	637	230	268	552	50	18	1067	243	18
183503	413	110	493	637	229	268	552	50	18	1067	243	18
183509	414	109	494	637	229	268	552	50	18	1068	243	18
183515	414	110	494	637	229	268	553	49	18	1068	243	18
183523	413	110	494	637	229	269	553	50	18	1069	243	18
183534	414	110	494	637	229	269	554	50	18	1070	243	18
183554	413	109	494	637	229	269	554	50	18	1071	243	18
183583	414	110	494	638	229	269	555	50	18	1072	243	18

NAME	EG_1B	EG_1G	EG_1W	EG_2B	EG_2G	EG_2W	EG_3B	EG_3G	EG_3W	EG_4B	EG_4G	EG_4W
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184483	430	107	500	651	232	278	587	60	18	1116	248	18
184502	431	107	501	652	232	279	588	61	18	1118	248	18
184547	431	106	500	653	232	279	590	62	18	1121	248	18
184567	431	107	500	653	232	279	591	62	18	1120	249	18
184682	433	106	500	654	232	279	593	64	18	1123	249	18
184693	433	107	501	655	232	279	594	64	18	1124	249	18
184710	433	107	500	656	232	279	595	65	18	1126	249	18
184766	434	106	501	656	232	279	597	66	18	1128	250	18
184796	434	107	500	656	232	279	598	66	18	1128	250	18
184831	434	105	500	656	232	279	598	67	18	1129	250	18
184839	434	105	501	656	232	279	599	67	18	1130	250	18
184847	435	106	501	656	232	279	599	67	18	1131	250	18
184859	436	106	501	657	232	280	601	67	18	1133	251	18
184927	437	104	500	658	233	280	605	69	18	1138	251	18
184940	438	105	500	658	233	280	606	70	18	1140	252	18
185009	441	105	501	662	233	281	611	72	18	1147	253	18
185021	441	105	502	663	233	281	612	73	18	1149	253	18
185038	442	105	502	663	233	281	614	74	18	1152	253	18
185114	446	105	502	667	234	281	622	78	18	1162	255	18
185188	449	103	500	669	234	281	629	82	18	1171	257	18
185214	450	102	499	669	234	281	632	83	18	1175	258	18
185311	455	102	497	672	235	280	642	90	18	1190	261	18
185332	456	101	496	673	235	280	644	92	18	1193	262	18
185354	455	101	496	673	235	279	645	93	18	1194	262	18
185382	455	100	495	673	235	279	647	94	18	1196	263	18
185427	455	100	494	673	235	278	649	96	18	1199	264	18
185453	456	99	493	673	235	278	651	97	18	1202	265	18
185462	455	99	493	673	235	278	652	97	18	1203	265	18
185471	456	100	493	675	235	278	653	98	18	1206	265	18
185487	457	100	494	676	235	278	656	99	18	1209	266	18
185525	459	99	493	676	235	278	661	102	18	1215	267	18
185545	460	100	494	677	235	278	662	103	18	1217	268	18
185565	459	99	492	677	235	278	664	104	18	1218	268	18
185593	458	98	491	676	235	277	665	106	18	1220	269	18
185640	457	97	490	676	235	277	667	107	18	1222	269	18
185724	457	96	489	678	235	276	671	110	18	1227	271	18
185732	458	97	490	679	235	276	672	111	18	1229	271	18
185741	459	98	490	679	235	277	674	111	18	1231	271	18
185796	459	95	490	681	235	277	679	115	18	1238	273	18
185815	459	95	490	680	235	277	680	115	18	1238	273	18
185848	458	94	489	680	236	276	681	116	18	1240	274	18
185920	457	94	488	681	236	276	685	119	18	1243	275	18
185928	458	93	489	682	236	276	686	119	18	1245	275	18
185939	457	93	489	683	236	276	687	120	18	1247	275	18
186016	458	92	489	685	236	276	694	124	18	1254	278	18
186047	458	92	489	684	236	276	695	125	18	1255	278	18
186077	458	93	488	685	236	276	697	126	18	1256	278	18
186123	457	91	487	684	236	276	698	127	18	1257	279	18
186213	457	92	488	686	236	275	701	129	18	1259	280	18
186220	458	92	489	686	236	275	702	129	18	1260	280	18
186227	458	92	488	686	236	276	703	130	18	1262	281	18
186236	458	92	488	687	236	276	704	130	18	1263	281	18
186251	458	92	488	687	236	276	706	131	18	1266	281	18
186289	458	92	489	689	237	276	710	133	18	1270	283	18
186319	458	91	488	689	237	276	711	134	18	1271	283	18
186357	457	91	487	689	237	276	712	135	18	1272	284	18
186386	458	90	487	688	237	276	714	136	18	1273	284	18
186394	457	90	487	689	237	276	715	137	18	1274	285	18
186405	457	90	488	689	237	276	716	137	18	1276	285	18
186462	458	90	488	691	237	276	721	141	18	1281	287	18
186486	458	90	488	691	237	276	723	142	18	1282	287	18
186550	458	89	487	692	237	276	728	146	18	1284	289	18
186562	457	88	487	692	237	276	730	147	18	1286	289	18
186577	458	89	488	693	237	276	732	148	18	1288	289	18
186631	459	87	486	694	238	277	738	152	18	1293	291	18
186685	460	87	487	695	238	277	742	155	18	1296	293	18
186703	460	87	487	696	238	277	745	156	18	1299	293	18
186757	460	85	485	697	238	277	751	160	18	1303	295	18
186799	461	85	484	698	238	277	755	163	18	1306	296	18
186809	461	85	484	699	238	277	756	163	18	1308	297	18
186823	462	85	485	699	238	277	758	165	18	1311	297	18
186870	463	83	484	701	238	277	765	169	18	1316	299	18
186897	463	83	484	701	238	277	766	171	18	1317	300	18
187445	474	75	469	713	239	277	819	209	18	1362	320	18
187878	481	68	458	724	240	278	862	240	18	1407	341	18
188305	489	63	451	733	240	279	893	264	18	1438	382	18
188685	495	60	444	740	239	280	921	285	18	1446	417	18
189183	494	57	441	752	241	279	942	306	18	1434	460	18
189365	494	57	443	760	242	278	943	310	18	1425	495	18
189411	494	56	443	762	243	277	941	311	18	1414	510	18
189549	491	56	443	770	246	275	940	312	18	1385	556	18
189853	490	59	450	780	249	274	939	315	18	1334	624	18
190466	487	63	455	783	248	276	948	323	18	1302	702	18
190776	482	65	456	780	246	277	952	329	18	1288	738	18
191642	472	66	459	759	237	291	962	343	18	1290	788	18
191965	471	66	462	752	231	299	971	351	18	1309	797	18
192442	465	69	465	727	217	311	989	368	18	1344	798	18
192889	461	77	467	692	200	323	1008	389	18	1373	797	18
192912	459	77	466	689	199	322	1006	389	18	1368	797	18
193039	458	79	465	680	195	323	1006	392	18	1362	796	18
193235	455	80	464	670	192	323	1007	396	18	1356	796	18
193286	455	82	464	669	191	323	1005	397	18	1350	796	18
193350	454	82	464	667	191	322	1003	397	18	1345	796	18
193359	453	82	463	665	191	321	1001	397	18	1339	796	18
193369	450	82	461	663	191	320	998	397	18	1334	796	18
193381	449	82	461	662	190	319	995	397	18	1328	795	18
193392	448	82	460	661	190	318	992	397	18	1321	794	18
193402	446	83	460	659	190	317	989	396	18	1314	794	18
193414	443	82	459	656	189	316	986	396	18	1307	793	18
193424	441	82	458	654	189	315	982	396	18	1299	792	18
193434	439	83	457	651	188	314	978	396	18	1289	791	18
193446	437	82	455	648	188	313	974	395	18	1280	790	18
193648	431	82	452	640	186	311	968	396	18	1261	787	18
194938	430	82	452	633	185	311	968	399	18	1253	787	18
204163	427	83	450	623	183	314	968	405	18	1236	790	18
204290	428	83	451	623	183	314	970	405	18	1240	790	18
204494	428	84	452	625	183	316	972	406	18	1244	790	18
204631	429	82	452	623	182	317	975	406	18	1250	790	18
204744	430	82	453	624	182	318	977	407	18	1255	790	18
204841	432	82	454	625	181	319	980	408	18	1262	790	18
205058	434	82	456	626	181	321	984	409	18	1270	790	18
205202	436	82	456	626	180	323	989	411	18	1279	791	18
205905	440	83	458	625	178	327	999	418	18	1296	794	18
206234	443	84	461	627	177	331	1006	421	18	1310	795	18
206759	449	86	462	625	175	338	1022	432	18	1335	801	18
207127	456	89	462	622	172	345	1043	447	18	1364	808	18
207588	465	97	460	614	167	355	1093	491	18	1405	825	18
207915	469	105	458	609	165	358	1126	531	18	1421	839	18
208575	482	117	457	600	162	364	1183	615	18	1458	872	18
209107	494	134	461	601	164	375	1235	708	18	1492	911	18
209527	503	147	465	602	168	390	1284	797	18	1514	948	18
209772	507	158	469	608	174	401	1353	892	18	1518	976	18
210222	514	173	473	612	182	422	1551	1127	18	1516	1016	18
210602	524	186	475	613	191	443	1690	1304	18	1497	1052	18
210762	527	196	478	611	195	450	1703	1301	18	1476	1063	18
211063	540	212	481	608	203	462	1703	1290	18	1454	1080	18
211439	554	227	483	607	208	468	1693	1284	18	1438	1096	18
212246	576	250	487	606	213	473	1680	1282	18	1417	1122	18
213867	618	289	499	608	222	488	1676	1290	18	1409	1158	18
214870	654	325	509	610	231	506	1671	1300	18	1406	1190	18
215417	695	362	518	614	242	528	1664	1312	18	1399	1222	18
215818	733	397	524	619	252	544	1658	1326	18	1384	1250	18
215989	744	409	525	619	255	546	1651	1327	18	1372	1259	18
216017	745	411	525	619	256	545	1647	1326	18	1367	1261	18
216066	745	414	524	619	257	545	1643	1325	18	1360	1263	18
216123	747	415	523	617	258	544	1638	1324	18	1354	1265	18
216147	746	417	523	618	258	543	1634	1322	18	1349	1265	18
216180	748	418	522	618	258	542	1628	1320	18	1343	1266	18
216225	747	421	522	618	259	541	1623	1318	18	1336	1267	18
216271	748	423	521	617	259	540	1617	1315	18	1330	1268	18
216305	747	424	521	616	260	539	1611	1313	18	1323	1269	18
216348	747	425	519	616	260	538	1604	1310	18	1315	1270	18
216422	746	428	519	614	260	536	1597	1307	18	1305	1271	18
216466	745	428	518	613	261	535	1591	1305	18	1298	1272	18
216555	744	430	516	611	261	533	1583	1301	18	1288	1273	18
216638	742	432	515	611	262	531	1576	1298	18	1278	1273	18
216717	740	434	514	609	262	529	1568	1295	18	1268	1274	18
216808	738	435	512	606	262	527	1559	1291	18	1257	1275	18

NAME	EG_1B	EG_1G	EG_1W	EG_2B	EG_2G	EG_2W	EG_3B	EG_3G	EG_3W	EG_4B	EG_4G	EG_4W
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217037	730	438	508	601	263	519	1532	1279	18	1223	1275	18
217162	728	439	505	598	264	517	1522	1274	18	1211	1276	18
217224	726	439	504	597	264	514	1513	1270	18	1200	1276	18
217294	722	439	502	594	264	512	1502	1264	18	1188	1276	18
217375	717	441	501	593	265	509	1489	1257	18	1173	1276	18
217463	714	440	499	590	265	506	1478	1251	18	1161	1276	18
217549	711	442	499	589	265	503	1467	1245	18	1148	1275	18
217611	706	442	495	585	265	500	1455	1238	18	1134	1275	18
217723	703	443	494	583	266	496	1441	1231	18	1118	1274	18
217856	699	443	493	581	266	493	1428	1224	18	1103	1273	18
217997	694	443	489	577	266	488	1412	1215	18	1086	1272	18
221905	696	449	487	572	267	485	1395	1209	18	1068	1269	18
230874	701	456	487	572	269	484	1392	1218	18	1065	1269	18
230907	702	455	488	572	268	485	1394	1218	18	1067	1269	18
230961	703	455	488	571	268	486	1396	1219	18	1070	1269	18
231020	705	455	489	571	267	487	1399	1220	18	1073	1269	18
231072	706	454	489	570	267	489	1403	1222	18	1077	1269	18
231114	708	453	490	570	267	491	1407	1224	18	1081	1269	18
231181	709	454	491	570	266	493	1412	1226	18	1085	1269	18
231254	712	454	491	570	266	495	1417	1229	18	1090	1270	18
231289	714	455	494	571	266	497	1422	1231	18	1095	1270	18
231327	717	454	495	571	266	499	1429	1235	18	1101	1270	18
231375	719	455	496	571	266	502	1436	1239	18	1108	1271	18
231430	722	456	497	571	266	506	1445	1244	18	1116	1272	18
231509	727	456	500	572	266	509	1455	1251	18	1125	1273	18
231607	731	458	503	573	266	513	1464	1257	18	1133	1274	18
231668	734	458	504	573	266	516	1474	1262	18	1142	1275	18
231741	739	460	507	574	266	521	1484	1269	18	1151	1277	18
231813	744	462	509	575	267	526	1496	1277	18	1162	1279	18
231928	750	464	512	576	268	531	1507	1285	18	1173	1282	18
231995	755	466	514	577	269	536	1518	1292	18	1183	1284	18
232079	762	468	518	578	270	543	1531	1302	18	1196	1288	18
232192	771	473	522	581	272	551	1547	1314	18	1210	1293	18
232327	782	481	528	584	276	561	1561	1327	18	1224	1301	18
232489	798	490	533	587	280	574	1578	1342	18	1240	1311	18
232627	816	503	541	591	286	588	1597	1360	18	1257	1323	18
232814	843	526	551	600	295	608	1616	1382	18	1274	1342	18
232986	870	550	563	609	305	627	1634	1403	18	1288	1363	18
233133	894	578	577	623	316	646	1647	1422	18	1295	1384	18
233302	911	607	598	641	326	660	1655	1435	18	1286	1404	18
233454	927	633	617	665	332	667	1665	1447	18	1268	1422	18
233637	946	663	636	699	337	666	1667	1453	18	1231	1446	18
233772	964	684	650	733	335	659	1668	1455	18	1200	1468	18
233885	983	704	661	773	331	646	1667	1457	18	1157	1508	18
234006	1004	730	671	816	329	629	1666	1456	18	1112	1569	18
234144	1029	761	681	853	327	611	1672	1457	18	1074	1643	18
234291	1061	798	692	880	326	592	1677	1458	18	1045	1744	18
234417	1097	841	704	895	328	582	1685	1462	18	1026	1838	18
234557	1131	886	718	906	338	578	1694	1467	18	1003	1957	18
234711	1160	928	733	918	351	582	1700	1470	18	982	2088	18
234846	1182	962	746	930	366	589	1706	1473	18	965	2210	18
234989	1201	997	758	945	384	602	1716	1482	18	945	2333	18
235081	1211	1020	770	957	396	608	1723	1487	18	934	2412	18
235148	1215	1039	780	966	406	612	1716	1480	18	926	2486	18
235178	1218	1057	789	973	411	613	1705	1470	18	924	2528	18
235203	1220	1071	794	975	416	616	1692	1458	18	918	2562	18
235229	1223	1086	798	976	422	619	1677	1443	18	910	2592	18
235274	1227	1111	807	977	433	628	1656	1423	18	900	2632	18
235347	1235	1147	817	969	457	660	1640	1403	18	879	2684	18
235397	1238	1167	823	962	481	687	1632	1398	18	864	2715	18
235467	1238	1187	832	960	507	712	1623	1393	18	847	2747	18
235592	1236	1211	840	963	534	735	1612	1387	18	826	2784	18
235760	1235	1230	847	964	554	750	1601	1382	18	805	2815	18
235879	1235	1239	850	966	564	759	1602	1380	18	799	2832	18
236014	1240	1255	858	969	584	780	1606	1383	18	792	2860	18
236100	1244	1271	869	974	606	803	1610	1387	18	786	2887	18
236195	1245	1288	877	981	643	838	1610	1391	18	772	2923	18
236272	1245	1302	885	988	679	874	1611	1395	18	761	2953	18
236344	1246	1317	894	998	718	913	1612	1400	18	749	2983	18
236425	1243	1333	900	1007	763	958	1611	1404	18	735	3016	18
236505	1242	1350	910	1023	813	1005	1609	1407	18	718	3047	18
236580	1242	1367	919	1038	862	1052	1608	1411	18	704	3076	18
236679	1241	1389	928	1056	915	1101	1605	1415	18	685	2617	18
236758	1240	1405	936	1069	957	1140	1607	1419	18	673	2616	18
236833	1241	1422	944	1087	1003	1182	1605	1423	18	659	2616	18
236911	1240	1441	953	1103	1045	1221	1605	1427	18	646	2614	18
236972	1239	1454	959	1116	1082	1255	1606	1431	18	636	2614	18
237059	1238	1478	970	1136	1132	1301	1605	1436	18	622	2613	18
237151	1237	1500	980	1155	1183	1347	1605	1442	18	608	2612	18
237258	1235	1530	991	1179	1241	1398	1603	1446	18	593	2614	18
237340	1234	1557	1002	1201	1295	1448	1603	1450	18	581	2617	18
237394	1234	1569	1005	1211	1318	1466	1598	1450	18	573	2619	18
237541	1230	1592	1008	1228	1357	1493	1588	1449	18	553	2619	18
238130	1227	1644	1020	1256	1423	1540	1578	1449	18	520	2620	18
238143	1227	1645	1020	1257	1424	1539	1575	1449	18	518	2620	18
238181	1227	1648	1019	1258	1426	1538	1570	1448	18	513	2620	18
238258	1227	1652	1019	1258	1429	1538	1566	1447	18	508	2620	18
238338	1226	1656	1019	1260	1432	1538	1561	1445	18	503	2620	18
238384	1225	1659	1017	1260	1434	1537	1557	1444	18	499	2619	18
238440	1225	1660	1015	1261	1435	1535	1552	1443	18	494	2619	18
238499	1224	1663	1015	1261	1436	1533	1546	1441	18	488	2618	18
238553	1223	1668	1014	1262	1438	1530	1540	1439	18	483	2618	18
238627	1222	1671	1014	1262	1439	1527	1533	1436	18	476	2617	18
238698	1221	1674	1012	1262	1440	1524	1526	1434	18	469	2616	18
238758	1219	1677	1011	1262	1441	1520	1519	1431	18	462	2615	18
238882	1217	1682	1009	1262	1442	1514	1508	1427	18	452	2613	18
238965	1215	1685	1007	1262	1443	1510	1499	1424	18	445	2611	18
239079	1212	1689	1007	1263	1443	1503	1488	1419	18	435	2608	18
239161	1209	1692	1006	1263	1444	1498	1479	1415	18	427	2606	18
239265	1206	1695	1004	1263	1443	1491	1466	1409	18	416	2602	18
239384	1202	1700	1003	1263	1443	1484	1453	1403	18	406	2597	18
239502	1200	1703	1002	1265	1443	1478	1440	1398	18	397	2592	18
239671	1196	1706	999	1264	1443	1471	1428	1392	18	387	2587	18
239799	1193	1709	998	1265	1442	1463	1415	1386	18	378	2581	18
239965	1188	1711	995	1263	1440	1454	1400	1378	18	366	2573	18
240128	1183	1713	994	1264	1439	1445	1387	1372	18	355	2566	18
240300	1179	1714	993	1265	1437	1436	1374	1365	18	344	2557	18
240480	1175	1717	991	1265	1434	1426	1361	1358	18	333	2549	18
240686	1170	1719	989	1265	1431	1414	1346	1349	18	321	2538	18
240981	1165	1719	988	1265	1427	1404	1333	1341	18	310	2527	18
241002	1162	1719	985	1266	1426	1398	1326	1339	18	304	2523	18
241033	1157	1720	983	1267	1422	1386	1312	1331	18	294	2515	18
241065	1151	1717	981	1267	1417	1374	1299	1322	18	283	2504	18
241106	1145	1718

North SGs

NAME	N_{XT1}	N_{XB1}	N_{YT2}	N_{XB2}	N_{YT1}	N_{YB1}	N_{YT2}	N_{YB2}	N_{YT3}	N_{YB3}
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ROW #										
1	-1	3	-2	2	-3	0	2	-1	7	1
3790	-13	-7	-9	-9	-1	2	2	3	8	4
3806	-10	-4	-8	-7	0	2	3	3	6	4
3822	-10	-3	-9	-8	1	3	3	3	7	5
3961	-16	-15	-13	-12	2	7	2	5	6	6
4118	-12	0	-11	-7	3	7	1	5	5	10
27328	2	4	-10	-2	-1	2	-2	1	1	42
59268	3	-40	-7	0	-3	2	-5	-1	-6	41
65462	4	-49	-8	1	-2	2	-4	0	-11	40
65601	2	-44	-9	-1	-4	1	-5	-1	-9	41
65686	3	-46	-9	2	-1	3	-4	0	-8	41
65839	6	-106	-5	5	-1	6	-3	1	-8	43
66240	1	-144	-9	-1	-3	2	-5	-2	-8	40
68683	5	-68	-5	6	1	7	-3	2	-6	43
68967	3	-61	-7	3	-1	5	-4	0	-7	42
69104	1	-61	-8	1	-3	3	-4	0	-9	42
69200	-1	-59	-11	0	-3	3	-5	-1	-8	42
69489	1	-57	-7	4	0	7	-3	3	-10	44
69713	2	-64	-6	6	0	9	-1	4	-5	45
69825	1	-73	-8	3	1	8	-3	2	-5	45
69921	-1	-71	-8	2	0	10	-3	1	-3	46
70128	-1	-48	-9	2	3	12	0	3	-3	48
70320	1	-75	-5	6	7	18	3	7	2	50
70444	1	-64	-3	7	10	23	4	9	5	51
70669	0	-67	-6	4	11	22	5	8	5	52
70997	7	-60	-1	11	21	30	11	15	13	57
71243	12	-61	1	17	28	34	15	18	21	62
71373	17	-60	4	22	35	39	18	22	24	65
71557	25	-61	5	33	43	45	23	30	30	80
71860	43	-54	15	59	60	66	38	43	39	100
72184	58	-49	26	73	74	85	55	67	45	126
72500	75	-43	32	101	86	104	73	110	67	157
72910	88	-38	42	134	99	142	109	136	80	187
73144	100	-17	64	169	117	182	145	162	98	208
73445	124	-13	57	185	151	227	175	168	127	239
73769	151	0	64	216	175	279	202	185	150	272
74090	176	12	73	272	193	322	234	206	173	307
74506	197	32	81	301	213	351	254	227	194	339
74713	216	46	92	324	241	375	262	246	216	364
76558	232	67	105	344	292	407	275	271	248	400
76799	239	77	111	349	311	424	286	286	263	411
77056	252	123	121	354	332	445	301	294	282	426
77272	266	116	138	363	353	468	320	307	307	440
77775	281	102	163	377	374	501	354	329	330	456
77909	290	111	185	386	388	519	367	344	342	467
78492	308	133	246	403	413	529	397	368	362	490
78613	313	106	261	409	422	536	407	375	369	500
79516	321	152	305	415	432	547	420	386	376	513
80118	321	151	309	412	430	545	420	385	376	512
83849	318	166	310	405	426	539	418	382	376	512
99294	319	145	313	403	424	537	416	380	376	510
103450	324	137	317	410	429	542	420	384	378	514
103579	325	137	320	414	432	546	422	388	380	517
103664	328	141	322	418	436	552	427	391	384	522
103892	338	148	333	433	450	565	439	403	395	533
104001	341	146	338	439	456	572	445	408	402	539
104187	351	150	352	453	471	589	460	422	414	554
104377	359	163	371	460	482	603	472	432	425	565
104630	383	206	425	508	502	639	508	461	446	579
104830	387	203	405	490	517	640	504	464	469	598
105035	402	226	419	502	534	664	520	484	485	617
105400	417	253	432	515	549	678	537	505	504	641
105715	434	266	448	531	568	697	556	527	523	662
105946	449	285	465	550	586	717	575	546	541	680
106220	465	313	480	566	602	734	591	562	558	698
106538	478	359	494	582	620	756	612	580	585	717
106918	491	401	506	597	637	772	632	600	602	737
107216	520	463	557	651	657	806	673	637	620	753
107427	523	443	531	631	671	806	666	641	638	773
107736	535	469	542	644	688	826	686	658	664	790
107929	553	484	559	665	707	847	703	678	692	812
108193	560	492	564	674	718	861	716	691	707	827
108620	582	517	585	696	743	890	740	715	734	852
109784	604	546	601	715	765	916	761	740	765	877
109910	610	560	608	725	775	927	770	749	776	887
110098	622	574	617	739	789	944	785	764	793	904
110425	640	595	637	761	808	969	806	786	817	925
110725	656	611	652	780	826	992	824	804	838	943
111677	662	613	650	779	828	998	828	807	844	950
113390	664	602	649	779	825	995	828	808	846	947
114004	670	602	658	787	832	1003	833	814	854	952
114107	675	606	662	796	840	1012	842	823	861	960
114287	682	614	670	808	850	1025	853	834	871	973
114460	692	627	679	819	862	1040	866	846	884	986
114560	701	638	688	830	873	1053	877	857	898	999
114740	715	631	701	845	889	1073	894	874	918	1016
115034	736	672	724	871	910	1103	918	898	940	1037
115365	745	666	727	877	921	1114	931	912	957	1052
116420	757	677	736	888	930	1127	943	926	971	1060
117644	755	686	730	883	925	1121	939	922	968	1054
117764	756	693	731	885	927	1124	942	924	971	1057
117864	765	700	742	898	938	1137	950	933	979	1066
118042	770	710	745	907	947	1147	961	944	968	1077
118364	785	725	761	923	963	1169	979	962	1007	1094
118542	797	733	774	938	977	1187	992	976	1023	1107
118822	815	744	789	957	996	1211	1013	997	999	1127
119023	825	751	796	967	1008	1227	1026	1012	1035	1141
119308	844	786	814	987	1025	1251	1047	1035	1062	1158
119769	864	798	829	1004	1042	1278	1069	1058	1083	1175
120100	891	847	874	1052	1064	1319	1110	1095	1107	1192
120508	900	838	860	1039	1074	1326	1112	1107	1135	1210
120956	930	854	883	1063	1097	1359	1137	1135	1158	1228
121410	936	872	885	1062	1096	1363	1142	1143	1162	1226
121496	933	857	880	1056	1091	1356	1138	1139	1158	1221
121598	932	864	876	1051	1088	1351	1134	1134	1151	1216
121629	929	860	872	1047	1083	1346	1130	1130	1146	1210
121874	923	844	867	1039	1076	1335	1122	1122	1138	1202
121961	921	833	861	1034	1071	1329	1118	1118	1127	1198
123298	916	752	855	1027	1062	1318	1109	1109	1125	1184
124120	909	743	847	1017	1052	1308	1102	1102	1111	1177
147223	907	847	840	1010	1037	1296	1090	1091	1081	1155
147346	905	699	843	1033	1041	1301	1095	1094	1090	1160
147457	912	705	851	1045	1051	1313	1104	1103	1100	1167
147551	922	711	863	1058	1061	1326	1113	1114	1107	1177
147733	927	714	867	1065	1069	1336	1123	1124	1114	1188
147897	942	731	883	1083	1084	1357	1140	1141	1136	1203
148115	947	740	888	1091	1092	1367	1148	1149	1145	1212
148225	961	752	902	1107	1107	1384	1161	1162	1164	1223
148533	977	768	916	1122	1122	1406	1180	1180	1181	1238
148780	994	799	933	1138	1139	1429	1198	1204	1200	1252
149126	1010	789	943	1149	1150	1448	1210	1222	1214	1260
149435	1027	798	959	1164	1165	1470	1228	1242	1236	1270
149985	1059	805	982	1186	1187	1502	1252	1262	1257	1274
150102	1066	816	988	1192	1192	1516	1260	1268	1262	1275
150119	1068	817	993	1194	1194	1519	1261	1268	1265	1277
150236	1074	820	998	1198	1197	1524	1265	1268	1270	1274
150354	1076	819	1000	1198	1198	1525	1266	1266	1271	1271
150364	1068	819	1000	1198	1198	1527	1266	1265	1272	1271
150378	1077	822	1001	1200	1199	1530	1268	1268	1274	1272
150431	1079	820	1005	1202	1201	1532	1270	1270	1275	1273
150470	1081	820	1004	1201	1200	1531	1270	1267	1274	1271
150497	1082	817	1005	1201	1201	1532	1270	1268	1274	1271
150510	1082	824	1006	1203	1203	1535	1272	1269	1277	1272
150533	1084	824	1008	1204	1203	1537	1273	1271	1279	1274
150594	1088	826	1012	1208	1208	1542	1277	1274	1283	1275
150609	1090	830	1014	1210	1209	1545	1279	1277	1285	1277
150658	1093	831	1016	1213	1211	1548	1282	1277	1289	1277
150679	1093	826	1016	1211	1210	1548	1282	1276	1288	1275
150700	1093	825	1016	1211	1210	1546	1282	1276	1285	1275
150728	1092	822	1015	1209	1208	1546	1280	1276	1283	1273
150804	1092	849	1013	1207	1207	1544	1280	1272	1285	1270
150918	1095	862	1018	1211	1208	1549	1282	1272	1285	1268
150928	1096	865	1019	1211	1210	1550	1282	1274	1287	1269
150941	1097	858	1021	1213	1211	1552	1283	1274	1289	1269
151019	1102	865	1026	1218	1215	1558	1288	1278	1287	1272
151041	1103	866	1029	1218	1215	1558	1287	1278	1290	1270
151046	1104	870	1028	1218	1214	1557	1287	1277	1289	1270
151050	1103	870	1026	1217	1214	1556	1287	1276	1288	1269
151054	1103	869	1026	1216	1213	1555	1286	1275	1286	1268
151058	1101	867	1026	1214	1212	1554	1284	1274	1285	1267

NAME	N_{XT1}	N_{XB1}	N_{XT2}	N_{XB2}	N_{YT1}	N_{YB1}	N_{YT2}	N_{YB2}	N_{YT3}	N_{YB3}
UNIT	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]
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151068	1101	870	1026	1213	1210	1552	1283	1272	1285	1265
151074	1100	865	1024	1212	1209	1550	1283	1272	1285	1264
151170	1097	855	1021	1209	1206	1547	1281	1268	1282	1261
151179	1097	858	1021	1208	1205	1546	1280	1267	1281	1260
151183	1097	861	1020	1207	1205	1544	1279	1265	1280	1259
151191	1095	856	1019	1204	1203	1542	1277	1263	1279	1257
151200	1095	852	1017	1203	1202	1540	1275	1261	1278	1255
151212	1093	855	1016	1202	1200	1539	1275	1261	1277	1254
151361	1090	855	1012	1198	1196	1535	1272	1257	1274	1250
151370	1088	850	1011	1197	1196	1534	1272	1257	1272	1250
151374	1089	849	1009	1196	1195	1533	1271	1256	1269	1249
151379	1087	848	1008	1194	1194	1532	1270	1254	1268	1248
151384	1087	847	1008	1192	1193	1530	1269	1253	1267	1246
151390	1086	844	1007	1192	1192	1528	1267	1252	1267	1245
151705	1089	847	1012	1196	1192	1531	1269	1252	1270	1243
151712	1089	849	1014	1196	1194	1533	1268	1252	1272	1243
151719	1091	851	1014	1197	1194	1533	1269	1252	1273	1243
151727	1091	850	1015	1197	1194	1533	1270	1253	1272	1244
151735	1091	849	1014	1197	1195	1533	1270	1252	1274	1244
151746	1092	853	1015	1199	1196	1534	1272	1254	1275	1245
151761	1092	853	1016	1199	1196	1535	1272	1255	1276	1246
151848	1089	852	1013	1195	1194	1533	1271	1253	1275	1244
151886	1090	854	1013	1195	1193	1532	1270	1252	1277	1244
151908	1088	849	1014	1196	1194	1533	1271	1253	1278	1243
151942	1091	859	1014	1198	1195	1535	1272	1254	1278	1245
151947	1092	859	1014	1198	1195	1535	1271	1255	1277	1245
151953	1092	855	1015	1199	1196	1536	1272	1255	1277	1244
151969	1093	857	1015	1200	1196	1538	1273	1255	1278	1244
152017	1095	858	1017	1201	1198	1538	1273	1255	1279	1245
152048	1099	875	1035	1218	1198	1546	1284	1262	1279	1243
152104	1096	860	1019	1203	1197	1539	1273	1255	1277	1245
152163	1096	856	1021	1203	1197	1539	1273	1256	1278	1244
152170	1097	858	1021	1203	1197	1539	1273	1256	1279	1243
152176	1098	863	1023	1204	1199	1541	1275	1257	1281	1245
152183	1098	861	1022	1204	1199	1541	1274	1257	1281	1245
152192	1098	863	1023	1205	1200	1543	1276	1258	1280	1247
152204	1098	863	1025	1207	1201	1545	1277	1260	1278	1247
152266	1097	857	1024	1204	1200	1543	1276	1259	1281	1247
152291	1096	856	1023	1204	1199	1543	1276	1258	1282	1247
152329	1095	862	1023	1204	1198	1543	1276	1258	1282	1247
152330	1096	860	1022	1204	1199	1544	1277	1259	1283	1247
152344	1097	861	1022	1204	1199	1544	1277	1260	1283	1247
152354	1097	863	1024	1206	1200	1546	1278	1261	1285	1249
152420	1101	864	1026	1211	1203	1550	1282	1264	1288	1251
152453	1102	863	1028	1211	1204	1552	1283	1265	1288	1251
152462	1104	863	1029	1213	1206	1553	1284	1266	1290	1252
152473	1105	865	1027	1212	1207	1553	1283	1265	1292	1254
152489	1114	889	1061	1244	1211	1571	1303	1278	1293	1252
152533	1111	866	1031	1227	1212	1561	1289	1271	1295	1256
152569	1112	869	1040	1222	1213	1563	1290	1272	1295	1257
152581	1113	868	1039	1222	1214	1564	1291	1272	1294	1257
152658	1114	871	1041	1223	1215	1567	1295	1275	1300	1260
152672	1114	875	1042	1225	1216	1569	1295	1277	1302	1260
152748	1119	883	1046	1230	1220	1575	1301	1282	1303	1264
152766	1120	884	1048	1232	1222	1578	1303	1283	1305	1266
152841	1128	887	1055	1239	1227	1584	1307	1286	1311	1268
152863	1127	893	1055	1238	1226	1584	1306	1286	1308	1266
152888	1128	890	1057	1238	1226	1584	1306	1286	1310	1266
152897	1127	892	1056	1238	1227	1585	1307	1286	1311	1267
152909	1127	888	1058	1239	1228	1586	1309	1288	1313	1268
152927	1129	891	1059	1241	1229	1588	1310	1289	1315	1270
152979	1131	895	1060	1241	1230	1590	1312	1289	1317	1271
153026	1130	893	1060	1241	1229	1591	1313	1289	1317	1270
153052	1132	892	1064	1244	1232	1594	1315	1291	1320	1272
153083	1133	894	1064	1245	1233	1595	1316	1292	1321	1273
153105	1134	913	1067	1247	1234	1597	1317	1293	1320	1272
153141	1141	912	1090	1268	1236	1607	1330	1300	1320	1270
153160	1140	901	1078	1257	1237	1604	1323	1297	1323	1273
153255	1141	902	1080	1259	1238	1606	1324	1299	1327	1276
153378	1143	912	1087	1257	1242	1610	1327	1300	1331	1275
153401	1144	912	1090	1258	1243	1612	1329	1301	1328	1277
153443	1143	901	1092	1259	1244	1613	1331	1302	1331	1277
153473	1143	904	1092	1259	1244	1613	1331	1301	1333	1276
153502	1144	904	1094	1261	1244	1613	1331	1302	1334	1275
153535	1145	907	1097	1261	1245	1614	1332	1302	1334	1275
153559	1146	904	1099	1264	1246	1617	1334	1303	1334	1276
153611	1148	906	1104	1266	1248	1619	1335	1305	1337	1276
153650	1149	906	1104	1266	1248	1619	1335	1305	1336	1276
153669	1148	902	1110	1265	1248	1618	1334	1302	1334	1273
153703	1146	906	1109	1264	1246	1617	1334	1302	1334	1272
153742	1146	905	1110	1263	1245	1616	1334	1301	1334	1271
153751	1146	903	1110	1263	1246	1615	1333	1301	1336	1271
153764	1146	902	1112	1264	1246	1617	1334	1301	1337	1272
153832	1144	908	1114	1263	1245	1616	1335	1302	1336	1271
153867	1145	911	1116	1263	1245	1616	1335	1301	1336	1271
153905	1147	913	1120	1265	1247	1618	1337	1303	1338	1272
153917	1144	910	1119	1264	1245	1618	1335	1302	1327	1271
153938	1147	913	1123	1268	1248	1622	1339	1305	1332	1272
154008	1151	915	1133	1272	1251	1624	1341	1305	1339	1272
154038	1148	914	1128	1270	1250	1623	1340	1305	1338	1272
154298	1140	924	1167	1275	1249	1619	1344	1305	1344	1269
154321	1137	922	1171	1274	1248	1618	1344	1306	1341	1268
154342	1134	928	1173	1273	1246	1614	1342	1303	1343	1267
154368	1134	925	1174	1273	1244	1612	1340	1301	1341	1265
154398	1128	923	1174	1269	1241	1609	1339	1299	1340	1262
154433	1123	919	1173	1266	1238	1604	1337	1295	1338	1261
154450	1122	920	1175	1266	1238	1604	1338	1297	1337	1260
154456	1122	920	1174	1265	1237	1603	1337	1296	1336	1259
154462	1121	920	1174	1263	1236	1602	1335	1294	1336	1258
154468	1121	920	1173	1263	1235	1600	1334	1293	1335	1257
154474	1118	916	1170	1262	1234	1599	1334	1292	1332	1255
154485	1117	913	1170	1260	1232	1597	1332	1291	1329	1254
154585	1116	916	1178	1264	1229	1595	1332	1288	1323	1248
154663	1111	907	1172	1257	1224	1587	1324	1282	1321	1243
154785	1103	901	1167	1249	1216	1578	1318	1275	1315	1235
154881	1102	893	1159	1247	1208	1568	1313	1267	1308	1229
154983	1091	890	1153	1235	1202	1561	1306	1262	1302	1223
154992	1089	886	1151	1232	1200	1559	1303	1260	1300	1221
154997	1087	883	1150	1230	1199	1557	1303	1258	1298	1219
155003	1088	884	1149	1230	1198	1556	1302	1258	1298	1219
155011	1087	885	1150	1229	1197	1555	1301	1257	1297	1219
155127	1091	901	1168	1248	1197	1561	1312	1262	1290	1212
165553	1025	778	1138	1222	1157	1524	1273	1229	1248	1175
171859	1014	807	1123	1216	1144	1512	1264	1219	1240	1163
171898	1012	807	1123	1216	1144	1512	1264	1219	1239	1163
174034	1017	765	1127	1223	1146	1515	1266	1221	1244	1162
176124	1010	783	1120	1214	1140	1509	1262	1215	1238	1158
176133	1010	770	1120	1217	1141	1510	1262	1217	1239	1158
180778	1009	804	1119	1221	1139	1508	1260	1215	1238	1155
183169	1008	763	1121	1223	1137	1508	1260	1214	1241	1152
183498	1010	815	1121	1224	1138	1510	1261	1215	1238	1153
183503	1010	819	1121	1226	1139	1510	1261	1216	1240	1154
183509	1010	819	1122	1226	1139	1511	1262	1216	1239	1154
183515	1011	820	1123	1227	1140	1512	1262	1217	1241	1156
183523	1012	820	1125	1229	1142	1513	1264	1218	1241	1156
183534	1013	823	1126	1229	1143	1515	1265	1219	1242	1158
183554	1014	823	1129	1232	1144	1517	1265	1220	1243	1159
183583	1015	826	1129	1232	1145	1517	1267	1221	1246	1159
183598	1016	825	1131	1233	1146	1518	1267	1222	1246	1160
183625	1016	827	1131	1233	1146	1518	1267	1221	1250	1160
183695	1017	831	1132	1234	1147	1520	1268	1222	1251	1161
183710	1015	816	1131	1233	1147	1520	1269	1223	1247	1162
183729	1016	820	1132	1234	1147	1521	1269	1224	1246	1162
183829	1015	815	1131	1236	1148	1522	1271	1226	1251	1164
183840	1017	832	1133	1237	1149	1524	1272	1227	1250	1166
183847	1018	823	1134	1239	1152	1525	1274	1229	1253	1167
183854	1019	821	1134	1240	1153	1526	1274	1229	1254	1167
183864	1020	822	1136	1242	1154	1528	1276	1231	1255	1169
183878	1021	827	1137	1243	1155	1529	1276	1232	1257	1171
183944	1027	824	1146	1252	1162	1537	1283	1238	1261	1174
183962	1028	829	1147	1254	1163	1539	1285	1239	1264	1177
184048	1032	833	1154	1259	1167	1544	1288	1243

South SGs

NAME	S_{XT1}	S_{XB1}	S_{XT2}	S_{XB2}	S_{YT1}	S_{YB1}	S_{YT2}	S_{YB2}	S_{YT3}	S_{YB3}
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3790	7	10	4	12	-5	-23	-5	-4	-10	-6
3806	8	14	6	16	-2	-23	-3	-3	-9	-5
3822	8	15	6	18	-2	-21	-3	-3	-10	-6
3961	21	20	16	27	-5	-31	-9	-8	-13	-10
4118	16	16	10	21	-4	-23	-7	-6	-12	-8
27328	6	8	-1	8	0	-10	-4	-2	-34	-4
59268	1	5	-5	6	3	-118	-11	-3	-36	-3
65462	1	3	-5	7	3	-136	-6	-21	-94	-4
65601	-1	4	-6	7	2	-117	-6	-21	-114	-5
65686	-1	4	-6	7	3	-118	-6	-21	-96	-4
65839	1	6	-3	9	4	-135	-6	-17	-88	-3
66240	1	5	-3	9	4	-126	-7	-17	-85	-3
68683	4	8	-1	11	5	-115	-5	-11	-143	-3
68967	1	8	0	11	4	-128	-7	-12	-103	-3
69104	4	10	0	11	6	-149	-5	-12	-90	-3
69200	6	13	0	12	6	-142	-4	-10	-96	-2
69489	13	22	7	17	10	-137	-1	-6	-108	3
69713	18	26	9	19	11	-123	2	-3	-112	5
69825	20	28	13	21	10	-128	3	-3	-106	6
69921	23	32	18	23	13	-116	6	-1	-101	9
70128	30	42	28	29	23	-102	14	5	-114	22
70320	35	47	36	33	26	-116	23	9	-89	27
70444	38	57	43	38	30	-118	32	15	-87	35
70669	45	72	56	39	33	-110	42	20	-76	41
70997	54	83	68	40	40	-94	54	27	-62	48
71243	62	92	79	39	44	-105	65	32	-61	56
71373	67	91	91	39	46	-94	73	35	-50	61
71557	90	88	112	37	50	-81	90	48	-33	72
71860	130	114	135	42	59	-58	124	64	-32	91
72184	169	137	164	83	69	-25	160	88	-30	154
72500	197	159	187	135	79	-2	188	118	2	223
72910	227	180	205	181	94	75	207	159	8	269
73144	261	195	221	234	130	144	213	183	16	291
73445	301	215	240	232	164	209	224	201	55	313
73769	325	231	256	254	191	239	238	217	57	332
74090	348	248	273	277	217	280	258	237	86	350
74506	366	264	286	299	236	294	278	253	116	370
74713	381	278	302	316	252	333	294	288	168	388
76558	400	295	320	346	287	361	323	328	189	414
76799	409	306	331	358	303	355	338	342	186	429
77056	422	317	345	372	322	386	354	359	232	445
77272	438	328	362	386	349	386	373	374	211	459
77775	457	341	377	401	384	408	400	396	302	474
77909	468	350	388	412	399	428	414	407	316	484
78492	487	366	405	433	432	425	447	431	351	502
78613	497	374	414	442	444	467	460	445	376	512
79516	503	381	416	452	462	470	474	458	415	515
80118	497	377	412	450	462	481	475	456	424	512
83849	493	375	406	448	465	462	477	455	379	507
99294	488	372	402	446	467	346	476	459	359	504
103450	491	375	406	449	469	365	479	462	327	507
103579	495	380	412	452	473	333	482	466	333	511
103664	500	385	418	457	477	397	489	472	340	518
103892	510	394	429	466	487	408	500	482	356	529
104001	518	401	438	472	493	440	508	489	447	538
104187	531	412	449	484	507	435	523	503	445	550
104377	545	422	460	496	521	506	535	515	475	560
104630	559	435	471	504	533	513	556	534	472	577
104830	576	449	486	522	556	504	573	549	482	590
105035	588	462	495	534	575	524	591	565	511	603
105400	601	479	505	559	597	507	610	584	530	604
105715	615	494	517	575	620	526	630	603	551	617
105946	629	511	527	588	639	544	646	619	584	631
106220	641	525	538	600	657	530	664	634	603	643
106538	655	540	550	612	677	581	682	650	622	659
106918	670	559	560	625	700	580	702	667	632	674
107216	683	574	570	632	714	623	720	684	647	689
107427	698	589	582	649	737	648	735	697	648	703
107736	712	607	590	665	760	667	755	716	668	722
107929	728	623	604	678	779	656	773	733	687	739
108193	739	636	612	690	795	684	787	746	695	751
108620	762	657	629	708	822	663	810	767	719	772
109784	799	685	646	726	851	662	832	789	754	794
109910	810	691	655	735	860	720	842	798	765	803
110098	828	705	667	748	875	713	856	813	778	818
110425	849	724	681	763	898	706	876	831	799	837
110725	866	740	692	778	919	714	895	849	803	854
111677	872	747	694	780	930	802	902	854	772	860
113390	872	747	692	778	931	766	901	854	782	859
114004	875	752	699	783	936	695	906	856	803	862
114107	882	758	706	790	942	739	914	863	821	869
114287	894	769	715	800	955	750	927	876	824	881
114460	906	781	724	812	970	722	940	889	838	894
114560	919	792	735	822	981	738	952	901	844	905
114740	935	806	746	836	1000	729	969	918	851	920
115034	956	824	761	851	1022	767	989	936	864	941
115365	973	838	772	863	1040	826	1003	953	870	954
116420	985	848	777	870	1054	834	1014	964	875	965
117644	981	846	772	866	1052	830	1011	960	872	962
117764	985	850	775	869	1055	853	1015	963	874	965
117864	992	857	783	876	1062	833	1023	972	880	972
118042	1002	867	791	887	1075	871	1035	983	901	981
118364	1017	881	802	900	1093	899	1054	1000	906	998
118542	1029	892	812	910	1106	892	1068	1012	925	1010
118822	1051	910	827	926	1129	901	1089	1032	946	1029
119023	1067	924	836	938	1146	940	1105	1048	945	1041
119308	1084	942	851	954	1169	935	1126	1068	956	1062
119769	1106	963	867	972	1197	938	1148	1089	974	1083
120100	1124	983	880	984	1219	958	1170	1113	1000	1103
120508	1143	1004	895	1004	1249	992	1192	1134	985	1125
120956	1164	1028	914	1022	1278	1001	1218	1158	1010	1153
121410	1167	1036	916	1024	1291	1050	1225	1164	1024	1167
121496	1163	1032	912	1020	1287	1055	1222	1161	1016	1164
121598	1159	1029	906	1015	1283	1043	1217	1158	1010	1161
121629	1153	1024	903	1009	1277	994	1213	1152	1002	1157
121874	1147	1020	898	1003	1272	990	1207	1147	997	1153
121961	1142	1016	894	998	1266	982	1202	1143	961	1149
123298	1133	1010	887	989	1258	961	1194	1133	952	1143
124120	1122	1004	880	981	1253	952	1190	1127	973	1139
147223	1113	1007	880	976	1244	808	1178	918	1129	1133
147346	1118	1008	884	981	1249	818	1183	754	33129	1136
147457	1125	1015	891	989	1256	844	1191	822	33129	1141
147551	1133	1023	901	997	1265	864	1200	906	33129	1151
147733	1142	1032	908	1006	1278	856	1210	940	33129	1160
147987	1155	1044	920	1019	1293	876	1226	986	33129	1174
148115	1165	1054	927	1027	1303	900	1236	983	33129	1183
148225	1177	1064	938	1037	1315	953	1247	791	33129	1195
148533	1193	1080	952	1051	1336	890	1267	900	33129	1211
148780	1209	1096	964	1066	1355	898	1285	33322	33129	1238
149126	1221	1109	975	1078	1373	949	1299	1124	33129	1261
149435	1237	1124	988	1093	1393	938	1318	1216	33129	1288
149985	1261	1149	1004	1115	1425	997	1346	995	33129	1332
150102	1265	1155	1006	1120	1433	1019	1354	1032	33129	1342
150119	1267	1156	1009	1122	1434	1010	1355	33322	33129	1344
150236	1271	1160	1013	1125	1439	1014	1360	33322	33129	1353
150354	1276	1162	1015	1126	1441	1032	1362	33322	33129	1359
150366	1276	1163	1015	1127	1442	1028	1362	33322	33129	1359
150378	1279	1164	1016	1129	1443	1049	1364	33322	33129	1361
150431	1282	1167	1019	1131	1447	1039	1366	1258	33129	1367
150470	1281	1167	1017	1129	1446	1041	1366	1264	33129	1366
150497	1283	1168	1018	1131	1447	1036	1366	1262	33129	1368
150510	1284	1170	1020	1133	1449	1031	1367	33322	33129	1370
150533	1287	1172	1022	1135	1451	1028	1369	33322	33129	1373
150594	1291	1176	1024	1138	1456	1036	1374	33322	33129	1378
150609	1292	1177	1026	1139	1458	1041	1375	33322	33129	1380
150658	1295	1180	1026	1142	1462	1040	1380	33322	33129	1385
150679	1295	1180	1026	1141	1462	1020	1380	33322	33129	1386
150700	1295	1179	1026	1141	1461	1036	1378	777	33129	1386
150728	1294	1179	1024	1140	1461	1053	1378	766	33129	1387
150804	1295	1179	1022	1139	1461	1041	1378	979	33129	1388
150918	1298	1181	1022	1140	1462	1009	1380	889	33129	1392
150928	1298	1181	1024	1141	1464	1037	1380	889	33129	1392
150941	1299	1182	1024	1142	1464	1026	1382	888	33129	1393
151019	1304	1187	1027	1145	1469	1027	1387	816	33129	1400
151041	1304	1187	1027	1145	1469	1033	1387	33322	33129	1400
151046	1302	1186	1026	1144	1468	1028	1387	33322	33129	1400
151050	1303	1185	1026	1144	1468	1023	1386	33322	33129	1399
151054	1302	1184	1025	1142	1467	1008	1386	33322	33129	1399
151058	1301	1183	1023	1141	1466	1020	1385	33322	33129	1398

