A Comparison of 1D Beam-element and 3D Solid-element based Modelling Approaches based on a Developed Tool for the Nonlinear Analysis of Reinforced Concrete Structural Components

Clément Uwitonze

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______________________________ Chair

Prof. Khaled E. Galal

______________________________ Examiner

Prof. Khaled E. Galal

______________________________ Examiner

Prof. Ahmed Soliman

______________________________ Supervisor

Dr. Emre Erkmen

Approved by ______________________________

Dr. Samuel Li, Chair of Department of Building, Civil and Environmental Engineering

March 2024

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Dr Mourad Debbabi, Dean of
Faculty of Engineering and Computer Science

Abstract

A Comparison of Beam and Solid Element Based Modelling Approaches based on a Developed Tool for the Nonlinear Analysis of Reinforced Concrete Structural Components

Clement Uwitonze

Nonlinear material models are needed for the capacity analysis of structural components. Often, 1D-beam element-based models are preferred over more sophisticated solid element-based modeling approaches due to their efficiency. However, their reliance on uniaxial material representations often overlooks the crucial influence of shear stresses, potentially leading to inaccuracies in predicting structural responses. In response, this study introduces a novel approach by integrating a multi-axial 3D concrete model within a 1D finite element framework, effectively capturing the effects of shear stresses. The proposed multi-axial elasto-plastic concrete model offers a comprehensive representation of concrete behavior under both tension and compression, thus enhancing the predictive capabilities of the analysis. By adopting a 1D beam-type finite element formulation, the research enables a detailed examination of shear wall behavior under lateral loading conditions. The main purpose of the thesis is to validate the developed finite element analysis tool which employs a sophisticated 3D concrete material model. The inelastic material behaviour of steel reinforcements bars has also been considered in the analysis. For the beam-type finite element, a 2-node formulation was adopted based on the Timoshenko theory so that the shear deformation effects are also considered in the analysis. For the modelling of the concrete bulk with 3D material model, the 8-node solid element with 6-degreesof-freedom per node including the nodal rotations was adopted. The numerical formulation is then used for pushover analysis of beams and shear walls and compared with experimental results from literature for validation purposes. Five different structural components are tested. Validation efforts include comparisons with experimental data from existing literature and alternative modelling approaches. Parametric studies are conducted by changing the span sizes of the structural components.

Dedication

I cannot express enough Dr Emre Erkmen's impact on my life, Dr Emre Erkmen accepted openhandedly to be my master's supervisor. His unwavering support, knowledge, dedication, and invaluable guidance were instrumental throughout this research program. Your presence and assistance have been a constant source of inspiration. May God bless and fulfill your dreams.

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I am deeply indebted to my life partner, Prisca, for being my rock, my confidante, and my source of unwavering support and encouragement. Her love and belief in me have been the driving force behind my success. Her sacrifices, understanding, and unwavering faith in my endeavors have been the foundation upon which I built my academic and professional journey. It would not be possible for me to accomplish this challenge without your love. May God bless You abundantly.

My gratitude also goes to my parents and siblings, whose unconditional love, support, and inspiration have been my pillars of strength. Despite the physical distance, their prayers and well-wishes have accompanied me every step of this journey, without which I would not have achieved this milestone. I would like to offer a special acknowledgment to my father for his enduring motivation and financial support. May you be eternally blessed and have your faith only strengthen in Jesus Christ

Lastly, I want to express my appreciation to my uncle Francois, my brothers and sisters for their prayers and all those who provided words of encouragement. Your kindness has been a source of motivation, and I am truly thankful for your presence in my life.

Table of Contents

List of Figures

Chapter 1

Introduction

1.1.Overview

In the vast majority of civil engineering applications, reinforced concrete beams are used as flexural structural components to span distances. On the other hand, Reinforced Concrete Columns and Shear walls are also commonly used in building design, where those members are dominantly subjected to compressive stresses.

To forecast their response, analytical and numerical techniques can be adopted. However, analytical solutions can only be applied to limited number of cases. For example, analytical solutions of deformations and internal forces of a statically determined homogeneous beam can be obtainable only if concrete does not crack. To completely describe the "problem," it is required to take into account the sources of cross-sectional heterogeneity, including the influence of reinforcement, material non-linearity due to concrete damage, and the relative slip between constitutive materials.

Since the problem is no longer statically determinate or linear elastic, a non-linear analysis technique must be adopted to obtain the solution that satisfies equilibrium and compatibility conditions along with the constitutive material laws.

In the context of phenomenological material modeling, the inelastic response of materials is associated with two distinct mechanical phenomena: plasticity, involving dislocations along slip planes, and damage, which entails the nucleation and coalescence of cracks. Phenomenological models grounded in coupled elastoplastic-damage theory exhibit the ability to capture both the enduring deformations caused by the plastic component and the reduction in elastic moduli resulting from the damage component.

1.2.Problem Statement

Understanding the failure behavior of reinforced concrete structural components is very important in order to ensure the safety, durability, and good performance of civil engineering structures. To conduct accurate and reliable failure analyses, engineers and researchers rely on advanced computer modeling approaches.

The modelling approaches for the analysis of structural components made of reinforced concrete are based on both beam-element and solid-element modelling. Beam-element models are widely used for the study of structural components where uni-axial material models are commonly used due to their computational efficiency. However, the significance of shear stresses on the behavior of the material is ignored by such material models.

1.3.Objective

The objective of this study is a multi-axial elasto-plastic material model for concrete and adopt it for both 3D solid-element as well as 1D beam-element type modelling to integrate the impacts of confinement pressure and shear stresses. In order to do this, a multi-axial elasto-plastic material model for concrete is suggested and used for modelling 1D beam elements in along with 3D solid elements.

To achieve this objective, the following specific goals will be pursued:

- **Examine the approaches employed in conducting a 3D structural analysis of reinforced concrete structural elements, integrating a multi-surface elasto-plastic material model.**
- **Validate the developed modelling techniques using the ABAQUS program.**
- **Check the correctness of the numerical technique by comparing the findings to prior work's experimental results.**

1.4.Scope

To achieve the objective of this research, computational technology is adopted. The FORTRAN programming language is used to implement the numerical procedures. This program offers a user-friendly interface that simplifies the process from pre-processing to post-processing. It requires minimal input and the user is guided with keywords throughout the process. The 1D user-guide is described in Appendix 1 and the 3D user-guide is in Appendix 2.

Comparisons are made between Beam and solid type modelling approaches with the purpose of identifying the confinement effects. To capture the behavior of concrete beyond elasticity, the material model based on the plasticity theory is used Both steel and FRP reinforced concrete beams will be investigated. Various failure mechanisms are identified.

To ensure the reliability of the developed tool, its results with those based on experimental data were compared. Additionally, a finite element model is crafted within the ABAQUS software platform to analyze reinforced concrete beams and shear walls comprehensively. ABAQUS offers versatile capabilities for analyzing such structures, accommodating steel or FRP reinforcements. Consequently, employing ABAQUS provides a reliable means to corroborate the findings obtained from the numerical approach.

1.5.Outline of the Thesis

The thesis is structured across six chapters, with each contributing distinct insights and analysis to the overarching research endeavor.

- Chapter 2 offers a comprehensive review of modelling techniques, delving into existing formulations and models pertinent to reinforced concrete structures. It also provides a succinct overview of prior literature and publications in the field, including discussions on finite element modelling. Furthermore, this chapter concludes with a detailed presentation of the case study.
- Chapter 3 elucidates the intricacies of the multi-surface Elasto-Plastic Material Model, outlining the behavior of elasto-plastic materials and expounding upon the components of plasticity models.
- Chapter 4, the finite element model within the ABAQUS software is meticulously delineated, encompassing concrete, reinforcement, and FRP elements.
- Chapter 5 serves as the focal point for presenting the primary findings and results derived from the numerical methodology, encompassing both FORTRAN code and ABAQUS simulations. This chapter meticulously validates the 3D and 1D material models against ABAQUS simulations and experimental data from prior studies.
- The conclusion and future work recommendation

Chapter 2

Literature review

2.1.Introduction

The development of extremely powerful computers and sophisticated non-linear numerical analysis software, however, as well as the challenges in finding a prognostic solution for complex structural cases have all encouraged the adoption of numerical methods for the majority of engineering applications. The most used numerical method right now is the finite element method. If used correctly, it offers quick, efficient solution schemes with the accuracy the user specifies, based on the specific instance.

The adoption of the finite element approach in the given research is decided by a variety of parameters, including:

a. **The size of the construction, whether it is a single member or the full structure**
b. **The problem's difficulty (one dimension, two dimensions, or three dimensions)**
c. **The desired outcomes (global or local features)**
d. **The degree of accuracy**
e. **The model's limitations (material or mathematical non-linearity, computational apparatuses available)**

When performing a limited component examination, the examiner's main pressing concern is usually the balance between precision and computational expense. For the global investigation of a huge structure, a full model would most likely be computationally "expensive" or even superfluous. When looking at simple geometries or structural components, on the other hand, a more sophisticated model that can describe more complicated phenomena is often possible and necessary. Non-linearity types that arise from either the material manner of behaving or the calculation of the example, as well as nearby scale impacts. To capture the aforementioned properties, advanced computational approaches must be created. The term "advanced" can refer to more sophisticated constitutive models for materials or to additional components that must be incorporated in addition to the structural components that comprise the majority of the model.

In structural engineering practice, beam-type one-dimensional finite element formulations are frequently utilized as analysis and design tools for structural components. These models offer computational efficiency, which is particularly crucial in nonlinear analysis scenarios, and facilitate easier interpretation of results for design purposes. Among the various modeling approaches employed for the nonlinear analysis of reinforced concrete buildings, the lumped plasticity approach stands out as one of the simplest and most commonly adopted methods. This approach leverages the predicted moment distribution in frame buildings subjected to earthquake-induced lateral loads, allowing engineers to effectively assess the structural response and design appropriate reinforcement strategies.

2.2. FRP reinforced members

High- strength synthetic or organic fibers encased in a resin matrix typically make up FRPs. For applications in civil engineering, carbon (CFRP), aramid (AFRP), and glass (GFRP) are the FRPs that are most frequently utilized. In the real world, they are used as ground anchors, reinforcement for reinforced and prestressed concrete elements, and for strengthening or repairing existing concrete structures. Due to a dearth of research information and design guidelines, its extensive application in reinforced concrete structural engineering has been severely constrained.

These materials' strong corrosion resistance, high tensile strength, and light weight are advantages. According to the kind of FRP product and surface treatment, other typical features of FRP materials include their relatively low modulus of elasticity, linear stress-strain relationship till failure, and varied bond properties (Galati et al., 2006). Both the bond performance of reinforcement and the shear strength of FRP materials are impacted by their anisotropic behavior. Additionally, splitting cracks and concrete cover failure may result from the anisotropic behavior of FRP bars and the high transverse coefficient of thermal expansion with respect to concrete (Aiello et al., 2001).

In comparison to steel bars, FRP bars typically have a lower elastic modulus and a higher tensile strength. In order to meet the restrictions of deflection and crack width, FRP reinforced concrete beams must thus be over reinforced (Jaeger et al., 1997). As a result, the serviceability limit states frequently determine the design. As a result, numerous research projects have been focused on developing accurate analytical, numerical, and design methods for the prediction of deflections and crack width (Gao et al., 1998) as well as theoretical advancements regarding specific models of composite structures (Barretta et al., 2015; Barretta & Luciano, 2014). Some of the suggested techniques (Gravina & Smith, 2008) make use of the local bond slip relationship that distinguishes the FRP-concrete interface and is a distinctive quality of every single FRP product. Other studies (Kara et al., 2013) are aimed to calibrate the coefficients of a simple equation for the prevision of the deflection in the frame of the Branson's method (Branson, 1977).

When it comes to FRP and steel bars, the bond to concrete shear stress transmission phenomena is different. This is caused by the FRP bars' lower modulus of elasticity, the resin matrix's lower shear strength compared to steel, and the different coefficient of thermal expansion. Additionally, in the case of FRP and steel bars, the impact of transversal stresses and the size of the concrete cover are also different (Seo et al., 2013). There have been several experimental investigations on this subject (Cosenza et al., 1997); some of these were based on pull-out tests, which seem inappropriate for examining the bending behavior of concrete parts (Oh et al., 2007). To assess the relationship between concrete strength and bond properties, additional investigations were carried out. According to Achillides and Pilakoutas (2006), the strength of the concrete has no bearing on the binding of FRP bars to it. Concrete with strengths ranging from 29 to 60 MPa was used in Okelo and Yuan's (2005) study of the bond behavior of FRP reinforced parts. They discovered that when the concrete grade rises, bond performance is better. According to some research, a strong connection is not necessarily desired in FRP bars since it may cause localized overstress and an early failure of the member (Darby et al., 2007).

The absence of plastic deformations in FRP bars indicates that the reinforcements are incompatible with ductile behavior, which is needed, for example, in main members (beams and columns) of earthquake-resistant frame structures. Due to this, the majority of applications for FRP reinforcing bars have focused on structural components in many nations, such as floor structures, concrete slabs, and concrete members supporting hollow-tile floors, for which ductility is not a major concern (Rizkalla et al., 2003).

Utilizing FRP bars in the building of bridge decks is another useful usage for them. In this instance, the static redundancy of the structure and the FRP bars' superior corrosion resistance properties play a major role in limiting deflections. Additionally, these structures frequently lack transverse reinforcement, leaving them vulnerable to a shear-related early collapse (Tureyen & Frosch, 2002).

In order to resist lateral stresses brought on by wind or seismic occurrences, multistory structures must have a suitable amount of stiffness. In compared to alternative lateral-resisting systems, reinforced concrete shear walls, which have a high in-plane stiffness, have been shown to provide good, cost-effective lateral resistance (Cardenas et al. 1973; Wyllie et al. 1986; Fintel 1995). Shear-wall constructions have the advantages of reduced deformation and nonstructural element damage as compared to frame-type structures.

Despite this, the weather conditions that lead to the extensive use of deicing salts during the winter months typically speed up the rusting of steel reinforcement, resulting in the degradation of reinforced concrete buildings, particularly bridges and multistory garages.

One of the various methods proposed to improve the corrosion resistance of reinforced concrete structures is the use of fibre reinforced plastic (FRP) rebars in place of steel rebars (Clarke, 1993). Particularly in situations where traditional steel-reinforced concrete has produced poor service, FRP rebar provides tremendous promise for application in reinforced concrete construction (Neale & Labossière, 1992).