NAME	S_{XT1}	S_{XB1}	S_{XT2}	S_{XB2}	S_{YT1}	S_{YB1}	S_{YT2}	S_{YB2}	S_{YT3}	S_{YB3}
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151074	1299	1182	1022	1138	1464	1027	1382	33322	33129	1397
151170	1296	1180	1019	1136	1462	991	1381	33322	33129	1396
151179	1296	1179	1019	1135	1462	1005	1380	33322	33129	1396
151183	1295	1179	1018	1135	1462	1002	1380	33322	33129	1396
151191	1293	1178	1015	1133	1459	1006	1379	33322	33129	1394
151200	1291	1176	1015	1131	1458	1008	1377	33322	33129	1392
151212	1289	1175	1014	1131	1457	1000	1377	33322	33129	1391
151361	1288	1174	1010	1129	1455	1010	1375	33322	33129	1390
151370	1288	1174	1010	1128	1455	975	1375	33322	33129	1391
151374	1288	1174	1008	1127	1455	997	1374	33322	33129	1389
151379	1286	1173	1008	1126	1454	1016	1373	33322	33129	1389
151384	1285	1171	1006	1125	1452	1012	1373	33322	33129	1388
151390	1284	1170	1006	1123	1452	1025	1371	33322	33129	1386
151705	1282	1171	1006	1123	1451	1029	1371	33322	33129	1389
151712	1283	1171	1007	1123	1452	1026	1371	33322	33129	1388
151719	1284	1172	1007	1124	1453	1017	1372	33322	33129	1389
151727	1285	1173	1009	1126	1453	1032	1373	33322	33129	1389
151735	1283	1172	1009	1126	1453	996	1373	33322	33129	1389
151746	1285	1173	1008	1126	1454	1016	1373	33322	33129	1390
151761	1287	1175	1010	1128	1455	1025	1375	33322	33129	1390
151848	1286	1173	1008	1127	1455	992	1374	33322	33129	1390
151886	1287	1175	1008	1127	1455	994	1373	33322	33129	1390
151912	1286	1175	1008	1124	1456	1007	1374	33322	33129	1391
151942	1288	1175	1008	1128	1456	1009	1375	33322	33129	1392
151947	1288	1177	1009	1128	1457	1019	1375	33322	33129	1391
151953	1287	1175	1009	1128	1456	997	1376	33322	33129	1391
151960	1287	1176	1010	1130	1457	995	1376	33322	33129	1392
152017	1288	1177	1010	1130	1457	1012	1377	33322	33129	1392
152048	1287	1176	1009	1128	1456	998	1377	33322	33129	1393
152104	1288	1177	1010	1129	1457	1012	1377	33322	33129	1394
152163	1289	1178	1012	1130	1457	1027	1376	33322	33129	1395
152170	1289	1178	1012	1130	1457	1030	1377	33322	33129	1395
152176	1290	1178	1012	1131	1458	1006	1377	33322	33129	1395
152183	1291	1178	1013	1132	1459	1024	1379	33322	33129	1396
152192	1292	1181	1014	1134	1461	1023	1380	33322	33129	1397
152254	1293	1181	1015	1133	1462	1023	1381	33322	33129	1398
152266	1293	1181	1015	1133	1463	1023	1381	33322	33129	1399
152291	1293	1181	1014	1134	1462	1016	1381	33322	33129	1399
152329	1293	1181	1014	1134	1463	1025	1381	33322	33129	1400
152336	1295	1182	1014	1135	1464	1002	1382	33322	33129	1400
152344	1295	1183	1015	1136	1464	1034	1382	33322	33129	1401
152354	1296	1184	1016	1137	1466	1024	1383	33322	33129	1402
152420	1300	1187	1018	1140	1469	1024	1386	33322	33129	1405
152453	1300	1187	1018	1140	1469	1032	1387	33322	33129	1406
152462	1301	1188	1019	1141	1470	1007	1388	33322	33129	1406
152473	1301	1189	1020	1142	1471	1040	1389	33322	33129	1408
152489	1301	1190	1020	1140	1471	1021	1391	33322	33129	1410
152533	1305	1193	1024	1145	1476	1007	1394	33322	33129	1413
152569	1306	1194	1026	1146	1477	1035	1395	33322	33129	1414
152581	1307	1193	1026	1146	1477	1020	1396	33322	33129	1415
152658	1311	1198	1028	1151	1483	1010	1400	33322	33129	1420
152672	1311	1200	1029	1152	1484	1045	1401	33322	33129	1421
152748	1317	1204	1031	1156	1490	1024	1407	33322	33129	1428
152766	1319	1207	1032	1158	1493	1012	1409	33322	33129	1429
152841	1325	1209	1035	1160	1496	1020	1414	33322	33129	1435
152863	1322	1208	1034	1159	1496	1018	1413	33322	33129	1435
152888	1324	1210	1035	1159	1497	1038	1414	33322	33129	1436
152897	1324	1210	1036	1160	1498	1017	1415	33322	33129	1437
152909	1327	1212	1037	1163	1500	1015	1416	33322	33129	1439
152927	1328	1214	1038	1164	1502	1021	1419	33322	33129	1440
152979	1332	1216	1039	1165	1506	1027	1420	33322	33129	1444
153026	1334	1217	1039	1167	1507	1060	1422	33322	33129	1446
153052	1335	1219	1040	1168	1509	1048	1424	33322	33129	1448
153070	1337	1220	1041	1169	1510	1045	1425	33322	33129	1450
153105	1338	1220	1039	1169	1511	1060	1427	33322	33129	1451
153141	1340	1221	1039	1167	1510	1026	1427	33322	33129	1452
153160	1341	1223	1040	1171	1513	1041	1430	33322	33129	1455
153218	1342	1224	1041	1171	1514	1053	1431	33322	33129	1460
153378	1357	1232	1043	1178	1527	1046	1442	33322	33129	1468
153401	1361	1234	1044	1180	1531	1041	1445	33322	33129	1471
153443	1364	1236	1042	1180	1533	1037	1446	33322	33129	1472
153473	1366	1237	1041	1180	1534	1034	1447	33322	33129	1473
153542	1367	1238	1041	1180	1534	1032	1448	33322	33129	1475
153535	1370	1238	1041	1180	1535	1037	1449	33322	33129	1476
153559	1372	1238	1040	1181	1536	1029	1450	33322	33129	1476
153611	1376	1241	1040	1182	1539	1044	1454	33322	33129	1479
153664	1376	1241	1040	1182	1539	1045	1454	33322	33129	1479
153669	1377	1240	1038	1180	1539	1038	1453	33322	33129	1480
153703	1378	1240	1037	1180	1539	1028	1453	33322	33129	1481
153742	1380	1240	1036	1180	1540	1045	1454	33322	33129	1481
153751	1380	1240	1038	1179	1542	1028	1455	33322	33129	1482
153764	1382	1241	1037	1180	1541	1052	1455	33322	33129	1481
153832	1387	1243	1035	1181	1544	1044	1458	33322	33129	1484
153867	1388	1244	1034	1181	1546	1045	1459	33322	33129	1485
153905	1387	1243	1033	1181	1545	1034	1459	33322	33129	1485
153917	1390	1244	1034	1181	1546	1022	1460	33322	33129	1486
153938	1394	1247	1035	1183	1549	1022	1463	33322	33129	1489
154008	1402	1249	1033	1184	1553	1044	1467	33322	33129	1491
154038	1403	1249	1033	1184	1554	1048	1468	33322	33129	1491
154298	1438	1255	1024	1180	1563	1008	1480	33322	33129	1498
154321	1442	1256	1022	1179	1563	1030	1480	33322	33129	1498
154342	1443	1256	1022	1178	1562	1021	1481	33322	33129	1498
154363	1445	1255	1020	1176	1562	1027	1480	33322	33129	1497
154398	1446	1255	1018	1174	1561	1009	1479	33322	33129	1496
154433	1449	1253	1016	1172	1559	1028	1479	33322	33129	1494
154450	1450	1254	1015	1172	1559	1013	1480	33322	33129	1495
154456	1449	1253	1014	1172	1559	1018	1479	33322	33129	1494
154462	1450	1253	1014	1170	1558	1025	1478	33322	33129	1494
154468	1449	1252	1013	1168	1557	989	1478	33322	33129	1492
154478	1448	1252	1012	1167	1556	1001	1476	33322	33129	1491
154485	1447	1251	1009	1165	1554	1009	1475	33322	33129	1489
154585	1447	1247	1008	1160	1550	1024	1473	33322	33129	1487
154653	1446	1244	1005	1155	1546	998	1469	33322	33129	1482
154785	1442	1240	1000	1149	1540	979	1463	33322	33129	1477
154881	1441	1237	997	1145	1536	1017	1460	33322	33129	1472
154983	1431	1232	987	1137	1530	996	1455	33322	33129	1467
154992	1428	1229	986	1133	1527	999	1454	33322	33129	1465
154997	1427	1228	985	1133	1526	964	1453	33322	33129	1464
155003	1427	1228	984	1132	1526	953	1453	33322	33129	1464
155011	1426	1227	984	1132	1526	991	1451	33322	33129	1463
155127	1421	1224	979	1125	1519	990	1449	33322	33129	1460
165553	1416	1217	966	1109	1503	976	1434	33322	33129	1439
171859	1413	1214	957	1098	1496	1025	1426	33322	33129	1432
171898	1413	1214	958	1102	1496	1026	1427	33322	33129	1432
174034	1413	1215	959	1101	1495	987	1423	33322	33129	1432
176124	1412	1213	957	1100	1494	965	1419	33322	33129	1431
176133	1411	1213	958	1101	1494	965	1420	33322	33129	1431
180778	1416	1214	957	1099	1492	969	1420	33322	33129	1430
183169	1414	1213	957	1097	1490	977	1416	33322	33129	1428
183498	1414	1214	957	1098	1490	969	1418	33322	33129	1428
183503	1415	1214	957	1098	1491	916	1418	33322	33129	1428
183609	1415	1215	958	1099	1492	1014	1419	33322	33129	1429
183515	1416	1216	959	1100	1493	959	1420	33322	33129	1430
183523	1419	1216	959	1100	1493	967	1420	33322	33129	1430
183534	1419	1217	961	1102	1495	971	1422	33322	33129	1432
183541	1419	1218	961	1102	1495	961	1422	33322	33129	1433
183583	1419	1219	962	1104	1496	959	1424	33322	33129	1434
183598	1420	1219	963	1104	1497	965	1424	33322	33129	1433
183625	1422	1219	964	1105	1497	983	1425	33322	33129	1434
183668	1422	1220	964	1105	1498	983	1425	33322	33129	1435
183710	1425	1221	965	1107	1500	975	1426	33322	33129	1435
183729	1424	1221	965	1108	1500	1000	1427	33322	33129	1436
183829	1427	1224	964	1109	1503	1018	1430	33322	33129	1437
183840	1427	1224	965	1109	1503	1008	1430	33322	33129	1439
183847	1431	1226	966	1111	1506	1009	1432	33322	33129	1441
183854	1430	1226	967	1112	1507	994	1432	33322	33129	1440
183864	1433	1228	968	1113	1508	1011	1434	33322	33129	1442
183878	1433	1229	970	1116	1510	1004	1435	33322	33129	1444
183944	1439	1233	972	1117	1514	1033	1440	33322	33129	1447
183962	1440

B.2 Specimen ES2

Actuators

NAME	N_{fact}	N_{ftop}	N_{fcact}	N_{fwive}	S_{fact}	S_{ftop}	S_{fcact}	S_{fwive}	T_{wig}
UNIT	[kN]	[kN]	[kN]	[kN]	[kN]	[kN]	[kN]	[kN]	[kN*m/m]
ROW #									
3	-13.7	-20.7	-11.2	-8.4	-11.4	-10.1	-9.1	-10.9	2.4
4227	-7.9	-26.0	-14.4	3.9	-1.9	33.9	-0.1	-13.6	2.6
4233	-8.0	-20.7	-3.7	14.9	10.8	50.5	-6.8	-22.7	3.5
4238	-36.2	-34.3	-0.9	31.7	26.1	53.7	-8.2	-39.1	5.8
4240	-58.5	-42.6	-0.8	39.6	55.5	73.3	-12.2	-51.7	8.4
4244	-66.7	-57.9	13.8	53.1	69.0	97.9	-22.2	-63.7	11.1
4248	-61.6	-57.3	47.2	73.7	64.7	101.3	-35.1	-64.4	12.7
4272	-48.2	-40.9	50.5	56.2	50.3	100.0	-44.7	-53.1	11.2
4301	-37.3	-30.1	40.4	44.4	38.0	97.5	-36.0	-42.6	9.2
4394	-25.8	-20.7	29.5	32.2	22.7	95.3	-26.4	-30.1	7.1
4490	-25.0	-14.3	23.0	26.7	8.0	75.7	-20.9	-24.9	5.5
4510	-30.0	1.9	19.7	22.6	-0.9	46.0	-18.3	-20.5	4.0
4528	-23.4	18.4	10.1	12.1	-5.2	31.0	-11.1	-12.3	3.1
18434	-20.7	21.5	-0.5	2.6	-16.1	20.6	-0.6	-0.5	2.6
40202	-32.7	9.4	10.0	12.8	-6.4	30.2	-8.1	-9.3	3.0
42198	-41.9	0.1	21.1	21.0	3.5	39.1	-20.1	-21.0	4.2
42398	-53.5	-10.0	32.8	32.9	15.7	49.4	-30.3	-32.7	6.5
42410	-68.6	-13.4	47.7	48.0	30.0	53.1	-43.7	-47.7	8.9
42413	-49.0	-11.5	28.2	28.5	10.9	51.0	-26.8	-28.4	5.9
42520	-61.3	-19.3	40.5	40.7	23.5	59.1	-37.3	-40.5	8.1
42535	-74.2	-26.2	53.2	53.4	36.4	66.2	-48.6	-53.3	10.3
42718	-83.6	-41.6	62.8	62.8	45.7	81.5	-57.2	-62.8	12.5
43034	-94.7	-52.7	73.9	74.1	56.8	92.5	-67.1	-73.9	14.7
43056	-105.7	-63.7	85.0	85.0	67.8	102.9	-76.6	-85.0	16.9
43176	-116.9	-74.7	96.0	96.1	78.9	113.9	-86.2	-96.0	19.1
43328	-128.1	-85.9	107.2	107.2	90.1	125.2	-96.6	-107.2	21.3
43476	-138.9	-96.7	118.1	118.1	100.9	135.6	-70.9	-118.0	22.5
43596	-149.9	-107.7	129.1	129.2	111.9	146.9	-115.5	-129.1	25.6
43619	-160.5	-118.5	140.0	140.0	122.8	157.5	-125.1	-140.0	27.8
43740	-171.9	-129.8	151.2	151.3	134.0	168.7	-135.0	-151.2	30.0
43861	-183.1	-141.0	162.4	162.4	145.2	179.6	-144.6	-162.4	32.2
44061	-194.1	-151.9	173.3	173.4	156.1	191.2	-153.0	-173.3	34.3
44223	-205.0	-162.9	184.2	184.3	167.0	202.1	-163.2	-184.2	36.5
44358	-216.1	-173.9	195.3	195.4	178.1	213.0	-173.1	-195.3	38.7
44478	-227.4	-185.2	206.7	206.7	189.4	224.0	-183.4	-206.6	41.0
44628	-238.6	-196.5	218.0	218.1	200.7	235.3	-193.9	-218.0	43.2
45038	-227.5	-185.5	207.0	207.0	189.7	224.3	-185.7	-207.0	41.1
45474	-238.7	-196.5	217.9	218.0	200.6	235.4	-193.9	-217.9	43.2
45497	-249.4	-207.4	228.9	228.9	211.6	246.2	-203.6	-228.9	45.4
45619	-260.3	-218.2	239.7	239.7	222.4	256.6	-213.6	-239.7	47.5
45880	-271.2	-229.0	250.5	250.6	233.2	267.3	-223.5	-250.5	49.7
45990	-281.9	-239.9	261.4	261.4	244.1	278.1	-234.2	-261.4	51.8
46495	-292.6	-250.7	272.2	272.3	254.9	289.2	-245.4	-272.2	54.0
46669	-303.7	-261.5	283.2	283.1	265.7	299.8	-254.8	-283.1	56.2
47359	-314.8	-272.7	294.2	294.2	276.9	310.9	-264.9	-294.1	58.4
47758	-325.6	-283.5	305.0	305.0	287.7	321.3	-275.6	-305.0	60.5
48016	-314.7	-272.6	294.2	294.2	276.9	311.1	-266.3	-294.2	58.4
48061	-325.6	-283.5	305.0	305.0	287.8	321.4	-275.8	-305.1	60.5
48181	-336.2	-294.2	315.8	315.8	298.4	332.0	-285.3	-315.8	62.7
48696	-347.3	-305.2	326.8	326.8	309.4	342.5	-294.6	-326.8	64.8
50490	-336.6	-294.6	316.1	316.1	298.8	332.6	-286.4	-316.2	62.8
62108	-325.7	-283.7	305.3	305.3	287.9	322.0	-276.2	-305.3	60.6
66109	-337.2	-294.8	316.0	316.2	299.5	333.0	-280.9	-315.6	62.7
66149	-325.8	-283.9	305.4	305.3	288.0	322.2	-277.6	-305.5	60.7
73060	-337.1	-295.0	316.5	316.4	299.2	332.2	-285.5	-316.5	62.8
73167	-347.9	-305.9	327.3	327.4	310.0	342.8	-295.0	-327.4	64.9
73282	-359.0	-316.8	338.4	338.5	320.9	353.8	-304.1	-338.4	67.1
73394	-370.0	-327.8	349.3	349.3	331.9	364.2	-313.9	-349.3	69.3
73503	-381.2	-339.1	360.6	360.6	343.2	375.2	-324.5	-360.6	71.5
73638	-391.8	-349.8	371.5	371.4	353.9	385.7	-334.8	-371.4	73.6
74114	-381.1	-339.1	360.7	360.7	343.1	375.9	-324.9	-360.7	71.5
74236	-392.2	-350.0	371.6	371.5	354.1	385.9	-334.3	-371.6	73.7
74401	-402.9	-360.8	382.3	382.4	365.0	396.7	-344.9	-382.3	75.8
74666	-413.5	-371.5	393.0	393.1	375.7	406.8	-354.8	-393.0	77.9
74848	-424.4	-382.3	403.9	404.0	386.6	417.5	-365.4	-403.8	80.1
75214	-435.2	-393.2	414.9	414.8	397.4	427.6	-375.4	-414.9	82.3
75412	-446.2	-404.1	425.8	425.8	408.3	438.2	-384.8	-425.8	84.4
75660	-457.1	-415.1	436.8	436.9	419.3	448.9	-394.9	-436.8	86.6
75992	-468.0	-426.0	447.6	447.6	430.1	459.6	-404.4	-447.6	88.7
76382	-479.0	-436.9	458.7	458.7	441.2	470.5	-413.8	-458.7	90.9
76736	-490.3	-448.1	469.8	469.8	452.2	481.1	-424.0	-469.8	93.1
76975	-501.0	-458.9	480.6	480.7	463.1	491.5	-434.2	-480.6	95.3
77014	-512.0	-469.9	491.7	491.7	474.2	502.0	-443.9	-491.7	97.4
77583	-523.0	-480.9	502.5	502.6	485.0	512.6	-453.0	-502.6	99.6
77794	-534.1	-492.1	513.7	513.8	496.1	523.5	-463.8	-513.8	101.8
78091	-544.7	-502.8	524.6	524.6	507.0	533.9	-472.9	-524.6	103.9
78310	-555.9	-513.9	535.5	535.7	518.0	544.7	-483.6	-535.6	106.1
78555	-566.8	-524.8	546.5	546.5	528.9	555.9	-493.8	-546.6	108.3
79159	-577.9	-535.8	557.5	557.6	539.9	565.8	-504.0	-557.5	110.5
79593	-566.5	-524.6	546.6	546.5	528.9	555.9	-494.2	-546.6	108.3
79624	-555.3	-513.5	535.3	535.3	517.7	545.7	-483.8	-535.3	106.1
79721	-544.5	-502.6	524.3	524.4	506.8	535.5	-473.8	-524.4	104.0
79948	-533.2	-491.4	513.2	513.2	495.7	525.0	-462.7	-513.2	101.9
80344	-522.6	-480.6	502.3	502.3	484.8	514.0	-454.7	-502.3	99.6
87037	-511.5	-469.5	491.3	491.3	473.7	503.1	-444.8	-491.3	97.4
97407	-522.2	-480.1	501.9	502.0	484.5	513.1	-450.9	-501.9	99.4
97669	-511.4	-469.2	491.0	491.0	473.6	503.1	-441.6	-491.0	97.3
97775	-544.3	-502.3	524.1	524.2	506.6	534.0	-471.6	-524.1	103.8
97938	-555.4	-513.3	534.9	535.0	517.5	544.2	-481.6	-535.0	106.0
98040	-566.4	-524.3	545.9	545.9	528.4	554.8	-491.4	-546.0	108.2
98304	-577.4	-535.3	556.9	557.0	539.3	565.2	-503.3	-556.9	110.4
98416	-588.3	-546.3	568.0	568.1	550.4	575.8	-513.6	-568.0	112.6
98613	-599.2	-557.0	578.7	578.9	561.1	586.4	-524.0	-578.8	114.7
98720	-610.2	-568.1	589.9	589.9	572.3	597.2	-534.4	-589.9	116.9
98917	-621.1	-579.0	600.7	600.7	583.1	607.7	-544.6	-600.7	119.1
99115	-632.1	-590.1	611.9	611.9	594.2	618.2	-554.9	-611.9	121.3
99312	-642.9	-600.9	622.7	622.9	605.1	628.3	-564.9	-622.7	123.4
99500	-654.1	-612.0	633.8	633.9	616.1	638.9	-575.0	-633.8	125.6
99869	-665.1	-622.9	644.6	644.7	627.0	649.1	-585.0	-644.6	127.7
100074	-676.0	-633.9	655.6	655.6	638.0	659.6	-595.4	-655.7	129.9
100261	-686.8	-644.7	666.5	666.6	649.0	670.1	-605.7	-666.5	132.1
100487	-697.9	-655.8	677.7	677.7	659.9	680.5	-615.7	-677.7	134.3
100734	-708.9	-666.9	688.7	688.8	671.0	691.0	-626.0	-688.6	136.5
101232	-719.9	-677.8	699.6	699.6	681.9	701.2	-636.0	-699.5	138.6
101336	-730.8	-688.8	710.7	710.8	693.0	712.0	-646.5	-710.8	140.8
101796	-741.7	-699.6	721.7	721.7	703.8	722.4	-656.8	-721.7	143.0
101996	-752.8	-710.9	732.6	732.7	714.9	733.2	-667.0	-732.7	145.2
102240	-763.8	-721.7	743.4	743.4	725.8	743.5	-677.1	-743.5	147.3
102477	-774.8	-732.8	754.6	754.6	737.0	754.3	-687.8	-754.6	149.5
102614	-785.5	-743.5	765.5	765.5	747.7	764.6	-697.7	-765.5	151.7
102985	-796.5	-754.5	776.6	776.6	758.7	775.0	-708.0	-776.6	153.9
103370	-807.7	-765.6	787.3	787.4	769.6	785.5	-718.4	-787.5	156.0
103679	-818.6	-776.5	798.3	798.5	780.6	796.1	-728.8	-798.4	158.2
103964	-829.5	-787.4	809.2	809.4	791.5	806.7	-738.9	-809.3	160.4
104492	-840.5	-809.0	831.1	831.1	813.2	827.7	-759.0	-831.1	164.7
105202	-862.1	-820.1	842.1	842.2	824.3	838.2	-769.2	-842.1	166.9
105847	-873.0	-831.0	853.0	853.0	835.1	848.6	-779.8	-853.0	169.1
106129	-884.3	-842.1	864.1	864.2	846.2	859.5	-789.5	-864.1	171.3
106348	-895.0	-853.0	874.9	874.9	857.1	869.9	-800.1	-875.1	173.4
106886	-883.7	-841.9	864.3	864.1	846.2	860.7	-789.8	-864.2	171.3
106980	-872.7	-830.8	853.1	853.1	835.1	850.0	-779.0	-853.0	169.1
107092	-861.5	-819.6	841.9	841.8	824.0	840.3	-768.8	-841.9	166.9
107201	-850.8	-808.8	831.1	831.0	813.1	830.1	-758.9	-831.0	164.7
107245	-840.0	-797.9	819.8	819.9	802.0	819.7	-748.6	-819.9	162.6
107372	-829.1	-787.1	809.1	809.0	791.3	809.7	-738.7	-809.1	160.4
121270	-818.0	-776.0	798.1	798.1	780.2	799.1	-728.1	-798.1	158.2
128483	-829.1	-786.9	809.1	808.9	791.1	808.6	-737.2	-809.0	160.3
128584	-839.8	-797.8	819.9	819.9	802.0	818.4	-747.2	-819.9	162.5
128667	-850.9	-808.8	830.9	831.0	813.0	828.4	-757.0	-830.9	164.6
128861	-861.7	-819.7	841.8	841.8	824.0	838.5	-767.7	-841.7	166.8
128921	-872.9	-830.8	852.9	852.9	835.0	848.8	-778.7	-852.9	169.0
129134	-883.8	-841.7	863.7	863.7	845.8	858.8	-789.5	-863.7	171.2
129759	-894.7	-852.6	874.6	874.6	856.6	869.4	-800.0	-874.7	173.3
129894	-905.6	-863.5	885.6	885.7	867.6	880.0	-810.3	-885.6	175.5
130111	-916.5	-874.4	896.5	896.5	878.6	890.7	-820.8	-896.5	177.7
130395	-927.6	-885.6	907.6	907.6	889.6	901.2	-831.5	-907.7	179.9
130603	-938.3	-896.2	918.5	918.5	900.4	911.7	-841.5	-918.5	182.0
130918	-949.6	-907.4	929.5	929.5	911.4	922.1	-851.8	-929.5	184.2
131495	-960.1	-918.1	940.2	940.2	922.3	932.8	-862.3	-940.2	186.4
131857	-971.3	-929.2	951.1	951.2	933.2	943.3	-872.6	-951.2	188.6
132826	-982.3	-940.1	962.3	962.4	944.1	954.0	-882.8	-962.2	190.8
133339	-993.5	-951.4	973.3	973.4	955.5	964.8	-893.2	-973.4	193.0
134145	-1004.3	-962.3	984.5	984.4	966.5	975.9	-903.6	-984.5	195.2
134772	-1015.2	-973.2	995.4	995.3	977.4	986.2	-913.8	-995.4	197.3
134971	-1026.2	-984.1	1006.5	1006.5	988.3	996.8	-924.2	-1006.5	199.5
135702	-1037.2	-995.2	1017.3	1017.3	999.3	1007.4	-935.0	#####	201.7
136268	-1048.3	#####	1028.3	1028.4	#####	1018.7	-945.2	#####	203.8
137134	-1059.1	#####	1039.2	1039.3	#####	1028.8	-954.6	#####	206.0
137461	-1069.9	#####	1050.4	1050.4	#####	1039.5	-965.5	#####	208.3
137869	-1081.1	#####	1061.0	1061.1	#####	1049.8	-975.8	#####	210.4
138580	-1092.1	#####	1072.1	1072.3	#####	1060.4	-986.1	#####	212.6
139155	-1103.0	#####	1083.0	1083.2	#####	1071.0	-996.7	#####	214.8
140118	-1113.3	#####	1093.3	1093.3	#####	1081.5	#####	#####	216.8

NAME	N_{fact}	N_{ftop}	N_{fcact}	N_{fwive}	S_{fact}	S_{ftop}	S_{fcact}	S_{fwive}	T_{wig}
UNIT	[kN]	[kN]	[kN]	[kN]	[kN]	[kN]	[kN]	[kN]	[kN*m/m]
ROW #									
141639	-1101.8	#####	1082.5	1082.4	#####	1072.1	-997.0	#####	214.7
141796	-1090.8	#####	1071.3	1071.3	#####	1062.1	-986.8	#####	212.5
141933	-1079.6	#####	1060.3	1060.2	#####	1052.2	-976.7	#####	210.3
142066	-1068.3	#####	1049.1	1049.0	#####	1042.1	-966.5	#####	208.1
142220	-1057.5	#####	1037.8	1037.7	#####	1031.8	-956.3	#####	205.9
142363	-1046.2	#####	1026.9	1026.7	#####	1021.3	-946.1	#####	203.8
142473	-1035.4	-993.4	1015.9	1015.8	997.7	1010.8	-935.9	#####	201.6
142522	-1024.7	-982.7	1004.8	1004.8	986.9	1000.6	-925.7	#####	199.4
142720	-1013.6	-971.6	993.8	993.7	975.8	990.2	-915.6	-993.8	197.2
142932	-1002.6	-960.7	982.9	982.8	964.9	980.2	-905.4	-983.0	195.1
143042	-991.6	-949.6	971.8	971.9	953.8	969.9	-894.5	-971.9	192.9
162000	-981.4	-939.4	961.7	961.7	943.6	958.5	-883.2	-961.7	190.8
162752	-993.0	-950.8	972.6	972.7	954.8	967.5	-893.4	-972.6	193.1
162804	-1003.6	-961.9	984.0	983.9	966.2	978.3	-904.2	-984.0	195.2
162911	-1014.5	-972.5	994.7	994.8	976.7	988.0	-913.5	-994.7	197.3
163042	-1025.7	-983.6	1005.8	1005.9	987.8	998.3	-923.7	#####	199.4
163168	-1036.5	-994.4	1016.6	1016.7	998.5	1008.1	-933.6	#####	201.6
163258	-1047.7	#####	1027.7	1027.7	#####	1018.6	-944.1	#####	203.8
163358	-1058.8	#####	1038.9	1038.9	#####	1029.0	-954.6	#####	206.0
163501	-1069.6	#####	1049.6	1049.6	#####	1039.9	-963.9	#####	208.1
163649	-1080.8	#####	1060.6	1060.7	#####	1049.4	-975.7	#####	210.3
163804	-1091.5	#####	1071.4	1071.5	#####	1059.8	-985.9	#####	212.5
163937	-1102.6	#####	1082.8	1082.9	#####	1070.3	-996.5	#####	214.7
164147	-1113.4	#####	1093.5	1093.5	#####	1080.7	#####	#####	216.9
164343	-1124.6	#####	1104.5	1104.5	#####	1091.6	#####	#####	219.1
164454	-1135.4	#####	1115.5	1115.5	#####	1102.1	#####	#####	221.2
164862	-1126.5	#####	1106.4	1106.4	#####	1112.5	#####	#####	223.4
165156	-1157.2	#####	1137.3	1137.4	#####	1123.3	#####	#####	225.6
165483	-1168.1	#####	1148.5	1148.6	#####	1133.9	#####	#####	227.8
165886	-1179.1	#####	1159.5	1159.5	#####	1144.6	#####	#####	230.0
166571	-1190.6	#####	1170.2	1170.4	#####	1155.2	#####	#####	232.2
166795	-1201.1	#####	1181.3	1181.2	#####	1165.9	#####	#####	234.3
167156	-1212.3	#####	1192.2	1192.4	#####	1176.5	#####	#####	236.5
167438	-1223.2	#####	1203.5	1203.6	#####	1187.2	#####	#####	238.7
167545	-1220.6	#####	1201.5	1201.4	#####	1185.4	#####	#####	238.3
167581	-1218.2	#####	1199.1	1199.1	#####	1183.3	#####	#####	237.9
167608	-1215.9	#####	1196.9	1196.9	#####	1181.1	#####	#####	237.4
167627	-1213.6	#####	1194.6	1194.5	#####	1179.0	#####	#####	237.0
167643	-1211.5	#####	1192.2	1192.3	#####	1177.0	#####	#####	236.5
167663	-1209.3	#####	1190.0	1190.0	#####	1174.8	#####	#####	236.1
167690	-1207.1	#####	1187.8	1187.8	#####	1172.7	#####	#####	235.6
167730	-1204.8	#####	1185.3	1185.3	#####	1170.5	#####	#####	235.1
167782	-1207.4	#####	1187.0	1187.0	#####	1172.0	#####	#####	235.5
167797	-1205.6	#####	1185.3	1185.3	#####	1174.0	#####	#####	235.8
167828	-1211.6	#####	1191.7	1191.7	#####	1176.1	#####	#####	236.4
167895	-1213.8	#####	1193.9	1193.9	#####	1178.3	#####	#####	236.9
168135	-1211.2	#####	1191.8	1191.8	#####	1176.6	#####	#####	236.4
168197	-1209.1	#####	1189.5	1189.5	#####	1174.3	#####	#####	236.0
168237	-1206.4	#####	1187.1	1187.1	#####	1172.1	#####	#####	235.5
168266	-1204.1	#####	1184.6	1184.7	#####	1170.0	#####	#####	235.0
168301	-1202.1	#####	1182.5	1182.5	#####	1167.8	#####	#####	234.6
168352	-1199.6	#####	1180.0	1180.0	#####	1165.8	#####	#####	234.1
168424	-1202.1	#####	1181.6	1181.7	#####	1167.2	#####	#####	234.5
168442	-1204.3	#####	1184.3	1184.4	#####	1169.3	#####	#####	235.0
168468	-1206.4	#####	1186.4	1186.5	#####	1171.3	#####	#####	235.4
168510	-1208.5	#####	1188.5	1188.7	#####	1173.3	#####	#####	235.8
168547	-1210.8	#####	1190.4	1190.6	#####	1175.4	#####	#####	236.2
168555	-1212.1	#####	1192.2	1192.4	#####	1177.2	#####	#####	236.7
168561	-1215.6	#####	1195.3	1195.2	#####	1179.2	#####	#####	237.1
168568	-1218.0	#####	1197.8	1197.7	#####	1181.5	#####	#####	237.6
168600	-1222.7	#####	1200.3	1200.2	#####	1183.9	#####	#####	238.1
168604	-1224.9	#####	1204.7	1204.6	#####	1188.7	#####	#####	239.0
168635	-1226.6	#####	1207.0	1207.0	#####	1190.7	#####	#####	239.4
168652	-1225.8	#####	1209.1	1209.1	#####	1192.6	#####	#####	239.8
168700	-1226.4	#####	1207.3	1207.3	#####	1191.0	#####	#####	239.5
168719	-1224.1	#####	1204.9	1205.0	#####	1188.7	#####	#####	239.0
168745	-1222.1	#####	1202.2	1202.4	#####	1186.5	#####	#####	238.5
168838	-1219.5	#####	1199.7	1199.8	#####	1184.2	#####	#####	238.0
169028	-1221.9	#####	1202.4	1202.4	#####	1186.8	#####	#####	238.5
169141	-1224.4	#####	1204.5	1204.5	#####	1188.4	#####	#####	238.9
169305	-1226.2	#####	1206.3	1206.2	#####	1189.9	#####	#####	239.3
169321	-1224.5	#####	1204.5	1204.5	#####	1188.5	#####	#####	239.0
169419	-1226.5	#####	1206.7	1206.7	#####	1190.7	#####	#####	239.4
169502	-1229.1	#####	1208.9	1209.0	#####	1192.9	#####	#####	239.9
169529	-1227.2	#####	1207.0	1207.0	#####	1191.0	#####	#####	239.5
169685	-1228.4	#####	1209.0	1209.0	#####	1193.2	#####	#####	239.8
169725	-1226.2	#####	1206.7	1206.7	#####	1191.0	#####	#####	239.4
169816	-1228.2	#####	1208.8	1208.8	#####	1192.7	#####	#####	239.8
169883	-1230.8	#####	1211.1	1211.1	#####	1195.0	#####	#####	240.3
170000	-1233.3	#####	1213.4	1213.4	#####	1197.1	#####	#####	240.7
170184	-1235.4	#####	1215.6	1215.6	#####	1199.3	#####	#####	241.2
170229	-1235.2	#####	1215.4	1215.4	#####	1197.6	#####	#####	241.0
170411	-1235.3	#####	1215.4	1215.3	#####	1199.0	#####	#####	241.1
170455	-1237.4	#####	1217.7	1217.7	#####	1201.3	#####	#####	241.6
170573	-1239.8	#####	1219.9	1219.9	#####	1203.5	#####	#####	242.0
170740	-1241.9	#####	1222.1	1222.2	#####	1204.8	#####	#####	242.5
170917	-1244.4	#####	1224.5	1224.4	#####	1207.9	#####	#####	242.9
170988	-1246.6	#####	1227.0	1227.0	#####	1210.2	#####	#####	243.4
171066	-1245.2	#####	1225.1	1225.1	#####	1208.5	#####	#####	243.0
171185	-1246.6	#####	1227.0	1226.8	#####	1210.2	#####	#####	243.4
171670	-1249.1	#####	1229.3	1229.3	#####	1212.4	#####	#####	243.9
171692	-1251.4	#####	1231.7	1231.7	#####	1214.5	#####	#####	244.3
171848	-1253.7	#####	1233.9	1233.9	#####	1216.8	#####	#####	244.8
171948	-1255.7	#####	1236.1	1235.9	#####	1218.7	#####	#####	245.2
172120	-1253.2	#####	1233.7	1233.7	#####	1216.9	#####	#####	244.8
172134	-1260.0	#####	1240.0	1240.1	#####	1222.6	#####	#####	246.0
172176	-1261.9	#####	1242.4	1242.4	#####	1225.0	#####	#####	246.5
172234	-1259.7	#####	1240.4	1240.4	#####	1223.1	#####	#####	246.1
172258	-1257.0	#####	1237.9	1237.9	#####	1221.0	#####	#####	245.6
172279	-1255.3	#####	1235.6	1235.6	#####	1218.8	#####	#####	245.1
172297	-1253.3	#####	1233.6	1233.6	#####	1216.8	#####	#####	244.7
172471	-1255.7	#####	1235.5	1235.5	#####	1218.6	#####	#####	245.2
172484	-1258.2	#####	1237.9	1238.0	#####	1220.7	#####	#####	245.6
172499	-1260.1	#####	1240.4	1240.6	#####	1222.9	#####	#####	246.1
172573	-1261.1	#####	1242.2	1242.2	#####	1224.8	#####	#####	246.5
172579	-1264.4	#####	1244.7	1244.7	#####	1227.2	#####	#####	246.9
172814	-1267.0	#####	1246.9	1247.0	#####	1229.4	#####	#####	247.4
172830	-1269.5	#####	1249.4	1249.

LVDTs

NAME	NHB	NHT	NVE	NVW	NDE	NDW	SHB	SHT	SVE	SVW	SDE	SDW
UNIT	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
ROW #												
3	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	-0.03	0.00
4227	0.00	0.01	0.00	0.00	0.02	0.02	0.00	-0.01	-0.01	0.01	-0.05	0.00
4233	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	-0.01	0.01	-0.05	-0.01
4238	0.01	0.00	0.01	0.01	0.02	0.00	0.01	0.01	-0.01	0.01	-0.06	0.00
4240	0.01	0.00	0.02	0.02	0.03	0.00	0.02	0.01	-0.03	-0.03	-0.07	0.00
4244	-0.01	-0.01	0.02	0.03	0.03	0.00	0.02	0.02	-0.04	-0.03	-0.07	-0.01
4248	-0.02	-0.02	0.02	0.03	0.03	0.00	0.03	0.02	-0.04	-0.03	-0.07	0.01
4272	-0.03	-0.02	0.02	0.03	0.03	0.01	0.03	0.02	-0.04	-0.05	-0.07	0.00
4301	-0.03	-0.02	0.02	0.02	0.02	-0.01	0.02	0.02	-0.03	-0.03	-0.06	0.01
4394	-0.01	-0.01	0.02	0.02	0.02	0.00	0.02	0.01	-0.03	-0.02	-0.06	0.00
4490	0.00	-0.01	0.01	0.01	0.02	0.00	0.01	0.01	-0.02	-0.02	-0.05	0.01
4510	0.00	-0.01	0.01	0.01	0.02	0.00	0.01	0.01	-0.01	-0.02	-0.05	0.01
4528	-0.01	0.00	0.00	0.00	0.01	-0.01	0.01	0.01	-0.01	-0.01	-0.05	0.01
18434	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	-0.06	0.00
40202	0.00	0.00	0.01	0.02	0.02	0.00	0.01	0.01	-0.01	0.00	-0.01	0.01
42198	0.00	0.00	0.01	0.01	0.02	0.00	0.02	0.02	-0.02	0.00	-0.02	0.01
42398	-0.02	-0.01	0.02	0.02	0.02	0.00	0.02	0.02	-0.02	-0.02	-0.01	-0.01
42410	-0.01	-0.02	0.03	0.03	0.02	0.00	0.03	0.03	-0.03	-0.02	-0.01	-0.01
42413	-0.01	-0.01	0.02	0.02	0.02	0.00	0.02	0.02	-0.02	-0.02	-0.01	-0.01
42520	-0.01	-0.01	0.03	0.03	0.02	0.00	0.03	0.03	-0.03	-0.01	-0.02	-0.01
42535	-0.01	-0.02	0.03	0.03	0.02	0.00	0.04	0.04	-0.03	-0.02	-0.01	-0.01
42718	-0.02	-0.03	0.04	0.04	0.02	0.00	0.04	0.04	-0.04	-0.02	-0.01	-0.01
43034	-0.04	-0.03	0.04	0.04	0.02	0.00	0.05	0.04	-0.06	-0.04	-0.02	-0.02
43056	-0.03	-0.04	0.05	0.05	0.02	0.00	0.06	0.05	-0.05	-0.04	-0.02	-0.01
43176	-0.05	-0.05	0.06	0.06	0.02	0.00	0.06	0.06	-0.07	-0.06	-0.02	-0.01
43328	-0.05	-0.05	0.07	0.07	0.02	0.01	0.07	0.07	-0.08	-0.06	-0.02	-0.02
43476	-0.05	-0.06	0.07	0.07	0.02	0.01	0.08	0.07	-0.08	-0.08	-0.02	-0.01
43596	-0.07	-0.07	0.08	0.08	0.02	0.01	0.09	0.08	-0.11	-0.09	-0.02	-0.02
43619	-0.07	-0.07	0.09	0.09	0.02	0.01	0.09	0.08	-0.11	-0.11	-0.03	-0.02
43740	-0.09	-0.08	0.10	0.10	0.03	0.01	0.10	0.10	-0.12	-0.12	-0.04	-0.03
43861	-0.09	-0.09	0.12	0.11	0.03	0.01	0.11	0.11	-0.16	-0.12	-0.04	-0.04
44061	-0.11	-0.11	0.13	0.13	0.03	0.01	0.13	0.12	-0.19	-0.16	-0.07	-0.05
44223	-0.14	-0.14	0.15	0.15	0.03	0.01	0.15	0.14	-0.22	-0.19	-0.08	-0.05
44358	-0.15	-0.16	0.16	0.16	0.03	0.01	0.16	0.15	-0.25	-0.21	-0.09	-0.05
44478	-0.16	-0.17	0.18	0.17	0.03	0.00	0.18	0.16	-0.28	-0.21	-0.10	-0.07
44628	-0.17	-0.19	0.19	0.19	0.03	0.00	0.19	0.18	-0.31	-0.24	-0.11	-0.08
45038	-0.19	-0.20	0.20	0.20	0.03	-0.01	0.20	0.18	-0.34	-0.27	-0.12	-0.09
45474	-0.19	-0.21	0.20	0.20	0.03	-0.01	0.20	0.19	-0.34	-0.27	-0.12	-0.09
45497	-0.20	-0.22	0.22	0.21	0.03	-0.01	0.21	0.20	-0.35	-0.28	-0.12	-0.10
45619	-0.21	-0.23	0.23	0.22	0.03	-0.01	0.22	0.21	-0.37	-0.32	-0.13	-0.10
45880	-0.24	-0.27	0.25	0.25	0.03	-0.04	0.25	0.22	-0.40	-0.35	-0.13	-0.12
45990	-0.26	-0.30	0.27	0.26	0.03	-0.04	0.27	0.25	-0.47	-0.38	-0.14	-0.12
46495	-0.31	-0.36	0.31	0.30	0.03	-0.06	0.31	0.29	-0.57	-0.48	-0.17	-0.16
46669	-0.35	-0.39	0.33	0.32	0.03	-0.08	0.33	0.31	-0.64	-0.53	-0.20	-0.19
47359	-0.43	-0.49	0.38	0.37	0.03	-0.12	0.38	0.35	-0.79	-0.68	-0.26	-0.25
47758	-0.47	-0.56	0.42	0.40	0.01	-0.14	0.41	0.39	-0.91	-0.78	-0.32	-0.31
48016	-0.49	-0.57	0.42	0.40	0.01	-0.14	0.41	0.40	-0.93	-0.80	-0.33	-0.32
48061	-0.49	-0.58	0.43	0.41	0.01	-0.14	0.42	0.40	-0.94	-0.80	-0.34	-0.32
48181	-0.52	-0.61	0.45	0.43	0.01	-0.16	0.43	0.42	-0.98	-0.86	-0.35	-0.34
48696	-0.58	-0.68	0.49	0.47	0.00	-0.19	0.47	0.46	-1.11	-0.94	-0.42	-0.42
50490	-0.64	-0.74	0.51	0.49	-0.02	-0.22	0.50	0.49	-1.20	-1.03	-0.46	-0.48
62108	-0.64	-0.75	0.53	0.50	-0.02	-0.25	0.52	0.53	-1.21	-1.04	-0.45	-0.47
66109	-0.65	-0.76	0.54	0.51	-0.02	-0.25	0.52	0.51	-1.24	-1.07	-0.47	-0.49
66149	-0.65	-0.75	0.53	0.50	-0.02	-0.25	0.52	0.50	-1.23	-1.06	-0.47	-0.49
73060	-0.65	-0.76	0.54	0.51	-0.02	-0.25	0.52	0.51	-1.26	-1.07	-0.48	-0.50
73167	-0.67	-0.78	0.55	0.52	-0.02	-0.25	0.53	0.52	-1.27	-1.09	-0.49	-0.51
73282	-0.68	-0.79	0.56	0.53	-0.02	-0.25	0.54	0.53	-1.29	-1.11	-0.50	-0.51
73394	-0.70	-0.82	0.57	0.54	-0.03	-0.26	0.55	0.54	-1.34	-1.13	-0.51	-0.53
73503	-0.73	-0.85	0.59	0.56	-0.03	-0.27	0.57	0.56	-1.38	-1.17	-0.53	-0.55
73638	-0.76	-0.88	0.61	0.57	-0.04	-0.29	0.59	0.58	-1.43	-1.22	-0.54	-0.57
74114	-0.77	-0.90	0.61	0.58	-0.05	-0.30	0.60	0.58	-1.45	-1.24	-0.57	-0.59
74236	-0.78	-0.92	0.62	0.59	-0.05	-0.30	0.61	0.59	-1.47	-1.27	-0.57	-0.59
74401	-0.81	-0.95	0.64	0.60	-0.06	-0.32	0.62	0.61	-1.51	-1.30	-0.59	-0.61
74666	-0.84	-0.99	0.66	0.62	-0.07	-0.34	0.65	0.63	-1.58	-1.36	-0.62	-0.64
74848	-0.90	-1.05	0.68	0.64	-0.09	-0.36	0.67	0.65	-1.65	-1.43	-0.64	-0.67
75214	-0.94	-1.12	0.71	0.67	-0.11	-0.40	0.71	0.69	-1.74	-1.52	-0.68	-0.71
75412	-0.98	-1.17	0.74	0.70	-0.12	-0.43	0.73	0.72	-1.82	-1.58	-0.71	-0.74
75660	-1.03	-1.25	0.77	0.73	-0.14	-0.46	0.76	0.75	-1.91	-1.66	-0.75	-0.78
75992	-1.10	-1.34	0.80	0.76	-0.16	-0.51	0.80	0.79	-2.00	-1.73	-0.77	-0.81
76182	-1.15	-1.43	0.83	0.79	-0.18	-0.55	0.83	0.82	-2.09	-1.81	-0.80	-0.85
76736	-1.21	-1.51	0.86	0.82	-0.20	-0.59	0.87	0.86	-2.18	-1.89	-0.83	-0.88
76975	-1.26	-1.58	0.89	0.85	-0.22	-0.63	0.90	0.88	-2.25	-1.96	-0.86	-0.91
77155	-1.32	-1.66	0.91	0.88	-0.24	-0.67	0.93	0.91	-2.31	-2.02	-0.88	-0.94
77583	-1.46	-1.78	0.95	0.92	-0.29	-0.75	0.98	0.97	-2.41	-2.12	-0.92	-0.97
77794	-1.52	-1.85	0.98	0.94	-0.31	-0.75	1.02	1.00	-2.48	-2.18	-0.94	-0.99
78071	-1.59	-1.92	1.01	0.97	-0.32	-0.82	1.05	1.03	-2.55	-2.26	-0.97	-1.02
78310	-1.65	-1.98	1.03	1.00	-0.33	-0.85	1.07	1.05	-2.62	-2.32	-1.00	-1.04
78555	-1.70	-2.05	1.06	1.02	-0.35	-0.88	1.10	1.08	-2.68	-2.38	-1.03	-1.07
79159	-1.79	-2.14	1.09	1.06	-0.37	-0.93	1.14	1.12	-2.79	-2.49	-1.07	-1.11
79593	-1.80	-2.15	1.10	1.06	-0.37	-0.94	1.15	1.13	-2.80	-2.49	-1.07	-1.12
79624	-1.78	-2.14	1.09	1.05	-0.37	-0.94	1.14	1.12	-2.78	-2.48	-1.07	-1.11
79721	-1.78	-2.12	1.09	1.05	-0.37	-0.94	1.13	1.12	-2.78	-2.47	-1.07	-1.11
79948	-1.75	-2.11	1.08	1.04	-0.36	-0.93	1.13	1.10	-2.75	-2.45	-1.06	-1.11
80344	-1.74	-2.09	1.07	1.03	-0.36	-0.93	1.12	1.10	-2.72	-2.44	-1.05	-1.10
87037	-1.73	-2.07	1.08	1.04	-0.34	-0.90	1.13	1.12	-2.68	-2.40	-1.00	-1.03
97407	-1.74	-2.09	1.08	1.05	-0.33	-0.91	1.13	1.12	-2.73	-2.43	-1.04	-1.08
97669	-1.77	-2.11	1.09	1.05	-0.33	-0.91	1.13	1.12	-2.74	-2.46	-1.05	-1.05
97775	-1.78	-2.13	1.10	1.06	-0.34	-0.92	1.14	1.13	-2.77	-2.47	-1.05	-1.06
97938	-1.81	-2.15	1.11	1.07	-0.34	-0.93	1.14	1.14	-2.79	-2.51	-1.06	-1.07
98040	-1.82	-2.18	1.12	1.08	-0.35	-0.94	1.16	1.15	-2.82	-2.52	-1.07	-1.08
98304	-1.84	-2.21	1.14	1.10	-0.36	-0.95	1.18	1.17	-2.86	-2.56	-1.09	-1.10
98416	-1.88	-2.25	1.15	1.11	-0.37	-0.97	1.19	1.18	-2.90	-2.60	-1.10	-1.12
98613	-1.92	-2.30	1.18	1.13	-0.38	-0.99	1.22	1.21	-2.96	-2.65	-1.13	-1.14
98720	-1.94	-2.33	1.19	1.15	-0.38	-1.01	1.23	1.22	-3.00	-2.69	-1.14	-1.16
98917	-1.99	-2.40	1.22	1.17	-0.40	-1.04	1.26	1.25	-3.07	-2.75	-1.18	-1.19
99115	-2.05	-2.45	1.24	1.19	-0.41	-1.07	1.28	1.27	-3.13	-2.81	-1.20	-1.21
99312	-2.09	-2.50	1.26	1.22	-0.42	-1.09	1.29	1.29	-3.18	-2.86	-1.22	-1.23
99500	-2.15	-2.56	1.29	1.24	-0.44	-1.12	1.34	1.32	-3.26	-2.92	-1.26	-1.26
99869	-2.22	-2.64	1.32	1.27	-0.45	-1.16	1.37	1.35	-3.34	-3.00	-1.29	-1.30
100074	-2.26	-2.69	1.34	1.29	-0.47	-1.18	1.40	1.38	-3.38	-3.06	-1.31	-1.32
100261	-2.31	-2.75	1.37	1.32	-0.48	-1.21	1.43	1.41	-3.46	-3.12	-1.34	-1.35
100487	-2.36	-2.81	1.40	1.34	-0.49	-1.25	1.46	1.44	-3.52	-3.18	-1.36	-1.37
100734	-2.43	-2.89	1.43	1.37	-0.51	-1.29	1.49	1.47	-3.60	-3.25	-1.39	-1.40
101232	-2.50	-2.97	1.47	1.41	-0.54	-1.33	1.53	1.50	-3.69	-3.33	-1.42	-1.43
101336	-2.53	-3.02	1.48	1.42	-0.55	-1.35	1.55	1.53	-3.73	-3.37	-1.44	-1.45
101796	-2.62	-3.11	1.52	1.46	-0.57	-1.40	1.59	1.57	-3.82	-3.46	-1.47	-1.49
101996	-2.67	-3.18	1.55	1.48	-0.59	-1.43	1.62	1.60	-3.88	-3.51	-1.50	-1.51
102240	-2.74	-3.25	1.58	1.51	-0.61	-1.47	1.65	1.63	-3.95	-3.59	-1.52	-1.55
102477	-2.80	-3.32	1.61	1.54	-0.63	-1.50	1.69	1.65	-4.01	-3.66	-1.56	-1.56
102614	-2.84	-3.37	1.63	1.56	-0.64	-1.53	1.71	1.68	-4.07	-3.69	-1.57	-1.58
102985	-2.91	-3.47	1.68	1.60	-0.67	-1.58	1.76	1.72	-4.16	-3.79	-1.61	-1.62
103370	-2.98	-3.55	1.72	1.63	-0.69	-1.62	1.80	1.75	-4.25	-3.86	-1.64	-1.65
103679	-3.04	-3.62	1.75	1.66	-0.71	-1.65	1.83	1.79	-4.31	-3.92	-1.66	-1.68
103964	-3.11	-3.69	1.79	1.69	-0.73	-1.68	1.86	1.83	-4.38	-3.99	-1.69	-1.70
104433	-3.17	-3.77	1.82	1.72	-0.75	-1.72	1.90	1.86	-4.46	-4.06	-1.72	-1.73
104972	-3.24	-3.85	1.86	1.76	-0.77	-1.75	1.94	1.90	-4.54	-4.14	-1.75	-1.76
105202	-3.28	-3.90	1.88	1.78	-0.78	-1.78	1.97	1.92	-4.59	-4.19	-1.78	-1.78
105847	-3.37	-4.00	1.93	1.82	-0.80	-1.82	2.02	1.97	-4.70	-4.28	-1.81	-1.83
106129	-3.43	-4.06	1.96	1.84	-0.80	-1.84	2.04	2.00	-4.76	-4.32	-1.80	-1.86
106348	-3.48	-4.12	1.99	1.88	-0.84	-1.87	2.08	2.03	-4.82	-4.40	-1.86	-1.88
106886	-3.51	-4.16	2.01	1.89	-0.85	-1.89	2.10	2.05	-4.86	-4.44	-1.87	-1.90
106980	-3.50	-4.15	2.00	1.89	-0.84	-1.89	2.09	2.04	-4.84	-4.44	-1.87	-1.89
107092	-3.48	-4.13	2.00	1.88	-0.84	-1.89	2.09	2.04	-4.83	-4.42	-1.87	-1.89
107201	-3.47	-4.12	1.99	1.87	-0.84	-1.89	2.08	2.03	-4.81	-4.41	-1.85	-1.89
107245	-3.45	-4.10	1.98	1.87	-0.83	-1.88	2.07	2.02	-4.79	-4.39	-1.84	-1.87
107373	-3.44	-4.08	1.98	1.86	-0.83	-1.87	2.06	2.02	-4.77	-4.38	-1.83	-1.87
121270	-3.43	-4.08	2.01	1.90	-0.80	-1.84	2.10	2.05	-4.76	-4.37	-1.80	-1.86
128483	-3.46	-4.10	2.02	1.91	-0.81	-1.84	2.11	2.06	-4.79	-4.40	-1.81	-1.87
128584	-3.47	-4.12	2.03	1.92	-0.81	-1.85	2.12	2.07	-4.80	-4.41	-1.81	-1.88
128667	-3.49	-4.14	2.04	1.93	-0.81	-1.85	2.13	2.08	-4.82	-4.43	-1.82	-1.88
128804	-3.51	-4.16	2.05	1.94	-0.82	-1.86	2.14	2.09	-4.85	-4.45	-1.83	-1.90
128921	-3.54	-4.19	2.06	1.95	-0.83	-1.88	2.15	2.10	-4.88	-4.48	-1.84	-1.91
129334	-3.58	-4.24	2.08	1.97	-0.85	-1.90	2.18	2.12	-4.92	-4.53	-1.87	-1.93
129759	-3.62	-4.30	2.11	1.99	-0.86	-1.92	2.20	2.15	-4.98	-4.58	-1.89	-1.96
129894	-3.66	-4.33	2.12	2.01	-0.87	-1.94	2.22	2.17	-5.02	-4.62	-1.91	-1.97
130111	-3.70	-4.39	2.15	2.03	-0.88	-1.97	2.24	2.19	-5.08	-4.68	-1.93	-2.00
130395	-3.76	-4.45	2.17	2.05	-0.90	-1.99	2.27	2.21	-5.14	-4.74	-1.96	-2.03
130603	-3.79	-4.50	2.20	2.08	-0.91	-2.01	2.30	2.23	-5.19	-4.78	-1.97	-2.05
130918	-3.85	-4.56	2.22	2.10	-0.93	-2.04	2.32	2.27	-5.26	-4.85	-2.00	-2.08
131495	-3.91	-4.65	2.26	2.14	-0.95	-2.08	2.37	2.30	-5.34	-4.92	-2.03	-2.11
131857	-3.98	-4.72	2.29	2.17	-0.97	-2.11	2.40	2.34	-5.42	-5.00	-2.05	-2.15
132826	-4.06	-4.82	2.34	2.21	-1.00	-2.15	2.45	2.39	-5.51	-5.10	-2.09	-2.19
133339	-4.13	-4.88	2.37	2.24	-1.01	-2.17	2.49	2.42	-5.58	-5.17	-2.12	-2.21
134145	-4.19	-4.98	2.42	2.29	-1.04	-2.21	2.54	2.46	-5.67	-5.26	-2.15	-2.26
134772	-4.26	-5.06	2.46	2.32	-1.05	-2.24	2.58	2.50	-5.75	-5.32	-2.18	-2.29
134971	-4.31	-5.11	2.48	2.35	-1.07	-2.26	2.60	2.53	-5.80	-5.38	-2.19	-2.31
135702	-4.40	-5.23	2.54	2.40	-1.10	-2.30	2.66	2.59	-5.92	-5.49	-2.23	-2.35
136268	-4.47	-5.30	2.58	2.44	-1.11	-2.33	2.70	2.63	-6.00	-5.57	-2.26	-2.39
137134	-4.55	-5.41	2.64	2.49	-1.13	-2.37	2.76	2.68	-6.10	-5.68	-2.29	-2.42
137461	-4.62	-5.48	2.67	2.53	-1.15	-2.40	2.80	2.71	-6.17	-5.75	-2.32	-2.46
137869	-4.69	-5.56	2.71	2.57	-1.17	-2.42	2.84	2.75	-6.25	-5.82	-2.35	-2.49
138580	-4.79	-5.68	2.77	2.63	-1.19	-2.46	2.91	2.82	-6.37	-5.95	-2.38	-2.54
139155	-4.87	-5.79	2.83	2.68	-1.22	-2.50	2.97	2.87	-6.47	-6.05	-2.41	-2.58
140118	-5.00	-5.93	2.91	2.76	-1.24	-2.54	3.05	2.95	-6.61	-6.21	-2.45	-2.64

NAME	NHB	NHT	NVE	NVW	NDE	NDW	SHB	SHT	SVE	SVW	SDE	SDW
UNIT	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
ROW #												
141639	-5.08	-6.03	2.98	2.82	-1.26	-2.57	3.12	3.01	-6.69	-6.31	-2.47	-2.67
141796	-5.07	-6.01	2.97	2.82	-1.25	-2.57	3.12	3.01	-6.68	-6.30	-2.47	-2.66
141933	-5.06	-6.00	2.97	2.81	-1.25	-2.56	3.11	3.00	-6.66	-6.29	-2.46	-2.66
142066	-5.04	-5.98	2.96	2.81	-1.24	-2.56	3.11	3.00	-6.65	-6.27	-2.45	-2.65
142220	-5.02	-5.97	2.95	2.80	-1.24	-2.55	3.10	2.99	-6.63	-6.26	-2.44	-2.65
142363	-5.01	-5.95	2.95	2.79	-1.23	-2.55	3.09	2.99	-6.61	-6.23	-2.43	-2.64
142473	-5.00	-5.93	2.94	2.78	-1.23	-2.54	3.08	2.97	-6.58	-6.21	-2.42	-2.63
142522	-4.99	-5.91	2.93	2.78	-1.22	-2.53	3.08	2.96	-6.57	-6.21	-2.41	-2.62
142720	-4.97	-5.89	2.92	2.77	-1.22	-2.52	3.07	2.96	-6.55	-6.19	-2.41	-2.62
142932	-4.95	-5.86	2.92	2.76	-1.21	-2.51	3.06	2.95	-6.52	-6.16	-2.39	-2.60
143042	-4.92	-5.84	2.91	2.76	-1.20	-2.50	3.05	2.94	-6.49	-6.14	-2.38	-2.59
162000	-4.92	-5.82	2.95	2.80	-1.18	-2.46	3.08	2.97	-6.49	-6.14	-2.35	-2.56
162752	-4.93	-5.84	2.95	2.81	-1.18	-2.46	3.09	2.98	-6.49	-6.14	-2.34	-2.56
162804	-4.94	-5.85	2.96	2.82	-1.18	-2.46	3.10	2.99	-6.51	-6.16	-2.35	-2.56
162911	-4.95	-5.87	2.97	2.82	-1.19	-2.47	3.11	3.00	-6.53	-6.18	-2.36	-2.57
163042	-4.97	-5.89	2.98	2.83	-1.19	-2.47	3.12	3.01	-6.55	-6.19	-2.36	-2.58
163168	-4.99	-5.91	2.99	2.84	-1.20	-2.48	3.13	3.02	-6.57	-6.22	-2.37	-2.59
163258	-5.01	-5.93	3.00	2.85	-1.20	-2.49	3.14	3.03	-6.59	-6.24	-2.38	-2.60
163358	-5.03	-5.96	3.01	2.86	-1.21	-2.50	3.15	3.04	-6.62	-6.26	-2.39	-2.61
163501	-5.05	-5.99	3.02	2.87	-1.22	-2.51	3.16	3.05	-6.64	-6.29	-2.40	-2.62
163649	-5.08	-6.02	3.03	2.89	-1.23	-2.52	3.18	3.06	-6.67	-6.32	-2.41	-2.63
163804	-5.11	-6.07	3.05	2.91	-1.24	-2.54	3.20	3.08	-6.72	-6.36	-2.43	-2.65
163937	-5.15	-6.11	3.07	2.92	-1.25	-2.56	3.22	3.10	-6.76	-6.40	-2.44	-2.67
164147	-5.21	-6.17	3.10	2.95	-1.27	-2.58	3.25	3.13	-6.83	-6.46	-2.47	-2.70
164343	-5.26	-6.22	3.12	2.97	-1.28	-2.60	3.27	3.15	-6.87	-6.52	-2.49	-2.72
164454	-5.31	-6.27	3.13	2.98	-1.29	-2.61	3.30	3.18	-6.93	-6.57	-2.51	-2.75
164862	-5.38	-6.36	3.19	3.03	-1.31	-2.65	3.34	3.22	-7.01	-6.66	-2.54	-2.78
165156	-5.46	-6.44	3.22	3.07	-1.33	-2.68	3.38	3.25	-7.08	-6.73	-2.56	-2.81
165483	-5.53	-6.51	3.26	3.10	-1.35	-2.71	3.42	3.28	-7.15	-6.82	-2.58	-2.84
165886	-5.59	-6.60	3.30	3.15	-1.37	-2.74	3.47	3.33	-7.23	-6.90	-2.61	-2.87
166571	-5.73	-6.73	3.38	3.22	-1.40	-2.79	3.55	3.41	-7.37	-7.05	-2.65	-2.93
166795	-5.79	-6.81	3.42	3.26	-1.41	-2.81	3.59	3.44	-7.43	-7.12	-2.67	-2.95
167156	-5.89	-6.93	3.48	3.32	-1.43	-2.85	3.65	3.50	-7.54	-7.24	-2.70	-2.99
167438	-5.98	-7.04	3.53	3.37	-1.45	-2.88	3.70	3.56	-7.63	-7.34	-2.74	-3.03
167545	-6.01	-7.07	3.55	3.39	-1.45	-2.89	3.73	3.57	-7.66	-7.37	-2.74	-3.04
167581	-6.02	-7.07	3.55	3.39	-1.45	-2.89	3.73	3.57	-7.66	-7.37	-2.74	-3.04
167626	-6.01	-7.07	3.55	3.39	-1.45	-2.89	3.73	3.58	-7.66	-7.37	-2.74	-3.04
167627	-6.01	-7.07	3.55	3.39	-1.45	-2.89	3.73	3.57	-7.66	-7.38	-2.74	-3.04
167643	-6.02	-7.07	3.55	3.39	-1.45	-2.89	3.73	3.58	-7.66	-7.37	-2.75	-3.04
167663	-6.01	-7.07	3.55	3.39	-1.45	-2.89	3.73	3.57	-7.66	-7.38	-2.74	-3.04
167690	-6.02	-7.07	3.55	3.39	-1.45	-2.89	3.73	3.58	-7.65	-7.38	-2.74	-3.04
167730	-6.01	-7.07	3.55	3.39	-1.45	-2.89	3.73	3.57	-7.66	-7.38	-2.75	-3.04
167782	-6.02	-7.07	3.55	3.40	-1.45	-2.89	3.74	3.57	-7.65	-7.38	-2.74	-3.04
167797	-6.01	-7.07	3.56	3.40	-1.45

LPs

NAME	LP1	LP2	LP3	LP4	LP5	LP6	LP7	LP8	LP9	LP10	LP11	LP12	LP13	LP14	LP15
UNIT	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
ROW #															
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4227	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4233	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4238	0	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0
4240	0	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0
4244	0.004	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0
4248	0.006	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0
4272	0.007	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0
4301	0.007	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0
4394	0.007	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0
4490	0.013	0	0	0	0	0	0.001	0	0	0.001	0	0.001	0	0	0
4510	0.013	0	0	0	0.001	0	0.001	0	0	0.001	0	0.001	0	0	0
4528	0.013	0	0	0	0.001	0	0	0	0	0.002	0.001	0.001	0	0	0
18434	0.013	0	0.001	0	0.001	0	0	0.001	0	0.002	0.001	0.001	0	0	0
40202	0.013	0	0.001	0	0.001	0.001	0	0.001	0	0.002	0.001	0.001	0	0	0
42198	0.013	0	0.001	0	0.001	0.001	0	0.001	0	0.002	0.001	0.001	0	0	0
42398	0.013	0	0.001	0	0.001	0.001	0	0.001	0	0.002	0.001	0.001	0	0	0
42410	0.013	0	0.001	0	0.001	0.001	0	0.001	0	0.002	0.001	0.001	0	0	0
42413	0.013	0	0.001	0	0.001	0.001	0	0.001	0	0.002	0.001	0.001	0	0	0
42520	0.013	0	0.001	0	0.001	0.001	0	0.001	0	0.002	0.001	0.001	0	0	0
42535	0.013	0	0.001	0	0.001	0.001	0	0.001	0	0.002	0.001	0.002	0	0	0
42718	0.013	0	0.001	0.001	0.001	0.001	0	0.001	0	0.002	0	0.002	0	0	0
43034	0.013	0	0.001	0.001	0.001	0	0	0.001	0	0.002	0	0.002	0	0	0
43056	0.013	0	0.001	0.001	0.001	0	0	0.001	0	0.002	0	0.002	0	0	0
43176	0.013	0	0.001	0.001	0.001	0	0	0.001	0	0.002	0	0.003	0	0	0
43328	0.014	0.001	0.001	0.001	0.001	0	0	0.001	0	0.002	0	0.003	0	0	0
43476	0.015	-0.001	0.001	0.001	0.001	-0.001	0	0.001	0	0.002	0	0.003	0	0	0
43596	0.017	-0.001	0.001	0.001	0.001	-0.002	0	0.001	0	0.002	0	0.004	0	0	0
43619	0.017	-0.002	0.001	0.001	0.001	-0.003	0	0.001	0	0.002	0	0.004	0	0	0
43740	0.019	-0.002	0	0.001	0	-0.004	0	0.001	0	0.003	0	0.004	0	0	0
43861	0.02	-0.003	0	0.001	0	-0.005	0	0.001	-0.004	0.003	0.001	0.004	0	0	0
44061	0.022	-0.005	-0.001	0.001	0	-0.007	0	0.001	-0.006	0	-0.001	0.001	0.004	0	0
44223	0.023	-0.007	-0.002	0.001	0	-0.01	0	0.003	-0.006	0	-0.003	0	0.005	0	0
44358	0.024	-0.008	-0.003	0.001	0	-0.023	0	0.003	-0.006	0	-0.005	0	0.005	0	0
44478	0.025	-0.009	-0.004	0.001	0	-0.028	0.001	0.004	-0.006	0	-0.006	-0.001	0.005	0	0
44628	0.027	-0.01	-0.005	0.002	0.001	-0.033	0.001	0.005	-0.006	0	-0.007	-0.003	0.005	0	0
45038	0.03	-0.01	-0.005	0.002	0.001	-0.037	0.001	0.005	-0.006	0	-0.008	-0.003	0.005	0	0
45474	0.03	-0.01	-0.005	0.002	0.001	-0.037	0.001	0.006	-0.006	0	-0.008	-0.003	0.005	0	0
45497	0.031	-0.011	-0.005	0.002	0.001	-0.039	0.001	0.006	-0.006	0	-0.009	-0.004	0.005	0	0
45619	0.033	-0.011	-0.006	0.002	0.001	-0.042	0.001	0.007	-0.006	0	-0.009	-0.005	0.006	0	0
45880	0.037	-0.012	-0.006	0.002	0.002	-0.046	0.001	0.008	-0.006	0.001	-0.01	-0.005	0.006	0	0
45990	0.039	-0.013	-0.007	0.001	0.002	-0.049	0.001	0.009	-0.006	0.001	-0.011	-0.005	0.007	0	0
46495	0.051	-0.014	-0.009	0	0.003	-0.05	0.001	0.01	-0.006	0.001	-0.013	-0.008	0.007	0	0
46669	0.056	-0.016	-0.011	0	0.003	-0.052	0	0.01	-0.006	0.001	-0.014	-0.012	0.007	0	0
47359	0.061	-0.018	-0.013	-0.001	0.003	-0.052	-0.001	0.008	-0.007	0.002	-0.014	-0.015	0.009	0	0
47758	0.064	-0.017	-0.014	-0.002	0.003	-0.053	-0.002	0.007	-0.01	0.002	-0.016	-0.017	0.01	0	0
48016	0.065	-0.017	-0.014	-0.002	0.003	-0.054	-0.002	0.007	-0.01	0.002	-0.016	-0.018	0.01	-0.001	0
48061	0.065	-0.017	-0.014	-0.002	0.003	-0.054	-0.003	0.007	-0.01	0.002	-0.016	-0.019	0.01	-0.001	0
48181	0.065	-0.017	-0.014	-0.002	0.003	-0.055	-0.003	0.006	-0.013	0.002	-0.016	-0.019	0.011	-0.001	0
48696	0.065	-0.018	-0.016	-0.004	0.003	-0.057	-0.004	0.005	-0.014	0.002	-0.016	-0.021	0.011	-0.002	0
50490	0.065	-0.019	-0.019	-0.006	0.003	-0.058	-0.005	0.004	-0.015	0.002	-0.016	-0.022	0.012	-0.002	0
62108	0.068	-0.019	-0.022	-0.005	0.004	-0.057	-0.006	0.005	-0.014	0.003	-0.015	-0.023	0.012	-0.002	0
66109	0.068	-0.019	-0.022	-0.005	0.004	-0.057	-0.006	0.004	-0.014	0.002	-0.015	-0.023	0.012	-0.003	0
66149	0.068	-0.019	-0.022	-0.006	0.004	-0.057	-0.006	0.004	-0.014	0.002	-0.015	-0.023	0.012	-0.003	0
73060	0.068	-0.019	-0.023	-0.006	0.003	-0.057	-0.006	0.004	-0.015	0.002	-0.015	-0.024	0.012	-0.003	0
73167	0.068	-0.019	-0.023	-0.006	0.003	-0.057	-0.006	0.004	-0.015	0.002	-0.015	-0.024	0.012	-0.003	0
73282	0.068	-0.02	-0.024	-0.006	0.003	-0.058	-0.006	0.004	-0.015	0.002	-0.016	-0.024	0.013	-0.003	0
73394	0.068	-0.021	-0.026	-0.006	0.003	-0.06	-0.006	0.003	-0.015	0.002	-0.017	-0.025	0.013	-0.003	0
73503	0.068	-0.021	-0.028	-0.007	0.003	-0.06	-0.007	0.003	-0.018	0.002	-0.018	-0.025	0.013	-0.003	0
73638	0.068	-0.022	-0.03	-0.008	0.003	-0.06	-0.007	0.003	-0.019	0.002	-0.019	-0.025	0.013	-0.003	0
74114	0.068	-0.023	-0.032	-0.009	0.003	-0.06	-0.007	0.003	-0.019	0.002	-0.019	-0.025	0.013	-0.003	-0.001
74236	0.068	-0.023	-0.032	-0.009	0.003	-0.06	-0.008	0.003	-0.019	0.002	-0.019	-0.025	0.013	-0.003	-0.001
74401	0.068	-0.024	-0.034	-0.01	0.003	-0.06	-0.008	0.003	-0.019	0.002	-0.021	-0.025	0.013	-0.003	-0.001
74666	0.067	-0.026	-0.038	-0.012	0.002	-0.06	-0.009	0.002	-0.02	0.002	-0.023	-0.026	0.013	-0.003	-0.001
74848	0.065	-0.028	-0.043	-0.014	0.002	-0.06	-0.01	0.002	-0.022	0.002	-0.025	-0.027	0.013	-0.003	-0.001
75214	0.06	-0.031	-0.049	-0.017	0.001	-0.06	-0.01	0.002	-0.022	0.002	-0.029	-0.03	0.013	-0.005	-0.001
75412	0.055	-0.033	-0.059	-0.018	0	-0.062	-0.01	0.002	-0.022	0.002	-0.031	-0.032	0.013	-0.005	-0.001
75660	0.043	-0.035	-0.069	-0.02	0	-0.065	-0.01	0.002	-0.022	0.002	-0.034	-0.036	0.012	-0.006	-0.001
75992	0.035	-0.037	-0.076	-0.021	-0.001	-0.076	-0.009	0.002	-0.022	0.002	-0.037	-0.039	0.011	-0.007	-0.001
76382	0.027	-0.039	-0.081	-0.021	0	-0.087	-0.009	0.002	-0.022	0.002	-0.039	-0.041	0.01	-0.008	-0.001
76736	0.02	-0.041	-0.087	-0.021	-0.001	-0.094	-0.01	0.002	-0.022	0.002	-0.042	-0.043	0.008	-0.009	-0.001
76975	0.012	-0.042	-0.091	-0.021	-0.001	-0.099	-0.011	0.002	-0.023	0.002	-0.045	-0.044	0.007	-0.01	-0.002
77155	0.003	-0.042	-0.095	-0.021	0	-0.1	-0.013	0.002	-0.024	0.002	-0.049	-0.046	0.005	-0.012	-0.002
77583	-0.009	-0.053	-0.109	-0.02	0	-0.108	-0.015	0	-0.025	0.002	-0.04	-0.047	-0.004	-0.013	-0.044
77794	-0.012	-0.057	-0.118	-0.02	0	-0.11	-0.016	-0.002	-0.026	0.002	-0.04	-0.048	-0.005	-0.013	-0.044
78091	-0.013	-0.061	-0.128	-0.02	0	-0.113	-0.018	-0.004	-0.026	0.002	-0.04	-0.049	-0.007	-0.013	-0.044
78310	-0.015	-0.063	-0.135	-0.021	0	-0.114	-0.019	-0.005	-0.026	0.002	-0.039	-0.05	-0.009	-0.013	-0.044
78555	-0.016	-0.066	-0.14	-0.021	0	-0.116	-0.02	-0.006	-0.03	0.002	-0.039	-0.051	-0.011	-0.013	-0.044
79159	-0.018	-0.07	-0.145	-0.021	0	-0.118	-0.022	-0.008	-0.029	0.002	-0.039	-0.051	-0.014	-0.013	-0.044
79593	-0.018	-0.07	-0.146	-0.021	0	-0.118	-0.022	-0.008	-0.029	0.002	-0.039	-0.052	-0.017	-0.013	-0.044
79624	-0.018	-0.07	-0.146	-0.021	0	-0.118	-0.022	-0.008	-0.029	0.002	-0.039	-0.052	-0.017	-0.013	-0.044
79721	-0.018	-0.07	-0.146	-0.021	0	-0.118	-0.021	-0.008	-0.029	0.002	-0.039	-0.051	-0.017	-0.013	-0.044
79948	-0.018	-0.069	-0.145	-0.021	0	-0.118	-0.021	-0.008	-0.029	0.002	-0.039	-0.051	-0.017	-0.013	-0.044
80344	-0.018	-0.068	-0.145	-0.021	0	-0.118	-0.021	-0.008	-0.029	0.002	-0.039	-0.051	-0.017	-0.013	-0.043
87037	-0.017	-0.066	-0.144	-0.034	0.001	-0.116	-0.021	-0.007	-0.028	0.003	-0.038	-0.05	-0.017	-0.013	-0.043
97407	-0.017	-0.066	-0.144	-0.033	0.001	-0.116	-0.021	-0.008	-0.028	0.002	-0.037	-0.049	-0.017	-0.012	-0.042
97669	-0.017	-0.066	-0.144	-0.033	0.001	-0.116	-0.021	-0.008	-0.028	0.002	-0.037	-0.05	-0.017	-0.012	-0.042
97775	-0.017	-0.067	-0.145	-0.033	0.001	-0.117	-0.021	-0.008	-0.028	0.002	-0.037	-0.05	-0.017	-0.012	-0.042
97938	-0.017	-0.068	-0.147	-0.033	0.001	-0.117	-0.021	-0.008	-0.028	0.002	-0.037	-0.051	-0.017	-0.012	-0.042
98040	-0.017	-0.069	-0.149	-0.034	0.001	-0.118	-0.022	-0.008	-0.028	0.002	-0.037	-0.051	-0.018	-0.012	-0.042
98304	-0.017	-0.071	-0.152	-0.034	0.001	-0.119	-0.023	-0.009	-0.028	0.002	-0.037	-0.052	-0.021	-0.012	-0.042
98416	-0.018	-0.072	-0.157	-0.034	0.001	-0.12	-0.023	-0.009	-0.028	0.002	-0.037	-0.052	-0.023	-0.012	-0.042
98613	-0.019	-0.074	-0.162	-0.034	0.001	-0.121	-0.024	-0.009	-0.029	0.002	-0.038	-0.053	-0.025	-0.013	-0.042
98720	-0.02	-0.076	-0.164	-0.034	0	-0.122	-0.025	-0.01	-0.029	0.002	-0.038	-0.054	-0.027	-0.013	-0.043
98917	-0.022	-0.08	-0.169	-0.036	0	-0.123	-0.03	-0.01	-0.029	0.002	-0.038	-0.054	-0.032	-0.013	-0.043
99115	-0.023	-0.084	-0.172	-0.038	0	-0.124	-0.033	-0.011	-0.029	0.002	-0.039	-0.055	-0.034	-0.013	-0.043
99312	-0.024	-0.088	-0.177	-0.04	0	-0.125	-0.035	-0.011	-0.032	0.002	-0.04	-0.056	-0.037	-0.013	-0.043
99500	-0.025	-0.091	-0.183	-0.043	0	-0.127	-0.039	-0.012	-0.034	0.002	-0.041	-0.057	-0.04	-0.013	-0.043
99869	-0.027	-0.094	-0.188	-0.048	-0.001	-0.129	-0.045	-0.013	-0.034	0.002	-0.042	-0.059	-0.045	-0.013	-0.043
100074	-0.028	-0.096	-0.192	-0.049	-0.001	-0.131	-0.048	-0.013	-0.034	0.001	-0.043	-0.06	-0.05	-0.014	-0.043
100261	-0.029	-0.099	-0.196	-0.052	-0.001	-0.133	-0.051	-0.014	-0.038	0.001	-0.045	-0.061	-0.054	-0.014	-0.043
100487	-0.03	-0.101	-0.201	-0.054	-0.002	-0.135	-0.054	-0.014	-0.038	0.001	-0.046	-0.062	-0.057	-0.014	-0.054
100734	-0.031	-0.104	-0.206	-0.056	-0.002	-0.137	-0.058	-0.015	-0.038	0.001	-0.049	-0.063	-0.061	-0.015	-0.054
101232	-0.032	-0.107	-0.211	-0.06	-0.002	-0.139	-0.062	-0.016	-0.038	0	-0.053	-0.064	-0.066	-0.016	-0.054
101336	-0.032	-0.11	-0.214	-0.062	-0.002	-0.141	-0.064	-0.016	-0.038	0	-0.055	-0.065	-0.067	-0.016	-0.054
101796	-0.033	-0.113	-0.218	-0.067	-0.001	-0.143	-0.066	-0.017	-0.039	0	-0.059	-0.066	-0.071	-0.017	-0.059
101996	-0.034	-0.114	-0.22	-0.072	-0.001	-0.145	-0.069	-0.017	-0.04	0	-0.06	-0.067	-0.073	-0.018	-0.059
102240	-0.035	-0.116	-0.222	-0.077	-0.001	-0.146	-0.072	-0.017	-0.043	0	-0.063	-0.069	-0.077	-0.018	-0.059
102477	-0.035	-0.106	-0.224	-0.08	-0.001	-0.149	-0.076	-0.018	-0.043	-0.001	-0.065	-0.07	-0.081	-0.019	-0.059
102614	-0.036	-0.107	-0.227	-0.082	-0.001	-0.15	-0.08	-0.018	-0.043	-0.001	-0.066	-0.071	-0.084	-0.019	-0.064
102985	-0.037	-0.11	-0.235	-0.087	0	-0.153	-0.089	-0.019	-0.043	-0.001	-0.069	-0.072	-0.09	-0.02	-0.064
103370	-0.038	-0.113	-0.242	-0.091	0	-0.157	-0.1	-0.02	-0.044	-0.002	-0.071	-0.075	-0.094	-0.02	-0.064
103679	-0.038	-0.115	-0.245	-0.093	0	-0.16	-0.105	-0.02	-0.044	-0.002	-0.073	-0.076	-0.098	-0.02	-0.067
103964	-0.039	-0.118	-0.25	-0.096	0	-0.164	-0.107	-0.021	-0.048	-0.002	-0.074	-0.077	-0.102	-0.021	-0.067
104433	-0.04	-0.122	-0.263	-0.1	0	-0.17	-0.109	-0.022	-0.048	-0.003	-0.075	-0.08	-0.109	-0.021	-0.069
104972	-0.041	-0.126	-0.272	-0.104	0	-0.174	-0.111	-0.022	-0.049	-0.003	-0.076	-0.082	-0.113	-0.022	-0.069
105202	-0.042	-0.129	-0.277	-0.106	0	-0.177	-0.113	-0.023	-0.051	-0.003	-0.077	-0.083	-0.116	-0.022	-0.069
105847	-0.043	-0.134	-0.286	-0.109	-0.001	-0.181	-0.116	-0.024	-0.052	-0.009	-0.078	-0.087	-0.121	-0.023	-0.072
106129	-0.044	-0.136	-0.291	-0.11	-0.001	-0.185	-0.118	-0.025	-0.056	-0.01	-0.078	-0.089	-0.124	-0.024	-0.072
106348	-0.045	-0.139	-0.297	-0.111	-0.001	-0.188	-0.119	-0.025	-0.056	-0.012	-0.078	-0.095	-0.126	-0.025	-0.072
106886	-0.045	-0.142	-0.303	-0.113	-0.001	-0.19	-0.12	-0.025	-0.056	-0.014	-0.078	-0.099	-0.128	-0.025	-0.075
106980	-0.045	-0.142	-0.302	-0.113	-0.001	-0.19	-0.12	-0.025	-0.056	-0.014	-0.078	-0.099	-0.128	-0.025	-0.075
107092	-0.045	-0.142	-0.302	-0.113	-0.001	-0.19	-0.12	-0.025	-0.056	-0.014	-0.078	-0.099	-0.128	-0.025	-0.075
107201	-0.045	-0.141	-0.302	-0.113	-0.001	-0.189	-0.12	-0.025	-0.056	-0.014	-0.078	-0.099	-0.127	-0.025	-0.075
107245	-0.045	-0.141	-0.302	-0.113	-0.001	-0.189	-0.12	-0.025	-0.056	-0.014	-0.078	-0.099	-0.127	-0.025	-0.075
107372	-0.045	-0.141	-0.301	-0.113	-0.001	-0.188	-0.119	-0.025	-0.056	-0.014	-0.078	-0.099	-0.127	-0.025	-0.075
121270	-0.044	-0.141	-0.3	-0.112	-0.001	-0.186	-0.118	-0.02	-0.056	-0.013	-0.079	-0.101	-0.125	-0.025	-0.075
128483	-0.044	-0.142	-0.3	-0.112	-0.001	-0.186	-0.118	-0.02	-0.056	-0.014	-0.079	-0.101	-0.126	-0.025	-0.075
128584	-0.044	-0.142	-0.301	-0.112	-0.002	-0.187	-0.119	-0.02	-0.056	-0.014	-0.079	-0.101	-0.126	-0.025	-0.075
128667	-0.044	-0.143	-0.302	-0.112	-0.002	-0.188	-0.119	-0.02	-0.056	-0.014	-0.079	-0.101	-0.127	-0.025	-0.075
128804	-0.045	-0.143	-0.304	-0.112	-0.002	-0.19	-0.12	-0.021	-0.056	-0.014	-0.079	-0.101	-0.128	-0.025	-0.075
128921	-0.045	-0.144	-0.307	-0.112	-0.002	-0.192	-0.121	-0.021	-0.056	-0.014	-0.08	-0.102	-0.129	-0.025	-0.075
129334	-0.045	-0.146	-0.312	-0.113	-0.002	-0.196	-0.121	-0.022	-0.057	-0.014	-0.081	-0.104	-0.131	-0.025	-0.075
129759	-0.045	-0.147	-0.317	-0.114	-0.002	-0.199	-0.122	-0.022	-0.057	-0.014	-0.082	-0.107	-0.133	-0.026	-0.075
129894	-0.045	-0.149	-0.321	-0.115	-0.002	-0.2	-0.123	-0.023	-0.062	-0.014	-0.082	-0.108	-0.135	-0.026	-0.075
130111	-0.046	-0.152	-0.329	-0.117	-0.003	-0.203	-0.124	-0.023	-0.063	-0.014	-0.083	-0.11	-0.138	-0.027	-0.075
130395	-0.047	-0.154	-0.337	-0.118	-0.003	-0.203	-0.126	-0.024	-0.065	-0.014	-0.083	-0.114	-0.14	-0.028	-0.075
130603	-0.048	-0.156	-0.343	-0.118	-0.004	-0.205	-0.127	-0.024	-0.067	-0.014	-0.085	-0.117	-0.142	-0.028	-0.075
130918	-0.049	-0.158	-0.35	-0.12	-0.005	-0.206	-0.129	-0.024	-0.068	-0.017	-0.086	-0.12	-0.145	-0.029	-0.079
131495	-0.05	-0.161	-0.359	-0.121	-0.006	-0.209	-0.132	-0.025	-0.075	-0.019	-0.089	-0.124	-0.149	-0.03	-0.079
131857	-0.051	-0.164	-0.365	-0.122	-0.007	-0.211	-0.134	-0.025	-0.081	-0.021	-0.092	-0.128	-0.151	-0.031	-0.08
132826	-0.051	-0.168	-0.374	-0.123	-0.009	-0.215	-0.139	-0.026	-0.09	-0.024	-0.095	-0.133	-0.156	-0.033	-0.083
133339	-0.051	-0.172	-0.38	-0.123	-0.011	-0.217	-0.142	-0.026	-0.096	-0.025	-0.097	-0.136	-0.16	-0.034	-0.083
134145	-0.052	-0.177	-0.388	-0.125	-0.014	-0.219	-0.148	-0.027	-0.107	-0.027	-0.099	-0.143	-0.166	-0.036	-0.089
134772	-0.052	-0.184	-0.392	-0.125	-0.016	-0.221	-0.151	-0.028	-0.114	-0.031	-0.101	-0.148	-0.173	-0.038	-0.089
134971	-0.053	-0.187	-0.395	-0.126	-0.017	-0.223	-0.153	-0.028	-0.121	-0.033	-0.101	-0.151	-0.179	-0.039	-0.096
135702	-0.053	-0.195	-0.403	-0.127	-0.022	-0.226	-0.158	-0.029	-0.128	-0.036	-0.104	-0.164	-0.188	-0.043	-0.096
136268	-0.053	-0.201	-0.408	-0.128	-0.026	-0.228	-0.161	-0.029	-0.132	-0.039	-0.105	-0.175	-0.195	-0.047	-0.097
137134	-0.053	-0.209	-0.412	-0.129	-0.031	-0.232	-0.165	-0.03	-0.136	-0.043	-0.108	-0.19	-0.199	-0.054	-0.105
137461	-0.054	-0.214	-0.415	-0.13	-0.033	-0.234	-0.168	-0.031	-0.14	-0.046	-0.109	-0.197	-0.202	-0.057	-0.105
137869	-0.054	-0.218	-0.418	-0.131	-0.036	-0.237	-0.173	-0.032	-0.144	-0.05	-0.11	-0.204	-0.205	-0.061	-0.109
138580	-0.054	-0.225	-0.423	-0.133	-0.043	-0.242	-0.179	-0.033	-0.15	-0.054	-0.113	-0.215	-0.211	-0.069	-0.111
139155	-0.054	-0.232	-0.428	-0.135	-0.049	-0.247	-0.183	-0.034	-0.156	-0.056	-0.115	-0.224	-0.214	-0.079	-0.117
140118	-0.054	-0.242	-0.437	-0.137	-0.058	-0.251	-0.19	-0.036	-0.187	-0.06	-0.119	-0.248	-0.221	-0.088	-0.122

NAME	LP1	LP2	LP3	LP4	LP5	LP6	LP7	LP8	LP9	LP10	LP11	LP12	LP13	LP14	LP15
UNIT	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
ROW #															
141639	-0.054	-0.251	-0.444	-0.14	-0.065	-0.256	-0.2	-0.041	-0.202	-0.063	-0.123	-0.267	-0.228	-0.096	-0.126
141796	-0.054	-0.251	-0.443	-0.14	-0.065	-0.256	-0.2	-0.041	-0.202	-0.063	-0.123	-0.267	-0.228	-0.096	-0.126
141933	-0.053	-0.251	-0.443	-0.14	-0.065	-0.256	-0.201	-0.041	-0.202	-0.063	-0.123	-0.267	-0.228	-0.096	-0.126
142066	-0.053	-0.251	-0.443	-0.14	-0.065	-0.255	-0.201	-0.041	-0.202	-0.063	-0.123	-0.267	-0.227	-0.096	-0.126
142220	-0.053	-0.251	-0.443	-0.14	-0.065	-0.255	-0.201	-0.041	-0.202	-0.063	-0.123	-0.266	-0.227	-0.096	-0.126
142363	-0.053	-0.251	-0.443	-0.14	-0.065	-0.255	-0.201	-0.041	-0.202	-0.063	-0.123	-0.266	-0.227	-0.096	-0.126
142473	-0.052	-0.25	-0.442	-0.141	-0.065	-0.254	-0.201	-0.041	-0.202	-0.063	-0.123	-0.266	-0.226	-0.096	-0.126
142522	-0.052	-0.25	-0.442	-0.141	-0.065	-0.253	-0.201	-0.041	-0.202	-0.063	-0.123	-0.266	-0.226	-0.096	-0.126
142720	-0.051	-0.25	-0.441	-0.141	-0.065	-0.252	-0.201	-0.041	-0.202	-0.064	-0.123	-0.266	-0.225	-0.096	-0.126
142932	-0.051	-0.25	-0.441	-0.141	-0.065	-0.251	-0.202	-0.041	-0.202	-0.064	-0.123	-0.266	-0.225	-0.096	-0.126
143042	-0.05	-0.25	-0.44	-0.141	-0.065	-0.249	-0.202	-0.04	-0.202	-0.064	-0.123	-0.265	-0.224	-0.096	-0.126
162000	-0.047	-0.252	-0.446	-0.141	-0.067	-0.248	-0.204	-0.036	-0.202	-0.064	-0.122	-0.277	-0.225	-0.098	-0.126
162752	-0.047	-0.252	-0.446	-0.141	-0.068	-0.248	-0.204	-0.037	-0.202	-0.064	-0.122	-0.277	-0.225	-0.098	-0.127
162804	-0.047	-0.253	-0.446	-0.141	-0.068	-0.248	-0.204	-0.037	-0.202	-0.064	-0.123	-0.277	-0.225	-0.098