Due to these circumstances, other forms of reinforcement were required to solve the corrosion issues. ACI 440R (ACI 2007; Fédération Internationale du Béton (fib) 2007; ISIS Canada 2007) states that the effective application of fiber-reinforced polymer (FRP)-reinforcing bars as concrete reinforcement in a wide range of building elements has achieved an acceptable level. FRP bars have been used into a variety of building elements, including beams, one-way and two-way slabs, and columns (Kassem et al. 2011; Bakis et al. 2002; El-Salakawy et al. 2005; Sharbatdar and Saatcioglu 2009; Tobbi et al. 2012). This is because of their benefits. More than 20 years ago, the initial use of FRP bars in reinforcing beams demonstrated how expensive they were compared to steel bars. Although FRP materials are more expensive than steel, they also have cheaper shipping and handling expenses as a result of the smaller weight of the components. In addition, compared to steel-reinforced structures, FRP-reinforced structures require far less long-term maintenance. Investigation of the inelastic behavior of shear walls completely reinforced with FRP is required in order to construct a multistory building with acceptable stiffness employing FRP reinforcement.

Yamakawa and Fujisaki (1995) examined seven carbon-FRP (CFRP) grid-reinforced, one-third scale shear walls with dimensions of 800 mm by 950 mm by 80 mm. The walls have double-layered CFRP grid reinforcement with 100 mm meshes, giving them a 0.8% reinforcement ratio. When 1% drift and minimal energy dissipation were attained, the specimens quickly lost their ability to support lateral loads. This decrease in capacity was caused by three major flaws:

(1) The CFRP grids could not support compressive stress and broke under low compressive stresses;

(2) Adequate development lengths needed to be designed to prevent the reinforcing bars from pulling out of the wall base; and

(3) The CFRP grid reinforcement did not provide concrete confinement.

According to research on concrete shear walls reinforced with steel bars, factors affecting the behavior of shear walls, such as wall aspect ratio and configuration, axial load, shear-stress demand, and wall reinforcement ratios, have received the majority of attention (Barda et al. 1977; Wallace and Moehle 1992; Sittipunt et al. 2001). The design of reinforced concrete shear walls is governed by code provisions such as CSA A23.3 (CAN/CSA 2004) and ACI 318 (ACI 2008), which place emphasis on providing the necessary strength and stiffness to prevent or reduce damage from frequent earthquakes while ensuring adequate wall-deformation capacity (Massone and Wallace, 2004).

Therefore, this study focused on the behavior of shear walls with a medium aspect ratio, which are typical in parking garages and medium-rise structures. According to Jiang and Kurama (2010), the majority of shear walls built in the US and Canada are classed as medium rise structures with wall aspect ratios that generally range from 2 to 4. The lateral response of such shear walls is greatly influenced by nonlinear flexural and nonlinear shear deformations (Massone et al., 2006).

2.3.Modelling of Structural Components

2.3.1. Introduction

The process of creating a three-dimensional representation of an object or system using computer software is referred as 3D modeling. It allows the visualization and analyze of complex structures in a virtual environment. Simplified models or reduced-order models (ROMs) also known as reduced models, are approximations of complex systems. They aim to capture essential behavior while minimizing computational effort. applying a single axial load (force or displacement) along one direction to a structure, the Sugano model is a uni-axial model that considers axial stress-strain relations along the longitudinal fiber. This modeling approaches determine material properties and behavior under simple loading conditions.

Since 3D solid components demand more computing work than 1D structural elements or 2D continuum elements, beams are often not simulated with them. The use of 3D features has several benefits. They are able to detect failure modes that other types of elements cannot, such as spalling and anchoring failure in support zones. Various modelling techniques may be used to represent the reinforcement in 3D solid parts. Each bar is represented by one 3D solid element with a different constitutive relation in a 3D solid element. With this approach, it is feasible to represent the reinforcement as embedded, allowing for complete interaction between the two materials, or to put an interface layer between the concrete and steel. The interface layer needs to be defined using a constitutive model in order to be able to prescribe the bond-slip action between the two materials. The reinforcement can alternatively be described as a 1D truss with each bar's cross section defined within a 3D solid or as a 2D plane with an equivalent thickness of reinforcement layer. According to Lykidis et al. (2008) in both situations, it is possible to represent the bond-slip relation in commercial software using specific interface components, such as embedded reinforcement or line-solid interfaces for 1D and plane-solid interfaces for 2D.

In general, a line with a specific cross-sectional area represents a one-dimensional element. It can be composed of a single material, which would make it homogeneous, or of multiple materials, which are then homogenized across the cross-section. The simplest FE model that can be implemented, which consists of two-node bar or truss elements with one or two translational degrees of freedom per node. Higher order 1D elements are also used when capturing more complex phenomena, which contain more than two nodes and higher order approximating functions. Beam or structural elements occupy a unique position within the 'family' of 1D elements.

As depicted in Figure 2-1, they exist in their simplest form as two-node elements with a vertical translational and rotational degree of freedom per node. It is likely the most well-known and extensively used finite element, owing primarily to the simplifications that typically underlie its constitutive theories and its minimal computational cost, which make it very user-friendly. The principle that "plane sections remain plane and perpendicular to the reference axis of the beam," also known as the Euler-Bernoulli beam theory, covers an important section of such theories (Ottosen and Petersson, 1992). When the global response of a structure as a whole is desired, or when structural cases of extreme deformation are examined, they could be employed.

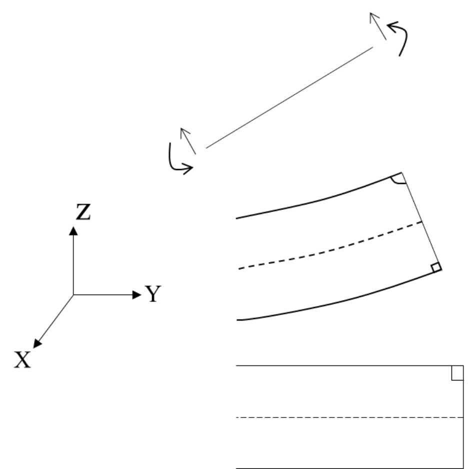


Figure 2-1. Euler-Bernoulli beam theory

The Timoshenko beam theory is also often used (Hjelmstad, 2005). This theory says that plane parts stay flat, but they don't have to be perpendicular to the reference line. Timoshenko bar component models are also employed for the global primary analysis; they offer benefits comparable to those of Euler-Bernoulli components, but their major usage is when shear activity is believed to be crucial for the prediction of the reaction of the part viable (Figure 2-2).

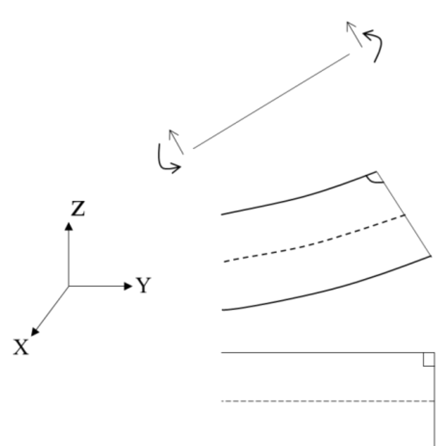


Figure 2-2. Timoshenko beam theory

The plane-frame element can be used with either of the two beam theories talked about so far, and it also takes into account the axial shift of the element's reference axis (Figure 2-3). The pertinent component is typically used in applications where the hub movement of the framework is important, such as recreations of plane casing structures. Consideration of the axial displacement degree of freedom is beneficial for modelling effects and geometries that occur and exist in the axial direction of the model, such as the reinforcement effect and the bold-slip in reinforced concrete members.

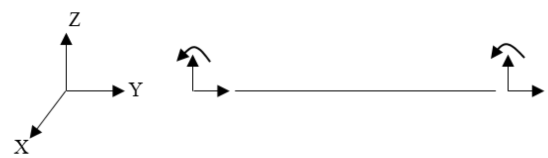


Figure 2-3. Plane-frame element

In addition to the previously mentioned fundamental structural elements, more advanced 1D beam-type models have been created. These are typically composed of multiple materials, homogenized across the cross-section, and modelled using more specialized techniques. The development of such models was necessitated by the need to account for more complex tasks in a simplified but nonetheless representative manner. These tasks may involve several localized phenomena that would be impossible to capture using the Euler-Bernoulli or Timoshenko beam theory alone.

As previously mentioned, simulating large civil engineering structures may be challenging. Therefore, a simplified technique has been developed. As a result, a method that has been developed has been provided (Spacone et al., 1996; Mazars et al., 2004; Kotronis and Mazars, 2005). Specifically, the assembly under consideration is discretized into beam elements that adhere to Euler-Bernoulli or Timoshenko beam theory Typically, beams and other flexural members are analyzed using the Euler-Bernoulli beam theory. When shear effects are stronger, the Timoshenko theory for beams is used for understanding them. The unique aspect of the applicable method is the subdivision of the cross-section into fibres (Figure 2-4). In Figure 2-4, (i) Reinforced concrete specimen (ii) Discretization into elements, nodes, degrees of freedom (iii) Separation of the cross-section into fibers. Each fibre represents a finite cross-sectional area and is created from one of the constituent materials, concrete or steel.

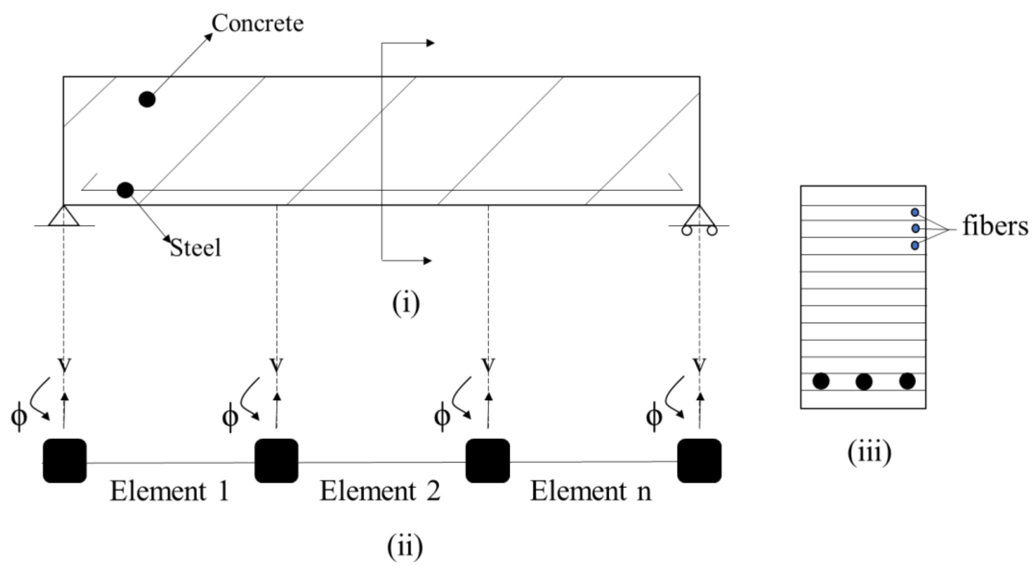


Figure 2-4. Multi-fiber beam model

The basic presumption that plain portions stay planar stays true in the suggested method's implementation strategy. The well-known beam theories discussed in the preceding paragraph are relevant based on that supposition.

The model's calculation is carried out at three different levels:

a) **the element level;**
b) **the sectional level; and**
c) **the fiber levels. The nodal displacements of the simulated member are connected to the normal strains (in the case of the Euler-Bernoulli beam theory) through the fundamental beam theories using a connection of the form.**

$$\varepsilon_{xx} = \frac{\partial u^o}{\partial x} + z\frac{\partial^2 w}{\partial x^2} \quad \text{Eq. 2.1}$$

Where, $\partial u^o/\partial x$, accounts for the axial deformation of the reference axis of the beam,$\partial^2 w/\partial x^2$ is the curvature, and z denotes the position of the fiber along the cross-section of the beam. In order to determine the stress at the location where the fiber resides along the cross-sectional height, the sectional strain of each fibre as determined by Eq. 2.1 is then placed into the constitutive law that is allocated for the material of the fibre.

Composites in the infrastructure sector have the potential to offer considerable cost and durability reductions if used properly. High strength-to-weight and stiffness-to-weight ratios, chemical and corrosion resistance, adjustable thermal expansion and damping properties, and electro- magnetic neutrality are additional benefits. These benefits might result in improved safety and life expectancy as well as cost savings for equipment, fabrication, and maintenance.

Although Galileo's simple theories may have inspired early plasticity theories (Jirásek & Bazant, 2002), the linear-elastic model, which takes Hooke's rule as a given, has become the most widely used material model. But as processing power has increased and numerical analysis methods have been developed, nonlinear material models and analysis methodologies have advanced. The two primary methodologies created for the investigation of nonlinear material behavior can be seen to be the theory of plasticity and damage theory.

The idea of plasticity, which first emerged in the late nineteenth century, has been the preeminent framework for studying material nonlinearity. However, the method's predictive capability was not as great for brittle materials (like concrete and rock) as it was for ductile materials (like metals).

The continuum damage theory was first published by Kachanov (1958a), in which a damage variable was used to describe the flaws in the material matrix. Although defects can be studied at the micro, meso, and macroscale levels, the mechanical behavior of various materials, such as metals and rocks, is similar enough that their common mesoscopic properties by using a few energy mechanisms in the context of damage mechanics can be understood. (Lemaitre, 1985).

Although they are very effective methodologies, plasticity and damage theories can capture various aspects of a material's inelastic response. For instance, whereas damage models might take material moduli deterioration into account, plasticity models are founded on the idea of persistent (irreversible) deformation.

One can account for both persistent deformations and the degradation of material moduli brought on by inelastic processes by coupling the plastic and damage models. A number of coupled elastoplastic-damage models have been used to simulate the non-elastic mechanical behavior of a variety of materials, including steel, concrete, porous metals, and geomaterials.

2.3.2. Concrete Modelling

The field of constitutive modelling in concrete is a complex and diverse area of study, encompassing numerous proposed methodologies. The primary objective of this work is to examine the modelling of concrete through the utilization of plasticity and continuum damage theories.

Concrete is a material that exhibits sensitivity to pressure, with distinct variations in its behavior when subjected to compressive and tensile forces. When subjected to uniaxial tensile loading, the initiation of tensile cracks occurs in a direction perpendicular to the primary tensile stress. These cracks have the potential to merge together, resulting in the formation of bigger cracks.

As a result, once the tensile strength threshold is attained, a decline in strength becomes evident by a pronounced decrease in stiffness on the stress-strain curve. Moreover, the existence of tensile cracks also leads to a decline in material moduli. In order to incorporate the aforementioned attributes of concrete inside the plastic-damage constitutive modelling framework, the process of softening is typically represented by the progressive development of yield criteria. Additionally, the deterioration of material moduli is accounted for by incorporating damage factors. It is important to acknowledge that instead of being distributed uniformly over the entire volume, inelastic strains tend to concentrate in the proximity of macro fractures.

Therefore, it may be inferred that plasticity and damage models, which are grounded in the continuum framework, can only offer imprecise predictions.