NAME	LP1	LP2	LP3	LP4	LP5	LP6	LP7	LP8	LP9	LP10	LP11	LP12	LP13	LP14	LP15
UNIT	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
ROW #															
175430	-0.051	-0.987	-0.746	-0.319	-0.222	-0.405	-0.736	-0.276	-0.912	-0.249	-0.35	-0.512	-0.515	-0.3	-0.32
175503	-0.052	-0.999	-0.75	-0.32	-0.226	-0.407	-0.739	-0.28	-0.919	-0.251	-0.353	-0.513	-0.52	-0.302	-0.321
175543	-0.052	-1.005	-0.752	-0.32	-0.229	-0.409	-0.741	-0.281	-0.923	-0.251	-0.355	-0.514	-0.523	-0.303	-0.322
175576	-0.053	-1.012	-0.754	-0.321	-0.232	-0.41	-0.742	-0.282	-0.928	-0.252	-0.357	-0.515	-0.527	-0.304	-0.323
175884	-0.057	-1.069	-0.779	-0.324	-0.257	-0.421	-0.755	-0.293	-1.007	-0.259	-0.377	-0.525	-0.541	-0.314	-0.328
175997	-0.058	-1.085	-0.794	-0.326	-0.271	-0.426	-0.761	-0.297	-1.041	-0.261	-0.383	-0.529	-0.543	-0.319	-0.331
176102	0.059	-1.1	-0.815	-0.327	-0.286	-0.431	-0.766	-0.301	-1.074	-0.263	-0.388	-0.531	-0.545	-0.325	-0.334
176231	-0.06	-1.118	-0.823	-0.331	-0.299	-0.439	-0.775	-0.305	-1.102	-0.265	-0.393	-0.534	-0.548	-0.331	-0.335
176278	-0.06	-1.128	-0.826	-0.332	-0.305	-0.443	-0.777	-0.307	-1.113	-0.265	-0.395	-0.535	-0.549	-0.333	-0.336
176410	-0.061	-1.156	-0.835	-0.334	-0.323	-0.453	-0.785	-0.313	-1.138	-0.267	-0.4	-0.539	-0.556	-0.337	-0.338
176668	-0.064	-1.213	-0.846	-0.339	-0.336	-0.471	-0.803	-0.332	-1.177	-0.276	-0.411	-0.548	-0.574	-0.345	-0.344
176858	-0.068	-1.246	-0.85	-0.342	-0.344	-0.486	-0.817	-0.342	-1.239	-0.283	-0.42	-0.556	-0.583	-0.352	-0.347
176962	-0.07	-1.273	-0.853	-0.344	-0.348	-0.492	-0.828	-0.347	-1.263	-0.292	-0.427	-0.56	-0.59	-0.355	-0.35
177002	-0.071	-1.281	-0.855	-0.346	-0.35	-0.495	-0.833	-0.35	-1.27	-0.295	-0.431	-0.562	-0.595	-0.357	-0.351
177048	-0.073	-1.289	-0.858	-0.348	-0.353	-0.498	-0.84	-0.356	-1.278	-0.299	-0.437	-0.564	-0.603	-0.36	-0.353
177121	-0.075	-1.299	-0.877	-0.354	-0.357	-0.502	-0.853	-0.369	-1.291	-0.304	-0.46	-0.569	-0.612	-0.364	-0.355
177135	-0.075	-1.301	-0.879	-0.355	-0.359	-0.503	-0.854	-0.371	-1.293	-0.305	-0.465	-0.57	-0.614	-0.365	-0.356
177151	-0.076	-1.303	-0.882	-0.356	-0.36	-0.504	-0.857	-0.373	-1.295	-0.306	-0.471	-0.57	-0.616	-0.366	-0.356
177163	-0.076	-1.304	-0.884	-0.357	-0.361	-0.505	-0.858	-0.374	-1.297	-0.307	-0.475	-0.571	-0.617	-0.366	-0.356
177175	-0.076	-1.305	-0.885	-0.358	-0.362	-0.505	-0.859	-0.376	-1.298	-0.308	-0.477	-0.571	-0.618	-0.368	-0.357
177185	-0.076	-1.306	-0.886	-0.358	-0.363	-0.506	-0.86	-0.377	-1.299	-0.308	-0.479	-0.572	-0.619	-0.368	-0.357
177195	-0.076	-1.307	-0.887	-0.359	-0.364	-0.506	-0.861	-0.378	-1.301	-0.309	-0.481	-0.572	-0.619	-0.368	-0.357
177207	-0.076	-1.308	-0.888	-0.36	-0.365	-0.507	-0.862	-0.379	-1.302	-0.309	-0.482	-0.573	-0.62	-0.369	-0.357
177224	-0.076	-1.31	-0.89	-0.361	-0.366	-0.507	-0.863	-0.381	-1.304	-0.31	-0.485	-0.576	-0.621	-0.37	-0.357
177247	-0.077	-1.311	-0.892	-0.362	-0.367	-0.508	-0.865	-0.385	-1.306	-0.311	-0.489	-0.579	-0.622	-0.371	-0.357
177279	-0.077	-1.313	-0.896	-0.363	-0.369	-0.509	-0.867	-0.392	-1.31	-0.313	-0.494	-0.582	-0.624	-0.372	-0.357
177315	-0.078	-1.315	-0.901	-0.365	-0.37	-0.51	-0.869	-0.399	-1.314	-0.314	-0.501	-0.584	-0.625	-0.373	-0.357
177361	-0.079	-1.318	-0.907	-0.366	-0.372	-0.511	-0.872	-0.397	-1.319	-0.316	-0.507	-0.587	-0.626	-0.374	-0.358
177389	-0.079	-1.319	-0.912	-0.367	-0.373	-0.511	-0.874	-0.398	-1.323	-0.317	-0.51	-0.59	-0.627	-0.375	-0.358
177398	-0.079	-1.32	-0.914	-0.367	-0.373	-0.512	-0.875	-0.399	-1.326	-0.318	-0.511	-0.591	-0.628	-0.375	-0.358
177413	-0.08	-1.322	-0.916	-0.368	-0.374	-0.512	-0.876	-0.4	-1.332	-0.318	-0.513	-0.592	-0.629	-0.376	-0.358
177549	-0.083	-1.338	-0.944	-0.373	-0.379	-0.516	-0.896	-0.409	-1.373	-0.331	-0.53	-0.605	-0.637	-0.385	-0.364
177574	-0.083	-1.34	-0.951	-0.375	-0.38	-0.517	-0.9	-0.411	-1.379	-0.334	-0.532	-0.607	-0.638	-0.388	-0.365
177598	-0.083	-1.342	-0.956	-0.376	-0.381	-0.517	-0.904	-0.413	-1.385	-0.335	-0.536	-0.61	-0.639	-0.39	-0.366
177621	-0.083	-1.345	-0.959	-0.377	-0.382	-0.518	-0.907	-0.416	-1.39	-0.336	-0.539	-0.613	-0.64	-0.392	-0.367
177639	-0.083	-1.347	-0.962	-0.377	-0.382	-0.518	-0.909	-0.417	-1.394	-0.336	-0.541	-0.614	-0.64	-0.393	-0.368
177659	-0.083	-1.35	-0.965	-0.378	-0.383	-0.518	-0.91	-0.419	-1.4	-0.337	-0.543	-0.617	-0.641	-0.394	-0.369
177682	-0.083	-1.352	-0.967	-0.379	-0.384	-0.519	-0.912	-0.421	-1.404	-0.338	-0.546	-0.62	-0.642	-0.396	-0.37
177988	-0.087	-1.379	-1.05	-0.391	-0.399	-0.529	-0.951	-0.452	-1.49	-0.368	-0.59	-0.666	-0.654	-0.421	-0.386
178024	-0.087	-1.382	-1.06	-0.392	-0.401	-0.53	-0.956	-0.459	-1.498	-0.348	-0.597	-0.669	-0.656	-0.424	-0.388
178049	-0.088	-1.385	-1.065	-0.394	-0.402	-0.532	-0.959	-0.464	-1.503	-0.349	-0.6	-0.671	-0.657	-0.425	-0.39
178293	-0.095	-1.409	-1.137	-0.401	-0.439	-0.544	-0.999	-0.491	-1.548	-0.356	-0.654	-0.69	-0.671	-0.446	-0.409
178327	-0.096	-1.412	-1.146	-0.401	-0.443	-0.546	-1.011	-0.495	-1.556	-0.359	-0.663	-0.693	-0.674	-0.448	-0.411
178408	-0.099	-1.429	-1.165	-0.403	-0.455	-0.551	-1.032	-0.504	-1.573	-0.364	-0.688	-0.703	-0.679	-0.452	-0.414
178503	-0.103	-1.444	-1.186	-0.407	-0.466	-0.558	-1.051	-0.519	-1.599	-0.37	-0.715	-0.711	-0.686	-0.457	-0.418
178624	-0.109	-1.466	-1.207	-0.414	-0.484	-0.565	-1.075	-0.551	-1.627	-0.382	-0.739	-0.721	-0.7	-0.465	-0.425
178702	-0.112	-1.479	-1.22	-0.421	-0.5	-0.568	-1.099	-0.568	-1.644	-0.388	-0.758	-0.726	-0.713	-0.471	-0.428
178729	-0.113	-1.484	-1.228	-0.423	-0.503	-0.569	-1.111	-0.572	-1.659	-0.389	-0.764	-0.729	-0.717	-0.473	-0.43
178805	-0.117	-1.495	-1.238	-0.432	-0.511	-0.572	-1.143	-0.581	-1.704	-0.394	-0.787	-0.736	-0.732	-0.477	-0.432
178848	-0.119	-1.503	-1.248	-0.437	-0.514	-0.574	-1.151	-0.586	-1.731	-0.396	-0.802	-0.738	-0.735	-0.479	-0.434
179059	-0.132	-1.544	-1.305	-0.464	-0.533	-0.584	-1.196	-0.635	-1.806	-0.404	-0.827	-0.748	-0.746	-0.484	-0.444
179177	-0.141	-1.569	-1.37	-0.501	-0.543	-0.6	-1.249	-0.686	-1.887	-0.411	-0.911	-0.764	-0.758	-0.506	-0.463
179295	-0.154	-1.595	-1.401	-0.525	-0.556	-0.625	-1.339	-0.733	-1.963	-0.419	-0.991	-0.794	-0.768	-0.523	-0.48
179468	-0.181	-1.638	-1.445	-0.533	-0.607	-0.652	-1.454	-0.8	-2.073	-0.429	-1.045	-0.836	-0.779	-0.541	-0.502
179638	-0.202	-1.668	-1.535	-0.54	-0.664	-0.67	-1.59	-0.897	-2.179	-0.444	-1.089	-0.871	-0.814	-0.558	-0.526
179756	-0.218	-1.712	-1.585	-0.549	-0.707	-0.682	-1.692	-0.962	-2.322	-0.462	-1.149	-0.887	-0.848	-0.574	-0.562
179847	-0.23	-1.773	-1.635	-0.562	-0.734	-0.703	-1.81	-1.043	-2.415	-0.479	-1.208	-0.909	-0.863	-0.596	-0.576
179896	-0.236	-1.789	-1.664	-0.569	-0.74	-0.718	-1.879	-1.074	-2.446	-0.494	-1.257	-0.925	-0.885	-0.606	-0.581
179940	-0.24	-1.802	-1.687	-0.578	-0.743	-0.724	-1.912	-1.088	-2.488	-0.501	-1.276	-0.94	-0.901	-0.611	-0.583
180109	-0.251	-1.837	-1.738	-0.617	-0.761	-0.743	-2.01	-1.157	-2.549	-0.516	-1.308	-0.985	-0.946	-0.625	-0.59
180198	-0.259	-1.862	-1.79	-0.657	-0.779	-0.764	-2.138	-1.41	-2.557	-0.532	-1.352	-1.019	-0.965	-0.636	-0.597
180306	-0.272	-1.919	-1.832	-0.682	-0.855	-0.781	-2.26	-1.574	-2.607	-0.546	-1.386	-1.051	-0.985	-0.649	-0.605
180360	-0.28	-1.962	-1.874	-0.69	-0.888	-0.787	-2.294	-1.636	-2.658	-0.55	-1.409	-1.062	-0.993	-0.654	-0.607
180402	-0.284	-1.974	-1.897	-0.694	-0.898	-0.791	-2.309	-1.667	-2.678	-0.552	-1.428	-1.073	-0.998	-0.658	-0.608
180463	-0.29	-1.984	-1.911	-0.701	-0.914	-0.795	-2.332	-1.715	-2.689	-0.554	-1.447	-1.084	-1.006	-0.663	-0.609
180785	-0.312	-2.026	-1.979	-0.738	-0.946	-0.816	-2.451	-1.859	-2.756	-0.566	-1.516	-1.13	-1.066	-0.696	-0.616
180906	-0.32	-2.04	-2.004	-0.76	-0.964	-0.832	-2.475	-1.938	-2.813	-0.571	-1.534	-1.15	-1.111	-0.701	-0.619
180921	-0.321	-2.041	-2.005	-0.762	-0.965	-0.833	-2.478	-1.942	-2.816	-0.571	-1.535	-1.151	-1.114	-0.701	-0.619
180943	-0.321	-2.042	-2.005	-0.763	-0.967	-0.833	-2.481	-1.946	-2.817	-0.571	-1.536	-1.151	-1.116	-0.701	-0.619
181110	-0.329	-2.049	-2.015	-0.769	-0.976	-0.845	-2.505	-1.963	-2.841	-0.573	-1.547	-1.159	-1.124	-0.704	-0.62
181311	-0.337	-2.057	-2.024	-0.773	-0.982	-0.855	-2.532	-1.979	-2.854	-0.574	-1.554	-1.165	-1.127	-0.708	-0.62
181454	-0.342	-2.061	-2.026	-0.775	-0.986	-0.858	-2.55	-1.989	-2.858	-0.574	-1.559	-1.168	-1.129	-0.71	-0.62
181633	-0.346	-2.065	-2.03	-0.777	-0.989	-0.86	-2.555	-1.999	-2.862	-0.574	-1.563	-1.172	-1.132	-0.712	-0.621
181740	-0.347	-2.067	-2.03	-0.777	-0.991	-0.86	-2.558	-2.005	-2.864	-0.574	-1.564	-1.173	-1.133	-0.713	-0.621
181846	-0.348	-2.068	-2.031	-0.778	-0.993	-0.86	-2.559	-2.015	-2.864	-0.574	-1.565	-1.173	-1.134	-0.713	-0.621
181968	-0.348	-2.069	-2.032	-0.779	-0.994	-0.861	-2.56	-2.025	-2.864	-0.574	-1.566	-1.174	-1.135	-0.714	-0.621
184040	-0.369	-2.097	-2.055	-0.787	-1.01	-0.868	-2.594	-2.088	-2.879	-0.575	-1.585	-1.189	-1.143	-0.722	-0.621
185345	-0.376	-2.112	-2.063	-0.791	-1.016	-0.871	-2.607	-2.11	-2.886	-0.575	-1.593	-1.194	-1.147	-0.728	-0.621
185375	-0.377	-2.115	-2.065	-0.792	-1.017	-0.872	-2.608	-2.112	-2.887	-0.575	-1.595	-1.195	-1.147	-0.729	-0.621
185455	-0.38	-2.119	-2.069	-0.793	-1.018	-0.873	-2.613	-2.117	-2.89	-0.576	-1.598	-1.197	-1.15	-0.733	-0.627
185526	-0.382	-2.123	-2.072	-0.794	-1.02	-0.873	-2.621	-2.123	-2.896	-0.577	-1.598	-1.199	-1.154	-0.733	-0.627
185577	-0.384	-2.127	-2.075	-0.795	-1.022	-0.874	-2.629	-2.131	-2.906	-0.577	-1.598	-1.202	-1.157	-0.735	-0.627
185648	-0.388	-2.14	-2.089	-0.795	-1.028	-0.875	-2.647	-2.156	-2.927	-0.581	-1.605	-1.21	-1.166	-0.739	-0.631
185759	-0.401	-2.155	-2.099	-0.799	-1.041	-0.882	-2.674	-2.211	-2.98	-0.589	-1.616	-1.223	-1.191	-0.746	-0.632
185828	-0.411	-2.172	-2.117	-0.806	-1.054	-0.888	-2.732	-2.275	-3.012	-0.6	-1.629	-1.242	-1.21	-0.752	-0.638
185930	-0.422	-2.205	-2.15	-0.819	-1.094	-0.904	-2.827	-2.399	-3.079	-0.62	-1.648	-1.297	-1.232	-0.777	-0.661
186054	-0.436	-2.234	-2.211	-0.858	-1.141	-0.924	-2.955	-2.5	-3.237	-0.637	-1.669	-1.34	-1.297	-0.803	-0.701
186182	-0.45	-2.293	-2.3	-0.875	-1.184	-0.945	-3.1	-2.647	-3.318	-0.659	-1.716	-1.4	-1.342	-0.824	-0.721
186285	-0.466	-2.344	-2.339	-0.909	-1.24	-0.963	-3.247	-2.758	-3.434	-0.686	-1.78	-1.447	-1.389	-0.837	-0.746
186386	-0.481	-2.392	-2.38	-0.943	-1.285	-0.987	-3.384	-2.934	-3.577	-0.715	-1.83	-1.506	-1.436	-0.845	-0.766
186454	-0.494	-2.423	-2.428	-0.962	-1.323	-1.005	-3.501	-2.998	-3.633	-0.728	-1.89	-1.613	-1.454	-0.851	-0.775
186523	-0.517	-2.465	-2.492	-0.991	-1.378	-1.054	-3.6	-3.13	-3.721	-0.749	-1.935	-1.702	-1.479	-0.864	-0.785
186584	-0.554	-2.523	-2.538	-1.025	-1.402	-1.078	-3.688	-3.2	-3.794	-0.796	-2.012	-1.738	-1.504	-0.874	-0.794
186681	-0.619	-2.56	-2.595	-1.066	-1.443	-1.099	-3.826	-3.337	-3.869	-0.839	-2.096	-1.891	-1.52	-0.888	-0.805
186774	-0.64	-2.595	-2.647	-1.109	-1.48	-1.123	-3.982	-3.444	-4.003	-0.873	-2.172	-1.998	-1.576	-0.9	-0.818
186863	-0.655	-2.638	-2.709	-1.139	-1.528	-1.155	-4.104	-3.549	-4.102	-0.889	-2.249	-2.144	-1.62	-0.911	-0.84
186926	-0.67	-2.666	-2.76	-1.155	-1.572	-1.173	-4.169	-3.637	-4.147	-0.899	-2.285	-2.22	-1.631	-0.926	-0.873
186962	-0.678	-2.682	-2.768	-1.164	-1.587	-1.182	-4.197	-3.668	-4.189	-0.904	-2.299	-2.277	-1.642	-0.934	-0.89
187023	-0.689	-2.694	-2.773	-1.172	-1.601	-1.189	-4.256	-3.703	-4.23	-0.909	-2.331	-2.339	-1.666	-0.942	-0.902
187155	-0.712	-2.731	-2.808	-1.221	-1.646	-1.202	-4.372	-3.795	-4.316	-0.928	-2.437	-2.507	-1.687	-0.957	-0.927
187243	-0.753	-2.769	-2.872	-1.262	-1.665	-1.216	-4.464	-3.9	-4.358	-0.964	-2.541	-2.754	-1.74	-0.995	-0.979
187324	-0.798	-2.803	-2.914	-1.292	-1.681	-1.229	-4.623	-4.014	-4.482	-0.992	-2.622	-3.004	-1.792	-1.02	-1.001
187408	-0.819	-2.854	-2.956	-1.327	-1.699	-1.244	-4.727	-4.099	-4.526	-0.999	-2.687	-3.214	-1.827	-1.041	-1.05
187497	-0.839	-2.899	-3.048	-1.415	-1.761	-1.271	-4.834	-4.183	-4.579	-1.013	-2.729	-3.402	-1.88	-1.057	-1.114
187605	-0.863	-2.919	-3.074	-1.442	-1.736	-1.308	-4.758	-4.148	-4.665	-1.039	-2.789	-3.598	-1.952	-1.073	-1.144
187698	-0.902	-2.953	-3.112	-1.476	-1.746	-1.33	-5.04	-4.359	-4.709	-1.068	-2.826	-3.748	-1.995	-1.089	-1.199
187753	-0.922	-2.964	-3.123	-1.492	-1.755	-1.34	-5.079	-4.389	-4.719	-1.075	-2.839	-3.789	-2.004	-1.095	-1.217
187894	-0.973	-3.001	-3.178	-1.533	-1.773	-1.366	-5.19	-4.482	-4.793	-1.1	-2.877	-3.885	-2.045	-1.111	-1.258
187978	-1.001	-3.053	-3.224	-1.577	-1.813	-1.389	-5.311	-4.587	-4.873	-1.126	-2.948	-3.97	-2.102	-1.147	-1.284
188020	-1.005	-3.069	-3.237	-1.601	-1.822	-1.394	-5.327	-4.604	-4.88	-1.131	-2.982	-4.03	-2.147	-1.164	-1.296
188097	-1.011	-3.084	-3.255	-1.611	-1.836	-1.398	-5.351	-4.624	-4.89	-1.135	-2.994	-4.113	-2.162	-1.18	-1.312
188256	-1.019	-3.095	-3.279	-1.627	-1.847	-1.403	-5.403	-4.654	-4.906	-1.142	-3.012	-4.151	-2.183	-1.2	-1.338
188544	-1.03	-3.121	-3.443	-1.655	-1.91	-1.472	-4.694	-4.924	-5.152	-1.197	-3.037	-4.125	-1.216	-1.357	
188739	-1.036	-3.126	-3.336	-1.67	-1.859	-1.415	-5.512	-4.732	-4.957	-1.161	-3.065	-4.218	-2.243	-1.226	-1.373
188852	-1.051	-3.151	-3.36	-1.73	-1.869	-1.425	-5.596	-4.806	-5.048	-1.187	-3.095	-4.331	-2.28	-1.24	-1.42
188978	-1.073	-3.177	-3.423	-1.774	-1.888	-1.445	-5.701	-4.874	-5.1	-1.199	-3.128	-4.43	-2.363	-1.262	-1.442
189094	-1.111	-3.234	-3.464	-1.789	-1.46	-1.46	-5.822	-4.955	-5.165	-1.216	-3.188	-4.586	-2.431	-1.29	-1.456
189200	-1.159	-3.303	-3.512	-1.795	-1.914	-1.482	-5.913	-5.016	-5.249	-1.242	-3.158	-4.699	-2.468	-1.339	-1.474
189308	-1.184	-3.327	-3.572	-1.804	-1.925	-1.508	-6.041	-5.085	-5.31	-1.263	-3.203	-4.774	-2.557	-1.367	-1.485
189412	-1.211	-3.353	-3.602	-1.843	-1.934	-1.544	-6.119	-5.157	-5.372	-1.287	-3.235	-4.873	-2.598	-1.386	-1.505
189545	-1.24	-3.407	-3.66	-1.888	-1.944	-1.557	-6.215	-5.231	-5.441	-1.312	-3.287	-4.98	-2.645	-1.406	-1.53
189685	-1.272	-3.466	-3.692	-1.915	-1.964	-1.568	-6.285	-5.274	-5.496	-1.333	-3.312	-5.082	-2.706	-1.424	-1.545
189792	-1.312	-3.507	-3.723	-1.939	-1.979	-1.582	-6.356	-5.314	-5.563	-1.363	-3.348	-5.133	-2.745	-1.438	-1.564
189890	-1.334	-3.538	-3.782	-1.974	-2.018	-1.601	-6.442	-5.384	-5.607	-1.371	-3.383	-5.228	-2.818	-1.455	-1.582
189989	-1.359	-3.619	-3.825	-1.989	-2.031	-1.615	-6.522	-5.431	-5.65	-1.379	-3.424	-5.333	-2.838	-1.48	-1.603
190089	-1.384	-3.675	-3.858	-2.001	-2.042	-1.628	-6.598	-5.487	-5.746	-1.389	-3.498	-5.449	-2.921	-1.508	-1.632
190178	-1.425	-3.731	-3.886	-2.072	-2.066	-1.647	-6.657	-5.542	-5.787	-1.404	-3.545	-5.498	-2.985	-1.563	-1.656
190281	-1.455	-3.814	-3.897	-2.11	-2.075	-1.662	-6.719	-5.593	-5.807	-1.429	-3.592	-5.618	-3.042	-1.59	-1.677
190373	-1.482	-3.923	-3.944	-2.139	-2.103	-1.681	-6.758	-5.688	-5.835	-1.446	-3.634	-5.67	-3.124	-1.614	-1.689
190464	-1.512	-4.032	-4.006	-2.173	-2.144	-1.698	-6.809	-5.755	-5.947	-1.46	-3.659	-5.735	-3.221	-1.635	-1.698
190575	-1.54	-4.141	-4.038	-2.211	-2.185	-1.73	-6.888	-5.796	-5.986	-1.493	-3.692	-5.833	-3.286	-1.665	-1.711
190672	-1.552	-4.252	-4.061	-2.255	-2.219	-1.759	-6.955	-5.883	-6.017	-1.512	-3.726	-5.901	-3.336	-1.684	-1.728
190773	-1.567	-4.354	-4.11	-2.288	-2.237	-1.78	-7.02	-5.953	-6.038	-1.535	-3.798	-5.992	-3.425	-1.718	-1.763
190881	-1.581	-4.489	-4.16	-2.338	-2.255	-1.801	-7.093	-5.977	-6.104	-1.552	-3.859	-6.072	-3.497	-1.758	-1.794
190980	-1.601	-4.629	-4.202	-2.357	-2.267	-1.814	-7.16	-6.022	-6.164	-1.562	-3.915	-6.158	-3.557	-1.775	-1.82
191091	-1.645	-4.808	-4.254	-2.372	-2.289	-1.828	-7.217	-6.07	-6.222	-1.582	-3.951	-6.244	-3.616	-1.801	-1.836
191194	-1.672	-4.955	-4.301	-2.415	-2.309	-1.837	-7.289	-6.118	-6.253	-1.609	-4.005	-6.314	-3.676	-1.834	-1.849
191274	-1.696	-5.217	-4.357	-2.509	-2.362	-1.849	-7.483	-6.149	-6.277	-1.625	-4.066	-6.396	-3.757	-1.865	-1.867
191347	-1.718	-5.377	-4.408	-2.526	-2.387	-1.855	-7.56	-6.182	-6.324	-1.639	-4.089	-6.5	-3.811	-1.88	-1.882
191441	-1.729	-5.532	-4.452	-2.544	-2.418	-1.865	-7.606	-6.26	-6.374	-1.648	-4.117	-6.573	-3.818	-1.898	-1.902
191566	-1.74	-5.669	-4.506	-2.565	-2.432	-1.87	-7.675	-6.309	-6.401	-1.661	-4.166	-6.682	-3.908	-1.925	-1.958
191681	-1.75	-5.795	-4.55	-2.596	-2.448	-1.877	-7.758	-6.344	-6.45	-1.673	-4.231	-6.773	-3.965	-1.945	-1.993
191778	-1.761	-5.927	-4.6	-2.661	-2.47	-1.883	-7.777	-6.382	-6.496	-1.687	-4.263	-6.901	-4.013	-1.959	-2.021
191856	-1.776	-6.06	-4.649	-2.693	-2.489	-1.896	-7.83	-6.446	-6.539	-1.706	-4.325	-6.96	-4.067	-1.986	-2.052
191924	-1.795	-6.135	-4.69	-2.708	-2.493	-1.908	-7.855	-6.478	-6.576	-1.722	-4.365	-7.031	-4.111	-2.004	-2.069
192015	-1.819	-6.274	-4.763	-2.763	-2.516	-1.931	-7.947	-6.514	-6.633	-1.747	-4.416	-7.176	-4.167	-2.023	-2.102
192096	-1.846	-6.394	-4.822	-2.782	-2.55	-1.948	-7.995	-6.541	-6.688	-1.775	-4.466	-7.248	-4.227	-2.041	-2.126
192178	-1.878	-6.499	-4.873	-2.79	-2.572	-1.961	-8.046	-6.565	-6.717	-1.796	-4.508	-7.342	-4.282	-2.065	-2.157
192261	-1.902	-6.644	-4.942	-2.836	-2.609	-1.984	-8.093	-6.595	-6.766	-1.814	-4.543	-7.449	-4.355	-2.097	-2.181
192338	-1.925	-6.746	-4.99	-2.866	-2.617	-2.002	-8.14	-6.624	-6.804	-1.823	-4.568	-7.551	-4.414	-2.111	-2.202
192418	-1.937	-6.852	-5.043	-2.891	-2.629	-2.026	-8.176	-6.652	-6.863	-1.831	-4.612	-7.623	-4.46	-2.128	-2.23
192510	-1.947	-6.987	-5.08	-2.91	-2.642	-2.043	-8.221	-6.676	-6.938	-1.84	-4.672	-7.699	-4.519	-2.148	-2.247
192604	-1.959	-7.093	-5.141	-2.944	-2.649	-2.054	-8.245	-6.707	-7.005	-1.857	-4.723	-7.784	-4.57	-2.197	-2.259
192698	-1.972	-7.222	-5.215	-2.98	-2.661	-2.064	-8.292	-6.74	-7.046	-1.88	-4.75	-7.885	-4.622	-2.235	-2.283

NAME	LP1	LP2	LP3	LP4	LP5	LP6	LP7	LP8	LP9	LP10	LP11	LP12	LP13	LP14	LP15
UNIT	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
ROW #															
192792	-1.985	-7.343	-5.281	-3.007	-2.667	-2.071	-8.324	-6.792	-7.112	-1.895	-4.785	-7.989	-4.692	-2.263	-2.316
192876	-1.999	-7.466	-5.332	-3.051	-2.684	-2.082	-8.361	-6.84	-7.165	-1.916	-4.837	-8.05	-4.75	-2.282	-2.327
192912	-1.999	-7.504	-5.341	-3.056	-2.686	-2.083	-8.368	-6.843	-7.166	-1.919	-4.844	-8.072	-4.757	-2.285	-2.329
193220	-2.003	-7.621	-5.387	-3.079	-2.713	-2.093	-8.409	-6.871	-7.24	-1.928	-4.864	-8.129	-4.784	-2.292	-2.337
193586	-2.009	-7.722	-5.422	-3.102	-2.78	-2.109	-8.437	-6.898	-7.265	-1.942	-4.908	-8.642	-4.812	-2.298	-2.345
193894	-2.01	-7.762	-5.437	-3.113	-2.785	-2.113	-8.447	-6.911	-7.267	-1.948	-4.925	-8.676	-4.848	-

EGs

NAME	EG_1B	EG_1G	EG_1W	EG_2B	EG_2G	EG_2W	EG_3B	EG_3G	EG_3W	EG_4B	EG_4G	EG_4W
UNIT	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]
ROW #												
1	-0.9	0.1	0.6	-0.8	-0.7	0.8	-0.7	-0.7	-0.3	-0.2	0.1	-5
4227	-0.2	-0.5	0.1	-0.6	-1.7	2.6	-1.2	-1.8	-1.5	-0.9	0	-13.5
4233	-0.9	-0.8	1.2	-0.5	-1.9	3	-1.5	-2.1	-1.7	-1.4	-0.4	-13.9
4238	-0.9	-0.3	0.9	-0.9	-1.7	3	-1.1	-1.7	-1.3	-2	0.1	-14.3
4240	-1.3	-0.8	0.3	-1.8	-1.4	3.1	-0.8	-1.5	-1.2	-2.5	0.6	-14.6
4244	-0.4	-1.4	0.2	-1.4	-1.7	3.2	-0.9	-1.8	-1.7	-3	0.2	-15.1
4248	-0.5	-1.8	-0.3	-1.4	-2.2	3.3	-1	-2.5	-1.4	-3.3	-0.7	-15.8
4272	-0.2	-1.9	-0.2	-0.6	-2.4	3.1	-1.9	-2.7	-1.4	-2.8	-1.1	-15.3
4301	-0.5	-2	0.7	-0.9	-2.4	3	-1.9	-2.7	-1.1	-2.4	-1.1	-14.8
4394	-1.3	-0.5	1	-0.3	-2.6	2.5	-1.9	-2.6	-0.7	-1.8	-1	-14.4
4490	-0.9	-1.9	-0.2	-0.3	-2.3	2.7	-2	-2.6	-0.9	-2	-0.8	-14.8
4510	-1.6	-2.4	0.3	-2.1	-2.2	2.5	-1.7	-2.8	-0.6	-1.9	-0.9	-14.5
4528	-0.6	-1.5	1.5	-1.4	-2.4	2.6	-1.8	-3	-0.7	-2	-1	-14.4
18434	4.5	-2.7	-0.1	-3.8	-5.8	12.2	-5.3	-6.6	-5.9	-2	-0.2	-43.6
40202	-11.9	-3.8	-2.4	-7.1	-10.4	21.4	-9.5	-11.3	-23.5	-1.8	1.1	-89.7
42198	-12.9	-3.9	-3.2	-7.4	-10.8	21.9	-9.7	-11.8	-25.1	-1.8	1	-93.4
42398	-12.3	-3.8	-3.5	-7.6	-10.8	22.2	-9.8	-11.8	-25.2	-2.1	1	-94.1
42410	-12.7	-4.1	-2.9	-8.5	-10.8	22.3	-9.6	-11.8	-24.9	-2.3	0.9	-94.2
42413	-12.5	-4.4	-3.2	-7.6	-10.8	22.1	-9.9	-11.6	-25.3	-1.9	1.2	-94.1
42520	-12.2	-3.5	-2.1	-7.9	-11	22.3	-9.8	-11.8	-25.3	-2.1	1	-94.5
42535	-12.1	-3.7	-3.8	-8.4	-10.9	22.4	-9.5	-11.7	-25.2	-2.5	0.8	-94.9
42718	-11.8	-3.4	-2.6	-7	-11	22.5	-9.5	-11.6	-25.4	-2.6	0.8	-95.5
43034	-11.9	-4.4	-3.8	-8.9	-11	22.7	-9.5	-11.9	-25.5	-2.8	0.8	-96.4
43056	-12.5	-4.8	-4.3	-9.1	-11.1	22.7	-9.4	-11.7	-25.5	-2.9	0.7	-96.6
43176	-13.1	-5.6	-4	-8.7	-11.2	22.7	-9.1	-12	-25.5	-3	0.5	-97.3
43328	-12.8	-6.3	-4.2	-8.8	-11.7	22.3	-9	-12.3	-25.5	-2.8	0.3	-98.3
43476	-12.7	-6.2	-4.1	-9	-12	22.1	-8.8	-12.6	-25.7	-2.2	0.6	-99.2
43596	-13.3	-7.8	-3.4	-8.6	-12.5	22.1	-8.5	-13.4	-26.1	-1.4	0.4	-100.2
43619	-13.1	-7.2	-3.9	-7.8	-12.6	22	-8.3	-13.7	-26.1	-1.4	0.2	-100.5
43740	-13.8	-8.8	-3.7	-8.8	-12.7	22.5	-7.9	-14.8	-26.8	-1.2	0.1	-101.6
43861	-14.7	-9.9	-4	-7.8	-12.6	22.6	-8.2	-17	-27.3	-0.8	-0.4	-102.5
44061	-19.7	-14.9	-1	-6.7	-8.2	26.2	-10.2	-21.3	-27.7	-0.3	-2.4	-104.4
44223	-24.1	-21.2	1.6	3.3	6.9	32	-11.3	-27.5	-28.1	0.6	-6	-110.5
44358	-25.4	-23.4	3.3	6.7	6.3	29.9	-13	-32.7	-28.5	1.2	-7	-112.9
44478	-28.6	-29	2.2	9.2	9.6	32.5	-13	-37.2	-30.1	1.6	-8.1	-114.7
44628	-30.6	-33.1	1.5	11.5	11.9	34.7	-11.3	-41.1	-31.9	2.4	-9.2	-117
45038	-32.8	-38.4	2.7	13.6	12.2	36	-11.1	-44.6	-33.8	3	-10.4	-118.7
45474	-33.8	-38.9	3.5	14.2	12.3	36.7	-11	-45.3	-34.4	3	-10.7	-119.9
45497	-34.1	-40.5	3	14.4	12.5	37.2	-11.1	-46.3	-34.7	3	-11	-120.6
45619	-35.6	-42	6.2	13	10.8	40.8	-11.2	-48.5	-35.4	2.5	-12	-120.8
45880	-39.5	-48.3	7.6	9	4.8	43.4	-12.8	-54.1	-37.1	0.6	-14.9	-121.3
45980	-41.3	-54	7.4	6.7	1	46.4	-12.8	-57.6	-38.7	-0.9	-16.5	-121.6
46495	-43.2	-68.1	2.4	3.8	-3.7	60.9	-10.2	-61.8	-42.8	-5.2	-23	-121
46669	-43.6	-73.2	-0.5	6.5	-2.2	67.4	-11.1	-59.7	-42.3	-6.7	-24.9	-121.2
47359	-45.2	-80.2	-5.7	46.1	14.2	117.7	16.2	-36.2	-12.3	-11.2	-28.4	-123.7
47758	-43.3	-83.2	-6.7	68.4	21.5	142.4	33.5	-28.4	23.8	-11.3	-25.8	-124.6
48016	-42.9	-83.3	-7.5	71.9	23.6	148.8	35.8	-23.9	36.5	-10.1	-22.9	-124.6
48061	-43	-84.1	-7	74.1	24	151.5	36.8	-23.7	38.5	-10.2	-22.9	-124.8
48181	-43.3	-85.5	-7.2	81	25.5	161.2	39.6	-22.5	46.6	-9.8	-21.2	-125.2
48696	-42.3	-86.5	-6.1	106.3	32.1	204.5	48.6	-17.3	79.8	-5.1	-10.8	-123.9
50890	-40.2	-85.1	-6.2	133.2	40.2	244.1	57.8	-10.7	103.4	4.8	0.8	-122.6
62108	-41.5	-85.3	-3.8	141.1	43.1	258.3	63	-10	105.5	10.2	5.7	-140.3
66109	-43.9	-87.4	-4.1	140.4	42.8	260.7	63.8	-11.4	104.5	10.7	6.2	-147.5
66149	-42.6	-85.2	-3.2	141.5	42.9	261	63.1	-11.3	104.4	10.5	6.2	-147.8
73060	-45.5	-87.6	-3.3	141.8	42.7	265.1	63.6	-14.1	102.3	10.9	6.8	-159.7
73167	-46.3	-87.9	-4.8	143.1	42.9	268.6	64.9	-14.2	104.1	10.9	6.6	-160
73282	-46.8	-89.1	-4.3	147.2	43.3	273.9	66.6	-14.5	107.5	11.2	6.4	-160.3
73394	-47	-91.6	-4.8	153.7	44.4	283.2	69.2	-14.4	113.7	12.2	6.6	-160.5
73503	-46.8	-93.5	-4.9	162	45.8	295	72.5	-14.8	122	13.5	6.8	-160.4
73638	-45.5	-94.6	-6.4	176.8	49	315.4	79.4	-14.9	147.5	16.3	7.2	-159.8
74114	-46.1	-92.7	-6	197.5	53.4	335.3	88.6	-14.8	173.5	21.2	9	-157.9
74236	-45.8	-94	-7.1	200.9	54.1	340.4	90.3	-14.8	177.5	21.7	9	-157.8
74401	-46.4	-94.9	-7.1	214.1	56.2	356	96.5	-15.2	190.4	24.4	9.3	-156.9
74666	-44.1	-95.9	-6.5	236.6	60.3	378.4	111.8	-14.6	208.6	30.6	10.3	-154.2
74848	-44.5	-97.9	-7.5	257.3	64.9	401.8	121.9	-12.5	227	37.8	11.4	-150.8
75214	-42.3	-99.5	-5.9	284.7	72.4	435.7	136.7	-10.3	252.2	52	12.8	-143.3
75412	-42.1	-102.4	-6.3	301.7	75.5	458.5	146.2	-7.3	273.8	60.4	11.4	-138.7
75660	-41.8	-103.2	-4.8	326.2	81.4	492.1	157.2	-3.9	296.8	68.9	6.6	-131.3
75992	-42.8	-105.3	0.7	362.4	89.2	529.1	162.6	-10.3	285.1	67.9	3	-126.4
76382	-44.3	-105.1	6.3	387.9	93.3	552.5	164.2	-13.6	281.9	68.5	0.8	-121.8
76736	-44.2	-105	12	412.9	98.8	578.5	168.5	-15.4	284.9	70.9	-1.7	-115.9
76975	-40.9	-102.2	17.7	432.2	101.8	599.7	175.9	-16.7	288.5	74	-3.8	-110.3
77155	18.2	-79.3	46.3	448.8	104.5	616.4	182.7	-17.8	290.3	88.2	-6.1	-97.2
77583	30.4	-61.1	78.3	472.8	103.3	635.2	196.6	-23.8	307.8	194.8	5.6	-60.3
77794	36	-57.9	91.4	489.5	103.9	649.6	203.2	-24.6	314.7	209.5	4.4	-35.3
78091	42.3	-54.2	103.3	504.9	101	652.7	209.3	-24.8	321.4	223.9	3.1	-20.7
78310	47.7	-47.3	114.2	516.8	101.8	663.8	214.4	-25.7	326.5	229.3	2.5	-8.5
78555	56.3	-38.3	129.7	530.8	103.2	679.7	219.7	-27.2	332.8	228.3	2.7	6.6
79159	66.7	-27.9	145.5	547	106.1	700.3	228.4	-29.5	338.2	231	3.2	23.7
79593	0.4	-24.9	150.2	548.9	106.4	702.7	228.5	-29.8	337.3	232	4.5	27.4
79624	68.5	-24.1	150.4	546.8	106.3	699.3	228.3	-29.1	335.5	231.3	5.2	26.8
79721	68.2	-22.9	149.9	543	106	695	227	-28.5	333	230.6	6.1	25.9
79948	67	-22.1	150.3	539.6	105.4	689.9	225.8	-28.2	330.2	229.9	7.1	24.8
80344	66.9	-21.8	149.9	535.7	105	684.8	224.1	-27.6	327.1	228.7	8.1	23.1
87037	67.1	-17.7	152.1	531.4	103.8	679.9	222.7	-29.7	319.1	228.8	11.1	14.8
97407	64.7	-17.1	154.6	531.7	102.7	684.5	224.1	-33.5	314.2	231.2	12.7	5.3
97669	66.1	-17.3	155.6	535.2	103.2	688.6	225.7	-34.1	315.9	232	12	5.9
97775	67.1	-18.5	156.2	537.8	103.8	693.7	227.6	-34.7	318.4	233	11.2	7.3
97938	69.6	-17.5	157	544.2	104.6	699.9	229.8	-35.5	321.4	234.1	10.4	9.2
98040	71	-17.9	159.1	550.1	105.7	708	232.2	-36.3	325.3	235.6	9.3	11.7
98304	73.9	-16.4	163.5	560.9	107.4	720.2	235.5	-37.4	330.7	237.6	8.2	15.8
98416	76.1	-17.2	164.7	567.8	108.7	727.2	238.3	-38.3	335.7	239.6	7.3	19.3
98613	81	-15	171.7	581.9	110.8	746.5	241.9	-39.7	342.9	243.1	6.4	26.5
98720	84.1	-12.9	176.2	590.1	112.2	757.3	244.5	-40.7	347.5	245.2	5.6	30.7
98917	92.4	-9	184.1	603.7	113.6	774.2	248	-42.1	353.4	249.4	5.1	39.8
99115	101.5	-3	194.9	613.9	115.2	789.8	251.3	-43.4	358.8	253.2	4.9	48.3
99312	111.6	0.7	206.2	622.7	116.7	804.3	254.8	-44.9	363.7	256.8	4.9	57
99500	124.9	9.3	223	631.8	117.9	821.4	258	-48.3	367.5	260.6	4.9	67.7
99869	149.1	28.1	249	641.4	118.1	839.2	261.5	-51.7	370.8	263.5	5.6	82.1
100074	160.7	36.5	259.9	650.3	118.5	853	263.8	-53.4	375.2	266.1	5.3	91.5
100261	174.1	44.8	272.8	660.4	119.3	867.6	266.2	-55.5	379.8	268.6	5	102
100487	190.4	54	287.5	667.8	119.9	880.4	267.9	-57.4	381.9	271.5	5.3	115
100734	210.9	65.7	306.3	677.9	121	896.9	269.8	-59.5	388.4	275	5.9	128.6
101232	241.2	81.2	328.8	686	124.2	917	270.9	-61.1	394.8	278.4	7.2	144.7
101336	253.3	85.2	337.7	693.4	125.1	928.4	272.4	-62.4	399.3	279.8	6.8	151.4
101796	282.5	100.2	362	698.5	123.9	951.3	272.5	-64.9	406.6	284.5	6.9	169.2
101996	297.5	106.5	373.1	706.5	124.8	967	273.4	-67.2	411.8	288.7	6.6	179.6
102240	316.4	113.1	386	715	125.5	985.5	274	-69.4	416.6	294.3	6.5	194.8
102477	331.9	118.8	394.2	724.5	127.4	1003.8	274.8	-71.1	421.8	300.3	6.9	208.5
102614	343	122.3	401.4	731.6	128.6	1017.9	275.7	-72.5	426.5	305.1	7	218.1
102985	369.1	129.2	416.4	747.8	130.2	1037	274.9	-74.6	433.3	314.2	8.6	236.3
103370	395.9	133.8	428.3	763.2	132.4	1055.5	275.3	-76.5	439.5	321.2	10.4	252.6
103679	415.8	137.8	435.4	774.7	133.6	1069.2	277.1	-76.6	444.1	325.9	11.6	262.1
103964	438.3	144.2	444.9	789.3	135.2	1086.6	279.6	-77	450.1	332	12.6	272.7
104433	465.3	149.4	452.8	804.9	137.2	1105.3	280.7	-76.7	455.4	338.3	15.6	284.3
104972	487.3	152.3	459.6	819	140.1	1124.3	283.1	-75.9	460.6	343.6	18.7	294.3
105202	501.7	155.2	465.6	831.3	142.4	1139.6	284.9	-75.9	465.1	347.6	20.1	302.3
105847	534.9	159.8	473.7	851.3	146.2	1165.3	286.5	-73.6	471	357.4	26.4	319.1
106129	549.9	160.8	478.5	862.7	148.9	1181.8	288.4	-73.2	475.6	364.3	28.7	327.7
106348	568	164.3	484.4	876.8	151.9	1199.2	289.8	-72.5	480.5	370.3	30.9	335.5
106886	581.7	166.2	483.2	880.5	155.2	1207.2	289.5	-69	480.5	374.5	36.3	339.5
106980	579.5	165.3	481.8	876.5	154.8	1202.5	288.1	-68.3	478.4	373.9	37.1	337.2
107092	578.4	167	480.9	873.3	154.5	1198	286.7	-67.6	476.4	373.2	37.9	335
107201	575.4	167.5	479.5	870.5	154.2	1193.2	285.4	-66.9	474.3	372.2	38.6	332.8
107245	572.5	166.3	477.2	866	153.8	1188.3	283.9	-66.4	472.4	371.4	39.2	330.6
107372	570.4	166.9	476.1	862.6	153.4	1182.9	282.3	-65.6	470.2	370.6	40	328
121270	566.6	168.5	469.4	845.5	154.4	1173.6	276.4	-63.1	455	369.2	48.5	310.5
128483	568.2	170.5	471.3	846.2	154.5	1177.5	276.2	-65.7	449.3	369.6	50.1	306
128584	570.1	169	470.9	847.6	154.9	1182.2	277.4	-66	451.1	370.6	49.7	308
128667	574.3	169.6	472.7	852.2	155.5	1187.3	278.6	-66.6	453.1	371.5	49.3	310.4
128804	578.8	170.9	476	858.4	156.4	1194.6	280.1	-67.4	455.9	373	49	313.7
128921	585.2	170.5	478.8	865.7	157.8	1204.1	281.7	-68.2	459.7	374.9	48.7	318
129021	595.8	171.6	483.8	876.4	159.8	1218.3	283.7	-68.8	465.5	378.4	48.9	324.5
129759	607.2	173.9	490.6	888.1	162	1233.9	285.6	-69.5	471.1	382.9	49.1	332.2
129894	613.9	174.4	493.3	895.7	163.1	1243.6	286.8	-70.1	474.7	385.4	48.9	336.6
130111	626.3	177.2	500.3	908.8	165.1	1259.7	288.4	-70.8	480.5	390.3	49.7	344.8
130395	640.4	178.6	504.8	921.8	167.6	1273.3	289.5	-70.9	485.9	395.1	51.1	353.1
130603	651.4	179.8	508.6	931.9	171.1	1289	290.1	-71	490.6	399.1	52.1	360.5
130918	664.8	182.6	513.1	944.2	174.7	1304.2	290.8	-70.6	495.3	403.1	54	369.1
131495	682.3	185	517.2	959.1	180	1323.4	291.2	-69.4	501.3	408.3	58	381.3
131857	697.3	187.2	522	972.9	184.1	1339.9	292.3	-68.8	507	412.8	60.7	391.3
132826	717.6	191.3	523.2	990.2	190.5	1358	293.2	-66.2	513.2	419.7	66.2	405.1
133339	729	191.4	524.9	999.1	193.9	1370.3	294.7	-65.4	517.5	424	68.7	413.4
134145	746.2	192.3	525.4	1015	198.9	1387.5	295.7	-63.3	523.7	430.6	73.4	426.2
134772	759.5	193.6	528.6	1027.1	200.4	1402.2	296.6	-61.8	529	435.8	76.7	436.3
134971	769.4	195.8	531.6	1037.9	205.5	1415.2	298.1	-61.3	533.7	440.1	78.3	444.3
135702	785.9	199.3	537.7	1053.4	210.5	1430.7	299.7	-57	540.5	447.4	85.2	459
136268	797.3	202.1	544.5	1062.6	213.9	1441.8	301.9	-53.7	545.3	452.3	89.9	469.1
137134	812	205.3	550	1076.3	217.8	1456.1	304.2	-48.9	550.6	457.8	96.1	482.7
137461	822.9	208.1	556.5	1089.1	220.6	1469.9	306.2	-47	556.1	462.4	99.4	493
137869	823.2	210.7	561.5	1099.5	223.7	1482.1	307.7	-43.8	560.8	466.3	104.1	503.8
138580	831.4	214.2	568.8	1108.8	227.7	1497.8	309.1	-38.1	566.4	471.5	112.3	520.2
139155	843.1	219.2	576.9	1114.1	230.4	1513.1	310.7	-33.6	571.7	475.7	121	537.2
140118	858.2	224.7	586.8	1119.7	233.8	1530.3	312.4	-26	577	480.8	132.8	560

NAME	EG_1B	EG_1G	EG_1W	EG_2B	EG_2G	EG_2W	EG_3B	EG_3G	EG_3W	EG_4B	EG_4G	EG_4W
UNIT	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]
ROW #												
141639	865.8	228.8	592.8	1117.4	237	1534.1	309.7	-17.7	577.5	482.1	144.2	574.5
141796	863.5	229.2	591.2	1113.1	236.7	1529	308.3	-17	575.6	481	144.9	572.5
141933	860.7	228.4	590.3	1109	236.2	1524.2	307	-16.4	573.7	479.7	145.4	570.3
142066	858.2	229.6	589.2	1105.6	235.9	1519	305.4	-16	571.8	478.6	145.9	567.9
142220	855.5	229.5	588.5	1101.4	235.5	1513.4	303.7	-15.4	569.7	477.2	146.4	565.4
142363	853.4	229.8	586.8	1097.9	235.1	1508.2	302.4	-14.9	567.9	475.8	146.8	563
142473	849.3	229.2	584.3	1093.1	234.6	1502.2	300.5	-14.5	565.8	474.2	147.2	560.1
142522	847.6	229.6	583.2	1090.2	234.2	1496.9	299.2	-14.1	563.8	473	147.5	557.6
142720	843.8	228.6	580	1084.3	233.7	1489.8	297.4	-13.6	561.2	471.4	147.9	554
142932	839.6	227.4	578.6	1077.3	233.1	1482.7	295.6	-13	558.6	469.6	148.4	550.7
143042	835.8	227.6	575.9	1072.5	232.5	1475.5	293.9	-12.6	556	468	148.9	547.4
162000	823.1	228.6	569.8	1047.4	232.4	1452.6	283.1	-10.2	518.5	459.7	156.9	524.9
162752	825.1	227	569.1	1048.2	232.5	1455.4	283.4	-10.3	518.2	459.9	156.7	525.7
162804	828.4	228.4	571.4	1053.1	233.1	1460.4	284.6	-10.7	520	461.3	156.6	528.3
162911	829.2	227.4	571.4	1054.8	233.5	1464.6	285.7	-11.1	521.3	462.4	156.5	530.6
163042	832.6	228.9	573.3	1058.7	234.1	1469.5	286.9	-11.3	523.1	463.7	156.5	533.3
163168	835.6	227.6	574.2	1061.9	234.5	1474.5	287.9	-11.6	524.7	464.9	156.6	536
163258	838.6	228.1	576.1	1066.4	235.2	1480.3	289.3	-11.8	526.6	466.5	156.6	539.3
163358	842.5	228.5	578.2	1070.6	236	1486.7	290.7	-11.9	529.1	468.4	156.9	543.2
163501	847	228.7	580.5	1076.8	237	1494	292	-12.2	531.5	470.4	157.3	547.6
163649	852	229.3	583.3	1083.4	238	1502.2	293.3	-12.2	534.3	472.7	157.8	552.3
163804	859.1	230.2	587.6	1091.2	239.5	1513.3	295	-12.4	538.3	476.2	158.7	559.2
163937	865.2	231.3	591.1	1099.6	240.7	1523.6	296.4	-12.4	541.9	479.2	159.6	565.6
164147	876.8	233.5	596.7	1111.4	242.8	1539	298.2	-12	547.2	484.3	161.8	576.4
164343	883.7	235	601.4	1120.3	244.5	1551.1	299.7	-11.6	551	488.1	163.9	584.9
164454	892.5	236.9	606.3	1130.5	246	1563.3	301.4	-11.4	554.8	491.9	165.5	593.3
164862	903.9	239.5	612.7	1140.2	248.7	1579.7	303.6	-8.8	558.4	496.9	170.4	607.9
165156	915.1	243.1	620.5	1151.6	251.2	1597	306.6	-6.6	562.2	501.7	174.7	622.6
165483	925.9	246.9	627.1	1160.7	253.4	1611.9	309.5	-3.7	565.1	505.3	179.3	636.4
165886	936.6	251.4	634.6	1169.7	255.9	1627.4	312.7	0.3	567.7	508.8	185	652.2
166571	955.5	258.4	646.4	1180.6	260.4	1649.2	316.3	8.8	569.6	513.2	197.2	679.6
166795	964.8	262	653.1	1187.8	262.5	1663.1	318.8	11.7	572.1	516.6	201.6	693.1
167156	980.3	268.4	661.5	1195.5	265.9	1680.7	322	17.9	573	520.1	210	713.4
167438	992	274	669.4	1202.3	268.8	1697.1	325.8	23.4	573.3	523.4	217.4	732.6
167545	995.6	275.8	671.5	1202.4	269.6	1700	326.4	26.1	572.3	523.8	220.3	738.2
167581	995.3	276	671	1201.2	269.8	1699.5	326.3	26.8	571.6	523.5	221	739
167608	995.7	276.6	671.6	1200.2	269.9	1698.9	326	27.4	571.1	523.1	221.5	739.4
167627	994.1	275.2	670.6	1199.9	270	1698.1	325.9	27.7	570.7	522.9	221.9	739.3
167643	994.5	276.1	671.1	1198.5	270	1697.1	325.7	28.1	570	522.5	222.1	739.1
167662	994	276	670.7	1198.2	270	1696.2	325.5	28.5	569.5	522.2	222.5	738.9
167690	993.2	276.3	670.3	1196.4	270.1	1695	325.2	29	568.8	521.7	222.7	738.7
167730	992.9	276.5	670.8	1195.2	270.2	1693.5	324.9	29.5	568.1	521.1	223.2	738.7
167782	993.4	277.5	669.9	1194.6	270.2	1693	324.9	30.2	567.6	520.8	223.8	739.2
167797	993.6	277.8	669.8	1194.7	270.2	1693.7	324.9	30.1	567.5	520.9	224	739.8
167828	994.9	277.9	670.8	1195.8	270.6	1694.6	325.3	30.6	567.6	521	224.4	740.9
167895	995.9	279.3	671.6	1195.9	270.8	1695.9	325.7	31.5	567.4	521.1	225.3	743
168135	998

NAME	EG_1B	EG_1G	EG_1W	EG_2B	EG_2G	EG_2W	EG_3B	EG_3G	EG_3W	EG_4B	EG_4G	EG_4W
UNIT	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]
ROW #												
175430	1151.4	370.4	763.5	1199.1	354.2	1909.5	462.3	147.5	485.3	541.9	327.2	1017.1
175503	1153.4	372.4	766.3	1200.4	355.9	1914.4	465.9	148.4	484.1	542.7	328.3	1021.4
175543	1154.6	372.5	766.2	1200.7	356.9	1917.4	467.9	148.9	483.3	543.2	329	1023.8
175576	1156.2	373.3	767.1	1202.5	357.8	1920.8	470.1	149.3	482.9	543.8	329.6	1026.8
175884	1165.9	381.7	775.3	1201	367.7	1940	486.7	153.7	474.6	545.5	336.2	1044.1
175997	1170.3	385	778.6	1202.1	371.8	1945	493.3	155.3	471.5	546.4	339.2	1052.1
176102	1173.7	387.5	780.6	1201	376.1	1955.8	499.3	157.2	468.2	546.8	342.4	1058.5
176231	1175.7	390.6	782.7	1197.9	380.7	1960.2	504.9	159.3	463.3	545.9	345.7	1063.2
176278	1175.8	390.9	783.1	1197.1	382.4	1961	506.5	160	461.7	545.5	347	1064.3
176410	1177.7	395.4	784.3	1195.5	387	1964.4	512.5	162.1	457.5	545.1	350.2	1069.2
176668	1182.9	401.6	789.9	1193.7	397.3	1980.4	526.3	166.2	448.7	544.5	357.9	1081.5
176858	1185.9	406.9	793.9	1191	405	1990.4	536.4	170.1	442.1	543.8	363.4	1089.2
176962	1190.7	410.7	796	1190.2	410.4	1999.4	544.4	172.6	438.5	543.8	366.8	1095.5
177002	1193.3	412.7	797.8	1191	412.7	2004	548.2	173.9	437	543.7	368	1098.7
177048	1195.1	414.2	799.3	1190.7	415.9	2010	553.5	175.5	434.9	543.6	369.9	1102.7
177121	1199	418.2	802.5	1189	422	2019.4	563	178.9	430.6	543.2	373.6	1107.6
177135	1198.7	418.9	802.4	1186.8	423.1	2020.2	564.4	179.4	429.4	542.9	374.1	1107.7
177151	1198.3	419.3	803	1186.1	424.5	2020.6	565.8	180.2	428	542.4	374.8	1107.5
177163	1198.3	419.8	803.2	1184.1	425.4	2020.6	566.7	180.8	426.9	541.9	375.3	1107
177175	1197.1	420.6	801.8	1183.1	426.4	2020.6	567.6	181.4	425.9	541.5	375.7	1106.6
177185	1196.5	420.2	802.2	1181.8	427.1	2020.3	568.1	181.8	424.9	541.1	376.1	1106
177195	1196.1	420.3	802.2	1179.9	427.8	2020	568.8	182.2	424	540.7	376.4	1105.5
177207	1195.7	420.3	801.4	1178.7	428.5	2019.5	569.2	182.7	422.9	540.3	376.7	1104.9
177224	1195.1	421.2	801.7	1176.2	429.6	2018.9	570.1	183.3	421.5	539.6	377.3	1104.1
177247	1194.2	421.5	800.9	1173.9	430.9	2018.4	571.2	184.2	419.9	539	377.9	1103.1
177279	1193.5	422.1	801.1	1171	432.6	2018	572.8	185.1	417.7	538.1	378.8	1102.2
177315	1192.2	423.6	800.8	1167.9	434.4	2017.6	574.4	186.4	415.5	537.3	379.5	1101.2
177361	1191.4	424.4	801.3	1164.7	436.3	2017.2	576.4	187.7	412.7	536.3	380.6	1100.1
177389	1191.3	424.9	800.5	1162.3	437.5	2017.9	577.9	188.5	411.4	536.1	381.4	1100.2
177398	1191.5	424.3	800.3	1161.8	437.7	2018.9	578.6	188.7	411.1	536.2	381.5	1100.7
177413	1192.2	425.1	800.6	1162.6	438.4	2022.2	580	189.2	410.5	536.2	381.9	1101.5
177549	1193	430.2	805.2	1159.6	445.2	2028.8	592.6	195	403	535.6	386.4	1105
177574	1192.1	431.6	805.7	1158.6	446.3	2028.7	595.1	196.2	401.2	535.2	387.2	1104.8
177598	1191.2	432.1	806.2	1155.8	447.3	2028.4	597.6	197.4	399.3	534.7	388.1	1104.7
177621	1189.4	432.6	806.5	1154.4	448.3	2028.2	599	198.5	397.5	534.3	388.8	1104.4
177639	1188.9	433.6	807.2	1151.9	449.1	2027.5	601.5	199.4	396.1	533.9	389.4	1104.1
177659	1187.7	432.8	807.4	1150.2	449.7	2026.7	603.3	200.3	394.5	533.5	390	1103.6
177682	1186.3	433.7	807.8	1148	450.4	2025.6	605.3	201.5	392.7	532.8	390.6	1103.1
177988	1183.3	449.4	823.4	1135.1	459.7	2034.5	649.1	219.2	369.7	534	398.8	1112.3
178024	1183.7	452.2	825.8	1133.2	461.4	2036.1	655	222	366.4	534.6	399.7	1113.3
178049	1184	454.3	826.5	1131.5	462.5	2036.7	658.5	223.8	364	534.7	400.1	1113.4
178293	1191.5	468.2	838.4	1114.3	475.2	2056.7	700	243.9	342.5	539.6	406	1122.1
178327	1193.6	470.7	840	1112	477.3	2059.8	706.2	247.2	339.1	540.2	407.1	1123.3
178408	1196.6	474.1	841.9	1103.6	482.4	2067.2	720.3	254.8	331.4	540.7	409.9	1126.9
178503	1201.3	478.1	843.1	1093.5	488.2	2076.5	736.5	264	323	540.9	413.3	1131.5
178624	1207.8	483.6	846.2	1083.2	495.4	2088.5	756.8	276.3	313.2	541	416.9	1135.8
178702	1212.5	487.2	847.3	1074.1	500.2	2096.9	769.5	284.5	307.1	540.7	419.1	1137.9
178729	1213.8	488.8	847.9	1071	501.6	2099.5	773.6	287.4	304.9	540.5	419.8	1138.4
178805	1217.8	491.9	848.1	1062.3	505.9	2106.5	784.5	295.3	299.1	539.7	421.7	1139.7
178848	1219.4	493.6	848.3	1057.5	508.4	2110.7	790.5	300	296	539.4	422.8	1140.4
179059	1235	502.1	851	1041.2	520.8	2137.7	816.7	323.3	283.4	538.4	428.4	1147.2
179177	1252.4	508.1	853.6	1035.3	529.8	2165.3	841.3	344.3	275.2	539.6	432.6	1157.1
179295	1266	514.8	853.5	1022.3	540.7	2187.2	864.5	372.6	264.1	536.5	436.7	1159.8
179468	1278.4	522.9	850.8	1001.3	551.7	2208.3	893.7	407.8	248.9	529.8	442	1157.5
179638	1291.6	532.3	850.7	986.1	562.7	2232.9	925.3	441	235.8	523.7	446.9	1156.7
179756	1310.7	539.7	850.2	978.3	574.5	2266.2	960.7	469.7	226.9	520.7	452.4	1161
179847	1328.7	549	851.2	974	590	2299.7	996.4	500.9	218.9	516.5	458.1	1165.7
179896	1336.4	554.7	850.7	968.7	598.8	2312.6	1011.4	517.6	214.5	513.2	461.3	1164.7
179940	1338.8	557.8	849	961.7	604.3	2319.1	1018.9	528.9	211.1	509.9	463.7	1161.3
180109	1355.3	568.8	845.6	956.4	621.8	2345.1	1050.5	561.5	202.9	504.2	470.7	1161.3
180198	1372	582.2	847.8	964.3	643.4	2381.5	1085.3	592.8	197.6	500.7	475.2	1166.4
180306	1387.9	599.8	848.3	972.8	675	2419.3	1123.1	633	193.1	495.5	482.4	1164.9
180360	1394	610.3	848.8	975.1	689.3	2433.3	1137.1	650.1	188.1	492.8	486.3	1162.3
180402	1394.1	616	848.4	973.3	697.1	2436.3	1141.6	658.8	185.8	490.3	488.7	1157.5
180463	1393.6	624.1	847.2	971.3	706.3	2439.2	1144.9	667.7	183.1	487.7	491.5	1151.3
180785	1401.7	659	850.5	965.2	736.5	2470.3	1166.9	703.2	178	483.8	503	1143.4
180906	1404	672.3	853.1	964.9	747.1	2481.8	1175.4	717	177.8	483	506.9	1141.5
180921	1401.7	673.8	851.4	961.7	747.8	2478.5	1173.8	717.9	177.4	482	507.3	1138.4
180943	1398.9	674.8	851.3	957.9	748.3	2473.9	1171.8	718.8	176.7	480.7	507.8	1134.6
181110	1393	683.9	851.5	948.3	751.9	2467.5	1169.5	725	174.8	477.8	510.4	1126.2
181311	1387.1	690.8	851.9	938.7	755.5	2462	1166.9	729.8	172.5	477	513.1	1118.6
181454	1382.3	694.3	851.9	932	757.2	2458.8	1164.8	732.3	171.1	475.6	514.6	1113.3
181633	1378.2	697.1	851.3	924.8	758.3	2450.8	1162.2	734.6	169.2	474.1	516	1107.6
181740	1375	699	851.2	920.8	758.7	2445.3	1160	735.4	168.1	472.9	516.7	1103.2
181846	1370.3	698.7	848.8	913.7	758.8	2439.4	1157.4	736	166.9	471.7	517.3	1098.8
181968	1366.7	699	848.1	908.9	758.9	2436.6	1154.7	736.6	165.7	470.5	517.8	1094.3
184040	1353.6	708.9	847	883.9	761.9	2416.2	1143.6	743.5	156.5	465.9	525.3	1074.1
185345	1350.6	712.7	846.1	875.5	762.7	2414.2	1141.9	746.4	151.9	465	527.8	1068.7
185375	1353.2	713	846.2	877.6	762.8	2418	1144.4	747.3	152.2	466	527.9	1071.2
185455	1355.8	714.4	847.7	879.7	763.4	2422.9	1147.8	748.6	152	467.1	528.3	1073.2
185526	1357.9	714.8	847.4	881.5	764.2	2428.4	1151.6	750.4	151.9	468.1	528.6	1075.9
185577	1361.4	715.9	849.2	884.1	765.1	2436.1	1156.8	752.5	152	469.6	529	1079.5
185768	1367.2	719.9	853.1	890.5	767.5	2449.4	1167	757.4	152.2	471.8	530.1	1085.5
185793	1376.2	725.4	857.7	899.9	773.1	2470.6	1184.1	767.6	152.3	474.7	532.2	1093.9
185828	1384.8	732.2	862.5	908.2	779.1	2490.6	1200.9	778	152.6	477.9	534.2	1101.9
185930	1398.5	746.1	871.1	924.9	791.9	2523.3	1230.9	802.2	153.8	483.1	538.3	1114.3
186054	1408	766.1	882.8	937.2	808.6	2551.2	1257.7	831.7	155.9	488.3	543.9	1123.1
186182	1411.5	794.7	903.9	947	824.6	2575.4	1280.6	859.9	159.4	492.5	551.2	1131
186285	1408.8	830.7	922.6	952.4	839.4	2596.8	1303.7	891.7	162.3	510.9	560.4	1136.3
186386	1401	860.6	937.7	945.5	854.1	2615	1326.6	929.4	166.8	526.8	573.5	1135.9
186454	1395.7	877.4	946.5	936	860.8	2612.5	1331.4	951.3	173.3	537.9	586.8	1132.4
186523	1388.5	894.1	951.9	930.1	869.9	2618.8	1336.3	978.1	183.8	549.8	602.7	1132.1
186584	1381.3	909.5	957	924.5	880	2629.2	1341.3	1003.3	192.1	559.9	621.3	1132.5
186681	1369.5	929.7	961.7	913.4	906.5	2644	1346.3	1036.9	201.1	574.7	657.5	1133.5
186774	1355.2	948.3	968.4	893.9	931.7	2663.6	1352	1069.3	210.7	593.5	704.5	1139.4
186863	1337.6	961.2	971.8	874.5	948.2	2685.2	1354.6	1100.6	221.1	615.1	758.1	1145.7
186926	1325.8	971.2	976.8	864	955	2700.4	1353.6	1122.1	227.7	629.5	796.8	1150.4
186962	1315.4	974.4	976	854.8	952.7	2701.7	1348.7	1130.8	229.4	635.2	815.5	1149.9
187023	1304	977.8	976.3	843	947.9	2701.4	1341.5	1140.4	230.2	641.5	837.1	1147.2
187155	1290	990	983.8	829.7	953.1	2706.2	1346.7	1167.6	237	662.3	886.3	1159.3
187243	1275.6	1001.5	990.4	818.7	963.2	2766.9	1352.6	1196.6	246	689.7	948.4	1174.7
187324	1263.1	1011.8	995.8	806.2	977.7	2801.6	1353.2	1224.1	254.8	720.6	1017.5	1191
187408	1247.9	1024.1	1001.7	790.6	994.3	2837.2	1350.1	1250.8	263.4	751.3	1083.7	1209.8
187491	1232.1	1038.1	1006.7	773.2	1015.4	2872.1	1346.1	1277.6	271.9	782	1153.9	1230.7
187605	1218.8	1052.3	1007.7	756	1043.5	2907.3	1342.1	1304.5	280.3	808.8	1229.5	1254.1
187698	1209.5	1067	1010.7	746.2	1069.3	2940.2	1340.9	1328.5	288.9	838.9	1298.5	1275.8
187753	1203.6	1072.2	1009.5	741	1077.7	2943.4	1334.4	1336.8	291.9	849.3	1323.1	1279.4
187894	1198	1086.7	1012.9	736	1102.2	2972.1	1337.7	1360.9	301	874.7	1370	1293.7
187978	1195.3	1101.1	1017.3	735.3	1127.3	3001	1342.3	1386.8	312.3	896.1	1413.2	1305.7
188020	1191.6	1106.8	1016.9	734.4	1135.4	3003.3	1338	1394.8	315.9	902.1	1428	1305
188097	1184	1114.2	1015	730	1144.8	3002.4	1330.1	1402.7	318.8	908.2	1443.9	1302.3
188256	1174.4	1126.9	1013.9	725.3	1156.5	3001.7	1320.3	1413.2	322.2	919.7	1467.4	1298.6
188503	1163.3	1142.1	1014.4	720	1171.1	3005.1	1310.6	1425.3	326.2	935.2	1496.4	1296.4
188739	1161	1151.3	1016.5	719	1182.5	3017.7	1312.3	1434.2	330.2	946.6	1512.2	1300.6
188852	1164.7	1163.2	1024.3	722.5	1202.8	3052	1325	1452.4	339.4	964	1540.5	1314.7
188978	1167.7	1177.8	1029.8	726.6	1230.8	3086.2	1329.6	1475.6	351.6	984	1579	1325.7
189094	1170.9	1192.9	1036.4	730.1	1258.7	3113.1	1328.1	1497.2	362.7	1002.7	1614.2	1338.3
189200	1175.4	1210.3	1042.2	735.7	1289.6	3153.4	1335.1	1521.8	375.9	1023.7	1653.4	1350.6
189308	1178.8	1227.9	1047.8	740.8	1320.4	3183.9	1335.1	1545.4	389	1044.7	1690.3	1362.1
189412	1182.7	1245.7	1055.3	745.1	1350.3	3212.3	1332.7	1569.6	403	1065.8	1727.4	1373.1
189545	1183.4	1266.6	1060.3	746.1	1379.3	3225.4	1324.4	1593.1	417.1	1089	1764.8	1379.3
189685	1185.9	1287.7	1067.6	747.3	1406.1	3260.3	1321.8	1615.1	430.5	1110.8	1799.2	1388.9
189792	1190.7	1306.7	1074.1	749.6	1431.5	3285.8	1321.5	1637	444.2	1133.3	1830.7	1399.5
189890	1196	1325.3	1079.6	751.3	1456.3	3309.3	1320.4	1659	458.4	1154.1	1860	1408.4
189989	1199.7	1344.3	1085.6	751.6	1481.5	3333.3	1318.1	1682.8	473.9	1174.7	1890.3	1417.1
190089	1207.1	1365.9	1092.3	751.5	1506.1	3349.7	1316.6	1707.4	489.9	1197.9	1922.8	1428.6
190178	1215.5	1387.4	1099	750	1526.6	3357.8	1315.6	1731.6	507.1	1225	1957.2	1443
190281	1226.1	1414.3	1107.9	750.4	1547.8	3364	1312.6	1758.1	525.9	1255.5	1994.5	1454.6
190373	1235	1437.9	1114.3	749.2	1565.7	3372	1311.8	1783.7	543.5	1285	2027.9	1464.9
190464	1242.2	1459.6	1120.7	749.2	1582.4	3378.7	1309.9	1809.7	561.1	1315.6	2060.4	1471.4
190575	1249.2	1484.4	1125.2	748.9	1599.4	3382.7	1306.9	1837.8	578.7	1346.3	2090.9	1475.6
190672	1259	1506.9	1133.9	751	1614.8	3391	1308.8	1865.5	595.4	1376.2	2118.7	1482.1
190773	1267.3	1528.6	1140	751.9	1630.8	3393.5	1310.2	1895.3	613.2	1408	2148.1	1489.6
190881	1275.4	1552.2	1148.1	755	1646.9	3405.1	1311.4	1925.7	631.9	1443.6	2179.1	1494.9
190980	1284.7	1573.7	1155.3	757.8	1661.2	3412	1313.4	1954.1	648.9	1473.8	2205.1	1498.9
191091	1291.7	1594.2	1160.9	760.3	1676.4	3418.8	1315.3	1984	666.1	1504.6	2232.1	1502.8
191194	1299.2	1615.1	1169.2	764.3	1690.6	3428.1	1319.2	2012.5	682	1533.1	2257.7	1507.1
191274	1307.7	1631.6	1175.7	769.2	1703.8	3439.8	1326.3	2040.7	697.8	1559.7	2282	1512.8
191347	1314.5	1647.7	1180.9	773.4	1716.1	3448.6	1331.6	2068.2	713.4	1583.3	2305.2	1516.3
191441	1321.5	1665.5	1186.9	778.6	1730.3	3455.3	1335.3	2100.4	731.3	1609.5	2329.8	1518.1
191566	1326.4	1683.9	1191.1	782.6	1744.8	3458	1338.1	2133.6	748.8	1638.2	2353.9	1517.2
191681	1332.8	1701.9	1197	788.3	1757.1	3464.8	1342.8	2163.1	765.7	1662.6	2375.5	1518.5
191778	1338.2	1715.7	1201.1	791.5	1768.3	3473.5	1348.9	2191	781.4	1684.7	2395.5	1520.8
191856	1344.1	1727.3	1206.2	795.5	1778.6	3482.5	1355.3	2217.8	796.8	1704.7	2414.6	1523.3
191924	1348.1	1738.7	1210.2	798.2	1787.9	3490.3	1361.1	2241.8	810.5	1721.7	2431.7	1524.7
192015	1355.9	1754	1215.6	804.5	1801.5	3502	1369.3	2277.5	832	1746.6	2457.4	1526.7
192096	1362	1768.2	1220.3	808.7	1813.7	3510.5	1375.6	2310.2	851.6	1769.2	2479.9	1526
192178	1366.5	1780.2	1225.3	812.3	1825.3	3517.9	1381.6	2341.2	869.8	1789.9	2500.7	1524.8
192261	1372.7	1794.6	1230	817.3	1837.3	3525.6	1388	2373.1	888.5	1811.2	2522.2	1523.9
192338	1378.9	1807.8	1235.3	819.8	1848.2	3532.6	1394.7	2403.5	906.4	1831.8	2542.8	1523.4
192418	1384.7	1821	1241.3	823	1859.5	3539.1	1401.7	2436.5	926.4	1853.6	2564.1	1521.9
192510	1389.3	1835.4	1246.2	825.8	1871	3544.2	1410.4	2471.8	947.5	1876.1	2585.3	1518.9
192604	1393.6	1850.7	1252.7	828.8	1882.3	3551.3	1419.1	2505	966.8	1899	2606.3	1516.5
192698	1399	1866.6	1260.1	832.6	1893.8	3559	1427.7	2538.4	985.8	1921.5	2627.1	1514.8

NAME	EG_1B	EG_1G	EG_1W	EG_2B	EG_2G	EG_2W	EG_3B	EG_3G	EG_3W	EG_4B	EG_4G	EG_4W
UNIT	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]	[µStrain]
ROW #												
192792	1404.4	1882.7	1265.5	836.3	1905.3	3568.8	1437.7	2573.7	1006.1	1944.5	2649	1514
192876	1408.3	1896	1271.5	838.8	1915.7	3576.6	1445.8	2606.9	1025.3	1965.1	2668.8	1512.9
192912	1406.8	1899.5	1271.2	838.7	1918.3	3572.6	1444.5	2615.1	1029.2	1968	2671.7	1508.8
193220	1401.2	1918.3	1273.2	838.1	1929	3558	1439.5	2641.9	1042.1	1983.8	2683.6	1490.7
193586	1396.7	1932	1274.2	836.4	1936.7	3549.4	1438	2663.2	1052	1998.6	2694.5	1480
193894	1390.7	1937.7	1274.4	833.7	1939.9	3539.1	1434.2	2671.3	1054.4	2003.4	2697.2	1470.8
194148	1390.9	1943.8	1274.8	832.9	1942.3	3537.8	1434.9	2676.8	1056.9	2009.7	2700.9	1467.3
194209	1396.8	1950	1279.2	834.5	1944.9	3548.8	1443.1	2687.8	1064.5	2020.9	2710.5	1472.5
194283	1403.3	1960.1	1285.9	838.1	1950.5	3563.1	1455.4	2710.7	1079.6	2038.4	2727.2	1479.8
194371	1411.5	1971.3	1291.8	841.1	1958.2	3575.9	1468.1	2739.5	1096.8	2057.1	2745.6	1485.3
194473	1418.1	1982.4	1296.7	844.2	1966.7	3587.2	1479.2	2769.1	1113.6	2075.1	2763.4	1488.1
194599	1422.1	1994.6	1299.8	846.3	1976.7	3595	1487.5	2801.9	1131.6	2093.4	2781.4	1487.9
194725	1418.9	1998.6	1299.3	845.6	1980.7	3589.4	1484.4	2811.4	1135	2095.9	2783.4	1481.2
194971	1419.4	2007.4	1300.8	845.7	1986.7	3590.8	1485.9	2824.7	1141.6	2106.1	2790.7	1476.9
195020	1427.3	2018.3	1309	850	1991.8	3606.4	1498.2	2843.9	1154.8	2122.6	2806	1484.6
195069	1434.5	2028	1314	852.4	1999.8	3621.4	1510.9	2871.4	1171.6	2140.7	2824.3	1491
195122	1442.6	2039.9	1320.1	856	2009.5	3635.9	1523.1	2900.8	1188.9	2157.7	2842.5	1496
195169	1449.1	2051.6	1324.5	859.8	2019.8	3650.3	1534.5	2930.3	1205.9	2174.9	2861	1500.1
195208	1455.5	2061.7	1327.4	862.5	2029.8	3664.2	1544.9	2958.6	1221.9	2191.8	2878.6	1503.7
195246	1461.7	2073.9	1332.4	867.5	2040.8	3677.7	1554.8	2989.3	1239.3	2210.3	2897.6	1507.2
195280	1467.9	2084	1335.6	869.5	2050.9	3688.9	1562.5	3017.4	1255.3	2226.7	2914.2	1509.3
195322	1473.8	2097.2	1340.9	874.5	2063.9	3700.8	1569.8	3050.4	1274.1	2245.8	2933.2	1510.9
195327	1474.9	2098	1341.1	875.2	2065.9	3702.4	1570.7	3054	1276.1	2247.9	2935.2	1511
195329	1474.9	2098.8	1341.5	875.2	2065.9	3702.4	1570.9	3055.3	1276.9	2248.7	2936	1511
195331	1475.8	2099.2	1340.7	875.4	2066.3	3702.7	1571.1	3056.6	1277.6	2249.5	2936.6	1511
195338	1476.8	2102.1	1342	877.4	2068.4	3704.2	1572.1	3061.5	1280.3	2252.3	2939.3	1511.2
195340	1476.8	2101.9	1342.1	877	2068.8	3704.4	1572.3	3062.7	1281	2252.9	2940.1	1511.1
195342	1477	2103	1342.5	877.5	2069.3	3704.8	1572.6	3064.1	1281.8	2253.8	2940.8	1511.1
195343	1476.6	2102.3	1342	876.2	2069.5	3705.2	1572.8	3064.8	1282.1	2254.2	2941.2	1511.1
195386	1482.1	2114.7	1345.8	880.5	2081	3714.6	1579.5	3093.7	1298.3	2271.4	2957.9	1511.9
195432	1489	2129	1352	885.4	2092.4	3723.8	1586.7	3122.8	1314.3	2288.4	2974.4	1512.9
195470	1493.5	2141	1357	889.4	2103.2	3733.6	1594.5	3150.9	1330	2305.6	2991

North SGs

NAME	N_{XT1}	N_{XB1}	N_{YT2}	N_{YB2}	N_{YT1}	N_{YB1}	N_{YT2}	N_{YB2}	N_{YT3}	N_{YB3}
UNIT	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]
ROW #										
3	-3.3	-3	-1.9	-5.4	0.3	-4.3	-2.1	-0.1	-2.5	0.5
4227	-7.1	-6.4	-5.9	-7.8	1.6	-1.1	-1.4	2.6	-0.1	9.2
4233	-7.6	-8.7	-7.8	-10	1.1	-1.2	-1.4	2.3	-0.2	9.7
4238	-8	-7.7	-8.5	-11	1.3	-0.4	-2.2	2.3	-2.1	8.9
4240	-9.4	-9.6	-11.5	-13.5	0.4	-1.5	-2.6	2.3	-3.3	9.8
4244	-10.9	-9.7	-10.3	-13.9	1.5	-0.4	-1.8	3.9	-1.5	10.8
4248	-10.2	-11.4	-9.9	-13.8	1.4	1.6	-1.3	4.5	0.3	11.5
4272	-6.8	-7.6	-5.6	-10.3	4.3	2.1	-0.1	5	1.4	11.1
4301	-4	-6.4	-4.5	-8.8	5.2	1.6	0.4	3.6	-0.5	11
4394	-2.4	-5	-1.8	-6.2	4.7	1.9	0.4	4.4	0.4	10.5
4490	-2.1	-6	-3.7	-7.1	5.8	1.8	0.6	3.9	0.2	10.6
4510	-2	-4.4	-3.3	-6.4	5.9	2.5	-0.1	4.1	-1.4	9.9
4528	-0.8	-4.7	-3.3	-5.5	6.1	1.3	0.3	5.2	-0.9	10.7
18434	-1.3	-11.4	-4.5	-5.9	-2.6	3.8	-11.5	-6.1	3	0.8
40202	-0.8	-16.5	-3.3	-3.1	-0.5	3	-17.1	-2.9	5.9	-12.5
42198	-1.9	-18.7	-4.3	-5.3	-3.3	0.8	-18.4	-3.5	-4.7	-11.2
42398	1.9	-15.8	-1.9	-2.7	-2.7	1.6	-17.1	-3.3	6.4	-10.1
42410	1.3	-16.7	-2.7	-4.1	-1.3	2.3	-17.6	-3.1	5.9	-9.8
42413	-0.3	-17.8	-3.7	-4.2	-0.9	1.6	-17.7	-3.2	5.5	-10.9
42520	1	-16.6	-2.1	-3.9	-1.1	2.8	-17.6	-1.9	6	-10.3
42535	1.7	-16.5	-2	-3.5	-0.1	2.7	-17	-3	6.2	-10.6
42718	1.5	-16.7	-1.3	-2.5	-0.3	4.1	-15.9	-2	6.3	-9.3
43034	1.2	-16.5	-1.6	-5.3	-1.1	2.5	-18	-3.8	5.6	-11.9
43056	1.5	-16.2	-1.5	-4.7	-1.9	3	-16.1	-3	5.5	-10.5
43176	0.4	-16.1	-0.5	-6.1	-1.2	2.2	-16.5	-3.2	5.4	-10.7
43328	1.3	-16.2	0	-6.1	-1.4	2.8	-17	-3.4	5.4	-10.5
43476	0.8	-17.1	0.3	-8	-1.7	1.6	-16.3	-3.4	5.4	-10
43596	2.6	-14.8	2.4	-6.9	0.8	3.6	-14.6	-3.2	6.5	-9.7
43619	2.5	-15.6	3.7	-6.6	0	3.6	-16.7	-3	6.8	-9.5
43740	4.3	-13.7	7	-5.5	1.6	6.7	-13.4	-1.3	7.2	-7.8
43861	3.5	-14.4	10	-4.8	2.8	7.4	-12.5	0	8.7	-6.2
44061	2.6	-11.9	23.3	-2.3	6.9	10.5	-10	0.9	11.2	-3.7
44223	4.5	-12.9	33.6	-4.5	7.4	17.7	-6.5	4	13.8	-0.8
44358	11.4	-0.1	44.6	0.8	17.1	26	3.7	11.1	19.4	3.7
44478	11.1	2.6	48.2	-0.2	18.8	26.9	6.6	13.3	19.3	3.8
44628	15	7.6	54.6	2.9	24.7	30.9	12.2	19.8	23.6	7.7
45038	17.6	12	56.6	11.5	27.4	35.6	16.7	28.3	27.3	12.3
45474	19.9	14.2	58.6	14.9	28.7	37.4	17.1	28.1	28.8	14.3
45497	20.1	15.5	59.9	15.6	30	38.3	18.3	29.6	29.5	14.4
45619	22.5	20.1	62.6	21.1	30.3	45.6	22	35.7	33.3	17.5
45880	25.7	24.8	66.4	34.2	35.6	52.2	33.8	48.1	49.4	24.2
45990	29.2	27.5	73.2	42.5	41	67.1	42.7	56.9	56.1	35.5
46495	33.6	35.4	92.1	67.7	50.5	90.6	64.7	85.5	71.9	51.4
46669	36.5	39.1	101.6	79.5	58.6	98.6	75.2	96.7	77.5	54.2
47319	39.8	62.9	133.8	176.6	89.9	125.5	114.4	144.8	109.3	72.8
47758	49.3	82.9	157.9	216	127.6	144.4	139.2	169.8	126.3	72.6
48016	51.5	87.7	161.5	220.1	136.7	148.3	141.2	172.8	130.8	72.7
48061	52.6	91.9	165	224.6	140.8	149.6	146.2	175.5	132.6	73.9
48181	55.2	100.1	172.4	237.3	150.2	156.7	149	185.9	142.5	77.5
48696	66.1	139.9	198.2	260.7	180.8	170.9	174.6	208.2	191.2	89.3
50490	79.3	161.2	224	276.5	198.6	185.5	198.9	228.6	222.2	103.9
62108	82.3	154.1	233	276.8	203.5	188	205.1	233.1	229.5	111.2
66109	79.8	150.3	232.3	276.4	202.2	187	213.6	231.6	228	110.9
66149	82.3	152.3	234.3	277	206.2	188	214.1	233.1	229.8	112.2
73060	81.7	148.5	235.5	279.1	207.1	189.3	212.3	233.4	231	114.4
73167	82.4	151.5	238.1	282.5	208.9	191	214.7	236.2	233.6	114.5
73282	85	157.6	243	291.2	213	194.5	219.7	242.5	239.6	118.4
73394	87.1	165	250.5	301.6	218.4	200	228	251.1	246.8	121
73503	90.5	175.5	258.8	313.9	227.2	205.9	237.5	260.8	255.7	126.7
73638	93.8	189.5	270.3	330	258	212.7	248.7	273.6	266.9	134.7
74114	97.8	199.7	284.8	339.8	290.2	221.2	256.3	281.7	273.4	142.5
74236	96.2	202.4	286.6	342.9	292.2	222.3	258.6	284.8	275.9	154.6
74401	97.6	212.5	297.5	352.9	306.8	227.8	266.8	296.1	283.3	164.6
74666	104.9	230.7	319.8	372.6	331.1	242.4	282	316.4	298.8	185.2
74848	105.6	242.9	337.9	383.5	352.5	250.7	294.6	315.1	312.1	202.5
75214	114.4	264	370.1	399.7	383.4	274.7	314.5	359.3	330.9	236.9
75412	117.3	281.1	387.6	411.9	402.2	288	317.6	374.7	338.5	261.7
75660	125.1	302.6	413	429.5	421.1	311.6	329.1	397.9	354.6	295.3
75992	129.8	314	430.4	447.8	448.5	336.7	414.4	417.2	391.1	328.8
76182	134	325	447.8	461.3	472	372.8	350.4	417.2	390.5	353.2
76736	141.9	341.8	470.7	478.3	499.2	409.9	368.3	433.7	406.9	384.4
76975	149.4	355.5	489.3	492.7	516.6	437.7	384.2	454.1	420.9	410.3
77155	164	367.9	469.5	501.3	533.5	449.6	396.5	477.1	434.3	438.4
77583	172.9	381.7	487.2	505.9	528.2	464.2	412.5	490.4	449.7	451.3
77794	177.9	392.8	507	519.8	510.8	515.9	450.9	472.2	462.3	557
78091	182.1	390	526.5	531.9	513.3	543.3	467.3	483.3	476.5	583.3
78310	184.2	396.8	542.5	540.5	528.7	564.1	481.8	492.6	488.3	603.4
78555	188.3	408.2	564.4	553.6	549.9	595.2	501.2	507.3	503.7	635.1
79159	193.8	420	590.3	564.8	572.9	625.1	527.6	524.3	523.5	653.2
79593	193.6	418.5	593.9	562.9	598.1	630.1	532.2	526	525.7	657.7
79624	192.3	413.8	590	556.9	593.3	625.9	529	523.3	523.4	653.3
79721	190.2	410.1	587.6	552.8	589.8	623.6	526.7	520.6	520.3	648.8
79948	187.5	404.6	581.3	542.6	589.6	618	522	515.1	516.3	640.9
80344	187	399.4	577.8	536.8	583.1	614.4	519.5	513.3	511.9	635.9
87037	187.5	388.9	577.1	528.7	630.5	612	517.9	512.9	508.6	625.5
97407	184.2	382.5	578.2	525.6	640.1	609.8	520.6	513.9	507.4	621.2
97669	189.1	388.9	584.6	535.4	645.5	616.9	525.5	519.3	512	626.9
97775	188.6	391.4	586.7	538.1	649.5	618.8	527.2	521.3	514.7	631.5
97938	189.9	396.6	593.1	543.6	656.6	623.8	533.1	525.9	519.4	638.5
98040	192.8	402.8	599.6	552.1	664.2	632.5	539.3	532.7	527.5	645.9
98304	195.9	411	608.9	562.7	675.6	643.1	548.5	540.2	534.1	658.4
98416	198	418.2	615.1	569	685.2	650.5	555	546.9	540.5	668.1
98613	201.2	428.9	629.8	581.3	701.3	666.1	568.6	559.4	551.5	684.3
98720	203.6	437.7	638.6	589.8	718.9	676.6	577.8	567.9	559.4	697.4
98917	208.9	449.9	654.9	602.7	732.5	694.3	594.2	581.6	572.4	715.9
99115	214.6	461.5	669.8	614.4	749.5	711.6	609.2	595.2	585.7	734.3
99312	214.8	471.5	682.5	620.5	761.4	724.8	620.4	605.9	594.9	749.6
99500	217.6	481.8	698.6	629.6	778.1	743.1	636	620.3	610.8	768.2
99869	223.3	496.3	721.4	639.2	799.5	769.7	656	638.7	630.7	789.3
100074	228.9	506.2	737.4	647.3	813.3	787.5	670	652	645.7	805.9
100261	232.2	514.5	750.1	654.5	830.9	805.3	685.7	667.1	661.2	821.7
100487	238.3	523.3	768.7	664.5	847	827.7	702.5	683.4	676.2	839.1
100734	247.9	537.7	791.9	675.6	868.4	854.1	722.2	698.7	693.2	860.5
101232	252.7	549.9	811.2	666.7	875.7	878.6	741.8	715.6	708.9	879
101336	258	560.4	823.2	673.9	888	891.6	752.4	725.4	719.7	891.9
101796	268.9	577.1	848.2	684	915	921.3	775.2	744.5	741.1	922.9
101996	271	586.5	864	691.4	927.4	938.8	788.3	758	753.2	924.7
102240	280.3	601	904.5	709.1	944.8	964.8	806	777.4	771.2	944.6
102477	283.7	611	928.7	717.1	958.8	984.4	821.1	794	786.4	960.9
102614	287.5	620.1	944.4	723.3	967.8	1003	831.5	805.9	796.5	973.4
102985	302.6	636.8	975.4	741.7	985.1	1038	856.3	834.4	820	991.7
103370	308.7	647.3	996.6	750.6	1001	1067	874.8	858.2	838	1004
103679	313.2	656.9	1010	757.7	1016	1085	888.1	872.9	851.6	1017
103964	323.3	672.5	1030	771.9	1034	1111	906.8	891.9	868.4	1035
104433	333.3	685.1	1049	787.5	1053	1140	926.3	911	888.4	1051
104972	341.1	698	1065	795.6	1072	1162	943.8	926.8	906.5	1068
105202	345.8	707.8	1077	805.7	1096	1178	955.8	938.3	920	1082
105847	356	721.8	1086	817.9	1117	1207	976.9	960.9	943.3	1102
106129	359.7	730	1107	824	1128	1222	988.4	972.1	955.6	1115
106348	368.6	743	1124	837.9	1146	1244	1005	988.2	971.9	1132
106886	373.8	744.2	1129	836.5	1150	1254	1010	993.8	980	1132
106980	374.2	741.9	1125	832.2	1145	1250	1007	990.8	977.1	1127
107092	373.1	737.6	1122	829.7	1144	1247	1005	987.7	973.7	1121
107201	372.1	734.8	1116	823.2	1137	1242	1000	985	970.5	1116
107245	371.4	729.8	1112	819.6	1133	1237	996.6	980.5	966.3	1109
107372	370.9	726.5	1109	816	1129	1233	993.6	977.7	962.3	1106
121270	369.8	710.4	1099	793.2	1111	1231	992.5	983.5	958.3	1092
128483	371.7	710.4	1100	788.3	1108	1220	985.2	974	948.8	1082
128584	373	713.8	1103	792.8	1112	1224	987.9	977	951.3	1086
128667	374.4	718.4	1109	798.3	1116	1231	992.9	982.8	955.1	1093
128804	378	724.6	1117	806.4	1124	1239	1000	989.5	961.5	1104
128921	381.2	731.1	1126	813.6	1133	1247	1007	994.1	968.1	1112
129334	386.9	739.4	1137	829.2	1148	1261	1019	1006	979.6	1127
129759	390.1	748.8	1150	829.5	1159	1273	1030	1017	990.7	1139
129894	392.7	755.7	1157	837.5	1169	1283	1038	1025	999.3	1141
130111	401.1	767	1174	851.4	1185	1303	1053	1040	1013	1167
130395	406.2	775.6	1189	862.6	1198	1320	1066	1053	1027	1181
130603	409.1	784.6	1199	865.7	1209	1332	1077	1064	1038	1195
130918	420.3	799.4	1216	877.6	1227	1355	1092	1081	1055	1212
131495	428.6	807.2	1232	887.3	1243	1378	1109	1100	1074	1229
131857	442.8	822.3	1251	903.2	1261	1402	1126	1118	1094	1249
132826	454.3	834.1	1270	916.3	1274	1430	1146	1141	1117	1272
133395	461.7	842.7	1281	923.4	1284	1445	1156	1153	1129	1284
134145	477.7	859.7	1304	938.1	1303	1474	1177	1176	1155	1308
134772	489.5	870.4	1319	951.5	1318	1496	1192	1192	1173	1326
134971	496.6	880.9	1332	959.3	1331	1511	1205	1205	1187	1338
135702	515.7	896.8	1355	977.3	1351	1543	1226	1229	1212	1362
136268	523.3	906.8	1369	984.4	1366	1562	1240	1244	1230	1377
137134	538.8	919.7	1388	998.7	1387	1589	1261	1267	1253	1397
137461	553.7	934.6	1406	1016	1406	1613	1276	1285	1273	1419
137869	565.8	945.2	1421	1025	1420	1633	1292	1301	1293	1434
138580	582.8	958.7	1438	1038	1439	1659	1310	1324	1318	1456
139155	600.9	973.7	1458	1054	1461	1686	1330	1347	1341	1479
140118	629.9	992.5	1484	1072	1486	1722	1355	1376	1372	1507