The inelastic behavior of concrete under uniaxial compression loading is typically characterized by the formation of compression cracks that frequently emerge in a direction parallel to the applied compressive stress. The tangential stiffness of a material decreases as it is subjected to increasing deformation beyond its elastic limit, ultimately leading to a reduction in its ability to resist tangential forces. Additionally, the compression stress experienced by the material reaches its maximum value at the point of compressive strength. Under conditions of continuous loading, a regime of softening occurs. Just like in the case of tensile strength, the moduli of materials also experience degradation due to inelastic processes.

The behavior of concrete can undergo considerable changes, particularly in the case of multiaxial stress, with a notable impact observed in triaxial compressive loading scenarios. The strength and ductility of concrete exhibit a significant rise as the confining pressure is elevated. Hence, it is crucial to consider and incorporate this particular attribute of concrete in constitutive models, especially where confinement pressure plays a key role. In the context of multiaxial tensile testing, it is observed that the inelastic behaviour is mostly influenced by the maximum tensile stress.

The aforementioned factors lead to the prevalence of Rankine-type yield surfaces, characterised by triangular shapes in the deviatoric plane, in tensile modelling. Conversely, Drucker-Prager type yield surfaces, which exhibit round shapes in the deviatoric plane, offer superior performance in compressive modelling of concrete. Simultaneous utilisation of several yield criteria, such as the Rankine criterion for tension and the Drucker-Prager criterion for compression, is a prevalent practice in order to get a more precise representation of both compressive and tensile features. The utilisation of a multi-surface technique enables the incorporation of distinct damage evolutions in both tension and compression, hence enhancing the model's capacity to accurately represent the observed behaviour.

The authors Feenstra and de Borst (1996) proposed a multi-surface plasticity model to analyse the behaviour of plain and reinforced concretes subjected to monotonic biaxial loading. The composite yield surface is comprised of the Rankine criterion for tension and the Drucker-Prager criterion for compression. As previously stated, the corners resulting from the junction of various yield requirements were addressed through the use of Koiter's rule. The authors place significant emphasis on the fact that their model does not take into account the loss of rigidity.

Although the yield requirements and hardening/softening formulas exhibit variations, Erkmen & Sarikaya (2019) and Feenstra & de Borst (1996) demonstrate certain similarities. The utilisation of two distinct surfaces to represent tension and compression, and their ability to undergo distinct hardening or softening processes, has enabled enhanced control in the simulation of concrete. The model proposed by Feenstra & de Borst (1996) is appealing due to its incorporation of connection between various damage variables.

The hardening plasticity model for planar concrete under multiaxial compression was developed by Grassl, et al. in 2002. The yield surface proposed in the work of Menetrey and Willam (1995) was utilised by the study authors.

Subsequently, Grassl and Jirásek (2006a) proposed an integrated plastic-damage model to analyse the behaviour of concrete subjected to different types of stress, including tension, shear, and multiaxial compression. One notable aspect of the paper involves the examination of the requirements pertaining to local uniqueness in the context of coupled plasticity-damage. According to the paper, the assurance of local uniqueness was observed in cases where the plasticity component of the linked plasticity-damage model relied on the effective stress formulation. However, the authors assert that this was not consistently observed in the coupled scenario involving the nominal stress-based plasticity component.

According to the model proposed by Grassl and Jirásek (2006a), the process of hardening is influenced by the plastic hardening variable. Conversely, the softening behaviour is achieved by the evolution of the damage loading function, which is controlled by the damage-driving variable. One notable aspect of the model is the definition of the damage-driving variable, which is expressed as a function of plastic strain.

The model demonstrated a satisfactory level of accuracy in predicting the inelastic behaviour of concrete and reinforced concrete parts. The authors also said that the model shown greater suitability for monotonic loadings compared to tension-compression cyclic loadings, primarily because it employed a single damage variable for all loading regimes.

Subsequently, Grassl et al. (2013) made enhancements to their prior model (Grassl & Jirásek 2006a), referred to as 'Concrete Damage Plasticity Model 1' (CDPM1), while introducing a new model known as 'Concrete Damage Plasticity Model 2' (CDPM2). One notable enhancement was the implementation of distinct damage variables for tension and compression, enabling the modelling of varying stiffness properties of concrete during tension-compression loading cycles. In addition, the authors have addressed the mesh-dependency problem that is inherent in CDPM1 by incorporating complete plasticity in the post-peak area. The authors incorporated the concept of hardening plasticity into the post-peak regime within the CDPM2 model. The significance of employing distinct damage criteria in concrete models, particularly during tension-compression cycles, is exemplified by the contrast between CDPM1 and CDPM2 (Sarikaya et al., 2021).

The proposition of employing distinct damage factors has been put forth in various other scholarly investigations. Lee and Fenves (1998) introduced a coupled plasticity-damage model that incorporates changes in the compressive and tensile stiffness of concrete through the utilization of distinct damage variables for compression and tension.

One notable feature of the model is the coupling of the tension and compression damage variables. The phenomenon of tensile fracture closure can be observed by the recovery of stiffness when switching from tensile loading to compressive loading.

In their study, Červenka and Papanikolaou (2008) put out a model that combines plasticity and fracture. The fracture component of the analysis is derived from the Rankine criterion, and a smeared crack technique is utilised in the analysis. The plasticity component, however, relies on the Menetrey-Willam yield surface that was previously examined. The Rankine criterion and the yield surface given by Menetrey and Willam (1995) were utilised by the writers. The study conducted by Sarikaya and Erkmen (2019) utilises various aspects of the concrete model proposed by Červenka and Papanikolaou (2008), as well as its earlier iteration by Papanikolaou and Kappos (2007). However, the expression for hardening was altered as a result of the infinite derivative produced after the onset of hardening.

In several prior models, the consideration of degradation in material characteristics, such as a decrease in strength or material moduli, was achieved by implementing external reduction factors, rather of deriving these reductions as a result of the model. Subsequent studies introduced plasticity-based models as a means to effectively represent the strength, as exemplified by the work of Ulm et al. (2002). In a similar vein, many scholars have employed damage-based models to effectively represent the decrease in material moduli, as demonstrated by the work of Comi et al. (2009).

In recent studies, researchers have employed coupled plastic-damage models, as demonstrated by Grimal et al. (2008a) and Morenon et al. (2019). The plasticity-damage model proposed by Sarikaya et al. (2021) in their thesis might also be included in the aforementioned category. The inclusion of the plasticity component allows for the simultaneous analysis of both the development of permanent displacements and the evolution of material strength. The damage component, however, enables the capture of the deterioration in the material moduli. When these two components are integrated, they form a precise analysis tool that is applicable in circumstances where the behaviour is governed by inelastic material characteristics.

In the context of plasticity theory, it is necessary to have a yield function and a flow rule in order to establish the permissible stresses and plastic (permanent) strains. In contrast, beliefs pertaining to damage exhibit a greater degree of diversity. However, Armero and Oller (2000a) demonstrated that many damage mechanisms can be consolidated and incorporated into the conventional plasticity approach. The incorporation of damage strain as an additional component of total strains facilitated the attainment of this outcome. Given the overall independence of plasticity and damage components, it becomes imperative to establish distinct yield functions for each component. Sarikaya and Erkmen (2019) introduced a novel direct connection technique that enables the utilisation of a shared yield surface for both plasticity and damage.

Concrete is a multifaceted substance that exhibits a stress-strain relationship that is not linear in nature. The observed data reveals a notable disparity in the compressive and tensile strengths, with the strength being contingent upon the applied pressure, specifically influenced by the confinement pressure. In order to discuss the aforementioned aspects, Sarikaya et al. (2020-2022) formulated an innovative composite yield surface and conducted an analysis of the stress integration circumstances.

2.3.3. Computational Plasticity

In general, engineering problems present difficulty in geometry, boundary conditions, actions, and constitutive behavior that is extremely challenging to address analytically. Computational methods like the finite element method (FEM) are used to solve these difficult problems. The FEM can be used to solve the overall problem of determining strains and stresses (thus, forces and displacements) in the framework of continuum mechanics. However, in order to link strains and stresses, the FEM needs the constitutive model to be implemented. The constitutive relations make up the local component of the issue in the context of plasticity.

2.3.3.1. Integration schemes

Integration schemes are commonly categorized into two main types: explicit and implicit. In the explicit situation, the present solution is dependent on the prior solutions, but in the implicit case, the current answer is found to be self-dependent. Within the realm of algorithmic stability, implicit schemes exhibit a higher level of superiority due to their reduced susceptibility to the influence of step size. In the case of fully implicit schemes, stability is guaranteed regardless of the step size, thereby rendering them unconditional in their stability. Conversely, explicit systems typically possess conditional stability. In contrast, explicit schemes are more computationally efficient as they do not necessitate an additional step of solving a system of equations, which is typically required for implicit systems.

Moreover, the categorization of integration schemes can be determined by the quantity of steps incorporated in the integration process (Scalet & Auricchio, 2018). For example, if the variables at time tn+1 are calculated only based on the variables obtained at the previous step tn, the process can be considered as a single step. If the process involves multiple steps, it can be classified as a multi-step method. One-step or multi-step frameworks can be utilised to design both implicit and explicit schemes.

The seminal research conducted by Wilkins (1963) can be regarded as a forerunner to contemporary integration methods. The radial return approach was developed for J2 elastoplasticity in the study. Subsequently, the scholarly contributions of Simo and Taylor (1985) and Ortiz and Popov (1985) have emerged as very significant exemplars of one-step integration techniques within the realm of plasticity theory.

The study conducted by Ortiz and Popov (1985) extensively examines the precision and reliability of two integration algorithms, specifically the generalised trapezoidal and generalised mid-point rules. Their work demonstrated that the generalised trapezoidal and mid-point algorithms had the ability to combine explicit and implicit strategies. The authors demonstrated that, in circumstances involving ideal plasticity and certain no associative flow scenarios, the mid-point algorithm exhibited higher stability performance compared to the trapezoidal rule.

In a significant study, Simo and Taylor (1985) established the concept of algorithmically consistent tangent moduli, which effectively maintained the quadratic rate of convergence of the implicit integration scheme. Subsequently, Simo and Taylor (1986) demonstrated the necessity of imposing the consistency constraint on the generalized mid-point state in order to maintain the symmetry of the consistent tangent moduli (Eq. 2.2).

$$f_{n+\theta} = f(\sigma_{n+\theta}, q_{n+\theta}) \quad \text{Eq. 2.2}$$

Subsequently, Ortiz and Martin (1989) demonstrated that just the fully implicit variant of Simo and Taylor's (1985) approach could guarantee the symmetry of the consistent tangent moduli. The researchers conducted an investigation into the criteria that preserve symmetry in algorithmic moduli within return mapping techniques. In their work, Simo and Govindjee (1991) introduced a set of algorithms that rely on fully associative models. These algorithms aim to achieve symmetry and enforce the consistency criterion, as described in Eq. 2.2 mentioned before, which pertains to consistency upon reaching the mid-point state.

2.3.3.2. Plastic-Damage Coupling

The development of coupled plastic-damage constitutive models has been undertaken in order to ascertain the mechanical behavior of materials that demonstrate both persistent deformations and degradation of material moduli. These models have been utilized for the purpose of simulating the inelastic behavior of many materials, including concrete, geomaterials, and metals. An example of this may be seen in the work of Jason et al. (2006), where they proposed a linked plastic-damage model that effectively accounts for the irreversible deformations and stiffness degradation observed in concrete materials. As elucidated in their scholarly publication, neither a purely damage-based nor a purely plasticity-based model is capable of accurately representing the stiffness of a concrete element experiencing inelastic deformations. The underlying factors can be attributed to the fact that in a purely damage-based model, the stress-strain curve is centered around the origin, while in a purely plasticity-based model, the initial stiffness remains constant during the unloading process. However, as illustrated in Figure 2-5, a connected model has the ability to address these limitations.

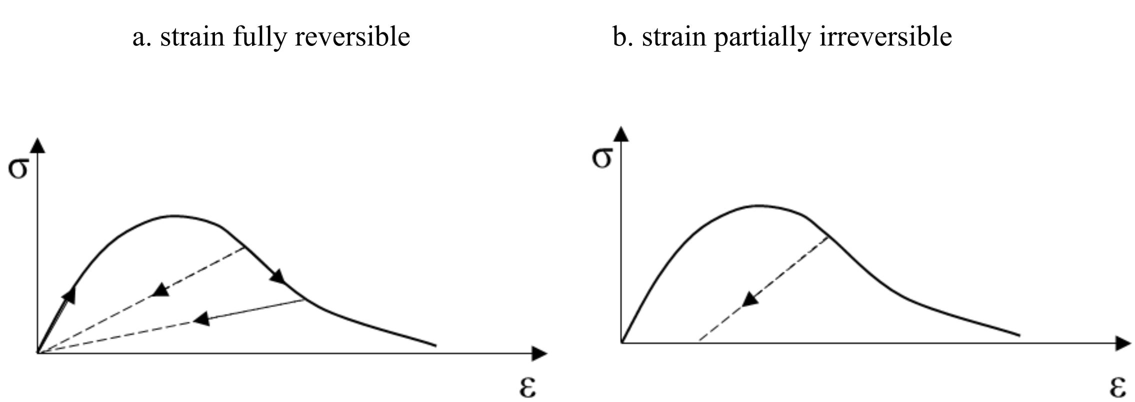


Figure 2-5. Unloading to the origin (Jirasek & Bazant, 2002)

In contrast to the prevailing plasticity hypothesis, the methodologies within the damage mechanics framework exhibit a notable degree of diversity. One of the strategies utilised in damage modelling is founded on the effective stress notion, which can be dated back to.

The introduction of a continuous damage variable to account for the impact of microscale faults on the macroscale was initially proposed by Kachanov in 1958b. In the scenario of isotropy, the scalar damage variable φ, ranging from 0 to 1, quantifies the proportion of areas that have undergone damage in relation to the areas that remain undamaged (intact) under the influence of stress. Based on the aforementioned observations, it is possible to create the idea of effective stress, which corresponds to the stress exerted on the undisturbed surface. Theories that are grounded in the concept of effective strain have also been formulated in a comparable manner. Simo and Ju (1987, 1989), Lubliner et al. (1989), and Luccioni et al. (1996) represent notable instances of damage formulations that rely on the effective stress notion.

The incorporation of spatial orientation as a factor in the effective stress/strain approach leads to the consideration of damage tensors in the characterization of anisotropic damage. Several examples of relevant literature include Murakami's (1993) work, Chaboche's publication from 1984, and the study conducted by Voyiadjis and Park in 1997.

Models that employ the fourth-order compliance tensor as the primary internal variable represent a distinct category within the field of continuum damage mechanics. The derivation of the evolution of the compliance tensor often follows a thermodynamically consistent framework, such as the principle of maximal damage dissipation. There are numerous similarities seen between the aforementioned technique and the associative plasticity framework. In the current study, it is aimed to establish a coupled damage-plasticity model by leveraging this similarity. Ortiz (1985) and Simo and Ju (1987) can be regarded as pioneer exemplifications utilising the compliance tensor methodology. Additional examples of relevant studies in the field include the works of Hansen and Schreyer (1994), Govindjee et al. (1995), Ibrahimbegović, et al. (2003), Ibrahimbegović and Markovič (2003), Ibrahimbegović et al. (2008), as well as Brancherie and Ibrahimbegovic (2009).

The literature also presents an alternative class of models, known as smeared crack damage models, which address the formation and advancement of macrocracks resulting from the commencement and progression of microcracks. In the earlier studies, such as the one conducted by Rashid (1968), it was thought that the direction of the crack would remain constant. The introduction of the idea of fracture rotation was observed in subsequent investigations (Gupta & Akbar, 1984). Subsequently, Jirásek and Zimmermann (1998) demonstrated that the rotating crack model exhibited the stress locking phenomenon previously seen in models utilising a non-aligning finite element mesh with crack orientation.

In relation to the smeared crack approach, it is important to highlight the kinematic decomposition, which involves separating the total strain into elastic and inelastic components. This decomposition is expressed as follows:

$$\varepsilon = \varepsilon_e + \varepsilon_c \qquad \text{Eq. 2.3}$$

Here, ε represents the total strain tensor, which consists of the elastic strain tensor ε_e and the crack strain tensor ε_c. The crack strain tensor is specifically associated with the inelastic deformations, as described by Jirásek and Zimmermann (1998).

In the context of classical plasticity, the primary strategy involves the additive decomposition of the strain tensor ε into its elastic ε_e and plastic ε_p components, as expressed by the Eq. 2.4.

$$\varepsilon = \varepsilon_e + \varepsilon_p \qquad \text{Eq. 2.4}$$

One of the primary differentiating factors among the several alternative damage models lies in the manner in which kinematic decomposition is implemented. Hence, many formulations emerge within the context of coupled damage-plasticity frameworks. In several studies, the overall strain is divided exclusively into elastic (ε_e) and plastic (ε_p) components, as demonstrated by Lemaitre (1985), Ju (1989), Hansen & Schreyer (1994), Cicekli et al. (2007), Grassl et al. (2013), and Alfarah et al. (2017). In certain literature, however, an additional component known as the damage strain (ε_d) has been incorporated into the strain decomposition, represented as

$$\varepsilon = \varepsilon_e + \varepsilon_p + \varepsilon_d \qquad \text{Eq. 2.5}$$

Previous studies have explored the division of total strain into elastic, plastic, and damaging strains. Notable contributions in this area include the research conducted by Klisiński & Mróz (1988), as well as the work of Yazdani & Schreyer (1990). Subsequently, several research have incorporated coupled constitutive models that incorporate a damage strain component. These studies include Armero and Oller (2000a), Al-Rub and Voyiadjis (2003), Ibrahimbegović et al. (2008), Ayhan et al. (2013), and Wu and Cervera (2016).

In addition to the aforementioned sources, Sarikaya et al. (2021) conducted a detailed examination of the works by Armero & Oller (2000a) and Armero & Oller (2000b) in order to provide a more comprehensive analysis of their plastic-damage coupling method within the context of the current study. Armero and Oller (2000a) proposed a novel conceptual framework that allows for the integration of various alternative damage therapies, as previously stated, into a coherent approach. The central significance in their architecture is attributed to the concept of damage strain, which allows for the inclusion of various damage mechanisms. The authors of the study have adopted the additive decomposition of the strain tensor, which is consistent with the formulation presented in Eq. 2.5. The damage strain, denoted as ε_d, is composed of various contributions originating from different damage mechanisms.

$$\varepsilon_d = \sum_{d_i=1}^{n_{dam}} \varepsilon_{d_i} \qquad \text{Eq. 2.6}$$

Each damage mechanism is represented by d_i, where i is the corresponding number assigned to the mechanism. The overall number of damage mechanisms is denoted as n_{dam}.

It is worth mentioning that Armero and Oller (2000a) classify the damage strains as recoverable. The recoverability of damage strains can be attributed to the correlation between each damage mechanism and its corresponding damage energy potential. Based on the aforementioned information, the stored energy function W was expressed by Sarikaya et al. (2021) by incorporating the damage terms,

$$W = W^e(\varepsilon_e) + \beth^p(K_P) + \sum_{d_i=1}^{n_{dam}} W^{d_i}(\varepsilon_{d_i}, K_{d_i}) \qquad \text{Eq. 2.7}$$

The variables W^e and W^e represent the stored energy associated with elasticity and damage, respectively. The symbol $ב^p$ is used to denote the potential related to the plastic hardening process, which is influenced by the development of the internal plastic hardening variable K_P. Likewise, K_d denotes the variable associated with damage hardening.

One notable aspect of Armero & Oller's (2000b) work is the similarity between the stress return algorithms for plasticity and damage models. Furthermore, the modular treatment of the numerical integration problem is facilitated by representing each damage mechanism according to its contribution to the total damage strain.

Subsequently, Ibrahimbegovic et al. (2003, 2008) incorporated the coupled plasticity-damage framework proposed by Armero and Oller (2000a) and its numerical implementation (Armero and Oller 2000b) in several studies, including Ibrahimbegović et al. (2003), Ibrahimbegović and Markovič (2003), Ibrahimbegović et al. (2008), and Ayhan et al. (2013). These studies focused on utilising this framework for constitutive modelling of concrete and other materials.

It is important to acknowledge that the concept of damage strain is employed in many ways within the existing body of literature.

In the studies conducted by Armero & Oller (2000a), Ibrahimbegović (2009), and Wu & Cervera (2016), the damage strain is found to be recoverable. However, in the works of Al-Rub & Voyiadjis (2003) and Brünig & Michalski (2017), the damage strain is associated with permanent deformations. The observed disparity arises as a result of variations in the conceptualization and operationalization of damage and strain.

The authors of the Sarikaya et al. (2021) study chose to utilise the linked plasticity-damage framework developed by Armero & Oller (2000a) and Armero & Oller (2000b) due to its straightforward nature and computational effectiveness. The authors proposed a direct coupling strategy to modify the framework developed by Armero and Oller (2000a), resulting in a more streamlined and computationally efficient algorithm. Instead of employing distinct yield (and potential) functions for plasticity and damage, the researchers developed a framework that use a single yield (and potential) function to encompass both plasticity and damage components. The research article by Sarikaya and Erkmen (2019) presents a study on the direct coupling method and its utilization in analyzing the behavior of concrete subjected to compressive forces.

Other research in the literature have also recommended the utilisation of a solitary yield function to encompass both plasticity and damage. In the study conducted by Meschke et al. (1998), it was observed that both plastic and damage strains can be associated with a common yield surface. In contrast to employing distinct energy potentials for plasticity and damage, the formulation uses a single potential, hence restricting the ability to get individual plasticity and damage strains from the optimisation problem. The distinction between plastic and damage strains is established by incorporating a participation factor, denoted as β, which satisfies the condition $0 \leq \beta \leq 1$. This factor enables the consideration of three distinct scenarios: pure elastoplastic behaviour when $\beta = 0$, pure elastic-damage behaviour when $\beta = 1$, and coupled plastic-damage behaviour for intermediate values of β. The determination of the participation factor was achieved through calibration with experimental data. Subsequently, Wu and Cervera (2016) employed a comparable methodology to develop a cohesive elastoplastic-damage framework, serving as a foundation for the modelling of strain localizations characterised by pronounced discontinuities in quasi-brittle materials.

In relation to the utilisation of a singular yield function for plasticity and damage, it is pertinent to engage in a discourse concerning a specific category of interconnected plastic-damage modelling methodologies. These methodologies are founded upon the principles of thermodynamics, incorporating internal factors. In the pursuit of thermodynamic consistency, potential functions are commonly employed within the framework.

Houlsby and Puzrin (2000) developed a framework for a constitutive model that is thermodynamically consistent. This was achieved by incorporating two thermodynamic potentials, specifically the energy potential and the dissipation potential. These two potentials are the sole determinants of the constitutive behaviour, eliminating the requirement for any extra ad-hoc assumptions. The model is sometimes referred to as the hype plasticity model, which suggests the significance of prospective functions. One notable aspect of the hyperplastic model is its ability to derive the yield surface directly using the Legendre transformation of the dissipation function. The historical data pertaining to the material is encapsulated inside the internal variables, such as the plastic strain.

The coupled and uncoupled plasticity damage model created by Einav et al. (2007) can be viewed as an expansion of the thermodynamically consistent hyper plasticity model proposed by Houlsby and Puzrin (2000) to incorporate the hyper-plastic-damage formulation. The introduction of damage as an internal variable is a key aspect in the development of both pure damage and coupled plastic-damage constitutive models. In this manner, it is possible to derive both the yield surface and the damage internal variable through the dissipation potential.

2.3.3.3. Lumped plasticity

Lumped Plasticity is a modeling technique used in structural analysis, particularly in the context of seismic performance assessment. This method leverages the simplicity of the plastic hinge by separating a line element into inelastic and elastic components. Michael et al. (2008) conducted an assessment of models applicable to Performance-Based Earthquake Engineering (PBEE) of bridge columns. Their evaluation encompassed novel formulations for effective elastic stiffness, plastic-hinge length, and strain thresholds for the onset of bar buckling. A dataset comprising 37 tests of large-scale circular bridge columns was utilized to refine and assess these models. The primary objective of this investigation was to formulate expressions compatible with existing lumped-plasticity models, thereby enhancing the efficacy of performance-based design methodologies for bridge columns. The findings underscored the viability of incorporating the proposed expressions, along with the recommended effective stiffness expressions and strain thresholds specific to the plastic-hinge length formulation, into existing models. Notably, the study concluded that the incorporation of existing expressions with the newly proposed parameters yielded satisfactory predictions of the force-displacement behavior and the corresponding displacements associated with various damage thresholds.

In their work, Fablo and Mazza (2010) introduced a lumped plasticity model (LPM) tailored for nonlinear static and dynamic analyses of three-dimensional reinforced concrete (r.c.) frames. The model incorporates a bilinear moment curvature law and an interaction surface axial force-biaxial bending moment relationship. For nonlinear dynamic analyses, a two-parameter implicit integration scheme coupled with an initial-stress like iterative strategy, following the Haar–Kàrmàn principle, was employed. The study revealed that the nonlinear seismic response, as predicted by the LPM, is highly sensitive to the selection of strength and stiffness input parameters, such as the reduction factor in flexural stiffness and the hardening ratio in the bilinear moment-curvature law. These parameter choices significantly influence the maximum response parameters, waveform characteristics, and periodicity of the seismic response time histories. Comparative analysis with a refined fibre model demonstrated that the LPM adequately captures the flexural hysteretic behavior of r.c. frame elements, particularly in low- and medium-risk seismic regions, thereby offering a viable simulation approach for seismic performance assessment.

In the study conducted by Mohammadreza et al. (2019), the efficacy of the lumped plasticity model in predicting the nonlinear response of reinforced concrete frames subjected to gradually increasing vertical loads was studied. To this end, two full-scale RC frames featuring varying shear spans were fabricated and subjected to vertical loading applied through their beams. Finite element (FE) models of these experimental specimens were developed using SAP2000 software, enabling a comparison between numerical predictions and experimental findings. The investigation encompassed an analysis of the impact of different plastic hinge lengths, initial effective stiffness values, and plastic hinge locations on the accuracy of the FE models. It was observed that irrespective of the selected plastic hinge lengths, the FE models effectively approximated the yield and ultimate loads of the frames. However, discrepancies arose in accurately estimating the corresponding vertical displacements at yield and ultimate load stages. The study also highlighted the significant influence of chosen plastic hinge locations on the predicted yield and ultimate loads. Furthermore, the FE models tended to underestimate the damage levels at mid-span of beams compared to experimental observations upon reaching the ultimate load conditions.

Chang et al. (2021) conducted a study focusing on the parameter estimation of a lumped plasticity model designed to accurately replicate the nonlinear load-deformation behavior exhibited by circular reinforced concrete columns subjected to cyclic lateral loading. The calibration of model parameters relied on a comprehensive experimental dataset comprising 210 circular columns, each characterized by a variety of input parameters including material strength, reinforcement arrangement, specimen geometry, and testing configuration. Specifically, parameter values for initial stiffness, plastic rotation capacity, moment strength, and cyclic damage parameters were fine-tuned to match the first-cycle envelope of individual test datasets. To facilitate parameter estimation, empirical predictive equations were formulated, correlating model parameters with input parameters through four distinct regression techniques: stepwise, ridge, lasso, and elastic net regression. The implementation of the proposed lumped plasticity model yielded a notable reduction in computational time, approximately 50% lower compared to the distributed plasticity model. Furthermore, as ground motion intensity escalated, disparities in response between the two models became more pronounced. The predictive accuracy of the bridge class response was significantly influenced by bent configuration and deck mass. Notably, due to the concentration of nonlinear response at column ends and the linear pre-yield behavior, the proposed lumped plasticity model demonstrated a lesser susceptibility to record-to-record variability compared to the existing distributed plasticity model.

2.4. Uni-axial material models

When using beam-type 1D elements to accommodate various loading conditions, it becomes imperative to establish inelastic behavior at the stress-strain level, especially when dealing with arbitrary stress distributions. These one-dimensional generalized stress-strain relationships are contingent upon preconceived conditions, such as assumed confinement pressures, which must be defined prior to conducting the analysis.

The analytical model proposed by Saatchioglu and Razvi (1992) comprises a parabolic ascending segment followed by a linear descending portion described in Eq. 2.8. This model is rooted in the computation of lateral confinement pressure induced by both circular and rectilinear reinforcement, aiming to enhance the strength and ductility of confined concrete. Through meticulous analysis of extensive test data encompassing various levels of confinement, ranging from poorly confined to well-confined concrete specimens, the parameters of the analytical model were rigorously established. The strength and corresponding strain of confined concrete were characterized in relation to the equivalent uniform confinement pressure exerted by the reinforcement configuration. This equivalent uniform pressure was derived from the average lateral pressure determined based on sectional and material characteristics. The combined effect of different types of lateral reinforcement configurations was assessed by superimposing individual confinement effects. The stress-strain relationships delineated by the proposed methodology exhibited notable concordance with those derived from column tests featuring diverse geometries and reinforcement schemes, conducted under both concentric and eccentric loading conditions.

$$f_c = f'_{cc}\left[2\left(\frac{\varepsilon_c}{\varepsilon_1}\right) - \left(\frac{\varepsilon_c}{\varepsilon_1}\right)^2\right]^{1/(1+2K)} \leq f'_{cc} \qquad \text{Eq. 2.8}$$

Where $K = k_1 f_{le}/f'_{co}$, $k_1 = 6.7(f_{le})^{-0.17}$, f_{le} being the effective uniform confining pressure in Mpa

f'_{co} and f'_{cc} unconfined and confined strengths of concrete in a member respectively.