NAME	N_{XT1}	N_{XB1}	N_{YT2}	N_{YB2}	N_{YT1}	N_{YB1}	N_{YT2}	N_{YB2}	N_{YT3}	N_{YB3}
UNIT	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]
ROW #										
141639	649.5	998.4	1496	1088	1496	1741	1367	1390	1394	1517
141796	648.1	995.1	1491	1082	1491	1737	1364	1386	1388	1510
141933	647.2	991.6	1486	1079	1486	1732	1360	1383	1383	1504
142066	645.7	988.3	1483	1075	1481	1727	1357	1379	1380	1498
142220	644.7	984	1478	1070	1476	1722	1353	1375	1376	1494
142363	643	980.7	1474	1068	1472	1717	1350	1371	1372	1486
142473	641	976.3	1467	1061	1464	1708	1344	1366	1366	1481
142522	639.7	972.2	1462	1056	1460	1704	1340	1362	1362	1473
142720	636.2	966.9	1455	1050	1452	1696	1335	1356	1360	1467
142932	633.6	961.1	1449	1045	1445	1689	1328	1350	1352	1459
143042	631.2	957.3	1443	1041	1438	1683	1323	1346	1346	1452
162000	629.2	955.2	1439	1035	1435	1678	1319	1341	1333	1427
162752	630.8	937	1423	1042	1422	1661	1307	1331	1335	1430
162804	632.3	941.9	1429	1046	1425	1666	1312	1334	1340	1436
162911	632.4	943	1430	1051	1429	1669	1314	1335	1342	1439
163042	634.1	947	1436	1064	1433	1676	1317	1339	1346	1443
163168	635.8	951.2	1440	1068	1437	1680	1322	1343	1349	1449
163258	638.2	955	1446	1073	1442	1687	1326	1347	1356	1457
163358	641.9	960.4	1453	1079	1450	1694	1332	1352	1361	1465
163501	645.2	964.8	1460	1084	1456	1700	1338	1358	1368	1472
163649	647.9	971.2	1467	1091	1463	1710	1345	1365	1375	1481
163804	652.4	978.9	1477	1097	1473	1721	1353	1375	1384	1495
163937	658.1	987.9	1487	1106	1484	1733	1363	1384	1395	1508
164147	670.4	1000	1505	1123	1502	1751	1378	1400	1411	1526
164343	672.3	1002	1512	1126	1509	1762	1388	1410	1421	1537
164454	682.7	1018	1528	1140	1524	1779	1401	1422	1435	1551
164862	692.5	1029	1543	1151	1538	1802	1415	1437	1456	1567
165156	703.6	1042	1560	1166	1556	1826	1430	1455	1475	1585
165483	715.3	1054	1576	1183	1569	1847	1444	1471	1494	1603
165886	727.8	1065	1591	1196	1583	1871	1460	1488	1515	1621
166571	753.7	1086	1618	1217	1606	1909	1487	1517	1551	1649
166795	763.3	1096	1629	1233	1618	1926	1498	1530	1567	1665
167156	783.5	1112	1650	1253	1639	1954	1519	1554	1596	1683
167438	797.2	1126	1663	1277	1647	1979	1535	1569	1617	1705
167545	804.8	1130	1669	1284	1652	1987	1539	1574	1625	1710
167581	804.3	1128	1667	1283	1655	1987	1539	1574	1625	1708
167688	804.2	1128	1667	1281	1654	1988	1539	1571	1624	1709
167627	803.9	1127	1666	1281	1652	1985	1538	1572	1623	1706
167643	803	1128	1664	1280	1650	1984	1537	1571	1621	1704
167663	802.9	1126	1663	1279	1649	1982	1536	1571	1619	1703
167690	802.6	1125	1662	1279	1647	1980	1535	1568	1619	1701
167730	802.4	1123	1660	1274	1645	1980	1535	1569	1619	1700
167782	804.2	1125	1662	1278	1646	1982	1536	1569	1620	1698
167797	805.8	1126	1663	1278	1647	1982	1536	1570	1621	1699
167828	807.6	1127	1665	1280	1648	1985	1538	1572	1621	1700
167895	810.3	1130	1667	1279	1650	1990	1540	1575	1626	1704
168135	815.8	1131	1669	1283	1653	1993	1543	1578	1633	1706
168197	817.8	1131	1670	1286	1652	1995	1544	1578	1633	1707
168237	817.2	1132	1670	1285	1648	1996	1542	1577	1632	1705
168266	816.5	1130	1666	1285	1649	1993	1541	1576	1632	1703
168301	815.5	1128	1665	1283	1647	1991	1541	1577	1631	1703
168352	815.8	1128	1663	1283	1646	1989	1539	1574	1630	1700
168424	815.8	1128	1662	1283	1644	1988	1539	1574	1629	1701
168442	815.7	1128	1663	1284	1645	1989	1540	1575	1630	1703
168468	815.9	1127	1664	1284	1645	1990	1540	1575	1629	1703
168510	816.3	1129	1664	1283	1646	1990	1541	1576	1631	1704
168547	817.8	1130	1665	1285	1648	1956	1539	1573	1634	1706
168555	817.6	1130	1666	1286	1648	1994	1543	1578	1634	1707
168561	817.9	1132	1668	1287	1650	1994	1543	1579	1636	1709
168568	819.6	1133	1668	1288	1651	1997	1545	1580	1637	1711
168577	820.3	1134	1670	1289	1653	1998	1546	1582	1639	1713
168587	820.8	1135	1671	1290	1653	2000	1547	1583	1639	1715
168604	822	1137	1672	1292	1656	2002	1549	1585	1642	1718
168635	825	1141	1677	1297	1659	2007	1553	1590	1647	1722
168662	827.8	1142	1679	1299	1661	2009	1556	1593	1651	1726
168700	829.7	1144	1680	1302	1664	2013	1558	1594	1653	1727
168719	829.9	1144	1680	1301	1665	2013	1557	1594	1653	1728
168745	831.3	1145	1682	1302	1664	2014	1559	1595	1653	1728
168808	831.8	1148	1682	1303	1667	2014	1559	1595	1654	1730
168842	831.7	1148	1683	1304	1667	2015	1559	1596	1655	1730
169028	841	1149	1685	1311	1670	2023	1564	1601	1661	1737
169141	844.1	1152	1687	1315	1672	2027	1567	1604	1664	1734
169305	845.9	1153	1687	1316	1673	2029	1568	1605	1667	1737
169381	846.6	1153	1686	1316	1674	2029	1569	1607	1668	1737
169419	847.1	1154	1687	1317	1675	2031	1570	1608	1671	1740
169502	849.7	1157	1689	1318	1678	2034	1571	1610	1673	1744
169529	850.5	1159	1691	1336	1680	2036	1573	1612	1675	1746
169685	856.9	1162	1694	1320	1684	2042	1578	1617	1682	1751
169725	858.1	1163	1695	1321	1683	2043	1579	1616	1683	1751
169816	859.4	1164	1694	1326	1684	2044	1579	1617	1683	1748
169883	863	1166	1697	1330	1687	2048	1582	1619	1686	1751
170000	868	1170	1701	1338	1692	2054	1586	1625	1692	1760
170184	872.4	1171	1703	1341	1696	2060	1591	1630	1698	1766
170374	876	1178	1705	1343	1699	2063	1594	1634	1702	1770
170411	876.8	1178	1705	1342	1699	2064	1595	1634	1704	1770
170455	877.5	1180	1706	1345	1701	2066	1597	1636	1706	1772
170573	882.8	1184	1710	1349	1705	2071	1601	1641	1708	1778
170740	890.2	1190	1715	1355	1711	2079	1607	1646	1707	1780
170917	896.6	1196	1718	1371	1716	2087	1612	1652	1711	1789
170988	898.6	1198	1720	1372	1719	2091	1614	1655	1713	1792
171066	901.1	1201	1724	1374	1720	2094	1616	1656	1714	1795
171185	904.1	1204	1724	1373	1724	2098	1620	1660	1718	1798
171670	917.4	1214	1731	1388	1732	2111	1628	1671	1732	1808
171692	919.3	1217	1732	1387	1734	2113	1630	1673	1735	1810
171728	922.1	1218	1734	1394	1737	2117	1634	1676	1742	1813
171848	927.6	1225	1739	1385	1743	2124	1639	1681	1748	1821
171948	928.5	1226	1740	1386	1743	2125	1640	1683	1751	1820
172089	930.9	1230	1740	1388	1745	2129	1643	1686	1756

South SGs

NAME	S_{Y21}	S_{XB1}	S_{Y12}	S_{XB2}	S_{Y11}	S_{YB1}	S_{Y12}	S_{XB2}	S_{Y13}	S_{YB3}
UNIT	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]
ROW #										
3	-0.7	-0.6	0.1	-0.7	-1.1	-0.2	-0.8	-0.1	-0.3	-0.6
4227	8.7	3.5	5.7	2.4	1.5	-0.5	-0.2	0.9	-3.4	0.6
4233	11.1	4.7	7.2	4.2	1.9	0.3	-0.7	0.7	-2.5	0.2
4238	13.8	6.2	8.9	6.1	0.5	-0.7	-2.5	-0.8	-4.7	-1.2
4240	17.6	9.4	10.9	9.1	1.4	-0.8	-2.3	-0.2	-5.1	-0.3
4244	19.8	11.1	12.5	10	2.7	-1.7	-1.7	0.1	-4.1	-0.1
4248	19.5	9.7	11.4	8.8	1.4	-3.3	-1.3	-0.9	-4.9	-1.5
4272	15.4	9.5	8	8.1	1.8	0.2	-1	0.4	-4	0.1
4301	14.9	8.9	6.2	6.7	2.7	0.6	-0.8	1.2	-4.1	0.3
4394	12.6	9.3	5.2	7.2	3.4	2.5	0.4	2.1	-2.1	0.7
4490	9.9	8.1	3.6	6	2.5	1.5	-0.3	0.5	-3.7	-0.1
4510	9.2	7.7	3	5.1	1.3	0.3	-3.2	0.2	-6	-1.8
4528	6.6	7.9	2.1	6.5	0.2	0.3	-3.2	0.6	-6.2	-1.4
18434	4.7	6.3	0	2.8	1.6	1.7	-6.2	1.1	-7	-1
40202	4.8	5.7	-1.3	-0.1	3.3	3	-7.6	1.1	-9	-2.4
42198	4.1	4.1	-3.1	-2.7	2.2	-9.6	0.4	-11.3	-4	
42398	6.7	4.7	-1.7	-2.1	3.1	2.5	-8.7	1.5	-11.2	-3.3
42410	6.7	5.1	-1.7	-1.8	2.9	2.8	-9	0.3	-12	-2.9
42413	4.9	5.3	-1.5	-1.8	2.8	2.7	-9.1	0.8	-10.8	-2.5
42520	6.7	5.7	-1.3	-1.7	2.7	3	-8.5	1.8	-10.6	-2.2
42535	8.4	5.3	-1.4	-2	3.6	2.8	-8.5	1	-12.1	-3
42718	10.6	7.9	-0.4	-0.9	4.9	4.8	-8.4	1.8	-9.9	-1.8
43034	11.4	7.2	-0.8	-1.1	4	3.2	-9	1.2	-11.3	-2.3
43056	12.4	8.1	-0.6	-0.8	4.6	3.4	-8.4	1.3	-11.6	-2
43176	22.9	8.2	0.7	0.7	5.4	3.8	-8.6	2.8	-10.5	-1.7
43328	27.3	10.3	1.5	3.3	5.8	5.2	-6.5	4.8	-10.2	2.4
43476	30.8	12.4	2.5	7.3	7.3	6.9	-6.4	6.4	-9	5
43596	39.4	12.3	7.4	8.5	8.2	9.6	-3.3	9.4	-8.3	8.2
43619	41.5	12.7	9.4	9.9	8.2	10.2	-2.1	10.6	-8.1	10.3
43740	53.1	13.4	12.1	15.5	10.3	13.1	0.4	13.8	-6.6	16.7
43861	62	15	11.6	17.7	12.7	16.8	4.4	16.6	-4.8	21.5
44061	77.3	17.5	8.9	23.7	18.7	26.1	12.5	20.8	1.9	32
44223	92.5	16.5	6.8	23.9	24.8	36.7	19.1	25.6	4.2	41.4
44358	104.7	18.5	8	24.4	30.5	41.3	27.5	30.4	10.1	46.8
44478	113.3	15.8	6.5	23.9	35.7	45	34.6	34.8	10.7	52.9
44628	122.5	18.4	10.4	29	47.6	51.5	41.5	41.9	14	62.1
45038	127.3	17.9	15.4	32	59.7	59.1	49.2	44.7	16.9	68.9
45474	132.1	18.7	17	33	62.4	60.3	51.5	45	16.8	70.6
45497	135.8	18.4	18.1	33.1	63.9	60.7	54	45.6	16.6	72.4
45619	143.5	21	20.4	34.5	70.5	66	60.9	51	18.8	76.3
45880	153.2	21.6	29	33.3	86.1	74.5	75.6	58.1	23.5	82.2
45990	162.7	24.6	34.3	35	100.4	80.4	87.7	68.3	27.1	88.1
46495	187.6	35	61.7	39.7	139.1	103.3	118.6	109.2	34	100.3
46669	201.5	37.7	79	42	158.8	115.7	133.9	127.3	39.5	106.3
47319	236.9	62.2	110.5	58.3	213.7	157.2	168.1	221.7	56	131
47758	309	78.7	122.2	74.3	268.8	184	200.4	251.9	75.8	155.3
48016	314.8	80.1	127.1	78.5	278.5	190.3	201.3	255	81.5	160.3
48061	320.2	82.2	128.6	81.4	284.5	193.7	203	258.4	83.1	162.6
48181	333.2	86.8	134.9	86.8	299.2	204.7	213.2	270.8	87.5	172.5
48696	368.1	103.8	161.7	109.4	307.9	244	222.7	294.5	129.9	202.6
50490	387.9	121.8	186.8	129.8	319	271	231.2	307.7	183	237.2
62108	393.1	129.5	199	134.9	322.3	280.6	231.8	311.6	194.9	254.4
66109	397.2	130.6	201.3	135	323.6	282	232.3	313	195.2	254.6
66149	393.4	131.5	200.4	135.2	324	282.9	233.7	311.1	197.4	255.4
73060	395.8	132.1	202.1	136.7	325.6	284.9	232.9	312.9	195.5	257.7
73167	401	132.9	203.9	138.9	329.6	287.1	235.3	316.7	199.2	260.5
73282	410.3	136.4	207.6	143.1	336.4	294	239.9	323.8	204.9	266.6
73394	421.5	139.7	212.4	148.6	344.5	302.6	246.8	333.8	211.8	276.7
73503	434.6	144.8	219.2	158.8	354.6	313	255.3	345	223.9	293.6
73638	447.6	151.4	227.2	172.8	369.6	324.6	262.3	357	239.5	314.6
74114	454.7	159.8	236.2	189.6	381.2	331.8	263.8	363.2	254.5	340.7
74236	458.1	161.4	238	193.3	385.3	335.3	265.3	368.1	257.7	347.4
74401	470.7	167.4	245	204.1	397.2	346.9	272.9	378.5	270.4	364.4
74666	488.9	182.1	258.6	223.1	416.6	365.9	286.5	395.7	292.9	389.8
74848	505.8	196.3	271.1	241.6	437	383.8	300.6	412.3	312.9	412
75214	527.3	219.4	289.7	301	459.2	411.8	323.7	436.9	340.1	446
75412	544.4	238.9	301.9	333.1	474.4	434.6	339.8	454	359.7	469.5
75660	554.6	262.7	315.4	365.2	492.2	462.4	352.1	473.5	384	493.5
75992	564	288.2	330.1	391.4	514.6	494.9	364.5	494.9	410.5	520.4
76382	568.8	307.4	343.6	416	530	548.4	369.3	511.2	433	540.5
76736	581.9	335.4	357.4	441.2	549	584.4	388.7	532.6	458.7	562.8
76975	591.4	354.4	372.3	463	564.4	608.1	399.1	549.4	477.3	582.2
77155	603.8	370.6	384.7	479.1	575.9	627	409.2	572.2	493.7	601.1
77583	628.8	397.3	408.9	500.2	611.2	653.9	428.1	608.7	499.7	641.2
77794	644.2	414.3	423	516.2	625.7	674.7	445.9	602.8	511.8	659.2
78091	660.7	435.1	440.9	533.4	639.4	694.4	467.5	617.2	527	677.3
78310	674.4	450.5	455.9	550.4	652.6	711.8	480.7	629.1	542.1	694.4
78555	688.8	469.8	476.6	566.8	668	729.4	495.6	643.1	557.1	713.6
79159	704	492	506.8	585.2	684.3	757.8	512.7	666.8	580.8	737.1
79593	704.8	498.3	513.8	585.1	686.2	758.1	513.5	667.4	581.3	739.2
79624	701.3	496.3	512.4	582.8	682.6	753.6	510.9	663.6	577.7	734
79721	697.2	495.2	511.6	578.5	677.7	748.5	507.7	659.7	573.7	729
79948	693.4	492.6	510	572.5	671.4	742.8	503.2	654.3	567.5	723.6
80344	686.1	490.5	507.4	567	666.4	734.4	500.5	649.9	563	717.3
87037	678.5	492.3	508.8	560.5	661.8	724.6	496.5	643.4	550.2	709.6
90487	681.9	496.6	514	563	661.5	726.6	497.6	645.3	548.1	713.6
97669	686.9	500.2	517.2	567.5	666.5	731.8	498.9	650.3	553.4	719.6
97775	690.3	501.2	518.4	572.4	671.6	737.3	501.7	654.3	558.5	725.1
97938	695	505.4	523.2	578.8	678.4	744.9	507.4	660.5	562.4	732.8
98040	702	509.5	527.1	586.5	685.8	753.2	513.7	668	571.2	741.9
98304	709.5	516.8	533.4	597.6	697.9	766.8	521.8	678.8	581.9	753.9
98416	716.8	522.1	539.1	604.8	707.4	777.8	529.5	687.7	592	765
98613	729.5	534.5	551.8	619.6	722.2	795.8	540.2	703.4	605	782.4
98720	739.4	543.1	561.3	631.1	733.1	808.4	549.5	714.6	615.5	795.3
98917	753.2	559.4	578.8	646.9	749.4	826.3	561.8	732	628.9	815.2
99115	765.6	573.5	594	660.4	764	841.3	573.1	748.6	646.8	832.6
99312	776.1	585.6	610	673.8	779.8	855.2	580.3	762.2	655.6	848.5
99500	787.8	598.7	630	688.2	796.6	872.7	594.2	778.9	670.4	866.5
99869	800.4	616.5	659.4	704.9	815.5	891.2	603.1	800.6	706.7	885.7
100074	813	630.3	676.1	719.4	832.2	905.5	613.7	815.9	722.6	900.8
100261	825.7	644.9	692.9	733.8	850.9	920.8	626.7	831.7	739.4	916.9
100487	837.6	661.6	711.2	747.7	867.3	933.5	639.6	849	755.8	933.3
100734	851.9	683.5	731.9	763.8	888.2	950.7	654.8	868.5	773.2	954
101232	865	706.6	754.8	780.8	909.4	967.1	669.8	888.2	790.4	974.1
101336	874.6	717.8	766	792.8	923.7	980	679	900.9	803.8	986.5
101796	890.9	744.1	791.3	809.6	946.9	997.2	695.2	921.8	827.1	1007
101996	902.2	759.4	810.5	820.2	963	1012	709.7	940.3	836.1	1023
102240	916.1	779.8	836.2	835.5	980.6	1030	723.8	960.1	853.8	1043
102477	927.1	798.4	856.2	848.6	999	1045	736.8	977.7	869.3	1061
102614	936.7	812.5	871.9	860.2	1013	1057	746.8	991.6	881.2	1075
102985	953.2	844.4	902.9	877.6	1037	1077	765.1	1017	898.7	1098
103370	968.8	869.2	928.4	894.3	1058	1095	781	1040	916.2	1117
103679	979.5	886.6	945.6	906.4	1074	1108	793.6	1056	927.7	1132
103964	996	908	968	923.7	1094	1125	809.2	1076	945.3	1152
104433	1011	933.5	992.8	938.5	1113	1140	825.3	1097	955.6	1172
104972	1026	958.2	1013	952.9	1133	1158	840.1	1116	969.4	1190
105202	1036	973.6	1028	965.3	1149	1171	850.9	1131	983.4	1205
105847	1053	1006	1056	983.1	1174	1188	870.5	1156	1001	1231
106129	1065	1022	1071	995.8	1189	1203	881.3	1171	1015	1243
106348	1079	1041	1088	1012	1207	1218	881	1189	1029	1262
106886	1083	1058	1099	1013	1211	1219	897.9	1194	1031	1269
106980	1080	1056	1097	1009	1205	1214	894.9	1190	1027	1264
107092	1077	1055	1095	1004	1201	1209	892.1	1188	1025	1259
107201	1071	1052	1090	999.1	1196	1205	888.5	1182	1019	1254
107245	1065	1049	1087	992.8	1198	1198	883.3	1176	1010	1247
107372	1061	1047	1085	987.8	1184	1193	880.5	1172	1008	1243
121270	1047	1049	1075	969.9	1171	1173	869.2	1158	998.2	1233
128483	1050	1054	1082	971.1	1175	1173	877.5	1161	997.7	1236
128584	1053	1055	1085	976.5	1179	1176	880.5	1164	1001	1239
128667	1057	1059	1088	982.7	1186	1182	884.7	1169	1006	1247
128804	1063	1065	1094	989	1194	1188	890.4	1176	1014	1255
128921	1069	1072	1100	997.6	1204	1198	888.9	1185	1023	1264
129334	1079	1083	1110	1005	1220	1211	902.3	1198	1034	1278
129759	1089	1095	1123	1024	1235	1227	915.3	1213	1047	1295
129894	1098	1103	1132	1032	1245	1236	925.3	1223	1057	1305
130111	1110	1118	1146	1046	1263	1253	936.9	1241	1073	1324
130395	1122	1133	1161	1059	1280	1267	949.2	1255	1087	1341
130603	1133	1146	1174	1071	1293	1280	959.6	1268	1099	1356
130918	1145	1164	1193	1084	1310	1295	972.4	1284	1112	1374
131495	1159	1188	1210	1102	1331	1311	989.4	1307	1131	1397
131857	1173	1207	1228	1117	1351	1328	1005	1325	1147	1417
132826	1189	1237	1253	1138	1373	1347	1022	1348	1164	1442
133339	1203	1252	1267	1151	1389	1359	1033	1362	1175	1458
134145	1219	1282	1290	1173	1411	1380	1051	1387	1192	1484
134772	1231	1301	1308	1186	1429	1394	1065	1404	1201	1503
134971	1242	1316	1320	1200	1445	1408	1076	1419	1217	1520
135702	1260	1346	1346	1218	1471	1426	1096	1444	1233	1547
136268	1275	1366	1364	1231	1487	1441	1108	1460	1243	1566
137134	1293	1393	1386	1254	1510	1459	1127	1484	1260	1592
137461	1308	1413	1403	1271	1530	1475	1142	1503	1275	1612
137869	1323	1432	1420	1286	1548	1489	1156	1521	1284	1632
138580	1342	1462	1442	1309	1574	1506	1174	1543	1298	1658
139155	1362	1491	1463	1332	1599	1522	1193	1568	1314	1685
140118	1385	1528	1491	1358	1627	1540	1217	1601	1336	1717

NAME	S_{Y21}	S_{XB1}	S_{Y12}	S_{XB2}	S_{Y11}	S_{YB1}	S_{Y12}	S_{XB2}	S_{Y13}	S_{YB3}
UNIT	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]	[µs]
ROW #										
141639	1400	1557	1509	1369	1641	1543	1228	1613	1344	1731
141796	1395	1555	1506	1365	1635	1538	1224	1608	1338	1726
141933	1393	1552	1504	1360	1630	1534	1220	1605	1335	1722
142066	1387	1550	1500	1355	1626	1529	1217	1601	1330	1717
142220	1383	1546	1496	1351	1619	1522	1214	1596	1326	1712
142363	1379	1543	1492	1345	1613	1518	1208	1591	1322	1705
142473	1373	1538	1487	1338	1606	1510	1205	1586	1314	1700
142522	1367	1534	1483	1332	1598	1505	1201	1580	1311	1694
142720	1362	1530	1479	1326	1592	1499	1196	1574	1305	1686
142932	1355	1525	1473	1318	1584	1491	1191	1567	1298	1679
143042	1351	1521	1469	1311	1578	1485	1186	1561	1291	1673
162000	1333	1508	1454	1287	1558	1459	1168	1538	1254	1657
162752	1333	1508	1454	1288	1561	1461	1171	1540	1258	1660
162804	1338	1512	1459	1294	1568	1466	1176	1546	1263	1667
162911	1342	1514	1461	1299	1571	1469	1179	1548	1266	1669
163042	1346	1519	1463	1306	1578	1475	1183	1555	1267	1676
163168	1351	1522	1469	1311	1585	1479	1186	1558	1270	1681
163258	1356	1526	1474	1318	1592	1485	1191	1563	1278	1687
163358	1362	1531	1480	1324	1599	1491	1196	1570	1286	1694
163501	1368	1537	1485	1330	1606	1497	1202	1576	1292	1702
163649	1374	1544	1492	1339	1617	1505	1207	1584	1299	1710
163804	1383	1553	1501	1351	1629	1517	1217	1596	1309	1723
163937	1391	1563	1511	1359	1640	1527	1226	1607	1316	1735
164147	1400	1578	1525	1375	1660	1544	1239	1626	1327	1755
164343	1415	1601	1545	1397	1685	1565	1249	1639	1340	1770
164454	1427	1604	1549	1403	1688	1568	1260	1654	1354	1785
164862	1442	1625	1565	1420	1707	1583	1274	1673	1366	1805
165156	1458	1645	1582	1439	1728	1600	1289	1694	1387	1827
165483	1470	1664	1596	1456	1744	1614	1303	1713	1399	1847
165886	1488	1687	1613	1476	1766	1629	1313	1731	1406	1867
166571	1514	1723	1640	1499	1797	1650	1335	1764	1431	1899
166795	1529	1739	1653	1514	1813	1664	1348	1780	1445	1917
167156	1546	1760	1670	1533	1834	1680	1362	1798	1462	1943
167438	1569	1782	1690	1556	1859	1697	1385	1826	1481	1966
167545	1573	1787	1695	1560	1865	1699	1390	1831	1486	1971
167581	1572	1785	1694	1558	1864	1698	1390	1832	1485	1971
167626	1577	1787	1694	1559	1864	1698	1389	1831	1484	1971
167627	1572	1785	1693	1557	1862	1697	1388	1829	1482	1969
167643	1571	1785	1692	1556	1862	1695	1388	1829	1481	1969
167663	1569	1784	1691	1555	1861	1694	1386	1828	1480	1967
167690	1568	1783	1690	1553	1859	1693	1385	1827	1478	1966
167730	1570	1783	1690	1553	1859	1691	1385	1826	1477	1966
167782	1570	1783	1691	1554	1859	1692	1385	1827	1476	1966
167797	1571	1784	1691	1553	1860	1691	1386	1828	1476	1966
167828	1573	1786	1693	1554	1863	1693	1387	1829	1478	1969
167895	1575	1786	1695	1557	1864	1695	1389	1831	1480	1971
168135	1579	1789	1699	1559	1868	1696	1394	1836	1482	1975
168197	1579	1790	1699	1559	1869	1695	1394	1836	1482	1974
168237	1577	1790	1699	1560	1869	1694	1392	1834	1480	1973
168266	1578	1789	1698	1557	1866	1693	1392	1833	1479	1973
168301	1577	1789	1697	1556	1866	1692	1391	1832	1477	1972
168352	1577	1787	1696	1554	1864	1690	1390	1831	1476	1969
168424	1577	1786	1696	1554	1864	1689	1389	1831	1474	1970
168442	1577	1787	1695	1565	1865	1691	1390	1832	1476	1971
168468	1578	1787	1698	1556	1865	1691	1390	1832	1476	1971
168510	1579	1789	1698	1556	1867	1692	1391	1834	1478	1973
168547	1580	1790	1700	1560	1869	1694	1392	1835	1478	1975
168555	1581	1790	1700	1561	1870	1694	1394	1836	1480	1976
168561	1584	1792	1701	1562	1871	1695	1396	1837	1481	1977
168568	1585	1793	1703	1564	1873	1697	1396	1839	1483	1978
168577	1586	1793	1704	1564	1875	1698	1398	1841	1484	1981
168587	1588	1794	1705	1567	1876	1700	1398	1842	1485	1982
168604	1589	1796	1708	1569	1880	1702	1401	1845	1487	1985
168635	1594	1801	1712	1573	1884	1707	1404	1850	1493	1991
168642	1596	1798	1713	1569	1880	1709	1407	1854	1494	1990
168700	1597	1805	1715	1577	1889	1710	1409	1855	1495	1996
168719	1597	1805	1716	1576	1888	1709	1408	1855	1495	1996
168745	1600	1807	1716	1577	1890	1709	1409	1855	1495	1997
168808	1601	1810	1721	1581	1895	1713	1410	1858	1505	2000
169028	1605	1811	1721	1582	1895	1713	1415	1862	1497	2004
169141	1608	1813	1724	1583	1899	1713	1415	1863	1497	2006
169305	1610	1816	1726	1585	1902	1715	1417	1866	1499	2009
169381	1611	1816	1728	1586	1903	1715	1418	1867	1496	2011
169419	1614	1818	1729	1589	1905	1717	1419	1868	1501	2013
169502	1617	1820	1732	1591	1909	1719	1423	1872	1498	2016
169529	1619	1821	1732	1592	1910	1720	1424	1874	1500	2018
169685	1622	1826	1737	1595	1916	1724	1429	1879	1504	2024
169725	1623	1826	1737	1595	1916	1724	1429	1879	1504	2024
169816	1625	1826	1739	1595	1917	1723	1430	1879	1502	2025
169883	1626	1828	1741	1598	1920	1725	1433	1883	1506	2028
170000	1633	1833	1745	1602	1925	1729	1436	1887	1510	2034
170184	1638	1837	1750	1607	1931	1733	1440	1893	1517	2040
170374	1641	1841	1754	1611	1936	1735	1444	1897	1521	2049
170411	1643	1842	1755	1610	1937	1736	1445	1898	1522	2049
170455	1645	1843	1757	1612	1939	1737	1446	1901	1524	2050
170573	1647	1847	1760	1617	1945	1741	1451	1905	1528	2056
170740	1655	1851	1765	1623	1951	1745	1456	1911	1534	2062
170917	1661	1855	1771	1628	1957	1749	1461	1918	1538	2069
170988	1663	1858	1774	1631	1960	1752	1464	1922	1542	2074
171066	1663	1858	1774	1631	1960	1752	1464	1922	1542	2076
171185	1670	1862	1778	1637	1968	1755	1468	1927	1545	2078
171670	1681	1868	1787	1646	1980	1762	1477	1940	1557	2093
171692	1683	1870	1788	1647	1982	1763	1479	1942	1560	2095
171728	1686	1872	1791	1651	1987	1765	1482	1944	1562	2097
171848	1692	1878	1795	1655	1994	1771	1486	1951	1567	2104
171948	1694	1879	1797	1655	1998	1772	1488	1954	1569	2107
172089	1697	1880	1800	1656	2001	1774	1491	1957	1573	2110
172120	1700	1883	1801	1659	2004	1776	1492	1959	1575	2113
172134	1702	1884	1802	1660	2005	1777	1494	1961	1578	2116
172176	1704	1886	1805	1663	2010	1779	1497	1964	1582	2119
172230	1707	1888	1807	1663	2012	1781	1499	1967	1585	2122
172258	1707	1888	1807	1663	2012	1781	1499	1966	1585

T-Head SGs

NAME	TH_1	TH_3	TH_5	TH_8
UNIT	[µStrain]	[µStrain]	[µStrain]	[µStrain]
ROW #				
3	-1	-1.1	-0.1	0.6
4227	-1.1	-0.3	-0.5	0.7
4233	-1	-1.2	-1.1	0.2
4238	-1.7	-0.5	-0.7	0.3
4240	-3.5	-2.1	-1.8	-0.9
4244	-3.8	-1.8	-2.1	-0.9
4248	-3.8	-1.6	-3.1	-0.9
4272	-3.7	-1.9	-2.2	-1
4301	-3.8	-2.3	-2.2	-0.7
4394	-3	-2.2	-1.4	-0.2
4490	-3.1	-2.6	-1.7	-0.2
4510	-4.7	-1.5	-1.6	-0.6
4528	-4.1	-1.7	-1.5	-0.5
18434	-4.2	-2	-0.6	-0.1
40202	-4	-1.2	-0.8	0.4
42198	-5.2	-2.6	-1.4	0.4
42398	-5.7	-3	-2.1	-0.2
42410	-5.6	-2.6	-2.2	-0.2
42413	-4.1	-1	-1.5	-0.3
42520	-5.3	-2.3	-2	-0.6
42535	-5.6	-2.2	-2.2	-0.4
42718	-5.6	-1.3	-2	-0.3
43034	-6.7	-3.3	-3	-0.9
43056	-6.9	-3.1	-3.7	-0.6
43176	-7.7	-2.7	-4.1	-1.3
43328	-8.5	-4.1	-5.3	-3.2
43476	-8.8	-3.8	-5.8	-3.3
43596	-9	-5	-6.3	-4.9
43619	-9.8	-6	-6.5	-6.1
43740	-10.6	-6.2	-7.5	-6.5
43861	-11.1	-6.1	-8	-7.5
44061	-16.4	-11.2	-10.6	-7.8
44223	-20.6	-16.5	-18.3	-2.5
44358	-24.4	-20	-23.8	0.6
44478	-28.2	-23	-26.4	3.4
44628	-31.2	-25	-27.2	15.7
45038	-32.4	-27.6	-22.7	15.2
45474	-33	-27.7	-21.6	16.2
45497	-33.6	-30	-22.5	15.6
45619	-34.6	-28.5	-17.6	17.6
45880	-37.3	-30.7	-15.9	18.7
45990	-39.3	-32.7	-13.6	21.9
46495	-44.8	-39	-3.2	44
46669	-46.7	-41.8	4.6	54.8
47359	-59.4	-48.7	-2.3	59.4
47758	-63.9	-47.4	-4	66.2
48016	-63.7	-46.6	-4.3	65
48061	-66.2	-47.7	-5.7	66.3
48181	-67.2	-47.3	-5.8	68.1
48696	-51.8	-44.2	-10.4	75.1
50490	-31.6	-37.9	-13.6	80.8
62108	-25.7	-33.5	-13	80.5
66109	-26.5	-34.3	-13.2	80.1
66149	-25.6	-33.8	-12.9	81.3
73060	-25.7	-34.1	-13.2	77.3
73167	-27.3	-34.5	-13.6	76.5
73282	-26.9	-34.9	-13.7	77.6
73394	-26.1	-34.8	-12.8	77.4
73503	-25.3	-35.5	-14.2	80.8
73638	-26.1	-35.2	-16	81.8
74114	-24.1	-32.6	-16.3	71.4
74236	-24.1	-32.9	-15.7	71.7
74401	-22.9	-33.1	-16.8	72.5
74666	-17.7	-30.8	-17.4	74.1
74848	-7.9	-28.2	-16	75
75214	-1.4	-24.1	-14.7	77.3
75412	-0.4	-19.1	-12.8	80.5
75660	1.7	-15.7	-12.5	98.9
75992	2.8	-12.3	-11.3	109
76382	3.5	-14.1	-13	108.9
76736	4	-10.4	-14.8	128.6
76975	3	-7.1	-14	132.2
77155	3.4	-3.9	-13.3	137.9
77583	10.4	-2.7	-7.4	145.4
77794	8.9	-0.9	-3.9	148.3
78091	9.6	0.8	-0.8	153.5
78310	10.1	3.3	-0.5	155.3
78555	12.7	6.6	0.6	160.4
79159	14.5	11	0.4	156.4
79593	15.3	13.1	1.7	153.5
79624	15.3	12.8	1.7	153.6
79721	15	13.7	2.4	151.7
79948	14.9	13.5	2.8	150.1
80344	14.2	14.1	2	148
87037	15.1	15.5	2.5	139
97407	15.6	15.7	2.1	132.4
97669	15.5	16.5	2.3	132.3
97775	16.7	16.5	2.6	133.8
97938	16.9	16.2	2.7	135.1
98040	17	15.9	2.2	135.3
98304	17.2	17	2.3	136.4
98416	17.6	16.1	1.2	137.1
98613	17.9	16.7	1.6	140
98720	18.4	18.3	0.5	141.8
98917	19	18.9	1.3	144.4
99115	20.5	22.2	2.2	144.8
99312	20.9	22.7	4.3	148.8
99500	22.4	25.3	5.1	151.4
99869	22.4	30.8	9	157.8
100074	23.6	34	9.9	159.9
100261	24.4	36.8	11.3	163.8
100487	25.4	39.2	13.1	167.2
100734	27	43.8	15	172.9
101232	29.2	49.4	17.8	178.3
101336	30.4	51.3	18	181.5
101796	31.9	58.1	20.5	184.9
101996	32.9	61.7	20.9	186.5
102240	35.1	66.2	22.8	189.6
102477	35.9	70.2	24.6	190.2
102614	36.4	72.5	24.8	192.2
102985	38.8	79.5	25.3	194.3
103370	40	85.5	27	192.8
103679	41	89.1	27	194.2
103964	42.5	94.5	28.4	196.8
104433	44.4	99.2	28.9	197.1
104972	45.5	104.7	30.8	198
105202	46.5	107.3	31.7	200.2
105847	48.7	115	34.2	200.5
106129	49.3	117.6	33.8	201.3
106348	49.3	120.8	34.8	202.5
106886	49.1	124.8	35.9	200.9
106980	49.4	125	35.3	200.9
107092	49.7	126.6	37.1	201.6
107201	49.5	127.6	36.6	201.3
107245	48.4	125.6	36.2	199.7
107372	48.2	126.2	36.5	199.4
121270	47.6	130.8	37.1	186.1
128483	48.1	131.3	36.9	182.2
128584	47.8	130.3	36.8	181.7
128667	48.2	131.1	36.3	183.4
128804	48.9	131.2	36.6	183.9
128921	48.8	131.9	36.1	183.4
129334	49.4	133.8	36.2	183.8
129759	50.8	136.6	37.3	187.2
129894	50.1	136.7	36.8	186.8
130111	52.5	139.7	38.3	188.3
130395	52.9	141.5	39	190.3
130603	53.8	143.7	39.7	192.6
130918	55.4	147.5	40.1	193.6
131495	58.1	153.5	41.7	197.4
131857	59.9	158.5	42.9	200.6
132826	61.9	164.4	43.7	203.2
133139	63.3	167.3	43.8	204.2
134145	65.7	174.1	44.5	209.8
134772	67.2	178.7	45.7	212.2
134971	67.5	181.4	46.2	214.7
135702	69.3	188.5	45.4	215.6
136268	70.6	194.6	48	219
137134	71.5	201.8	48.4	221.8
137461	73.1	207.1	50.2	225.1
137869	74.7	213.1	50.7	227.5
138580	75.3	222.3	51.3	230.3
139155	77.1	230.5	51.3	233.9
140118	78.1	243.7	50.8	236.6

NAME	TH_1	TH_3	TH_5	TH_8
UNIT	[µStrain]	[µStrain]	[µStrain]	[µStrain]
ROW #				
141639	79.8	257.5	50.2	239.2
141796	79.6	258	49.5	239.8
141933	79.6	258	50.3	238.5
142066	79.2	258.8	50.6	239.6
142220	78.4	259.3	50.8	239
142363	78.4	260.3	50.8	240.2
142473	77.7	259.5	50.3	237.9
142522	77.8	260.3	50.4	239.7
142720	76.3	259.2	50.8	238.5
142932	75.7	259	50.7	237
143042	75.8	259.7	50.8	237.8
162000	74.2	263.7	48.3	230.5
162752	73.6	262.8	48.9	229.6
162804	73.9	263.4	48.6	231.8
162911	74.3	263.2	48.2	230.5
163042	75	264	47.7	232.5
163168	74	263.6	48.1	232.2
163258	74.6	263.3	48.4	231.4
163358	75.8	264.7	48.6	232
163501	76.5	265.3	48.6	232.2
163649	76.5	266.1	48.6	233.8
163804	77.4	267.3	49.1	234.5
163937	77.9	268.6	49.1	234.9
164147	78.9	272.1	50	237.3
164343	81	275.5	49.6	239.3
164454	81.9	278.2	51.1	242
164862	83.6	284.1	52.2	245.4
165156	84.6	289.7	52.7	249.7
165483	88.4	295.2	53.7	252.1
165886	89.4	302.1	54.5	256
166571	93.3	315.6	56.3	261.8
166795	94.6	320.2	57.8	264.2
167156	97.2	330.1	61	267.8
167438	99.1	338.3	64.4	271.6
167545	99.4	341.3	65.3	273.3
167581	99.6	341.1	65.2	273.4
167608	99.6	343.8	65.5	273.9
167627	99.7	343.6	65.4	274
167643	99.3	343.5	65.9	273.9
167663	99.4	344.3	66.9	274.3
167690	99.2	343.8	65.4	273.5
167730	100.2	345.2	66.2	274.9
167782	100	345.9	66.5	275.5
167797	99.7	344.7	65.7	273.5
167828	100.7	346	67.3	274.1
167895	100.6	346.4	67.2	275.1
168135	100.6	350.7	68.1	275.7
168197	101.3	352.4	69.1	275.7
168237	100.6	351.5	69.7	275.5
168266	100.5	351.8	69.3	275.8
168301	100.7	352.5	69.9	275.6
168352	100.7	352.3	69.3	275.2
168424	100	353.5	69.4	275.7
168442	101	354.3	69.7	276.4
168468	100.2	353.8	70.3	275.9
168510	101.1	354.3	69.1	275.3
168547	101.1	355	69.7	275.9
168555	101.3	355.5	70	276.8
168561	101.7	355.5	70	276.3
168568	101.1	355.6	69.5	276.6
168577	101.6	355.3	70.2	277.2
168587	102.2	355.6	71.1	278
168604	102.1	356.5	70.8	276.6
168635	101.5	358.1	71.2	276.9
168662	102.4	358.9	71.3	277
168700	101.7	358.6	71.8	276.8
168719	101.7	359.4	72.7	277.7
168745	103.3	361.3	72.9	279.5
168838	102.3	363	73.4	279.2
169028	103.6	365.9	73.4	279.4
169141	102.7	367.6	74.8	279.6
169305	103.7	371.5	75.6	281.5
169381	103.8	371	75.8	281.8
169419	103.3	372.5	75.3	281.6
169502	104.2	373.5	77	281.8
169529	103.9	374.5	76.7	281.5
169685	103.9	378.1	78.8	283.4
169725	105.1	379.8	78.6	283.7
169816	105.4	379.1	79.3	283.6
169883	105.2	379.8	77.7	283.3
170000	106.2	383.5	79.7	279.5
170184	107	387.5	80.7	286.6
170374	106.4	390.3	82	288
170411	106.8	390.6	81.7	288.9
170455	107.5	392.9	82.3	288.5
170573	108.4	394.8	83.6	289.8
170740	108.3	398.2	84	291.1
170917	109.7	402.4	85.1	291.5
170988	110.4	404.2	85.9	292.8
171066	109.8	405.8	85.3	292.6
171185	110.7	407.5	85.8	293.8
171670	113.7	417.1	88	297
171692	113.8	417.2	87.3	297.4
171728	114.2	418.2	87.9	299.1
171848	114	421.1	89.2	299
171948	114.7	423.4	89.5	299.3
172089	115.2	425.8	90.1	300.6
172120	116.2	427.6	90.3	300.6
172134	116.4	428.3	90.7	300.9
172176	116.6	428.4	91.2	302
172230	117	430.6	91.5	296.1
172258	116.5	431.3	91.2	303.5
172279	116.7	432.3	91.9	302.4
172297	117.1	432.2	91.8	303.6
172471	118.2	434.4	92.1	302.9
172484	118.2	434.8	92.3	303
172499	118.3	435.9	92.2	302.5
172521	118.5	436	92	302.9
172579	119.4	438.1	93.7	304.3
172814	122.1	445.2	96.1	307.3
172830	122	445.8	95.6	307.3
172851	122.2	446.9	96.7	307.3
172961	123.8	450.6	97.2	309.4
173131	125	455.5	98.7	309.4
173164	125.6	456.9	99.2	311.2
173329	127.1	460.2	100.9	311.4
173343	126.7	460.7	100.3	311.5
173360	126.2	460.4	100.5	312.3
173387	127	462.2	101.1	312.5
173462	128.2	464.6	102.2	314
173486	127.9	466.1	102.8	314.3
173506	128.7	466	103.3	313.7
173521	129.2	467.6	103.4	314.8
173535	129	467.2	103.4	315
173554	129.1	468.6	103.8	314.1
173613	129.6	468.3	103.9	314.2
173890	131.3	473.7	106.3	315.3
173945	131.5	474.1	106.6	315.2
174146	133.2	478.3	108.1	316.6
174166	134.1	479.3	108.2	316.5
174181	133.5	478.6	108.6	316.8
174205	133.4	479	108.8	317.1
174242	133.5	481.1	109.8	317.9
174275	135.1	482.1	110	318.5
174352	134.7	484.9	111.6	318.7
174373	135.4	485	111.7	320.7
174392	135.3	486	111.6	318.6
174407	135.6	485.8	111.6	312.1
174427	135.8	486.6	112.3	320.6
174586	136.6	488.2	112.7	318.8
174601	137.2	488.9	113.3	319.8
174614	136.8	488.4	112.8	320.8
174638	137.6	490.1	113.5	320.6
174673	137.6	490.5	114.6	320.7
174738	138.6	494.1	115	321.4
174765	138.9	493.9	115.4	321.4
174789	138.8	495	115.5	320
174808	138.8	494.7	115.9	322.1
174828	138.8	494.4	115.8	322.2
174931	139.6	495.7	116.9	322.4
175105	139.7	498.6	119	324.1
175134	139.9	498.4	119.4	324
175251	141.1	502.8	121.4	324.9
175329	141.5	503.2	121.3	324.1

NAME	TH_1	TH_3	TH_5	TH_8
UNIT	[µStrain]	[µStrain]	[µStrain]	[µStrain]
ROW #				
175430	143.5	506.9	123.1	327.3
175503	144.6	509.9	124.7	327.1
175543	143.9	509.9	124.7	326.5
175576	143.3	510.5	125	326.9
175884	148.3	521.7	131.6	330.3
175997	149.6	526.4	133.5	332
176102	150.5	529.5	136.3	332.9
176231	152.5	535.4	139.5	334.6
176278	152.6	537.3	139.1	332.9
176410	154.3	542.9	142.8	334.4
176668	158.4	557.8	149.5	337.9
176858	161.1	570.5	154.9	338.8
176962	162.9	580.7	158	340.3
177002	162.7	586.5	159.4	340.8
177048	163.6	592.4	161.4	342.6
177121	165.5	605.7	165.2	343.9
177135	165.3	607.4	165.2	344.1
177151	165.8	610.1	165.8	343.5
177163	165.9	611.9	165.5	343.8
177175	167	614.7	165.8	343.9
177185	166.5	615.9	166.1	343.9
177195	167	616.7	166.9	342.6
177207	167.1	618.8	167.2	344
177224	166.8	619.7	167.6	343.1
177247	168.1	623.6	168.3	341
177279	168.6	627.1	169.8	346.4
177315	169.9	631.1	170.1	345.4
177361	169.3	634.9	171.4	346.1
177389	170.2	637.4	171.6	345.8
177398	170.5	639.3	172.1	345.7
177413	169.9	639.6	171.9	344.9
177548	171.5	656.4	176.6	347.3
177574	172.1	659.2	178.2	347.9
177598	172.3	661	177.6	347.7
177621	173	663	178.6	348
177639	172.8	664.5	178.6	342.8
177659	173.1	666.2	180.3	345.9
177682	173.4	667.3	180	349.1
177988	178.4	687.4	189	351.1
178024	179.3	690.3	191.4	352.2
178049	179.3	691.2	191.9	349.7
178293	183.5	708	202.4	357.1
178327	184.3	710.7	204.9	358.1
178408	185.5	718.2	208.8	358.6
178503	186.7	726	213.8	360.9
178624	189.3	735.6	221.5	364
178702	190.4	739.9	227	367
178729	191.5	741.6	228.4	368.5
178805	193.4	744.5	231.7	370.5
178848	192.6	747.5	234.9	371.5
179059	197	759.5	247.8	379.6
179177	199	771.2	259.3	397.6
179295	204.5	787	274.4	420.6
179468	210.8	801.4	290.9	445.7
179638	217.2	815.1	305.2	472.1
179756	224.1	826.5	319.9	494.4
179847	234.1	839.4	334.7	516.6
179896	243.5	846.4	343.7	527.3
179940	250.9	850.4	348.2	532
180109	273.4	860.9	360.4	549.3
180198	291.6	871.4	371.8	561.7
180306	314.7	887.2	388.6	572.3
180360	325.4	896	397.6	575.6
180402	333.4	898.2	402	576.1
180461	343.2	900.9	407	575.3
180785	379.7	913.4	422.4	571.2
180906	394.2	920.1	428.5	565.9
180921	396.4	921.2	430	565.9
180943	398.1	920.7	431.1	565
181110	407.1	923.9	433.2	562.6
181311	413.8	925.5	437	561.2
181454	417.4	926.3	437.4	559
181631	418.9	926.2	439.2	558.3
181740	419.5	926.2	440.1	556.5
181846	420.7	925.1	440.7	555.3
181968	420.9	925.4	440.5	555.1
184040	428.9	923	442.6	547.8
185345	431.6	921.7	444	545.2
185375	431.6	921.3	443.7	545.2
185455	431.2	921.5	443.8	545
185524	431.9	921.6	444.2	545.1
185577	431.9	921.7	444.5	544.2
185648	433.7	923.5	446.7	544.5
185759	437.8	927.8	451.7	545.6
185828	442.1	931.2	455.8	543.9
185930	455.6	942.7	467.1	540.3
186054	473.9	959	479.3	539.1
186182	491.2	976.1	493.9	534.6
186285	511.6	993.4	507.6	531.8
186386	529.2	1010.7	523.3	527.8
186454	548.9	1029.2	535.8	525.3
186523	578	1047	548.7	522.8
186584	598.4	1061.8	558	523.1
186681	624.2	1080.6	572.1	523.3
186774	646.5	1098.8	586.8	526.5
186863	663.4	1118.8	602.2	529.5
186926	671.6	1131.2	613.4	532.1
186962	675.1	1137	618.9	532.3
187023	679.5	1144.5	624.4	535
187155	685.4	1157	638	537
187243	693.3	1171.9	653.6	542.4
187329	707.6	1187.2	669.3	545.3
187408	730.7	1202.7	687.4	549.6
187499	756.2	1216.5	706.1	552.4
187605	778	1230.4	723.8	554.2
187699	797.9	1242.9	740.1	554.9
187753	808.3	1246.6	747	553.9
187894	823.2	1256.2	761.3	553.7
187978	845.3	1269	779.3	559
188029	856	1277.5	785.2	558.8
188097	865.8	1277.9	790.1	559.2
188256	876	1281.5	796.3	558.8
188544	886.8	1285	802.3	559.7
188739	890	1286.3	807.8	561.3
188852	900.9	1295.2	820.3	564.1
188978	922.8	1305.9	838.2	567.3
189094	942	1316.6	854.7	569.8
189209	966	1329.2	873.2	576
189308	985	1339.2	890.7	582.1
189412	1006.6	1349.9	909.2	589.7
189545	1027.5	1358.5	923.9	597.1
189685	1043.1	1367.5	939.2	606.1
189792	1059	1376.9	953.4	612.4
189890	1072.4	1385.7	968.3	620.7
189989	1088.2	1395	982.5	629.6
190089	1102.8	1403.7	994.9	640.1
190178	1115.8	1411.8	1003.1	653.8
190281	1130.7	1420.5	1012.4	665.5
190373	1141	1427.8	1019.1	673.4
190464	1152	1435.5	1027.4	683.4
190575	1163.6	1442.1	1034.2	691
190672	1174.1	1450.2	1041.9	699.7
190773	1183.9	1457.1	1048.7	706.1
190881	1196.2	1464.8	1058.9	714.7
190980	1206.8	1472.8	1066.1	723.5
191091	1218.1	1477.2	1073.8	730.3
191194	1226.5	1483	1081.8	737.5
191274	1236.3	1488.7	1091.3	744.1
191347	1246.1	1494.2	1100.5	752
191441	1258.5	1501	1109.7	760.4
191566	1268.9	1505.8	1117.9	766.5
191681	1278.1	1510.2	1126.1	772.6
191778	1287.6	1515.3	1134	778.3
191856	1295.4	1517.7	1141.3	782.4
191924	1302.2	1522.9	1148.6	787.8
192015	1312.7	1529.2	1159.7	796.3
192096	1323.1	1534.3	1169.1	802.4
192178	1333.5	1538.5	1177.4	808.7
192261	1341.7	1543.5	1185.4	814.4
192338	1351.4	1548.4	1193.4	820.7
192418	1361.2	1552.9	1201.7	830.3
192510	1370.2	1557.3	1209.4	837.1
192604	1378.6	1560.7	1217.1	843.3
192699	1387.1	1564.9	1224.8	849.6

NAME	TH_1	TH_3	TH_5	TH_8
UNIT	[µStrain]	[µStrain]	[µStrain]	[µStrain]
ROW #				
192792	1396.3	1569.1	1232.9	854.5
192876	1406	1572.8	1241.2	860.6
192912	1410.3	1573.3	1242.1	862.7
193220	1417.6	1570.8	1242.8	864.6
193586	1422.9	1567.2	1240.9	863.8
193894	1424.2	1562.3	1240.1	862.2
194148	1423.4	1559.7	1238.9	860.3
194209	1422.8	1561.3	1241.9	860.3
194283	1426.5	1564.1	1247.4	863
194371	1435	1569.6	1255.8	868.1
194473	1441.3	1574	1263.1	871.5
194599	1450.7	1578.8	1271	877.8
194725	1455.3	1579.1	1271.2	879.9
194971	1456.9	1578	1273.1	879
195020	1458.8	1580.9	1278.8	882
195069	1464.6	1585.3	1287.7	886.7
195122	1471.1	1591	1298	892.2
195169	1476.7	1597.9	1308.3	898.7
195208	1482.4	1602	1317	904.2
195246	1489.7	1608.9	1327.1	912.1
195280	1495.8	1612.9	1336	916.8
195322	1505.9	1619.6	1346	925
195327	1506.1	1620.7	1347.2	924.9
195329	1507.1	1621.2	1347.4	926.3
195331	1507.2	1620.7	1347.7	927.1
195338	1508.5	1622.3	1349.4	929
195340	1508.8	1623.4	1349.6	929.2
195342	1508.9	1623.2	1350.1	929.1
195343	1509.2	1622.9	1350.4	928.8
195386	1515.8	1627.1	1358.4	934.2
195430	1523.8	1633.5	1366.9	942.7
195470	1528.6	1638	1375.6	948.9
195505	1534.6	1642.4	1383.8	955
195559	1542.3	1647	1391.7	961.9
195585	1545.8	1652	1400.2	969.4
195607	1551.7	1656.9	1409.1	978.3
195650	1562.5	1664.2	1418.9	987.1
195688	1567.8	1667.2	1427.8	995.2
195725	1574.1	1673.2	1435.6	1002.1
195761	1579.7	1673.4	1438.3	1006.6
195819	1582.8	1673.1	1438.2	1008.2
196002	1582.2	1667.7	1435.2	1014.7
196024	1583.8	1666.6	1433.5	1014.4
196041	1585.4	1665.9	1432.9	1014.6
196061	1585.5	1666.1

C. LED Load Stage Grids

The following appendix presents the LED element grids for the mohr's circle variables calculated at each load stages for both shell specimens. In the body of the thesis only the element grids at the peak torsion was shown to conserve space.