$\varepsilon_1$is peak stress

The ductility of ultra-high-strength concrete columns undergoes substantial influence from both axial compression levels and the effectiveness of lateral reinforcement. A pertinent indicator for assessing ductility is the capacity of lateral reinforcement normalized by concrete strength. To gauge displacement ductility, Sugano (1996) introduced empirical Eq. 2.9, derived from a comprehensive regression analysis of available column data for high-strength concrete. Despite the inherently brittle nature of ultra-high-strength concrete, effective confinement can still be achieved through the utilization of high- or ultra-high-strength lateral reinforcement. It is noteworthy that achieving adequate ductility in ultra-high-strength concrete demands a relatively greater capacity of lateral reinforcement compared to lower-strength concrete scenarios.

$$\delta_f = 0.127\frac{(\rho_c \times f_{yt})}{f_c} - 0.052\left(\frac{\sigma_c}{f_c}\right) + 0.041 \qquad \text{Eq. 2.9}$$

Where ρ_c is the Area ratio of ties, f_{yt} is the Yield strength of ties, f_c is the compressive strength of concrete cylinder and $\sigma_c$is the axial stress.

In the study conducted by Okan et al. (2010), it was determined that augmenting the confinement ratio resulted in enhanced ultimate drift capacities for reinforced columns subjected to strengthening measures. They introduced a drift-based equation incorporating key parameters such as longitudinal reinforcement ratio, axial load level, and confinement ratio. Through this equation, the drift capacities of the columns within the experimental dataset were accurately estimated, aligning closely with standard engineering expectations.

Fabio et al. (1991), Enrico et al. (1996), Bulent and Donald (2005), Ashraf (2006), Erkmen and Attard (2011), Saritas and Filippou (2013), and Pisca et al. (2017) have extensively explored beam element-based modeling approaches employing inelastic uni-axial stress-strain relations. These formulations, commonly referred to as fibre elements in academic discourse, operate under the assumption that plane sections remain plane and normal to the longitudinal axis. Within this framework, the intricate interplays of shear and bond-slip phenomena are often disregarded, reflecting a simplified representation of structural behavior.

2.5.Multi-axial material models

Multi-surface plasticity techniques are widely employed in various engineering disciplines, encompassing the characterization of concrete and geomaterials in constitutive modelling, as well as in crystal plasticity scenarios involving multiple slip planes. The concept revolves around the introduction of multiple plasticity yield functions, each corresponding to distinct surfaces within the principal stress space. This approach aims to more accurately capture the material's response under various conditions, such as disparities in compressive and tensile behavior.

The existence of several yield surfaces is a hurdle due to the occurrence of discontinuities in the stress space at specific spots. In situations when two surfaces cross in a non-smooth manner, it is commonly observed that the normal at the point of intersection lacks a well-defined value. Therefore, it is necessary to expand both the rate and incremental forms of plasticity equations in order to address non smooth sections, sometimes referred to as corners.

One of the techniques suggested in scholarly literature for addressing no smooth regions involves the incorporation of smoothing functions to mitigate sharp edges. In the study conducted by Nayak and Zienkiewicz (1972), a straightforward averaging method was utilized in the proximity to singularities. In numerous instances, the substitution of a segment of a criterion with an alternative lead to the introduction of additional corners at the points of intersection (de Borst, 1987).

The authors of Abbo & Sloan (1995) utilized a hyperbolic approximation to address the singularity issue associated with the apex point in the Mohr-Coulomb criterion. Furthermore, it should be noted that a yield criterion may exhibit discontinuous gradients at certain points, resulting in distinct boundaries in the major stress space. This phenomenon is observed in many criteria such as Tresca, Mohr-Coulomb, and Rankine criteria.

Menetrey and Willam (1995) suggested a failure criterion that includes common strength assumptions for a range of engineering materials and captures the key characteristics of triaxial concrete strength. The verification cases showed that the suggested failure criterion may capture information on biaxial and triaxial strength. They established that the von-Mises, Drucker-Prager, and Rankine criteria can all be included in a framework that uses the three-parameter failure criterion. The linear Mohr-Coulomb criterion's extension and compression meridians are also where the generalized failure envelope degenerates. It also reduces to the approximate parabolic two-invariant form of the Leon criteria. The unified formulation has the benefit of include several well-known failure criteria as special instances. Their proposed criterion integrated the traditional Rankine criterion for maximum tensile strength with the Mohr-Coulomb hypothesis governing shear strength. This amalgamation offered a balanced depiction of both the tensile/cohesive strength of cementitious materials and the shear strength of frictional materials. The three-parameter failure criterion devised for concrete is expressed as a function of the three stress invariants and is formulated using the Haigh-Westergaard coordinates, facilitating straightforward geometric interpretation. Notably, its cohesion and friction parameters are decoupled, enabling direct manipulation for hardening/softening extensions. Moreover, the criterion simplifies to the parabolic two-invariant approximation of the Leon criterion. The unified nature of this formulation proves advantageous as it encompasses numerous well-established failure criteria as special cases, consolidating diverse theoretical frameworks into a cohesive conceptual model.

As previously stated, the occurrence of corners can be attributed to the simultaneous utilization of many yield criteria. For example, the utilization of distinct yield requirements for compression and tension has been implemented in many concrete models, such as the ones proposed by Feenstra and de Borst (1996) and Červenka and Papanikolaou (2008). Compression caps and tension cut-offs are frequently utilized in the modelling of geomaterials. Some models in the literature, such as Dolarevic and Ibrahimbegovic (2007), favored a seamless transition between distinct surfaces. However, numerous other models employed Koiter's rule, which explicitly addresses corners.

Numerous models have been developed in the literature, drawing upon Koiter's rule as a foundational principle. As an example, de Borst (1987) examined a specific scenario involving two yield surfaces and devised a comprehensive backward-Euler integration technique. This method was further expounded upon in relation to yield functions of the Mohr-Coulomb and Tresca types. The single-point integration method does not require any iterations throughout the integration process. At the conclusion of the step, the consistency criterion was met. This was observed specifically in the scenario where hardening was modelled as a linear function solely dependent on the plastic strain. The author suggests use iterations for the case of nonlinear hardening. In order to ascertain the appropriate choice between the standard single-surface return method and the multi-surface return algorithm, de Borst devised a singularity indicator. Subsequently, an erroneous formula within his research was rectified in the study conducted by de Borst et al. (1991).

The classical work by Simo et al. (1988) is widely regarded as a significant contribution to the field of multi-surface plasticity. The researchers demonstrated that the Koiter's requirements are fundamentally identical to the optimality conditions of the corresponding convex mathematical programme. Additionally, they devised a comprehensive closest-point return mapping method for multi-surface plasticity that is associated with these circumstances. One notable aspect of their work involves the utilisation of the discrete formulation of Karush-Kuhn-Tucker (KKT) conditions.

One of the primary difficulties encountered when employing the elastic predictor-plastic corrector scheme is the limited availability of prior knowledge regarding the active surfaces for a particular trial stress state in multi-surface plasticity. This poses a significant difficulty when applying the discrete form of the Karush-Kuhn-Tucker (KKT) conditions.

This issue has been found in several investigations within the existing literature, such as the works of Simo et al. (1988) as well as Simo and Hughes (1998). In contrast, within the context of single-surface plasticity, the activation of the yield surface occurs directly when the trial stress exceeds the permissible stress. This characteristic of single-surface plasticity offers computational convenience.

In their classical work, Simo et al. (1988) put out a pair of methodologies, one conceptual and one practical, aimed at systematically identifying the active surfaces involved in the return mapping process. Both approaches were devised specifically for the instance of related plasticity.

The multi-surface plasticity algorithm established by Simo et al. (1988) remains widely recognized in the field because to its broad applicability. However, it is important to note that this method was specifically designed with associative plasticity in mind. The proposed approach systematically decreases the quantity of active surfaces until the resulting solution converges and meets the consistency criterion. Pramono and

Willam (1989) demonstrated that in instances of softening, there might be an increase in the quantity of active surfaces, contrary to the expected decrease. An alternative technique was proposed, wherein surfaces are engaged sequentially, beginning with the most dominant surface and subsequently including the next surface into the active set. Therefore, the collection of active surfaces expands until the consistency conditions are satisfied for all criteria.

In addition to the overarching multi-surface stress return methods, a substantial body of literature exists that examines specific criteria, such as the Tresca and Mohr-Coulomb yield surfaces. Pankaj and Bićanić (1997) devised a singularity indicator to assess if the trial stress conforms to the corner zone or not, specifically for the Mohr-Coulomb yield criteria with isotropic hardening. Perić and Neto (1999) introduced a stress-return algorithm for Tresca plasticity, utilising a geometrical perspective. This methodology was subsequently expanded upon by Neto et al. (2008) to encompass yield requirements of the Mohr-Coulomb type. In their study, Borja et al. (2003) examined the efficacy of integration algorithms in relation to smooth three-invariant representations of the Mohr-Coulomb model, such as the Lade-Duncan and Matsuoka-Nakai models.

Despite their higher computational demands, multi-axial material models offer the advantage of directly incorporating the influences of shear and confinement pressure, a capability stemming from the comprehensive nature of 3D analysis. Consequently, there has been substantial research interest and adoption of elasto-plastic material models for simulating concrete structural components.

In 1977, Ottosen introduced a failure criterion characterized by four parameters A, B, K_1, K_2 encompassing all three stress invariants as shown Eq. 2.10.

$$f(I_1, J_2, \cos 3\theta) = A\frac{J_2}{\sigma_c^2} + \lambda\frac{\sqrt{J_2}}{\sigma_C} + B\frac{I_1}{\sigma_C} - 1 = 0 \qquad \text{Eq. 2.10}$$

Where A and B are parameter and λ is a function of $\cos 3\theta$. It was suggested by the author that $\lambda = \lambda(\cos 3\theta)$ could be represented as follow;

$$\lambda = K_1 cos\left[\frac{1}{3}\arccos\left(K_2 cos3\theta\right)\right] \qquad \text{for } cos3\theta \geq 0 \qquad \text{Eq. 2.11}$$

$$\lambda = K_1 cos\left[\frac{\pi}{3} - \frac{1}{3}\arccos\left(-K_2 cos3\theta\right)\right] \qquad \text{for } cos3\theta \leq 0$$

In which parameters $K_1$and $K_2$are size and shape factor respectively ($0 \leq K_2 \leq 1$). This criterion delineated a smooth convex failure surface with meridians curving in the negative direction of the hydrostatic axis. Additionally, the trace in the deviatoric plane transitioned from an almost triangular to a more circular shape as hydrostatic pressure increased. Empirical verification confirmed the criterion's validity under short-time monotonic loading conditions.

Han et al. (1987) introduced a constitutive model aimed at capturing the intricate behavior of concrete materials within elastic-plastic regimes. This model, rooted in a modified plasticity theory, effectively delineates strain-hardening through stress-space plasticity mechanisms and strain-softening via strain-space plasticity principles. Key attributes of Ottosen's model encompass the utilization of sophisticated failure criteria such as the Willam-Warnke five-parameter or Hsieh-Ting-Chen four-parameter model, incorporation of a closed-shape yield surface, implementation of a nonuniform hardening rule, and modulation of plasticity modulus dependent on hydrostatic pressure and Lode angle. Additionally, the model adopts a no-associated flow rule and employs a dual criterion based on stress and strain to discern various failure modes. It also features linear tensile softening to simulate cracking behavior and multiaxial softening to replicate mixed failure modes. They validated their innovative work-hardening model across a diverse spectrum of experimental data, consistently achieving commendable agreement between theoretical predictions and empirical observations.

Nevertheless, in simulating the concrete material behavior using plasticity theory, the adoption of a non-associative flow rule becomes imperative due to dilatation effects. Consequently, a potential function distinct from the yield surface is required to accurately determine the volumetric component of the plastic flow. Previous investigations into non-associative plasticity models, particularly those predicated on pressure-sensitive yield criteria for compressive concrete behavior, are exemplified in studies such as Kang & Willam (1999), Grassl et al. (2002), Grassl (2004), and Bao et al. (2013).

For a comprehensive structural analysis, it is imperative to define the tensile behavior of concrete material as well. The delineation between compressive and tensile behavior in concrete failure criteria, stemming from their disparate phenomenological characteristics, is well-documented in both experimental and theoretical literature. Research focusing on developing concrete failure criteria primarily emphasizes compressive behavior, deeming tensile behavior relatively insignificant in reinforced concrete structural analysis. For tension failure, the adoption of Rankine's maximum tensile stress cut-off with strain softening is commonplace (Jirasek & Bazant, 2001).

In addressing the fluctuations of the carefully selected compressive yield surface of concrete under hardening and softening laws, the implementation of a tensile cut-off mechanism serves to mitigate unrealistic tensile strength. Numerous researchers such as Wan (1992), Fuschi et al. (1994), Bao et al. (2013), Papanikolaou & Kappos (2007) and Yu et al. (2010) have ventured into the development of multi-surface plasticity models for concrete.

The successful integration of elasto-plastic material modeling of concrete with multi-surface yield criteria into 3D structural level analyses has been achieved by various scholars, including Červenka & Papanikolaou (2008), Galic et al. (2011) and Lu et al. (2016). However, concerns regarding the robustness of numerical treatment have surfaced since the 1970s, as indicated by studies such as Červenka (1971) and Bergan & Holand (1979). Despite the extensive history of research in nonlinear finite element analysis, particularly concerning the 2D or 3D material nonlinear analysis of concrete structures, investigations into numerical robustness remain ongoing. Various aspects of numerical algorithms, including element and integration types, return mapping strategies at the material level, and adaptability of global equilibrium path-finding strategies, are known to impact convergence characteristics, especially when encountering softening and bifurcation points, as detailed in Geers (1999) and Hofstetter & Valentini (2013).

To address potential shear and volumetric locking issues, especially during plastic analysis of 3D solids, alternative numerical integration schemes have been developed, as seen in works such as Hu & Nagy (1997), Liu et al. (1994), and Olovsson et al. (2006). The introduction of multiple yield surfaces into material models necessitates specialized return mapping algorithms. For geo-materials and concrete specifically, multi-surface return mapping methodologies involving cut-off surfaces have been devised by researchers such as Pramono & Willam (1989), Hofstetter et al. (1993), Feenstra & De Borst (1996), Dolarevic & Ibrahimbegovic (2007), Adhikary et al. (2017) and Pech et al. (2021). Meanwhile, regularization techniques aimed at ensuring numerical stability in cases of softening have been proposed by De Borst (1987), De Borst (2001), Dias da Silva (2004), Engen et al. (2019) and De Borst & Duretz (2020).

2.6.Case studies

In order to perform numerical modeling to predict the behavior of beam and solid elements, experimental data were obtained from literatures Focacci et al. (2016), Benmokrane et al. (1995), Mohamed et al. (2014) and Qian & Chen (2005). The experimental program consisted of 3 beams and 2 shear walls. The choice of the beams, shear walls and FRP reinforcement is based on the fact that they generate tensile regions to test Multi-Surface Plasticity model and that the yielding occurs in concrete only when FRP rebars are used.

Focacci et al. (2016) investigated the response of FRP-reinforced members without shear reinforcement. Two series of specimens were tested in flexure, Shallow and deep rectangular cross section. All specimens were reinforced only in flexure with Steel, Carbon and Glass FRP bars. Over a clear span L of 2000 mm, the specimens were exposed to a one-point transverse force that was monotonically applied until failure. A response steel frame with a mechanical actuator to convey the displacement controlled transverse action was used for the tests. Shallow FRP-reinforced specimens failed in flexure and the deep FRP-reinforced specimens failed early due to shear.

Benmokrane et al. (1995) experimented span to depth ratio on glass fibre reinforced plastic concrete beams test to investigate their flexural behavior. This experimental program consisted of three series of reinforced concrete beams (Isorod, Kodiak GFRP and steel rebars) having different surface deformations. The beams were subjected to two equal symmetrical loads on a 3000 mm span. The research found that the span-to-height ratio would be crucial to consider when designing GFRP rebar-reinforced beams in order to manage deflection and fracture width. The GFRP rebars performed well and appeared to be a promising alternative to steel reinforcements. They claimed that GFRP rebars would work well in situations requiring long-term corrosion resistance, low conductivity to electrical and electromagnetic fields, high strength-to-weight ratios, and other similar qualities.

Qian & Chen (2005) conducted nine shear wall specimens experiment to verify the finite element-based macro model that the authors proposed. Two different sorts of elements made up the model: an RC column element for modelling boundary zones and an RC membrane element for modelling beams. Both elements' stiffness matrices were developed. Experimental findings for nine shear wall specimens confirmed the accuracy and applicability of the established analytical model. The analytical findings showed that the most important factors affecting the load carrying capacity and deformation capacity of shear walls are the axial load ratio, the confinement index of the boundary zone, and the boundary zone length ratio. The higher the axial load ratio, the larger the confinement index of the boundary zone, and the greater the boundary zone length ratio should be in order to generate the necessary deformation capacity for a shear wall. It was advised that as the axial load ratio changes, not only the border zone length ratio but also the confinement index should change as well.

In order to meet the appropriate strength and drift criteria outlined in various codes, Mohamed et al. (2014) researched the applicability of reinforced concrete shear walls completely reinforced with glass fiber-reinforced polymer (GFRP) bars. Three GFRP-reinforced specimens, were tested to failure as part of the experimental program. To guarantee flexural dominance and prevent slide and shear failures, they were constructed with an appropriate quantity of distributed and concentrated reinforcement. Without any indication of early shear, sliding shear, bond and anchorage failure, or instability failure, all specimens reached their flexural strength. Shear walls with GFRP reinforcement may achieve high strength, deformation capacity, and adequate energy dissipation. This means that shear walls with GFRP reinforcement can be employed as lateral resisting systems.

The specimens that were selected in this research for validation purposes were subjected to monotonic compression load until failure. The mechanical properties of concrete, steel reinforcement and FRP reinforcements are discussed in section 4.2.

Chapter 3

Material FORTRAN code model

3.1.Introduction

In this chapter, the work of Sarikaya et al. (2020-2022) is presented. In order to model the mechanical behavior of concrete, they created a coupled plastic-damage multi-surface constitutive model. In their attempt to do this they introduced the direct coupling technique, in which they suggested connections between the plasticity and damage parts of the plastic-damage constitutive model. They created an explicit integration algorithm for a multi-surface plasticity framework. Then, in an effort to accurately portray concrete's behavior, they suggested the three-surface concrete plasticity model.

The infinitesimal framework was established by Sarikaya et al. (2021) through the utilization of Koiter's rule in conjunction with the linear complementarity problem (LCP). The need of utilizing the Linear Complementarity Problem (LCP) to derive uniqueness requirements was underscored. An explicit integration algorithm for multi-surface plasticity has been devised based on the infinitesimal formulation. One of the primary challenges posed by multi-surface plasticity is that the trial state alone is insufficient to fully characterize the conditions of inelastic loading and unloading, as is the case in single-surface plasticity. In the context of the incremental formulation of multi-surface plasticity, it is important to note that the presence of a yield function with a positive value does not automatically imply the activation of the corresponding surface. A method was devised to ascertain the borders of the corner zone for the incremental scenario. A proposal was put out to modify the plasticity multipliers in order to enhance the precision of the approach. According to Pramono and Willam (1989), the quantity of active surfaces can exhibit variability as a result of the occurrence of hardening or softening. The approach has the capability to analyze the active surfaces throughout each iteration, enabling it to track the progression of surfaces over time.

3.2.Non-associative Multi-surface Plasticity

In structural analyses involving materials exhibiting distinct strengths when subjected to tensile and compressive loads, employing multiple yield surfaces to delineate the stress-strain behavior for each loading condition proves advantageous. Multi-surface plasticity models offer a pragmatic solution as they are simpler to establish and calibrate in comparison to intricate single yield surfaces. Consequently, composite yield surfaces find widespread application in modeling various geomaterials such as soil, rock, and concrete. A fundamental principle involves the additive decomposition of the total strain increment,

$$d\varepsilon = d\varepsilon_e + d\varepsilon_p \qquad \text{Eq. 3.1}$$

In the given expression, ε represents the overall strain experienced by the material, where ε_e denotes the elastic strain component and ε_p signifies the plastic strain component and d is the differential operator.

3.2.1. Plastic Flow Rule

Plastic potential is a function used to determine the direction of plastic strain increment in the material under load. If the plastic potential is the same as the yield surface, the plastic flow rule is called an associated flow rule, Otherwise, it is called a non-associated flow (Figure 3-1).

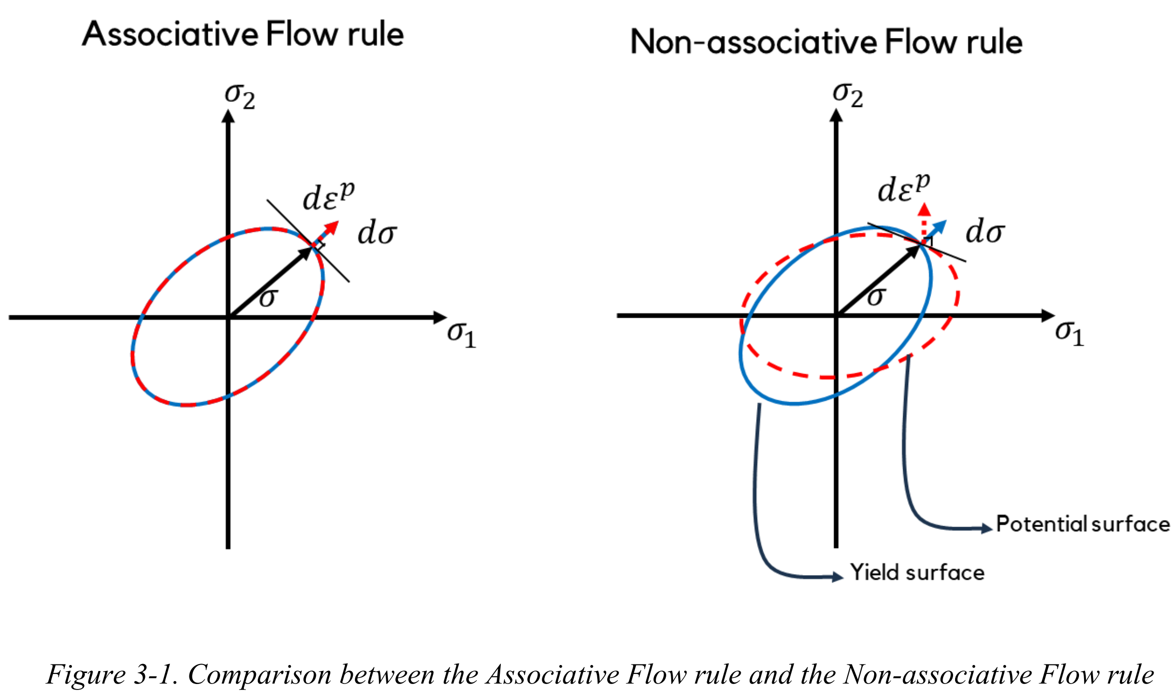


Figure 3-1. Comparison between the Associative Flow rule and the Non-associative Flow rule

Within the framework of non-associative mechanics, the plastic flow direction stems from the plastic potential function. In scenarios involving multi-surface plasticity, the flow rule extends its scope through the integration of multiple plastic functions. Thus, the increment in rate-independent plastic strain adheres to Koiter's rule (Warner, 1953), encapsulating the essence of plastic deformation mechanics.

$$d\varepsilon_p = \sum_{i=1}^{M} d\lambda_{p_i} \mathbf{g}_{p_i}, \boldsymbol{\sigma} \qquad \text{Eq. 3.2}$$

In the presented formulation, $\mathbf{g}_{p_i}(\boldsymbol{\sigma}, \kappa_{p_i})$ represents an active potential surface, while $d\lambda_{p_I}$ signifies the associated proportionality factor, with M denoting the total number of active potential surfaces. The terms featuring indices separated by a comma, such as $g_{p_i}, \boldsymbol{\sigma} = \partial g_{p_i} / \partial \boldsymbol{\sigma}$, indicate partial differentiation, representing the gradient of the potential function regarding the stress tensor. In this discourse, each active yield surface is denoted as $f_{p_i}(\boldsymbol{\sigma}, \kappa_{p_i})$, and for an associative flow rule, the potential function g_{p_i} aligns with the corresponding yield function f_{p_i}. Both the potential and hardening surfaces are dependent on the stress state $\boldsymbol{\sigma}$ and a hardening function κ_{p_i}, which tracks the plasticity evolution for each active surface. Consequently, the increment in the plastic hardening function κ_{p_i} can be expressed in terms of the plastic proportionality factor.

$$d\kappa_{p_i} = d\lambda_{p_i} c_{p_i} \qquad \text{Eq. 3.3}$$

$c_{p_i}(\boldsymbol{\sigma}, d\lambda_{p_i})$ is the equivalent hardening factor to be calibrated on physical basis.

3.2.2. Plastic Consistency Condition

The consistency condition should be assumed in order to obtain a whole relationship between stress and strain. For strain hardening solids, the consistency condition means that the stress remains on the new yield surface (expanded, contracted, or translated). In other words, plastic loading is known as a consistency condition where loading from a plastically deforming state leads to another plastically deforming state.

In the context of plastic deformations, it is imperative for stresses to remain confined within the yield surface. Consequently, the yield surface attains a value of zero during plastic flow to maintain this constraint.

Moreover, the proportionality factor, inherently non-negative, serves to prevent plastic unloading owing to the irreversible nature of plastic deformations. A proportionality factor of zero signifies exclusively elastic deformations. These principles, encapsulated within the Kuhn-Tucker conditions of plasticity, delineate the requisite conditions for plastic behavior and its constraints.

$$d\lambda_{p_i} \geq 0, \quad f_{p_i} \leq 0, \quad d\lambda_{p_i} f_{p_i} = 0, \quad 0 < i \leq N \qquad \text{Eq. 3.4}$$

where N is the number of total surfaces out of which only M surfaces can be plastically active at a time but one of the Kuhn-Tucker conditions always apply. In a scenario where the initial M surfaces exhibit plastic activity, while the remaining surfaces remain inactive, one can derive the subsequent equations for each distinct group.

$$\begin{aligned} f_{p_i} = 0, \quad d\lambda_{p_i} > 0, \quad 0 < i \leq M \\ f_{p_i} < 0, \quad d\lambda_{p_i} = 0, \quad M < i \leq N \end{aligned} \qquad \text{Eq. 3.5}$$

During a plastic process, when the yield surface function value remains at zero, the increase in the yield function is also zero, denoted as $df_{p_i} = 0$. This condition holds true as the yield surface is dependent on the stress state $\boldsymbol{\sigma}$ and the corresponding hardening function κ_{p_i}. Consequently, the cumulative increment of each active yield surface during plastic deformations can be expressed as,

$$df_{p_i} = \frac{\partial f_{p_i}}{\partial \sigma} : \, d\boldsymbol{\sigma} + \frac{\partial f_{p_i}}{\partial \kappa_{p_i}} d\kappa_{p_i} = 0, \quad , \quad 0 < i \leq M \qquad \textit{Eq. 3.6}$$

Both $\partial f_{p_i}/\partial \boldsymbol{\sigma}$ and $\boldsymbol{\sigma}$ represent second-order tensors, denoted by the symbol (:), indicating the tensorial product. Assuming that stress increments are solely elastic, expressed as $d\boldsymbol{\sigma} = \boldsymbol{E} : d\varepsilon_e$, and leveraging equations Eq. 3.1 and Eq. 3.2 along with *Eq. 3.6*, results in the derivation of Eq. 3.7.

$$\mathrm{d}\boldsymbol{\sigma} = \mathbf{E} : \left(d\varepsilon - \sum_{j=1}^{M} d\lambda_{p_j} \mathbf{g}_{\boldsymbol{p_j}}, \boldsymbol{\sigma} \right) \qquad \text{Eq. 3.7}$$

E is the fourth order elasticity tensor. By using Eq. 3.3 and *Eq. 3.6* in Eq. 3.7, the consistency condition can be re-written as

$$df_{p_i} = \frac{\partial f_{p_i}}{\partial \boldsymbol{\sigma}} : \mathbf{E} : \left(d\varepsilon - \sum_{j=1}^{M} d\lambda_{p_j} \mathbf{g}_{\boldsymbol{p}_j}, \boldsymbol{\sigma} - d\varepsilon_p \right) + \frac{\partial f_{p_i}}{\partial \kappa_{p_i}} d\lambda_{p_i} c_i = 0, \quad 0 < i \leq M \qquad \text{Eq. 3.8}$$

Eq. 3.8 represents the formulation for each of the M active surfaces, necessitating the determination of M proportionality factors, $d\lambda_{p_i}$. Consequently, these proportionality factors, $d\lambda_{p_i}$, assume the role of primary unknowns, as they dictate the increments in plastic strain and the hardening function as depicted in Eq. 3.2 and Eq. 3.3 respectively. Once established, these factors enable the determination of stresses as updated in Eq. 3.7. However, it's worth noting that Eq. 3.8 poses a non-linear differential equation, typically necessitating a numerical approach for resolution.