For reference, the load stages in each test occur at the following torsion values:

ES1	
	$[\frac{kN \cdot m}{m}]$
	M_{xy}
LS 1	86.8
LS 2	168.8
Peak	187.2
LS 3	182.9
LS 4	170.4
LS 5	147.9
LS 6	101.8

ES2	
	$[\frac{kN \cdot m}{m}]$
	M_{xy}
LS 1	64.8
LS 2	110.5
LS 3	173.4
LS 4	214.7
Peak	250.5
LS 5	219.6
LS 6	138.9

C.1 Specimen ES1

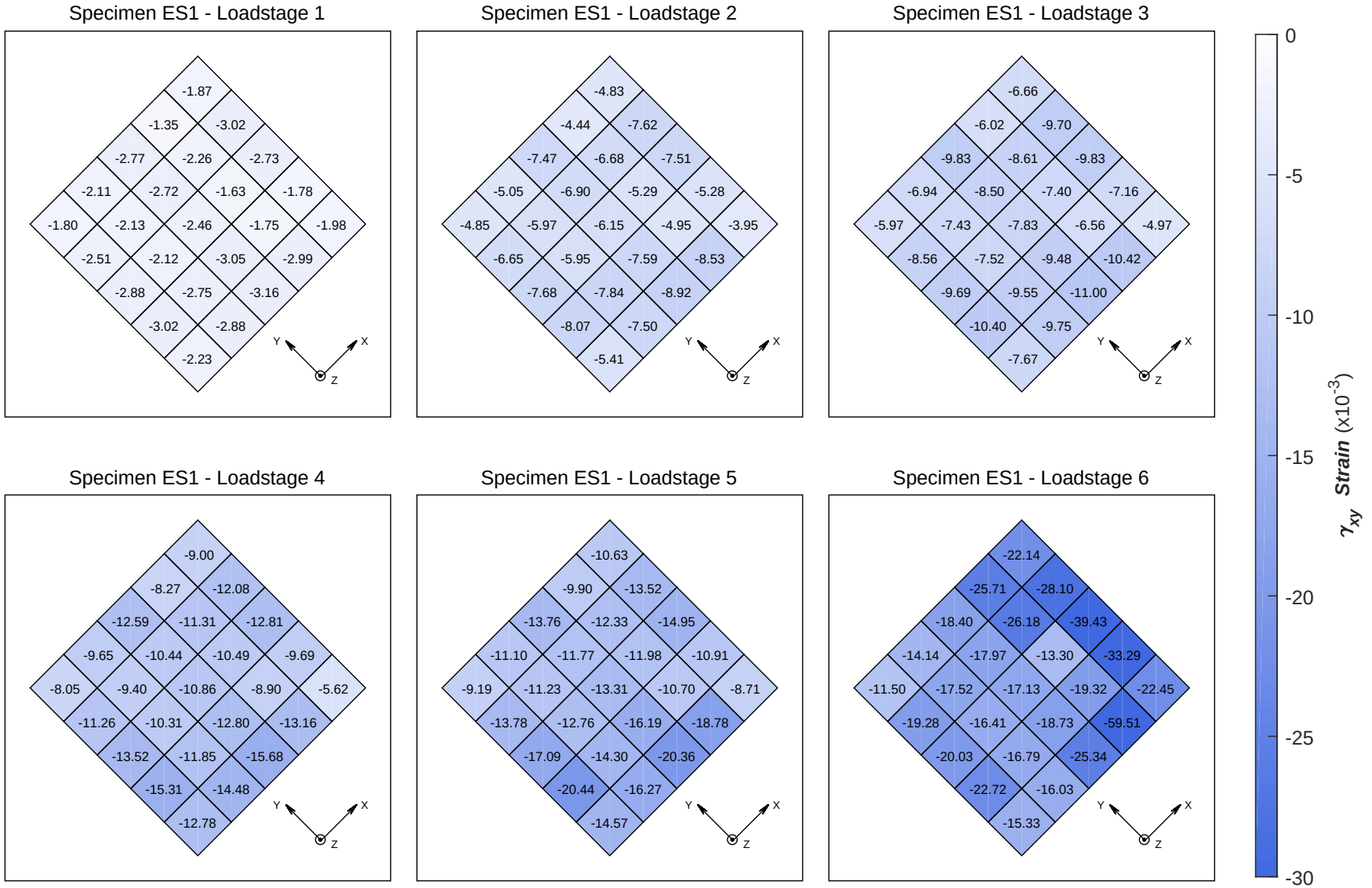


Figure C.1: *ES1 In-Plane (XY) Shear Strain at Load Stages*

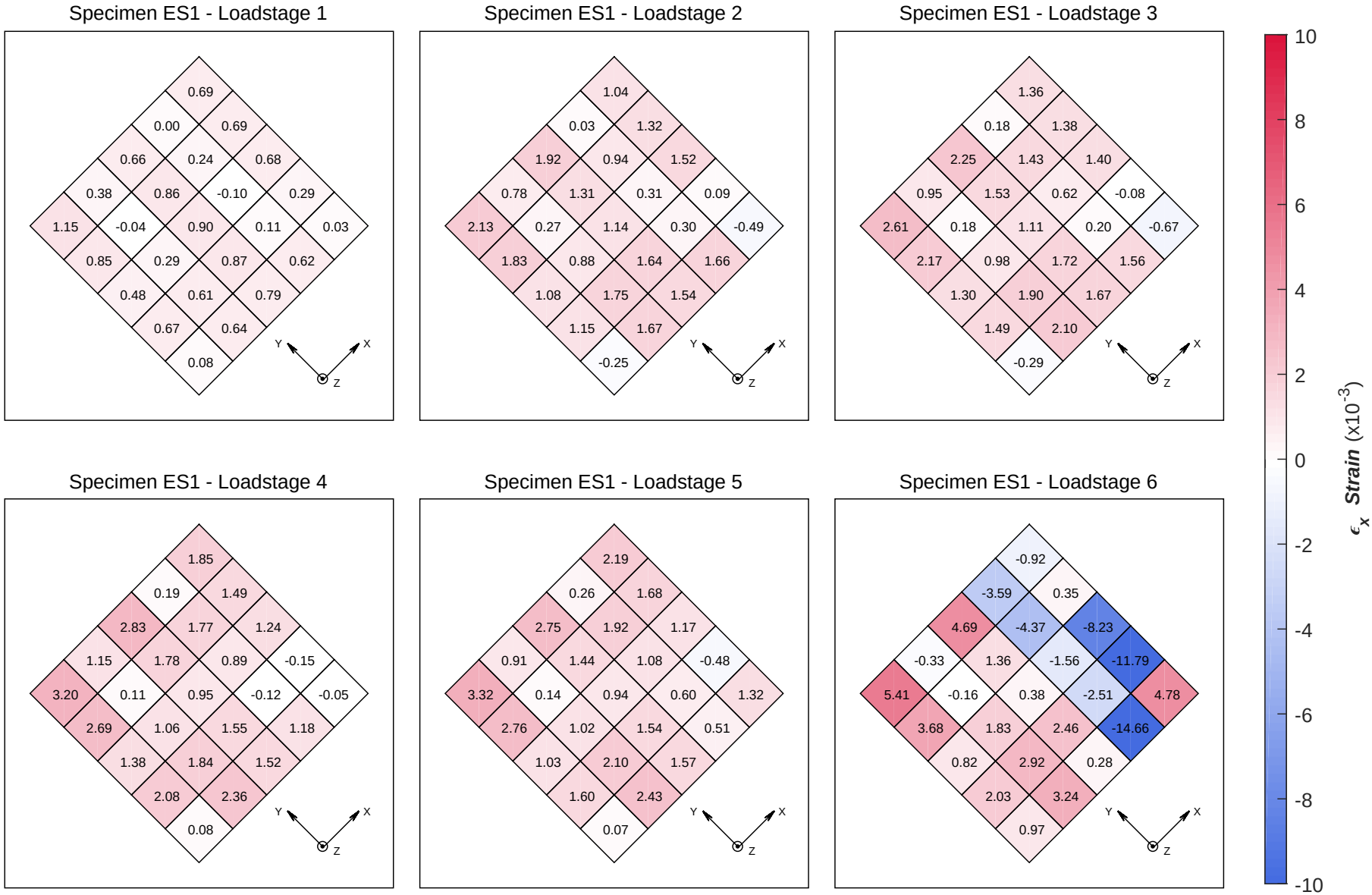


Figure C.2: *ES1 X-Direction Strain at Load Stages*

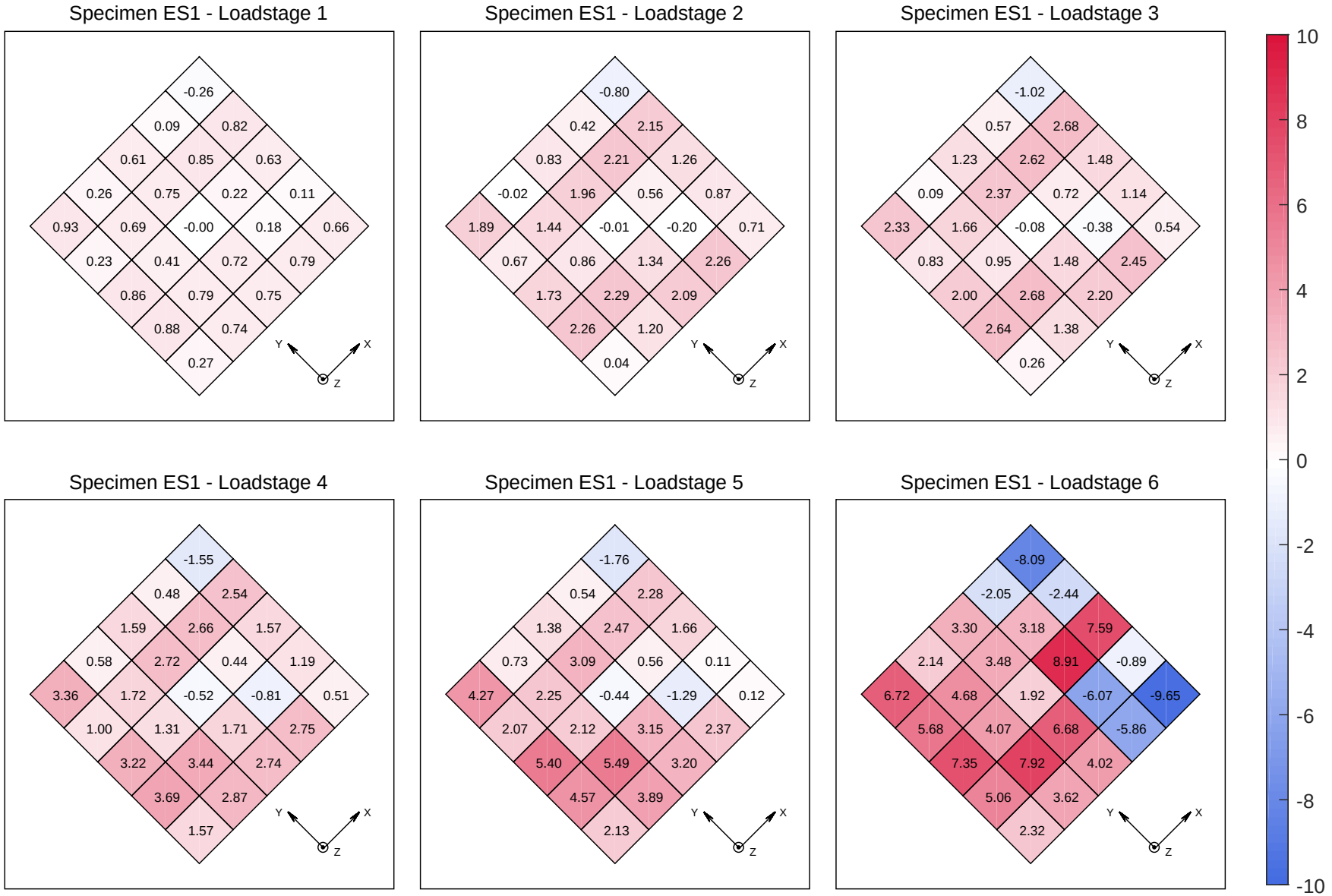


Figure C.3: *ES1 Y-Direction Strain at Load Stages*

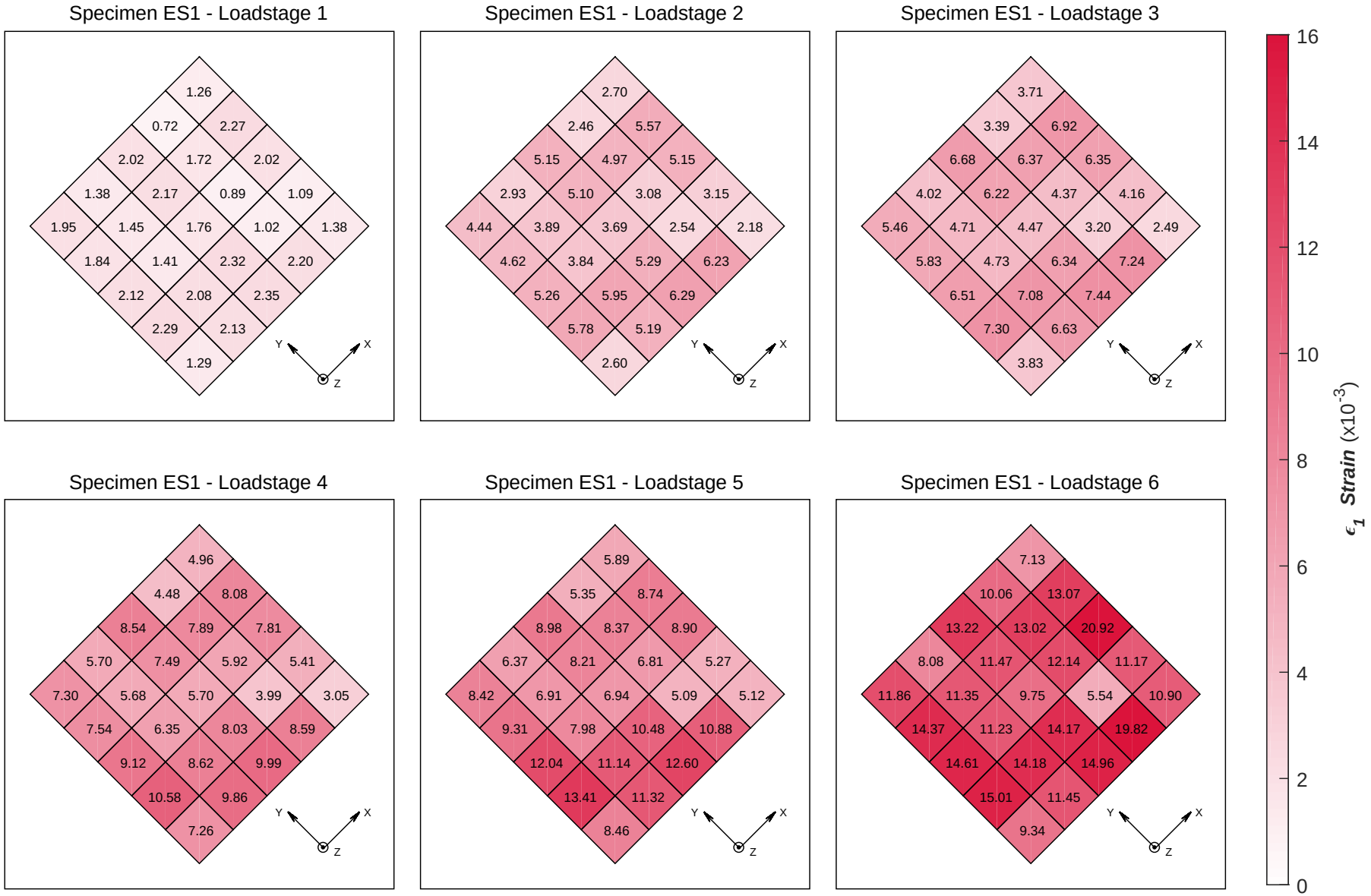


Figure C.4: *ES1 Principal Tensile Strain at Load Stages*

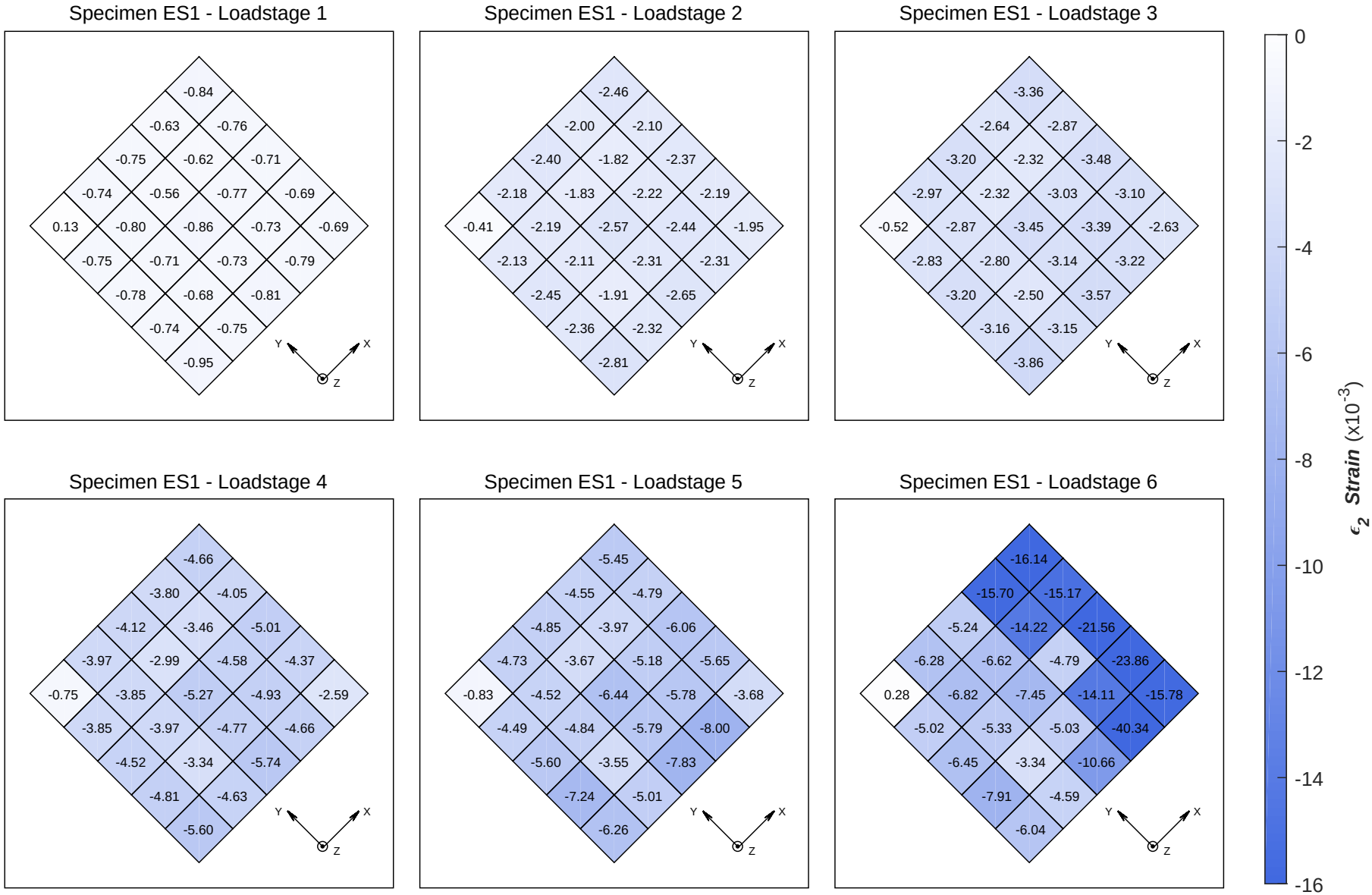


Figure C.5: *ES1 Principal Compressive Strain at Load Stages*

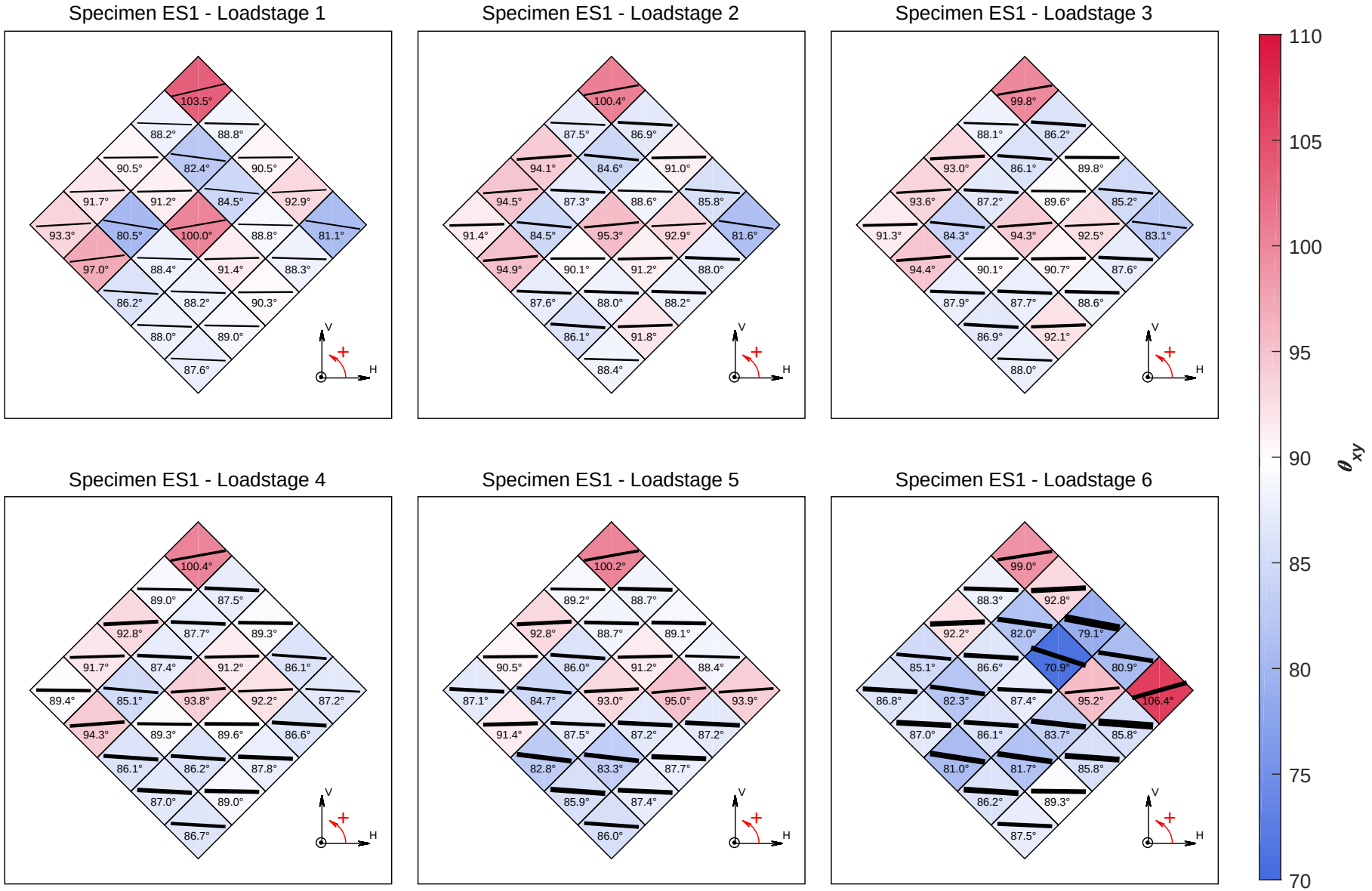


Figure C.6: *ES1 Angle of Principal Strain (CCW+) at Load Stages*

C.2 Specimen ES2

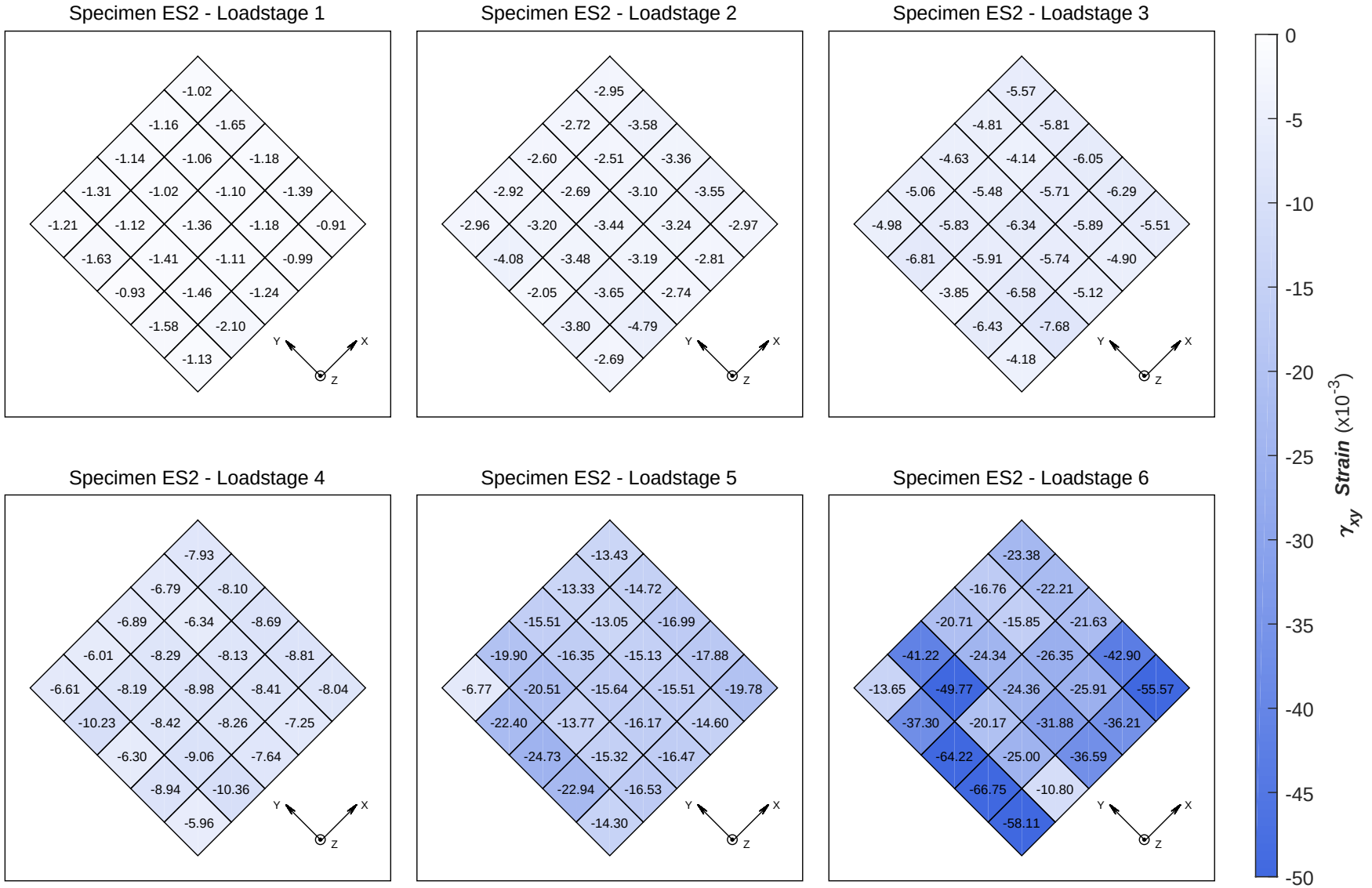


Figure C.7: *ES2 In-Plane (XY) Shear Strain at Load Stages*

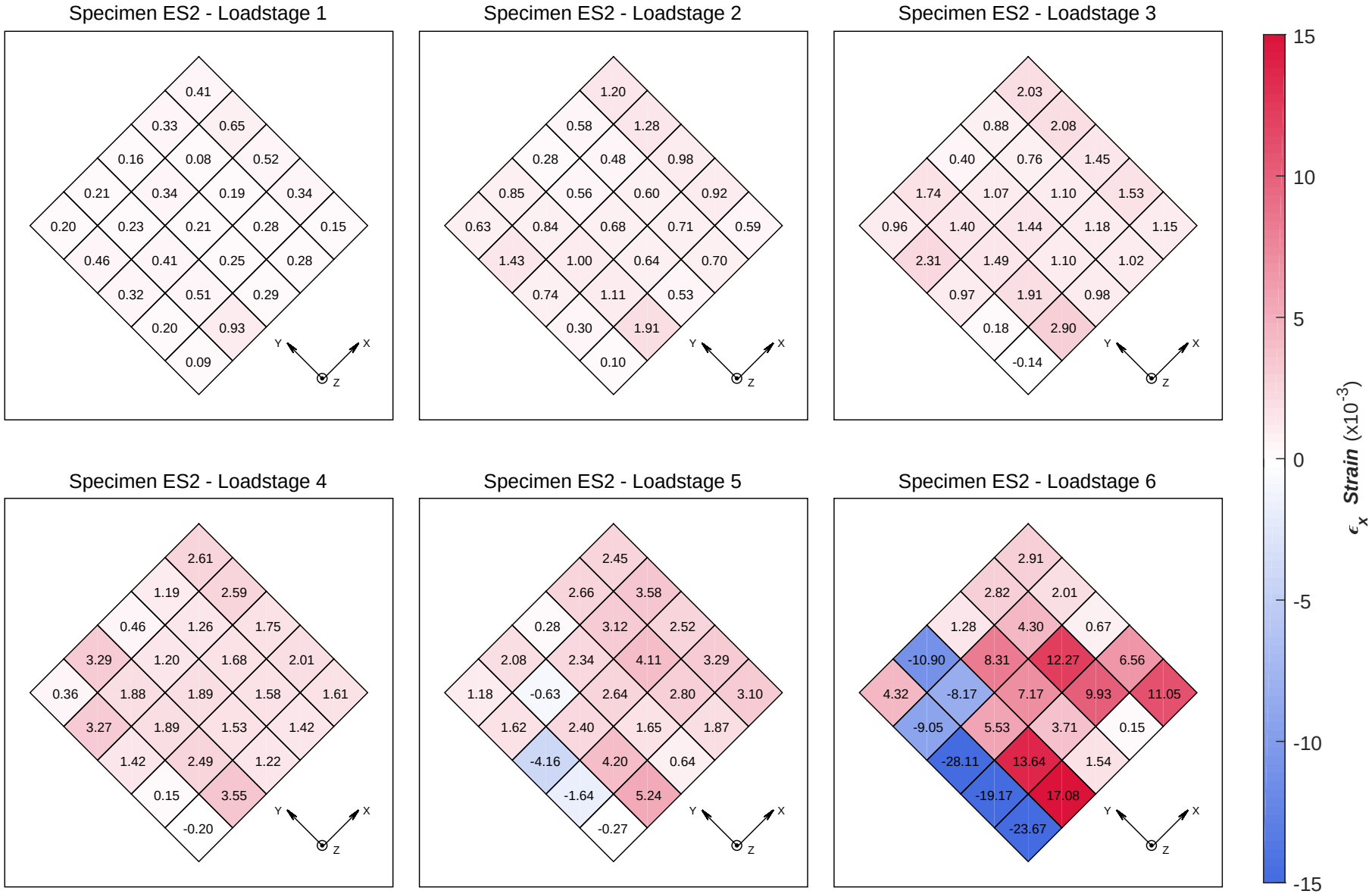


Figure C.8: *ES2 X-Direction Strain at Load Stages*

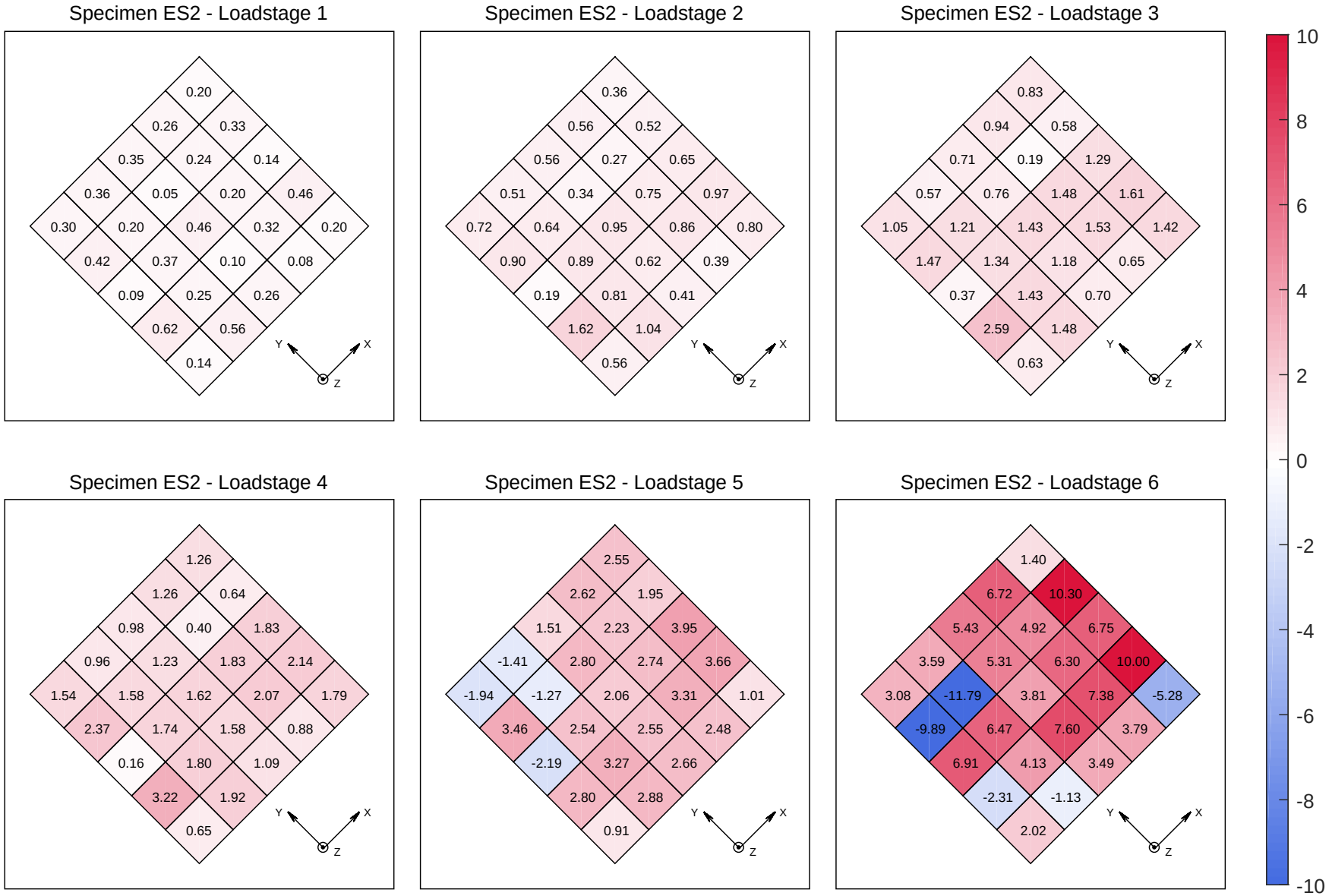


Figure C.9: *ES2 Y-Direction Strain at Load Stages*

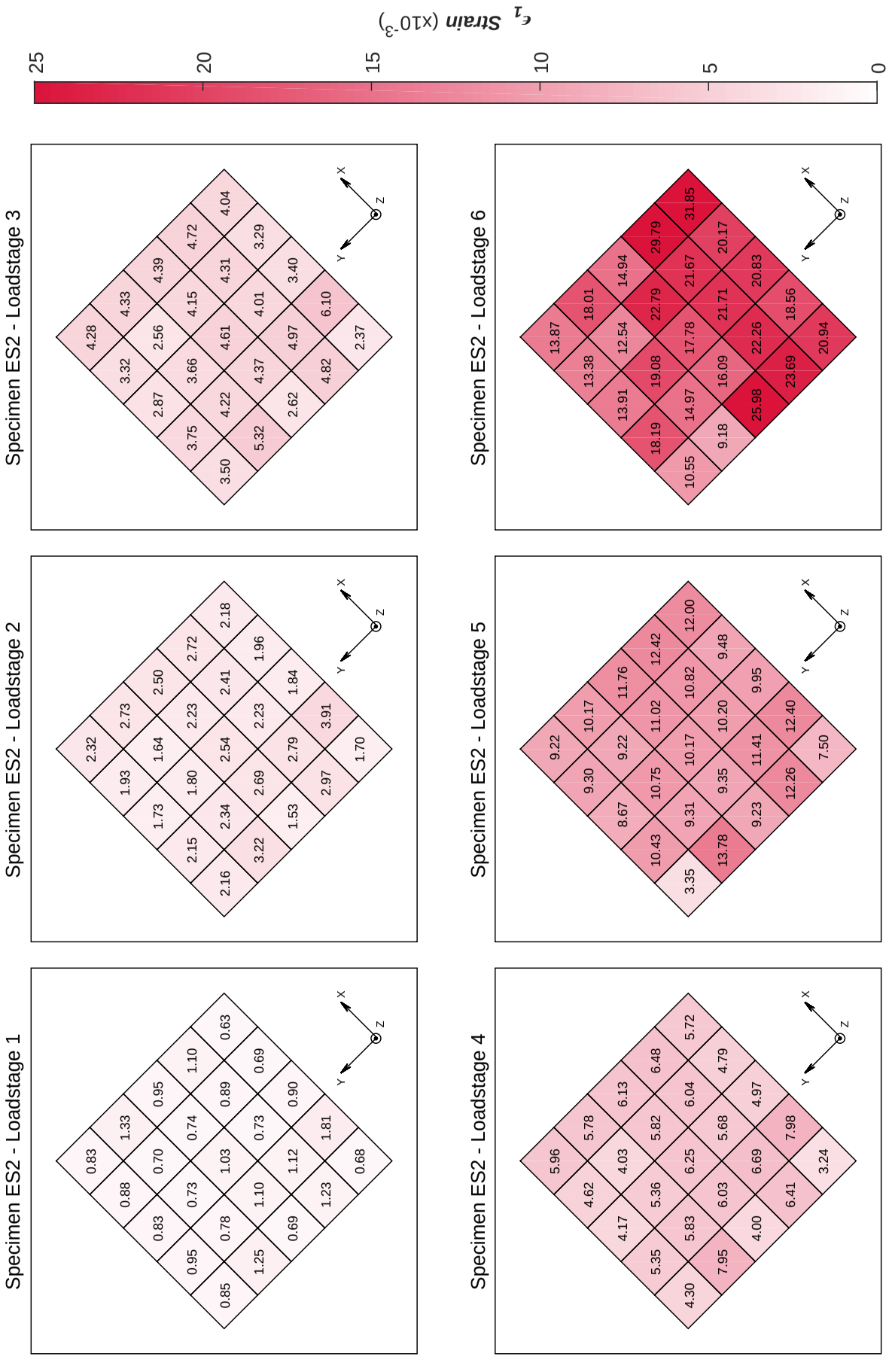


Figure C.10: *ES2 Principal Tensile Strain at Load Stages*

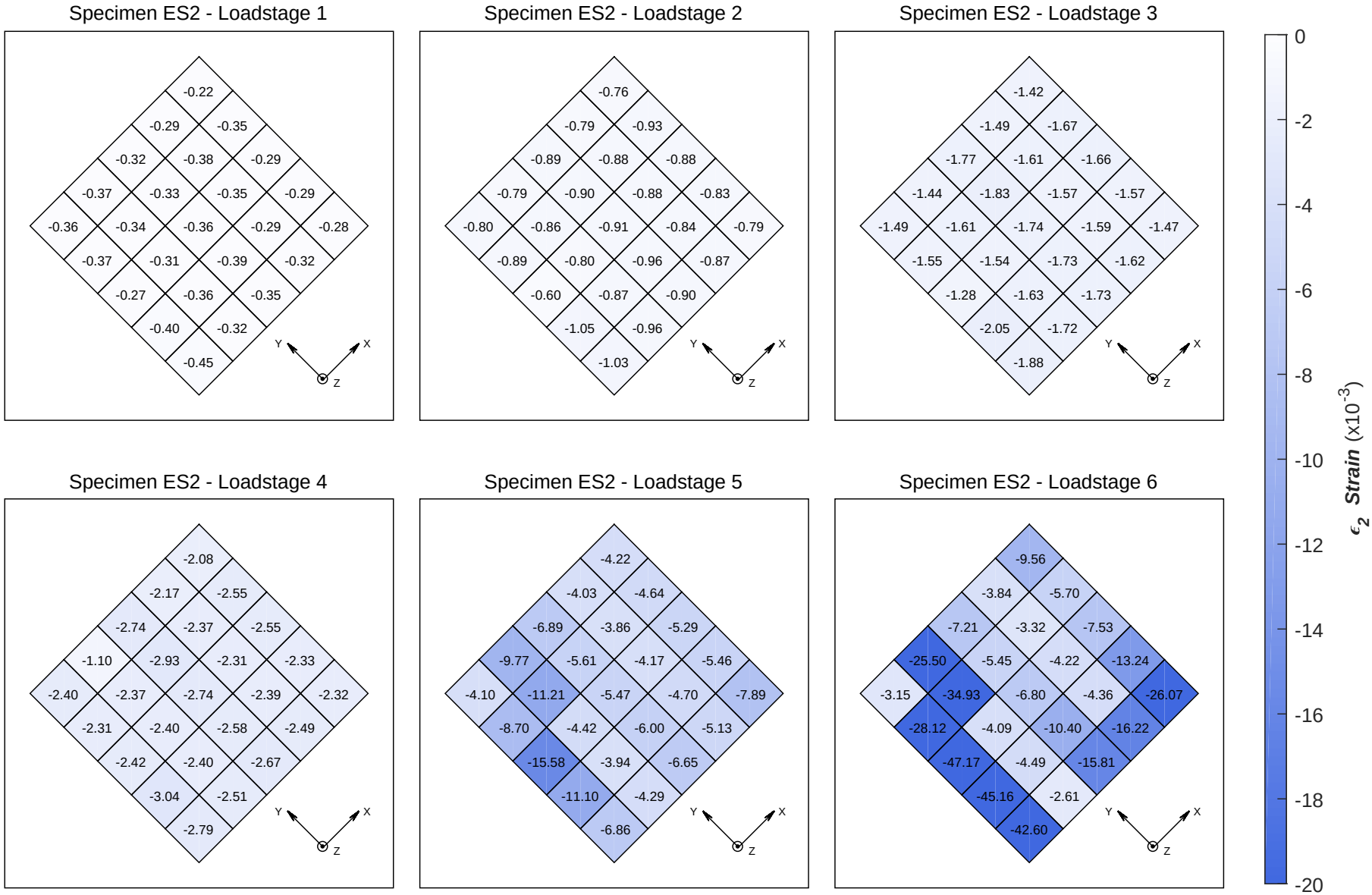


Figure C.11: *ES2 Principal Compressive Strain at Load Stages*

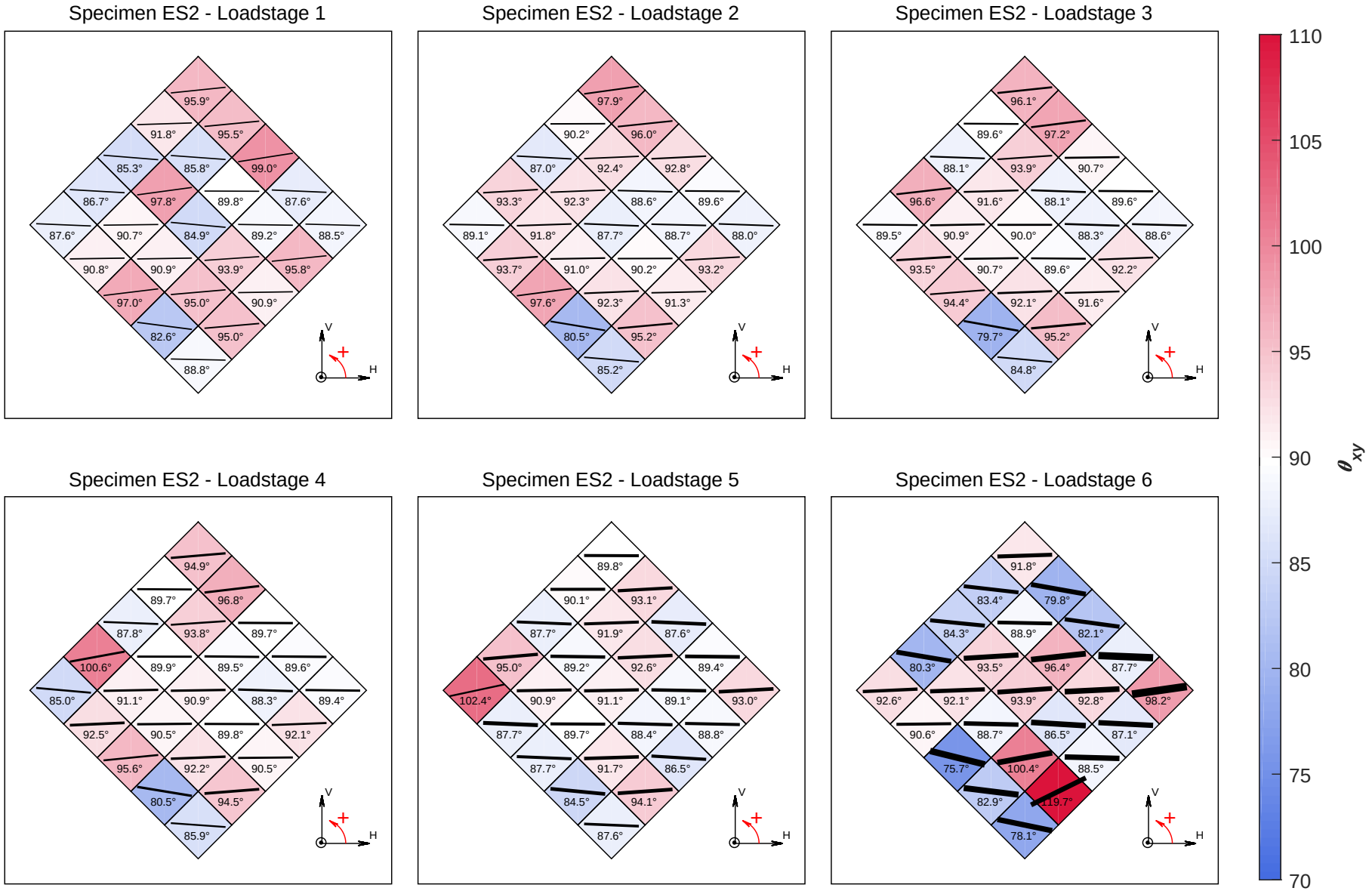


Figure C.12: *ES2 Angle of Principal Strain (CCW+) at Load Stages*

D. Analysis Program: Main Code Structure

The following appendix presents the skeleton code for the program written in MATLAB to implement the HyPT element formulation.

```
clearvars; close  all; clc;

O = IO;                                                                    % INPUT/OUTPUT CLASS

O.file_g = '3D_shell_large.txt' ;                                          % Name of Global File
O.directory(O.file_g)                                                      % Create File Directory

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% STEP #1 : READ THE GLOBAL TEXT FILE                                      %
% - Define the Type of Problem (2D or 3D)                                  %
% - Define the # of Sections Types and text file names                     %
% - Node/Restraint/Element/Loading Information                             %
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf('*******************************************************\n'  )
fprintf('STEP #1: DEFINE THE PROBLEM\n' )
fprintf('*******************************************************\n'  )

%%%% GLOBAL PROBLEM CLASS %%%%
G = R_Global(O);                                                           % GLOBAL CLASS

G.read_file                                                                % Read Text File
G.read_file_node                                                           % Save Node Data
G.read_file_restraint                                                      % Save Restraint Data
G.read_file_load                                                           % Save Load Data
G.read_file_beam                                                           % Save Element Data

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% STEP #2 : READ THE SECTION TEXT FILES                                    %
% - Loop depends on how many sections defined in problem                   %
% - Read information about the reinforced concrete section                 %
% - Read information about the material properties of section               %
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf('*******************************************************\n'  )
fprintf('STEP #2: DEFINE CONCRETE SECTION & MATERIAL PROPERTIES\n'  )
fprintf('*******************************************************\n'  )

S = R_Section(G.sec_num,O);                                                % SECTION CLASS
M = R_Material(G.sec_num,O);                                               % MATERIAL CLASS

for x=1:G.sec_num
    %%%% SECTION CLASS %%%%
    S(x).read_file(G,G.sec_name{x})                                        % Read Text File
    S(x).read_reinforcement                                                % Read X,Y,Z-Reinforcement
    S(x).calc_tstiff                                                       % Calc. Tension Stiffening
    S(x).calc_rho                                                          % Calc. Reinforcement Ratios
    S(x).plot(G)                                                           % Plot Section

    %%%% MATERIAL CLASS %%%%
    M(x).read_file(G.sec_name{x})                                          % Read Text File
    M(x).calc_xsteel                                                       % X-Steel Comp. & Tens.
    M(x).calc_ysteel                                                       % Y-Steel Comp. & Tens.
    M(x).calc_zsteel                                                       % Z-Steel Comp. & Tens.
    M(x).calc_comp                                                         % Concrete Comp. Curve
    M(x).calc_tens                                                         % Concrete Tens. Curve
    M(x).plot                                                              % Plot Material Curves
end

O.file_summary_G(G)                                                        % Global Summary File
O.file_summary_SM(G,S,M)                                                   % Sec./Mat Summary File
G.plot(S,0)                                                                % Display Structure
```

Figure D.1: *MATLAB Main File Code (Part 1/3)*

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% STEP #3 : ASSEMBLE & SOLVE GLOBAL STIFFNESS MATRIX                            %
% - 1st Loop = Load Stage (Initialize {p})                                      %
% - 2nd Loop = Iteration  (Initialize [K] & {u})                                %
% - 3rd Loop = Element Stiffnesses                                              %
% - Iterate until Global Convergence Achieved                                   %
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf('\n*************************************************************\n'   )
fprintf('STEP #3: ASSEMBLE & SOLVE GLOBAL STIFFNESS MATRIX\n'  )
fprintf('*************************************************************\n'   )

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% STEP #3a: APPLIED LOADS                                                       %
% - Load Stage Loop                                                             %
% - Initialize {p}                                                              %
% - Initialize 'Solver' class (wipe all previous)                               %
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
for i = 1:G.num_step

    fprintf( '\nLOADSTAGE #%d: %s\n' ,i,O.file_g)
    O.file_loadstage(G,i)                                                       % Make Load Stage Files

    C = Crack(G,O);                                                             % CRACK CLASS
    K = Solver(O);                                                              % SOLVER CLASS

    K.initialize_p(G,i)                                                         % Init. Load Vector

    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    % STEP #3b: GLOBAL CONVERGENCE & SOLVE                                        %
    % - Global Solution Iteration Loop                                            %
    % - Initialize [K] & {u}                                                      %
    % - Iterate until Absolute OR Relative Criteria Satisfied                     %
    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    while ((K.error1 >= K.max_error1) && (K.error2 >= K.max_error2)) &&
           (K.count <= K.max_iter)

        fprintf( 'Iteration #%2d --- \n' , K.count)
        O.file_iter1(K.count,K.error1)                                          % Load Stage Header

        K.initialize_k(G)                                                       % Init. Global Stiffness
        K.initialize_u(G)                                                       % Init. Disp. Vector

        %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
        % STEP #3c : ELEMENT STIFFNESS                                            %
        % - Global Matrix Assembly Loop (Sum element contributions)               %
        % - Numbers of Face (2D = 1, 3D = 6)                                      %
        % - Element Matrix Assembly Loop (Truss + Panel + Crack)                  %
        %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
        for j = 1:G.tot_elem

            x = K.select_section(G,j);                                          % Select Material/Section

            for k = 1:K.num_faces

                K.select_face(G,k,j)                                            % Select the Face
                O.file_iter2(G,K,j,k)                                           % Element/Face Iter. Header
```

Figure D.2: *MATLAB Main File Code (Part 2/3)*

```
                %%%%%%%%%%%%%%%%%%%%%%% TRUSS CLASS %%%%%%%%%%%%%%%%%%%%%%%
                T = Truss(O);                                                % TRUSS CLASS
                T.face_define(S(x),M(x),K,G.type)                            % Assign Face Variables
                T.concrete(M(x))                                             % Concrete Contribution
                T.steel(M(x),G.type)                                         % Steel Contribution
                T.assemble                                                   % Assemble Stiffness Terms
                T.dv_solve                                                   % Find Force Centroid
                T.crack_calc(M(x),K.face);                                   % Flexural Cracking

                %%%%%%%%%%%%%%%%%%%%%%% MCFT CLASS %%%%%%%%%%%%%%%%%%%%%%%
                P = MCFT(O,T);                                               % PANEL CLASS
                P.face_define(S(x),M(x),K.face)                              % Assign Face Variables

                while ((P.error1 >= P.max_error1) &&
                     ((P.error2 >= P.max_error2) || (P.error3 >= P.max_error3)) ) &&
                      (P.count <= P.max_iter)

                   P.strain_vector(K.face_u)                                 % MCFT Strain Input
                   P.strain_p                                                % Principal Strains
                   P.rotation_mat                                            % Rotation Matrix
                   P.stress_steel                                            % Steel Stresses
                   P.stress_conc_comp(M(x))                                  % Concrete Compression
                   P.stress_conc_tens(M(x))                                  % Concrete Tension
                   P.shear_crack(M(x),j,k)                                   % Shear on Crack
                   P.assemble_D                                              % Secant Moduli
                   P.next_iteration                                          % Next Iteration Terms
                end

                P.assemble(M(x),G.type)                                      % Assmeble Panel Terms

                %%%%%%%%%%%%%%%%%%%%%%% CRACK CLASS %%%%%%%%%%%%%%%%%%%%%%%
                C.record_g_crk(j,K.count,P.crack)                            % Face Cracked?
                C.record_shr_crk(j,k,P)                                      % Shear Cracking
                C.record_flex_crk(j,k,T)                                     % Flexural Cracking

                C.VM_disturbed(G,S(x))                                       % Disturbed Region?
                C.VM_interaction(P,G,T,j)                                    % Assemble M-V Terms

                K.k_face(k,T.k1,P.k1,C.k1)                                   % Assemble All K-terms
            end

            K.k_element(G.type,K.num_faces)                                  % Add to Element Stiffness
            K.k_global(G)                                                    % Add to Global Stiffness
        end

    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    % STEP #3b: GLOBAL CONVERGENCE & SOLVE                                      %
    % - [K]{u} = {p}                                                           %
    % - Partition Stiffness Matrix Based on Restrained DOFs                    %
    % - Compare Global Displacements to Previous Step                          %
    % - Calculate Relative and Absolute Errors, if diverging = terminate       %
    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

        K.partition(G)                                                       % Partition Matrix
        K.solve(G)                                                           % Solve Stiffness Problem
        K.loop_check(G)                                                      % Check Global Convergence
        K.next_iteration(G)                                                  % Prepare Next Iter.
    end

    O.file_summary_LS(G,K,C,i)                                               % Load Stage Summary File
end
```

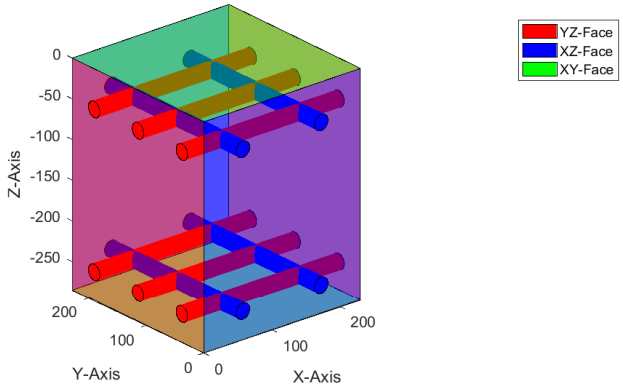
Figure D.3: *MATLAB Main File Code (Part 3/3)*

E. Analysis Program: Input/Output Files

E.1 Input Text Files for Shell Torsion Analysis

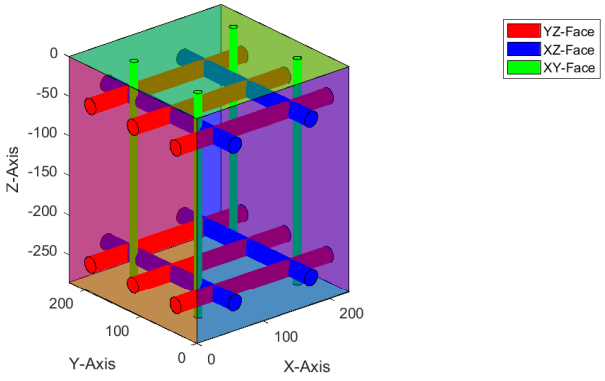
```
////////////////////////////////////////////////////////////////////////////////////////////////////
// Name:    Edvard Bruun
// Project: Shell Specimen (ES1 and ES2)
// Created: Semptember 14th, 2016
// Updated: July 1st, 2017
//
//
////////////////////////////////////////////////////////////////////////////////////////////////////

// Global file must be in same directory as the program

// FORMAT: Type = '2D' or '3D' (If 2D then ignore Y-data)
//           Number of Name Entries Must Match # of Sections Precisely
//         Enter the exact text file name to read
// NOTES : No Empty Lines in this list
//         Section names must be one word
//         For Multiple Sections, Add Additional Name Rows
-INPUT FILE-
Type     = 3D
Sections = 1
Name     = section_specimen.txt
-INPUT FILE END-


// FORMAT: [X_Start (mm), Y_Start (mm), Z_Start (mm)] / [#_nodes, d_node_#, d_x, d_y, d_z] / [#_lines, d_node_#, d_x, d_y, d_z] /
// NOTES : White space is not important so long as information lies between ' / '
//         Start a line with '//' if you want it to not be read
//         If '2D' Problem then the Y-data will be ignored
-NODE LIST-
0 0    0 / 6 6 230 0 0 / 6 1 0 -230 0 /
0 0 -285 / 6 6 230 0 0 / 6 1 0 -230 0 /
-NODE LIST END-


// FORMAT: [node #] / [X_restrain (0 | 1 | 2), Y_restrain (0 | 1 | 2), Z_restrain (0 | 1 | 2)] / [ #_Restraints d_node_#]
// NOTES : 0 = Unrestrained
//         1 = Fully Restrained
//         2 = Conditionally Restrained (Not Implemented)
-RESTRAINT LIST-
//OUT OF PLANEs
49 / 0 0 1 / 1 1 /
48 / 0 0 1 / 1 1 /
66 / 0 0 1 / 1 1 /
//
// IN PLANE
38 / 1 0 0 / 1 1 /
43 / 0 1 0 / 1 1 /
61 / 0 1 0 / 1 1 /
-RESTRAINT LIST END-


// FORMAT: [node #] / [X_Load, Y_Load, Z_Load] / [#_Loads, d_node_#, d_Fx, d_Fy, d_Fz ] / [Constant Toggle] / #_steps d_Fx d_Fy d_Fz /
// NOTES : 1 = Constant - ON
//         0 = Constant - OFF
//         Loads on Repeating Nodes are Cumulative
-LOAD LIST-
//
// Top Corner Nodes
1  / -45000  45000 0 / 1 1 0 0 0 / 0 / 300 -5000  5000 0 /
31 / -45000 -45000 0 / 1 1 0 0 0 / 0 / 300 -5000 -5000 0 /
6  /  45000  45000 0 / 1 1 0 0 0 / 0 / 300  5000  5000 0 /
36 /  45000 -45000 0 / 1 1 0 0 0 / 0 / 300  5000 -5000 0 /
// Top Sides
2  /  0      45000 0 / 4 1 0 0 0 / 0 / 300  0    5000 0 /
32 /  0     -45000 0 / 4 1 0 0 0 / 0 / 300  0   -5000 0 /
7  / -45000  0     0 / 4 6 0 0 0 / 0 / 300 -5000 0    0 /
12 /  45000  0     0 / 4 6 0 0 0 / 0 / 300  5000 0    0 /
//
// Bot Corner Nodes
72 / -45000  45000 0 / 1 1 0 0 0 / 0 / 300 -5000  5000 0 /
42 / -45000 -45000 0 / 1 1 0 0 0 / 0 / 300 -5000 -5000 0 /
67 /  45000  45000 0 / 1 1 0 0 0 / 0 / 300  5000  5000 0 /
37 /  45000 -45000 0 / 1 1 0 0 0 / 0 / 300  5000 -5000 0 /
// Bot Sides
68 /  0      45000 0 / 4 1 0 0 0 / 0 / 300  0    5000 0 /
38 /  0     -45000 0 / 4 1 0 0 0 / 0 / 300  0   -5000 0 /
48 / -45000  0     0 / 4 6 0 0 0 / 0 / 300 -5000 0    0 /
43 /  45000  0     0 / 4 6 0 0 0 / 0 / 300  5000 0    0 /
//
-LOAD LIST END-


// FORMAT: [N_1, N_2, N_3, N_4] [N_5, N_6, N_7, N_8] / [Section File Name] / [ #_Elements, d_node_#] / [#_lines d_node_#] /
// NOTES : Front (XZ-Face) defined first - Left nodes first followed by right nodes
//         Back  (XZ-Face) defined next  - Left nodes first followed by right nodes (ONLY IF 3D)
//         Last Entry Section is only for 3D (not possible to do lines of elements in 2D)
-BEAM LIST-
//
2 38 8 44 1 37 7 43 / section_specimen.txt  / 5 6 / 5 1 /
//
-BEAM LIST END-
```

Figure E.1: *Global Input File for Specimen ES1 and ES2 Models*




```
////////////////////////////////////////////////////////////////////////////////////////////////////
// Name:    Edvard Bruun
// Project: Experimental Shells (ES1)
// Created: Semptember 14th, 2016
// Updated: July 1st, 2017
//
// Do Not Include Empty Rows Between Titles
// Do Not Change Title Names
//
////////////////////////////////////////////////////////////////////////////////////////////////////

// Unknown = 0 (Use Default Value)
-MATERIAL-
Concrete Comp. Str. [MPa] = 30.4
Concrete Tens. Str. [MPa] = 0
Poisson Ratio             = 0.15
Aggregate Size      [mm]  = 10
X-Steel Yield       [MPa] = 509
X-Steel Ultimate    [MPa] = 636
X-Steel Modulus     [MPa] = 147000
Y-Steel Yield       [MPa] = 509
Y-Steel Ultimate    [MPa] = 636
Y-Steel Modulus     [MPa] = 147000
Z-Steel Yield       [MPa] = 0
Z-Steel Ultimate    [MPa] = 0
Z-Steel Modulus     [MPa] = 0


// All Units in 'mm'
// 2D Problem: X = Element Length,  Y = Section Width,   Z = Section Height
// 3D Problem: X = Length in X-Dir, Y = Length in Y-Dir, Z = Out-of-Plane Thickness
-GEOMETRY-
X-width       = 230
Y-width       = 230
Z-width       = 285
Clear Cover   = 25
Filename      = section_specimen.txt


// 1 Row:    bot_layers = 1 / rebar_size = 25       / num_bars = 7     / d = 572         /
// 1+ Row:   bot_layers = 3 / rebar_size = 25 20 15 / num_bars = 7 3 3 / d = 572 500 400 /
// No Rebar: bot_layers = 0 /
// Use '/' Between Inputs, Whitespace on Both Sides

// 'd' is Measured From Top of Section (i.e. Towards Negative Z-dir)
-X-REINFORCEMENT-
xy-inclination = 0
xz-inclination = 0
bot_layers = 1 / rebar_size = 20 / num_bars = 3 / d = 250 /
top_layers = 1 / rebar_size = 20 / num_bars = 3 / d = 50 /

// 'd' is Measured From Top of Section (i.e. Towards Negative Z-dir)
-Y-REINFORCEMENT-
yx-inclination = 90
yz-inclination = 0
bot_layers = 1 / rebar_size = 20 / num_bars = 2 / d = 250 /
top_layers = 1 / rebar_size = 20 / num_bars = 2 / d = 50 /

// 'd' is Measured From Left of Section (i.e. Towards Positive X-dir)
-Z-REINFORCEMENT-
zx-inclination = 90
zy-inclination = 90
bot_layers = 1 / rebar_size = 10 / num_bars = 0 / d = 250 /
top_layers = 1 / rebar_size = 10 / num_bars = 0 / d = 50 /
```

Figure E.2: *Section Input File for Specimen ES1*




```
////////////////////////////////////////////////////////////////////////////////////////////////////////
// Name:    Edvard Bruun
// Project: Experimental Shells (ES2)
// Created: Semptember 14th, 2016
// Updated: July 1st, 2017
//
// Do Not Include Empty Rows Between Titles
// Do Not Change Title Names
//
////////////////////////////////////////////////////////////////////////////////////////////////////////

// Unknown = 0 (Use Default Value)
-MATERIAL-
Concrete Comp. Str. [MPa] = 37.6
Concrete Tens. Str. [MPa] = 0
Poisson Ratio             = 0.15
Aggregate Size      [mm]  = 10
X-Steel Yield       [MPa] = 509
X-Steel Ultimate    [MPa] = 636
X-Steel Modulus     [MPa] = 147000
Y-Steel Yield       [MPa] = 509
Y-Steel Ultimate    [MPa] = 636
Y-Steel Modulus     [MPa] = 147000
Z-Steel Yield       [MPa] = 474
Z-Steel Ultimate    [MPa] = 657
Z-Steel Modulus     [MPa] = 213000


// All Units in 'mm'
// 2D Problem: X = Element Length,  Y = Section Width,   Z = Section Height
// 3D Problem: X = Length in X-Dir, Y = Length in Y-Dir, Z = Out-of-Plane Thickness
-GEOMETRY-
X-width       = 230
Y-width       = 230
Z-width       = 285
Clear Cover   = 25
Filename      = section_specimenb.txt


// 1 Row:    bot_layers = 1 / rebar_size = 25       / num_bars = 7     / d = 572         /
// 1+ Row:   bot_layers = 3 / rebar_size = 25 20 15 / num_bars = 7 3 3 / d = 572 500 400 /
// No Rebar: bot_layers = 0 /
// Use '/' Between Inputs, Whitespace on Both Sides

// 'd' is Measured From Top of Section (i.e. Towards Negative Z-dir)
-X-REINFORCEMENT-
xy-inclination = 0
xz-inclination = 0
bot_layers = 1 / rebar_size = 20 / num_bars = 3 / d = 250 /
top_layers = 1 / rebar_size = 20 / num_bars = 3 / d = 50 /

// 'd' is Measured From Top of Section (i.e. Towards Negative Z-dir)
-Y-REINFORCEMENT-
yx-inclination = 90
yz-inclination = 0
bot_layers = 1 / rebar_size = 20 / num_bars = 2 / d = 250 /
top_layers = 1 / rebar_size = 20 / num_bars = 2 / d = 50 /

// 'd' is Measured From Left of Section (i.e. Towards Positive X-dir)
-Z-REINFORCEMENT-
zx-inclination = 90
zy-inclination = 90
bot_layers = 1 / rebar_size = 10 / num_bars = 2 / d = 200 /
top_layers = 1 / rebar_size = 10 / num_bars = 2 / d = 50 /
```

Figure E.3: *Section Input File for Specimen ES2*

E.2 Analysis Summary Output Files for Torsion Specimen ES2

```
GLOBAL PROBLEM SUMMARY

Type of Problem    = 3D
Number of Sections = 1
---section_specimenb.txt

%%%%%%%%%  NODE DATA  %%%%%%%%%
Num. Nodes = 72

        [mm]     [mm]     [mm]
Node   X-Coord  Y-Coord  Z-Coord
  1        0        0        0
  2        0     -230        0
  3        0     -460        0
  4        0     -690        0
  5        0     -920        0
  6        0    -1150        0
  7      230        0        0
  8      230     -230        0
  9      230     -460        0
 10      230     -690        0
 11      230     -920        0
 12      230    -1150        0
 13      460        0        0
 14      460     -230        0
 15      460     -460        0
 16      460     -690        0
 17      460     -920        0
 18      460    -1150        0
 19      690        0        0
 20      690     -230        0
 21      690     -460        0