3.3.Computational Algorithm

In formulating the numerical algorithm, express the equations in finite incremental form as indicated by Eq. 3.9:

$$\boldsymbol{\sigma}_{(n)} = \mathbf{E}(\varepsilon_{(n)} + \varepsilon_{p_{(n)}}) \qquad \text{Eq. 3.9}$$

Here, the subscript (n) denotes the last converged step of the material level stress return algorithm, signifying $\boldsymbol{\sigma}_{(n)}$ as the last converged stress. It is essential to recognize that algorithm-related indices are denoted within parentheses. Step subscripts and iteration superscripts are employed accordingly. Moving forward to the subsequent step $(n + 1)$, following convergence, extract the strain $\varepsilon_{(n+1)}$ from the global algorithm. Initially, presume the strain increment $\Delta\varepsilon_{(n+1)} = \varepsilon_{(n+1)} - \varepsilon_{(n)}$ to be fully elastic. Consequently, establish the trial stress assuming a complete elastic increment, expressed as:

$$\boldsymbol{\sigma}_{(n+1)}^{trial} = \boldsymbol{\sigma}_{(n)} + \mathbf{E}\Delta\varepsilon_{(n+1)} \qquad \text{Eq. 3.10}$$

In the numerical computations, opt to utilize the Voigt notation, thus simplifying the treatment of stress, strain, and elastic tensors as vectors and matrices. When assessing the trial stress outlined in Eq. 3.10, should it fall within the elastic boundaries of the yield surface—potentially occurring during unloading or re-loading— accept this trial stress as the converged stress. Conversely, if the trial stress state surpasses the elastic threshold, indicating plastic deformation, trigger the plastic return mapping algorithm. This algorithm facilitates the adjustment of stress according to Eq. 3.11.

$$\boldsymbol{\sigma}_{(n+1)} = \boldsymbol{\sigma}_{(n)} + \mathbf{E}(\Delta\varepsilon_{(n+1)} - \Delta\varepsilon_{p_{(n+1)}}) \qquad \text{Eq. 3.11}$$

In the context provided, $\boldsymbol{\sigma}_{(n+1)}$ denotes the stress subsequent to the plastic return mapping convergence at the conclusion of the present step $(n+1)$. Eq. 3.11 delineates $\Delta\varepsilon_{p_{(n+1)}}$ as the cumulative total of plastic strain accrued during step $(n+1)$, typically necessitating iterative computations.

$$\Delta\varepsilon_{p_{(n+1)}}^{(k)} = \Delta\varepsilon_{p_{(n+1)}}^{(k-1)} + \delta\varepsilon_{p_{(n+1)}}^{(k)} \qquad \text{Eq. 3.12}$$

In the iterative process (k), the symbol δ represents the increment within each iteration, distinguished from the symbol Δ, which denotes the total increment within the step $(n+1)$. Upon achieving convergent mapping after the final iteration, the updated strain produces $\Delta\varepsilon_{p_{(n+1)}} = \Delta\varepsilon_{p_{(n+1)}}^{(k_{final})}$.

3.3.1. Plastic deformation

The total plastic strain accumulated within step $(n+1)$have already been determined, the next step is is to determine the plastic strain increment, denoted as $\delta\varepsilon_{p_{(n+1)}}^{(k)}$, within each iteration (k) of the current step $(n+1)$. To achieve this, recall Eq. 3.2,

$$\delta\varepsilon_{p_{(n+1)}}^{(k)} = \sum_{j=1}^{N=2} \delta\lambda_{p_j}^{(k)} g_{p_j}^{(k)},\sigma \qquad \text{Eq. 3.13}$$

The subscript $(n+1)$ is omitted from the right-hand side of Eq. 3.13 for the sake of notation simplicity. Nevertheless, it is implicit that the iterations consistently occur within the current step $(n+1)$. In Eq. 3.13, both the proportionality factor and the gradient of the potential function are denoted with the superscript (k), signifying that their values are refreshed in each iteration. The iterative proportionality factor stands as the primary unknown, which is determined from the iterative incremental expression of Eq. 3.8, expressed as

$$\delta\mathbf{f}^{(k)} = \delta\mathbf{b}^{(k)} - \mathbf{A}^{(k)}\delta\boldsymbol{\lambda}^{(k)} \qquad \text{Eq. 3.14}$$

In accordance with the consistency condition, $\delta\mathbf{f}^{(k)}$ is a zero vector. Eq. 3.14 facilitates the determination of the proportionality factor $\delta\boldsymbol{\lambda}^{(k)}$.

$$\delta\boldsymbol{\lambda}^{(k)} = \mathbf{A}^{(k)^{-1}}\delta\mathbf{b}^{(k)} \qquad \text{Eq. 3.15}$$

In order to delineate the constituents outlined in Eq. 3.15 with precision, introduce the premise that the total count of active surfaces is limited to a maximum of two. Subsequently, in Section 3.4, elaborated is multi-surface plasticity framework tailored for concrete, wherein the system incorporates solely two surfaces, denoted as $N = 2$. In the context of a broad two-surface plasticity framework, the matrix $\mathbf{A}^{(k)}$ articulated in Eq. 3.14 can be explicitly expressed as such:

$$\mathbf{A}^{(k)} = \begin{bmatrix} a_{11}^{(k)} & a_{12}^{(k)} \\ a_{21}^{(k)} & a_{22}^{(k)} \end{bmatrix} = \begin{bmatrix} \mathbf{n}_1^{(k)^T}\mathbf{R}^{(k)}\mathbf{m}_1^{(k)} + f_{p_1,\kappa_1}^{(k)}c_1^{(k)} & \mathbf{n}_1^{(k)^T}\mathbf{R}^{(k)}\mathbf{m}_2^{(k)} \\ \mathbf{n}_2^{(k)^T}\mathbf{R}^{(k)}\mathbf{m}_1^{(k)} & \mathbf{n}_2^{(k)^T}\mathbf{R}^{(k)}\mathbf{m}_2^{(k)} + f_{p_2,\kappa_2}^{(k)}c_2^{(k)} \end{bmatrix} \qquad \text{Eq. 3.16}$$

Where

$$\mathbf{m}_i^{(k)} = \mathbf{g}_{p_i,\boldsymbol{\sigma}}^{(k)}, \qquad 0 < i \leq 2 \qquad \text{Eq. 3.17}$$

$$\mathbf{n}_i^{(k)} = \mathbf{f}_{p_i,\boldsymbol{\sigma}}^{(k)}, \qquad 0 < i \leq 2 \qquad \text{Eq. 3.18}$$

$$\mathbf{R}^{(k)} = \left(\mathbf{E}^{-1}\mathbf{Q}^{(k)}\right)^{-1} \qquad \text{Eq. 3.19}$$

The hardening functions in Eq. 3.16 are assumed uncoupled. The matrix $\mathbf{Q_i}$ is

$$\mathbf{Q}^{(k)} = \left(\mathbf{I} + \mathbf{E}\sum_{j=1}^{N=2}\Delta\lambda_{p_j}^{(k)}\mathbf{H}_j^{(k)}\right) \qquad \text{Eq. 3.20}$$

where $\mathbf{I}$ represents the identity matrix and $\mathbf{H}_i$ denotes the Hessian matrix of the active potential surface.

$$\mathbf{H}_i^{(k)} = \mathbf{m}_{i,\boldsymbol{\sigma}}^{(k)}, \quad 0 < i \leq 2 \qquad \text{Eq. 3.21}$$

On the other hand, the vector $\delta\mathbf{b}^{(k)}$in Eq. 3.14 can be written as

$$\delta\mathbf{b}^{(k)} = \mathbf{f}^{(k)} - \mathbf{h}^{(k)} \qquad \text{Eq. 3.22}$$

in which $\mathbf{f} = \langle f_{p1} \quad f_{p2} \rangle^{\mathrm{T}}$ and the superscript (k) indicates that the yield surface values used in Eq. 3.22 are updated in each iteration, i.e.

$$f_{p_i}^{(k)} = f_{p1}(\boldsymbol{\sigma}_{(n+1)}^{(k)}, k_{p_i}^{(k)}) \quad 0 < i \leq 2 \qquad \text{Eq. 3.23}$$

Where

$$\boldsymbol{\sigma}_{(n+1)}^{(k)} = \boldsymbol{\sigma}_{(n)} + \mathbf{E}(\Delta\varepsilon_{(n+1)} - \Delta\varepsilon_{p_{(n+1)}}^{(k)}) \qquad \text{Eq. 3.24}$$

And

$$\kappa_{p_i}^{(k)} = \kappa_{p_i}^{(k-1)} + \delta\kappa_{p_i}^{(k)} \quad 0 < i \leq 2 \qquad \text{Eq. 3.25}$$

In Eq. 3.22 the vector $\mathbf{h}^{(k)}$ is defined as

$$\mathbf{h}^{(k)} = \begin{Bmatrix} h_1^{(k)} \\ h_2^{(k)} \end{Bmatrix} \qquad \text{Eq. 3.26}$$

whose components can be written as

$$h_i^{(k)} = \mathbf{n}_i^{(k)^T} \mathbf{R}_i^{(k)} \mathbf{E}^{-1} \mathbf{r}_i^{(k)} \qquad 0 < i \leq 2 \qquad \text{Eq. 3.27}$$

To derive vector $\delta\mathbf{b}^{(k)}$ in Eq. 3.14 in finite incremental form, the consistency condition, $d\mathbf{b} = \boldsymbol{f}_{,\boldsymbol{\sigma}} : \mathbf{E} : d\varepsilon$ is replaced with the finite incremental form of the consistency condition. For this purpose, first refer to the finite form of the yield condition i.e. $f_{p_i}^{(k)} = 0$, which is then truncated using first order Taylor series approximation in the neighbour of the trial stress $\boldsymbol{\sigma}_{(n+1)}^{(trial)}$. From Eq. 3.11, the converged stress state that satisfies the consistency condition can be written in terms of the trial stress as

$$\boldsymbol{\sigma}_{(n+1)} = \boldsymbol{\sigma}_{(n+1)}^{trial} - \mathbf{E}\Delta\boldsymbol{\varepsilon}_{\boldsymbol{p}_{(n+1)}} \qquad \text{Eq. 3.28}$$

Backward-Euler finite difference procedures derived from the first order Taylor series expansion are commonly adopted as time-stepping procedures in, (Pramono and Willam, 1989), which in our context lead to Eq. 3.14. Furthermore, two of the most commonly adopted time stepping procedures for plasticity are

Closest Point Projection and Cutting Plane Algorithms. Both are Elastic-Prediction-Plastic-Correction procedures in which, when triggered the return mapping to yield surface is performed after a full elastic assumption, for which the second term on the right of Eq. 3.28 is pursued. Thus, plastic strain is assumed zero for the initial iteration, i.e. $\delta\varepsilon_{p_{(n+1)}}^{(0)} = \mathbf{0}.$ On the other hand, the stress state in the gradients of the potential and yield surfaces in Eq. 3.17 and Eq. 3.18, respectively determine whether the algorithm is Cutting Plane or Closest Point Projection. For calculating the gradients, while the former algorithm uses the stress state at the end of the previous iteration, i.e. $\boldsymbol{\sigma}_{(n+1)}^{(k-1)}$, the later uses the updated stress state, i.e. $\boldsymbol{\sigma}_{(n+1)}^{(k)}$. To implement the Cutting Plane Algorithm, one enforces the satisfaction of the yield condition in iterations i.e., $f_{p_i}^{(k)} < tol$. In addition, the Closest Point Projection Algorithm employs the first order Taylor approximation of the finite form of the flow rule so that the direction between the trial and the converged stress is enforced to be the closest-point projection direction from the trial stress point $\boldsymbol{\sigma}_{(n+1)}^{trial}$ towards the last updated stress $\boldsymbol{\sigma}_{(n+1)}^{(k)}$, i.e.

$$\mathbf{r}^{(k)} = \boldsymbol{\sigma}_{(n+1)}^{(k)} - \boldsymbol{\sigma}_{(n+1)}^{trial} + \mathbf{E}\sum_{j=1}^{N=2} \Delta\lambda_{p_j}^{(k)} \mathbf{m}_j^{(k)} \qquad \text{Eq. 3.29}$$

Where $\mathbf{r}^{(k)}$ is a residual vector that should also vanish at the end of the iterations, i.e. $\left\| \sum_{j=1}^{N=2} \Delta\lambda_{p_j}^{(k)} \mathbf{m}_j^{(k)} - \Delta\varepsilon_{p_{(n+1)}}^{(k)} \right\| < tol$. The proportionality factor components in Eq. 3.20 and Eq. 3.29 are updated as

$$\Delta\lambda_{p_i}^{(k)} = \Delta\lambda_{p_i}^{(k-1)} + \delta\lambda_{p_i}^{(k)} \qquad 0 < i \leq 2 \qquad \text{Eq. 3.30}$$

To find a solution that satisfies both conditions $f_{p_i}^{(k)} = 0$ and $\left\| \mathbf{r}^{(k)} \right\| = 0$ of Closest Point Projection Algorithm, one can implement the Newton-Raphson solution scheme. Thus, from the linearization of Galic et al. (2011) and $f_{p_i}^{(k)} = 0$, respectively one obtains

$$\mathbf{r}^{(k)} + \delta\boldsymbol{\sigma}^{(k)} + \mathbf{E}\sum_{j=1}^{N=2} \Delta\lambda_{p_j}^{(k)} \mathbf{H}_j^{(k)} \delta\boldsymbol{\sigma}^{(k)} + \boldsymbol{E}\sum_{j=1}^{N=2} \Delta\lambda_{p_j}^{(k)} \boldsymbol{m}_j^{(k)} = 0 \qquad \text{Eq. 3.31}$$

And

$$f_{p_i}^{(k)} + \mathbf{n}_i^{(k)^T} \delta\boldsymbol{\sigma}^{(k)} + f_{p_i,\kappa_i}^{(k)} c_{p_i}^{(k)} \delta\lambda_{p_i}^{(k)} = 0, \qquad 0 < i \leq 2 \qquad \text{Eq. 3.32}$$

where Eq. 3.3 was used in iterative-incremental form, i,e, $\delta\kappa_{p_i} = \delta\lambda_{p_i} c_{p_i}$. Solving for $\delta\boldsymbol{\sigma}^{(k)}$ from Eq. 3.31 produces

$$\delta\boldsymbol{\sigma}^{(k)} = -\mathbf{Q}^{-1}\left(\mathrm{r}^{(k)} + \mathbf{E}\sum_{j=1}^{N=2} \Delta\lambda_{p_j}^{(k)} \mathbf{m}_j^{(k)}\right) \qquad \text{Eq. 3.33}$$

Substituting Eq. 3.33 into Eq. 3.32 produces the vector of proportionality factors as in Eq. 3.15, i.e.

$$\delta\boldsymbol{\lambda}^{(k)} = \begin{Bmatrix} \delta\lambda_{p_1}^{(k)} \\ \delta\lambda_{p_2}^{(k)} \end{Bmatrix} \qquad \text{Eq. 3.34}$$

The solutions of $\delta\lambda_{p_1}^{(k)}$ are then used in Eq. 3.13 to update the plastic strain increment within the current step $(n+1)$. On the other hand, to implement the Cutting Plane Algorithm as a special case, one needs to assume that the residual vector $\mathrm{r}^{(k)}$ in Eq. 3.29 *a-priori* vanishes and $\mathbf{R} = \mathbf{E}$ in all iterations, which bypasses the need for the calculation of the Hessian matrix Hi of the active surfaces in Eq. 3.21, which might be difficult to obtain analytically if the potential surface function is complicated. Nevertheless, the potential surface's function adopted in this study conveniently vanishes, i.e. $\mathbf{R} = \mathbf{E}$ is valid also for the Closest-Point Projection Algorithm by virtue of the concrete material model adopted in Section 3.4 due to the fact that selected potential functions are low order. Thus, which of the algorithms used in this study is only a matter of whether the vanishing of the residual vector $\mathrm{r}^{(k)}$ is adopted as a condition or not.