 22      690     -690        0
 23      690     -920        0
 24      690    -1150        0
 25      920        0        0
 26      920     -230        0
 27      920     -460        0
 28      920     -690        0
 29      920     -920        0
 30      920    -1150        0
 31     1150        0        0
 32     1150     -230        0
 33     1150     -460        0
 34     1150     -690        0
 35     1150     -920        0
 36     1150    -1150        0
 37        0        0     -285
 38        0     -230     -285
 39        0     -460     -285
 40        0     -690     -285
 41        0     -920     -285
 42        0    -1150     -285
 43      230        0     -285
 44      230     -230     -285
 45      230     -460     -285
 46      230     -690     -285
 47      230     -920     -285
 48      230    -1150     -285
 49      460        0     -285
 50      460     -230     -285
 51      460     -460     -285
 52      460     -690     -285
 53      460     -920     -285
 54      460    -1150     -285
 55      690        0     -285
 56      690     -230     -285
 57      690     -460     -285
 58      690     -690     -285
 59      690     -920     -285
 60      690    -1150     -285
 61      920        0     -285
 62      920     -230     -285
 63      920     -460     -285
 64      920     -690     -285
 65      920     -920     -285
 66      920    -1150     -285
 67     1150        0     -285
 68     1150     -230     -285
 69     1150     -460     -285
 70     1150     -690     -285
 71     1150     -920     -285
 72     1150    -1150     -285
```

Figure E.4: *Global Summary Output File for Specimen ES2 (Part 1/2)*

```
%%%%%%%%%  RESTRAINT DATA  %%%%%%%%%
Num. Restrained Nodes = 6
Num. Restrained DOFs  = 6

Node    X-Res    Y-Res    Z-Res
38        1        0        0
43        0        1        0
48        0        0        1
49        0        0        1
61        0        1        0
66        0        0        1

%%%%%%%%%  LOAD DATA  %%%%%%%%%
Num. Loaded Nodes = 40
Num. Load Stages  = 300

        [1/0]        [N]         [N]         [N]         [N]         [N]         [N]
Node    Constant    X-Load      Y-Load      Z-Load       X+          Y+          Z+
  1        0       -45000       45000          0       -5000       5000          0
  2        0            0       45000          0           0       5000          0
  3        0            0       45000          0           0       5000          0
  4        0            0       45000          0           0       5000          0
  5        0            0       45000          0           0       5000          0
  6        0        45000       45000          0        5000       5000          0
  7        0       -45000           0          0       -5000          0          0
 12        0        45000           0          0        5000          0          0
 13        0       -45000           0          0       -5000          0          0
 18        0        45000           0          0        5000          0          0
 19        0       -45000           0          0       -5000          0          0
 24        0        45000           0          0        5000          0          0
 25        0       -45000           0          0       -5000          0          0
 30        0        45000           0          0        5000          0          0
 31        0       -45000      -45000          0       -5000       -5000         0
 32        0            0      -45000          0           0       -5000         0
 33        0            0      -45000          0           0       -5000         0
 34        0            0      -45000          0           0       -5000         0
 35        0            0      -45000          0           0       -5000         0
 36        0        45000      -45000          0        5000       -5000         0
 37        0        45000      -45000          0        5000       -5000         0
 38        0            0      -45000          0           0       -5000         0
 39        0            0      -45000          0           0       -5000         0
 40        0            0      -45000          0           0       -5000         0
 41        0            0      -45000          0           0       -5000         0
 42        0       -45000      -45000          0       -5000       -5000         0
 43        0        45000           0          0        5000          0          0
 48        0       -45000           0          0       -5000          0          0
 49        0        45000           0          0        5000          0          0
 54        0       -45000           0          0       -5000          0          0
 55        0        45000           0          0        5000          0          0
 60        0       -45000           0          0       -5000          0          0
 61        0        45000           0          0        5000          0          0
 66        0       -45000           0          0       -5000          0          0
 67        0        45000       45000          0        5000       5000          0
 68        0            0       45000          0           0       5000          0
 69        0            0       45000          0           0       5000          0
 70        0            0       45000          0           0       5000          0
 71        0            0       45000          0           0       5000          0
 72        0       -45000       45000          0       -5000       5000          0

%%%%%%%%%  ELEMENT DATA  %%%%%%%%%
Num. Elements = 25

F = Front Face
B = Back Face
L = Left Side
R = Right Side

          [Node 1]  [Node 2]  [Node 3]  [Node 4]  [Node 5]  [Node 6]  [Node 7]  [Node 8]
Element     F-LT      F-LB      F-RT      F-RB      B-LT      B-LB      B-RT      B-RB    Section Name
   1         2        38         8        44         1        37         7        43  section_specimenb.txt
   2         8        44        14        50         7        43        13        49  section_specimenb.txt
   3        14        50        20        56        13        49        19        55  section_specimenb.txt
   4        20        56        26        62        19        55        25        61  section_specimenb.txt
   5        26        62        32        68        25        61        31        67  section_specimenb.txt
   6         3        39         9        45         2        38         8        44  section_specimenb.txt
   7         9        45        15        51         8        44        14        50  section_specimenb.txt
   8        15        51        21        57        14        50        20        56  section_specimenb.txt
   9        21        57        27        63        20        56        26        62  section_specimenb.txt
  10        27        63        33        69        26        62        32        68  section_specimenb.txt
  11         4        40        10        46         3        39         9        45  section_specimenb.txt
  12        10        46        16        52         9        45        15        51  section_specimenb.txt
  13        16        52        22        58        15        51        21        57  section_specimenb.txt
  14        22        58        28        64        21        57        27        63  section_specimenb.txt
  15        28        64        34        70        27        63        33        69  section_specimenb.txt
  16         5        41        11        47         4        40        10        46  section_specimenb.txt
  17        11        47        17        53        10        46        16        52  section_specimenb.txt
  18        17        53        23        59        16        52        22        58  section_specimenb.txt
  19        23        59        29        65        22        58        28        64  section_specimenb.txt
  20        29        65        35        71        28        64        34        70  section_specimenb.txt
  21         6        42        12        48         5        41        11        47  section_specimenb.txt
  22        12        48        18        54        11        47        17        53  section_specimenb.txt
  23        18        54        24        60        17        53        23        59  section_specimenb.txt
  24        24        60        30        66        23        59        29        65  section_specimenb.txt
  25        30        66        36        72        29        65        35        71  section_specimenb.txt
```

Figure E.5: *Global Summary Output File for Specimen ES2 (Part 2/2)*

```
SECTION AND MATERIAL SUMMARY

Type of Problem    = 3D
Number of Sections = 1

-----------------------------------------------------
                     Material Data
-----------------------------------------------------
Curve Increment     = 1.000e-04

Steel Model         = Trilinear
Concrete Comp Model = Popovics
Concrete Tens Model = 1986-Large

Rebar Table
[mm]  [mm^2]
Diam.  Area
  5      35
 10     100
 11     100
 12     110
 13     130
 14     150
 15     200
 16     200
 17     230
 18     250
 19     280
 20     300
 21     350
 22     380
 23     415
 24     450
 25     500
 26     530
 27     570
 28     615
 29     660
 30     700
 31     750
 32     800
 33     850
 34     900
 35    1000
 45    1500
 55    2500

-----------------------------------------------------
                     section_specimenb.txt
-----------------------------------------------------
X-dim       =   230 [mm]
Y-dim       =   230 [mm]
Z-dim       =   285 [mm]
Clear Cover =    25 [mm]

Concrete Comp. Strength (f'c)   =  30.0      [MPa]
Concrete Comp. Strain (e'c)     = -1.960e-03 [mm/mm]
Concrete Tens. Strength (f'cr)  =  1.807     [MPa]
Concrete Tens. Strain (e'cr)    =  7.206e-05 [mm/mm]
Concrete Uncracked Modulus (Ec) =  25084     [MPa]
Concrete Poisson Ratio          =  0.150
Concrete Aggregate Size         =  10        [mm]

X-Steel Modulus = 200000 [MPa]
X-Steel Yield   = 500.0  [MPa] @ 2.500e-03 [mm/mm]
X-Steel Rupture = 575.0  [MPa] @ 1.500e-01 [mm/mm]
X-Reinf Ratio   = 2.746%

Y-Steel Modulus = 200000 [MPa]
Y-Steel Yield   = 500.0  [MPa] @ 2.500e-03 [mm/mm]
Y-Steel Rupture = 575.0  [MPa] @ 1.500e-01 [mm/mm]
Y-Reinf Ratio   = 1.831%

Z-Steel Modulus = 200000 [MPa]
Z-Steel Yield   = 300.0  [MPa] @ 1.500e-03 [mm/mm]
Z-Steel Rupture = 500.0  [MPa] @ 1.500e-01 [mm/mm]
Z-Reinf Ratio   = 0.756%
```

Figure E.6: *Section Summary Output File for Specimen ES2*

E.3 Sample Load Stage Output Files for Torsion Specimen ES2

Note: This represents a small component of the "Load Stage Iteration" file generated during Load Stage #31 for the analysis of ES2. This particular excerpt shows the results of the program calculations for the Truss, Panel, and Interaction Terms for Iteration #3, Element #5, and face XZ-1.

```
Problem Type          = 3D
Num. Nodes            = 72

Num. Restrained Nodes = 6
Num. Loaded Nodes     = 40
Number of Elements    = 25

Number of Load Stages = 300
Max Iter. (Per Stage) = 50
Max Abs. Error (Per Stage) = 0.050 %
Max Rel. Error (Per Stage) = 0.050 [mm]


--------------------------------------------------------------------------------
================================================================================
                           GLOBAL ITERATION  #1

                       LAST ITERATION ERROR = N/A
================================================================================
--------------------------------------------------------------------------------
.
(Remove Other Iteration Calcs)
.
--------------------------------------------------------------------------------
================================================================================
                           GLOBAL ITERATION  #2

                       LAST ITERATION ERROR = 100.00%
================================================================================
--------------------------------------------------------------------------------
.
(Remove Other Iteration Calcs)
.
--------------------------------------------------------------------------------
================================================================================
                           GLOBAL ITERATION  #3

                       LAST ITERATION ERROR = 8035.41%
================================================================================
--------------------------------------------------------------------------------
.
(Remove Other Element Calcs)
.
------------------------------------------------------------
                        ELEMENT 5/25
                    FACE XZ-1  --- 1/6
------------------------------------------------------------

TRUSS BAR START
--------------------------------
e_bot = -4.171e-05
e_top = 1.407e-05
slope = -1.957e-07
Concrete Stiffness Component

Steel Stiffness Component
---Top Rebar Layer: 1
---Bot Rebar Layer: 1

CONCRETE RESULTS
k_t  [N/mm] = 1.196499e+06
k_bt [N/mm] = 5.993717e+05
k_tb [N/mm] = 5.993717e+05
k_b  [N/mm] = 1.196497e+06

TOP STEEL RESULTS
k_t  [N/mm] = 1.620165e+05
k_bt [N/mm] = 3.447161e+04
k_tb [N/mm] = 3.447161e+04
k_b  [N/mm] = 7.334384e+03

BOT STEEL RESULTS
k_t  [N/mm] = 3.593851e+03
k_bt [N/mm] = 2.567036e+04
k_tb [N/mm] = 2.567036e+04
k_b  [N/mm] = 1.833597e+05

COMPLETE TRUSS STIFFNESS
k_t  [N/mm] = 1.362110e+06
k_bt [N/mm] = 6.595137e+05
k_tb [N/mm] = 6.595137e+05
k_b  [N/mm] = 1.387191e+06

--------------------------------
TRUSS BAR END

CRACK FACE = no

DEPTH = 0.00
```

Figure E.7: *Load Stage Iteration File (Excerpt) for Specimen ES2 (Part 1/2)*

```
MFCT PANEL START: Iteration #1
--------------------------------

Input Stresses
    s1 =   0.000     [MPa]
    s2 =   0.000     [MPa]
    s3 =   0.000     [MPa]
Input Strains
    e1 =   7.034e-06 [mm/mm]
    e2 =   0.000e+00 [mm/mm]
    e3 =  -8.339e-06 [mm/mm]

Principle Direction Values
    Mohr Circle (Quadrant 1)
    Principal Strain (e1_p)   =    8.97e-06 [mm/mm]
    Principal Strain (e2_p)   =   -1.94e-06 [mm/mm]
    Concrete (ec1_p)          =    8.97e-06 [mm/mm]
    Concrete (ec2_p)          =   -1.94e-06 [mm/mm]
    Principal Angle (theta_p) =  -24.93     [deg]
    Steel-1 Angle (theta_2n)  =  -24.93     [deg]
    Steel-2 Angle (theta_2n)  = -114.93     [deg]

Steel Stresses & Strains
    Strain: 1-Steel          =   7.03e-06 [mm/mm]
    Stress: 1-Steel          =   1.03     [MPa]
    Strain: 2-Steel          =  -1.00e-35 [mm/mm]
    Stress: 2-Steel          =  -0.00     [MPa]

Concrete Compressive Stresses
    B-Factor =   0.48
    e_p      =  -9.359e-04 [mm/mm]
    f_p      = -14.48      [MPa]
    e_c2     =  -1.938e-06 [mm/mm]
    f_c2     =  -0.06      [MPa]

Concrete Tensile Stresses
    Cracked (yes/no) = no

Secant Moduli
    Ec1 =  25205 [MPa]
    Ec2 =  30902 [MPa]
    Es1 = 147000 [MPa]
    Es2 = 200000 [MPa]
    Gc  =  13882 [MPa]
Output Stresses
    s1 =   0.204 [MPa]
    s2 =   0.000 [MPa]
    s3 =  -0.109 [MPa]
Output Strains
    e1 =   7.034e-06 [mm/mm]
    e2 =   3.045e-07 [mm/mm]
    e3 =  -8.339e-06 [mm/mm]


MFCT PANEL START: Iteration #2
--------------------------------

Input Stresses
    s1 =   0.204     [MPa]
    s2 =   0.000     [MPa]
    s3 =  -0.109     [MPa]
Input Strains
    e1 =   7.034e-06 [mm/mm]
    e2 =   3.045e-07 [mm/mm]
    e3 =  -8.339e-06 [mm/mm]

Principle Direction Values
    Mohr Circle (Quadrant 1)
    Principal Strain (e1_p)   =    9.03e-06 [mm/mm]
    Principal Strain (e2_p)   =   -1.69e-06 [mm/mm]
    Concrete (ec1_p)          =    9.03e-06 [mm/mm]
    Concrete (ec2_p)          =   -1.69e-06 [mm/mm]
    Principal Angle (theta_p) =  -25.55     [deg]
    Steel-1 Angle (theta_2n)  =  -25.55     [deg]
    Steel-2 Angle (theta_2n)  = -115.55     [deg]

Steel Stresses & Strains
    Strain: 1-Steel          =   7.03e-06 [mm/mm]
    Stress: 1-Steel          =   1.03     [MPa]
    Strain: 2-Steel          =   3.05e-07 [mm/mm]
    Stress: 2-Steel          =   0.06     [MPa]

Concrete Compressive Stresses
    B-Factor =   0.44
    e_p      =  -8.570e-04 [mm/mm]
    f_p      = -13.25      [MPa]
    e_c2     =  -1.688e-06 [mm/mm]
    f_c2     =  -0.05      [MPa]

Concrete Tensile Stresses
    Cracked (yes/no) = no

Secant Moduli
    Ec1 =  25205 [MPa]
    Ec2 =  30903 [MPa]
    Es1 = 147000 [MPa]
    Es2 = 200000 [MPa]
    Gc  =  13882 [MPa]

Output Stresses
    s1 =   0.204 [MPa]
    s2 =   0.000 [MPa]
    s3 =  -0.109 [MPa]
Output Strains
    e1 =   7.034e-06 [mm/mm]
    e2 =   3.098e-07 [mm/mm]
    e3 =  -8.339e-06 [mm/mm]

Secant Shear Modulus  = 10959 [MPa]
--------------------------------
MCFT PANEL END

SHEAR-MOMENT INTERACTION START
--------------------------------

Shear-Moment Term = 'NO'

--------------------------------
SHEAR-MOMENT INTERACTION END


.
(Remove Other Face Calcs)
.

-------------------------------------------------------------------------------

.
(Remove Other Element Calcs)
.

-------------------------------------------------------------------------------
===============================================================================
                          GLOBAL ITERATION  #4

===============================================================================
-------------------------------------------------------------------------------
.
.
.
```

Figure E.8: *Load Stage Iteration File (Excerpt) for Specimen ES2 (Part 2/2)*

Note: This represents a reduced "Load Stage Summary" file generated at the end of load stage #31 for the analysis of ES2 - only the first and last entry in the node/element lists is shown.

```
Problem Type          = 3D
Num. Nodes            = 72

Num. Restrained Nodes = 6
Num. Loaded Nodes     = 40
Number of Elements    = 25

Number of Load Stages = 300
Max Iter. (Per Stage) = 50
Max Abs. Error (Per Stage) = 0.050 %
Max Rel. Error (Per Stage) = 0.050 [mm]


--------------------------------------------------------------------------------
================================================================================
                          GLOBAL SUMMMARY
                           LOADSTAGE #31
================================================================================
--------------------------------------------------------------------------------

%%%%%%%%%  ERROR DATA  %%%%%%%%%
Maximum Relative Error
                                [mm]
Iteration   Rel Error   Abs Error  Node  DOF  Direction
    1        100.000%      0.039     1     1      X
    2       8035.410%      0.000    21    62      Z
    3      -3151.925%      0.046    61   181      X
    4        759.789%      0.001    60   180      Y
    5       2014.577%      0.023    43   127      X
    6       3270.205%      0.126     2     5      Z
    7       -977.435%      0.007    69   207      Y
    8       1634.161%      0.001    57   171      Y
    9       -843.356%      0.072     6    16      X
   10       1887.582%      0.000    13    38      Z
   11       6208.785%      0.001    57   171      Y
   12       1460.501%      0.023    43   127      X
   13     -34223.359%      0.008    14    42      Y
   14        771.438%      0.002    52   155      Z
   15      -2815.980%      0.093     2     4      X
   16       1867.439%      0.002    60   180      Y
   17       2965.499%      0.039    39   116      Z
   18      13048.385%      0.038     6    16      X
   19       9993.195%      0.149    40   119      Z
   20     -22805.869%      0.000    18    53      Z
   21       1005.640%      0.004    55   165      Y

Maximum Absolute Error
              [mm]
Iteration   Abs Error  Node  DOF  Direction
    1         0.208     72   215      Z
    2         0.104     72   215      Z
    3         0.116     72   214      X
    4         0.085     72   214      X
    5         0.052     12    34      X
    6         0.133      4    10      X
    7         0.130      1     2      Z
    8         0.050     72   214      X
    9         0.088      5    14      Z
   10         0.068      6    17      Z
   11         0.088      1     2      Z
   12         0.129     42   125      Z
   13         0.069     72   214      X
   14         0.073     18    52      X
   15         0.121     37   110      Z
   16         0.117     37   110      Z
   17         0.067      6    17      Z
   18         0.058      1     2      Z
   19         0.157      6    17      Z
   20         0.109      6    16      X
   21         0.041     36   106      X


%%%%%%%%%  NODE DISPLACEMENT DATA  %%%%%%%%%
Num. Nodes = 72

        [mm]     [mm]     [mm]
Node   X-Coord  Y-Coord  Z-Coord
  1    -0.074    0.147   -0.175
.
 72    -0.399    0.019   -0.437


%%%%%%%%%  NODAL FORCE DATA  %%%%%%%%%

          [N]          [N]          [N]
Node     X-Load       Y-Load       Z-Load
  1      -35000        35000            0
.
 72      -35000        35000            0


%%%%%%%%%  CRACK INFORMATION %%%%%%%%%
Track the Global Cracking of the Structure (Every Iteration)
If anything cracks = yes

          I# 1  I# 2  I# 3  I# 4  I# 5  I# 6  I# 7  I# 8  I# 9  I#10  I#11  I#12  I#13  I#14  I#15  I#16  I#17  I#18  I#19  I#20  I#21
Ele #  1     no   yes   yes   yes   yes   yes   yes   yes   yes   yes   yes   yes   yes   yes   yes   yes   yes   yes   yes   yes   yes
.
Ele # 25     no   yes   yes   yes   yes   yes   yes   yes   yes   yes   yes   yes   yes   yes   yes   yes   yes   yes   yes   yes   yes


%%%%%%%%%  SHEAR CRACKING %%%%%%%%%
If a panel cracks = yes
This is only for the Final Iteration

   Face:   XZ-1   XZ-2   YZ-1   YZ-2   XY-1   XY-2
Ele #  1     no     no     no     no    yes     no
.
Ele # 25     no     no     no     no    yes     no

Rotation of Principal Plane (CCW = +)

   Face:   XZ-1   XZ-2   YZ-1   YZ-2   XY-1   XY-2
Ele #  1  -84.2   88.6    4.5   22.3   58.2  -65.9
.
Ele # 25  -88.6   84.2  -22.3   -4.5   58.2  -65.9


%%%%%%%%%  FLEXURAL/AXIAL CRACKING %%%%%%%%%
If a panel cracks = top/bot
(Looks at which face is more in tension)
This is only for the Final Iteration

   Face:   XZ-1   XZ-2   YZ-1   YZ-2   XY-1   XY-2
Ele #  1     no     no    top     no     no     no
.
Ele # 25     no     no     no    top     no     no

Depth of Neutral Axis
(Location in Global Coordinate System)

   Face:     XZ-1     XZ-2     YZ-1     YZ-2     XY-1     XY-2
Ele #  1      0.0      0.0    -68.9      0.0      0.0      0.0
.
Ele # 25      0.0      0.0      0.0    -68.9      0.0      0.0
```

Figure E.9: *Load Stage Summary File (Reduced) for Specimen ES2*