It is also important to note that to obtain a unique solution for $\delta\boldsymbol{\lambda}^{(k)}$ from Eq. 3.15, the matrix $\mathbf{A}^{(k)}$ should be invertible. In associative perfect plasticity, the uniqueness conditions are automatically met. For the case with associative plasticity with hardening, hardening-related terms enforce a limit on uniqueness of the solution (Simo & Hughes, 2006).

On the other hand, for the general case, where plastic flow is non-associative and hardening takes place, the uniqueness of the solution relies on all terms of the matrix $\mathbf{A}^{(k)}$. For the matrix $\mathbf{A}^{(k)}$ to be invertible, the conditions can be written as

$$a_{11}^{(k)} > 0, \qquad a_{22}^{(k)} > 0, \qquad det\left(\mathbf{A}^{(k)}\right) = \left|\mathbf{A}^{(k)}\right| = a_{11}^{(k)} a_{22}^{(k)} - a_{12}^{(k)} a_{12}^{(k)} > 0 \qquad \text{Eq. 3.35}$$

in which the first two conditions are related to the single-surface plasticity while the third condition arises when both surfaces are active. If any of the three conditions in Eq. 3.35 is not satisfied due to the fact that $f_{p_1,\kappa_1}^{(k)} c_1^{(k)} < 0$ or $f_{p_2,\kappa_2}^{(k)} c_2^{(k)} < 0$ in the softening regions, then assign $f_{p_1,\kappa_1}^{(k)} c_1^{(k)} = 0$ and/or $f_{p_2,\kappa_2}^{(k)} c_2^{(k)} = 0$, where necessary to prevent premature convergence failures.

3.3.2. Possible Scenarios of the Return Algorithm

When both surfaces are active, refer to it as the first scenario, which is when the non-converged stresses are in the corner zone region of the stress space. On the other hand, during the return mapping process at the intermediate iterations, if the stress state is outside of the corner zone, then it yields to the classical single-surface plasticity problem. When only the first surface is active, refer to it as the second scenario and when only the second surface is active, refer to it as the third scenario. Finally, when no surface is active and thus, the stress is in the elastic region, refer to it as scenario zero. Figure 3-2, the boundaries between corner zone and single-surface zones are denoted with the symbols ∂C_1 and ∂C_2 on both sides. In the following, introduce the criteria for the selection of the active surface.

3.3.2.1. Scenario 1 – Both surfaces are Active

When both surfaces are active at the initial iteration, the Kuhn-Tucker conditions given in Eq. 3.5 for $M = 2$ produces

$$\begin{aligned} f_1^0 > 0 \qquad \delta\lambda_1^0 > 0 \\ f_2^0 > 0 \qquad \delta\lambda_2^0 > 0 \end{aligned} \qquad \text{Eq. 3.36}$$

It should be noted that Eq. 3.36 is implemented in a finite incremental fashion therefore, before convergence is achieved both yield conditions are violated which makes the surfaces active during the iterations. As mentioned above, select the scenario to implement out of the four possible scenarios after evaluating the yield surface values of the initial iteration, i.e. $f_i^0 > 0$. On the other hand, from, Eq. 3.15 requirement of a solution for positive proportionality factors, i.e., $\delta\lambda_i^0 > 0$, produces

$$\delta\lambda_1^0 = \frac{a_{22}^0 \delta b_1^0 - a_{12}^0 \delta b_2^0}{|\mathbf{A}^0|}$$

$$\delta\lambda_2^0 = \frac{-a_{21}^0 \delta b_1^0 + a_{11}^0 \delta b_2^0}{|\mathbf{A}^0|} \quad \text{Eq. 3.37}$$

From Eq. 3.37, the criteria to activate Scenario 1 can be obtained as

$$a_{22}^0 f_1^0 \geq a_{12}^0 f_2^0$$

$$a_{11}^0 f_2^0 \geq a_{21}^0 f_1^0 \quad \text{Eq. 3.38}$$

which are in addition to the uniqueness conditions provided in Eq. 3.35 and violation of yield conditions in Eq. 3.36 for the initial iteration.

3.3.2.2. Scenario 2 – Only Surface 1 is Active

When only the first surface is active at the initial iteration, the Kuhn-Tucker conditions given in Eq. 3.5 produces

$$f_1^0 > 0 \qquad \delta\lambda_1^0 > 0$$

$$f_2^0 = 0 \qquad \delta\lambda_2^0 > 0 \quad \text{Eq. 3.39}$$

From, Eq. 3.15 requirement of a solution for positive proportionality factor for $i = 1$, i.e., $\delta\lambda_1^0 > 0$, produces

$$a_{22}^0 f_1^0 \geq a_{12}^0 f_2^0 \quad \text{Eq. 3.40}$$

$$a_{21}^0 f_1^0 > a_{11}^0 f_2^0 \quad \text{Eq. 3.41}$$

It is also interesting to note that, in this case the return point is affected by whether the algorithm is Closest-Point Projection or Cutting-Plane.

3.3.2.3. Scenario 3 – Only surface 2 is Active

For when only the second surface is active, the Kuhn-Tucker conditions produces

$$f_2^0 = 0 \qquad \delta\lambda_1^0 > 0$$
$$f_1^0 > 0 \qquad \delta\lambda_2^0 > 0 \qquad \text{Eq. 3.42}$$

From, Eq. 3.15 requirement of a solution for positive proportionality factor for $i = 2$, i.e., $\delta\lambda_2^0 > 0$, produces

$$a_{12}^0 f_2^0 > a_{22}^0 f_1^0 \qquad \text{Eq. 3.43}$$

$$a_{11}^0 f_2^0 \geq a_{21}^0 f_1^0 \qquad \text{Eq. 3.44}$$

Similar to Scenario 2, again the converged stress point is affected by whether the algorithm is Closest-Point Projection or Cutting-Plane.

3.3.2.4. Scenario 0 – No Surface is active

When the Kuhn-Tucker conditions at initial iterations are such that

$$f_1^0 < 0 \qquad \delta\lambda_1^0 = 0$$
$$f_2^0 < 0 \qquad \delta\lambda_2^0 > 0 \qquad \text{Eq. 3.45}$$

then there is no active surface and accept the trial stress as the final stress within the incremental step $(n + 1)$.

3.3.3. Parameters Considering Viscosity update

The viscous behavior can be considered as a modification to the values obtained after the above time integration algorithm described based on the rate-independent plasticity assumption. This approach is often referred to as Duvaut and Lions model (Ibrahimbegovic, 2009), in which the final value of stresses as well as hardening parameters are expressed as a linear combination of the trial elastic value and the converged stress of the rate independent algorithm, where the weighting factors are functions of the time step and the retardation time. Introducing viscous effects improves the numerical stability which may be required in the case of strain softening (Simo & Hughes, 2006). According to Duvaut and Lions model, the updated stress and evolution parameters can be written as

$$\boldsymbol{\sigma}_{(n+1)}^{final} = \boldsymbol{\sigma}_{(n)} e^{-\beta\Delta t} + \boldsymbol{\sigma}_{(n+1)}\left(1 - e^{-\beta\Delta t}\right) + \frac{\left(1 - e^{-\beta\Delta t}\right)}{\beta\Delta t}\mathbf{E}\Delta\varepsilon_{(n+1)} \qquad \text{Eq. 3.46}$$

And

$$\kappa_i^{final} = \kappa_{i_{(n)}} e^{-\beta\Delta t} + \kappa_{i_{(n+1)}}\left(1 - e^{-\beta\Delta t}\right) \qquad \text{Eq. 3.47}$$

in which $\beta = {}^{1}/_{\tau}$, where τ is the retardation time and Δt is the time increment of the step. The retardation time is a viscosity related material property which refers to the necessary time for complete stress relaxation to the final state. Thus, under the rate independent plasticity assumption of no relaxation, i.e., $\tau \to 0$, for any Δt, Eq. 3.46 and Eq. 3.47 regenerate $\boldsymbol{\sigma}_{(n+1)}$ and $\kappa_{i_{(n+1)}}$, respectively, which are the last converged values of the rate-independent plasticity algorithm described above.

3.3.4. Material Definition in Heigh-Westergaard Coordinates

As isotropic material assumption is adopted, Heigh-Westergaard coordinates for its convenience will be used. The return mapping will take place in the Rendulic plane due to the fact that the plastic return direction being limited to Rendulic plane as a result of the selected potential functions. Figure 3-2 depicts a generic two surface model in Rendulic plane, where ξ is a measure of the volumetric component of the stress state and ρ is a measure of deviatoric component of the stress state, i.e.

$$\xi = \frac{1}{\sqrt{3}} tr(\boldsymbol{\sigma}) \qquad \text{Eq. 3.48}$$

$$\rho = \sqrt{2J_2} \qquad \text{Eq. 3.49}$$

Heigh-Westergaard coordinates are related to the principal stress components as

$$\begin{Bmatrix}\sigma_1\\ \sigma_2\\ \sigma_3\end{Bmatrix} = \frac{1}{\sqrt{3}}\begin{Bmatrix}\xi\\ \xi\\ \xi\end{Bmatrix} + \sqrt{\frac{2}{3}}\rho\begin{Bmatrix}\cos\theta\\ \cos\left(\theta - \frac{2\pi}{3}\right)\\ \cos\left(\theta + \frac{2\pi}{3}\right)\end{Bmatrix} \qquad \text{Eq. 3.50}$$

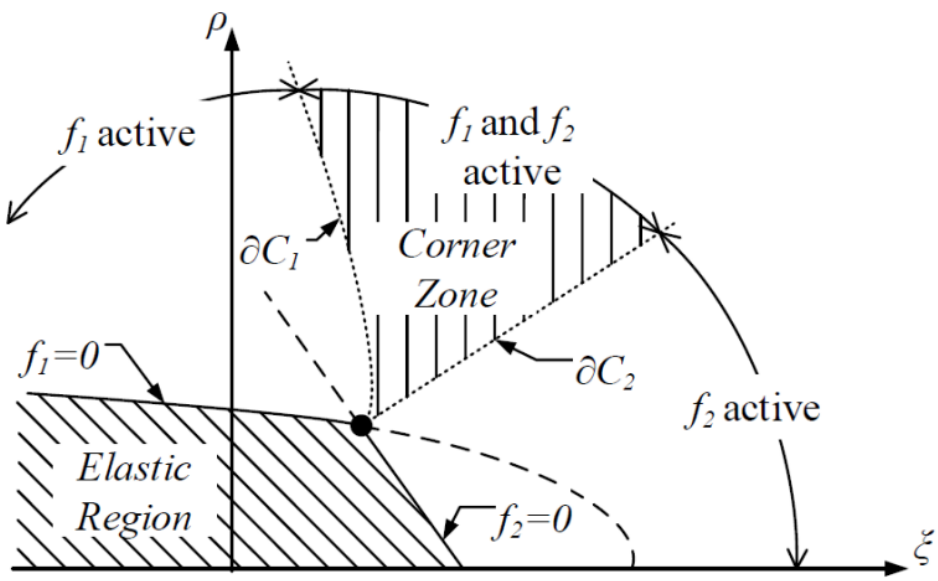


Figure 3-2. Two surface model in Rendulic Plane

in which θ is the Lode angle that defines the orientation according to the polar coordinate system within the deviatoric plane of the Heigh-Westergaard space.

For further details about Heigh-Westergaard coordinate system one is referred to (Jirasek & Bazant, 2001). The Lode angle θ is related to the deviatoric stress tensor components as

$$\cos 3\theta = \frac{3\sqrt{3}}{3}\frac{J_3}{J_2^{3/2}} \qquad \text{Eq. 3.51}$$

In Eq. 3.49, Eq. 3.53 and Eq. 3.51, the following stress tensor invariants have been used.

$$\sigma_V = \frac{I_1}{3} = \frac{1}{3}tr(\boldsymbol{\sigma})$$

$$J_2 = \frac{1}{2}tr(\boldsymbol{s}^2) \qquad \text{Eq. 3.52}$$

$$J_3 = \frac{1}{3} tr(\boldsymbol{s}^3) = \det(\boldsymbol{s})$$

in which tr is trace operator, σ_V is the volumetric stress and $\boldsymbol{s}$ is the deviatoric stress components of the stress tensor $\boldsymbol{\sigma}$, i.e.

$$\boldsymbol{s} = \boldsymbol{\sigma} - \sigma_V \boldsymbol{\delta} \qquad \text{Eq. 3.53}$$

where $\boldsymbol{\delta}$ is the Kronecker's delta

$$\delta_{ij} = \begin{cases} 1, & i = j \\ 0, & i \neq j \end{cases} \qquad \text{Eq. 3.54}$$

Material Parameters in terms of Bulk and Shear Moduli

By virtue of the material model selected in Section 3.4, the matrix **A** used in Eq. 3.15 for plastic stress return calculations can be conveniently expressed in terms of the bulk and shear moduli. For the alternative expression of **A**, first refer to the elastic stress due to elastic strain. From Eq. 3.53, one obtains

$$\boldsymbol{\sigma} = \boldsymbol{s} + \sigma_V \boldsymbol{\delta} = \mathbf{E} : \boldsymbol{\varepsilon} = 3\mathrm{K}\epsilon_V \boldsymbol{\delta} + 2G\boldsymbol{e} \qquad \text{Eq. 3.55}$$

Where

$$K = \frac{E}{3(1 - 2\upsilon)} \qquad \text{Eq. 3.56}$$

And

$$G = \frac{E}{2(1 + \upsilon)} \qquad \text{Eq. 3.57}$$

written above in terms of the Elasticity Modulus E and Poisson's ratio υ and in Eq. 3.55, volumetric strain

$$\epsilon_V = \frac{tr(\varepsilon)}{3} \qquad \text{Eq. 3.58}$$

and deviatoric strain

$$\boldsymbol{e} = \varepsilon - \epsilon_V \boldsymbol{\delta} \qquad \text{Eq. 3.59}$$

definitions were used. From the definition in Eq. 3.55 to Eq. 3.59, one obtains the relation

$$\boldsymbol{\sigma_V} = 3K\epsilon_V \qquad \text{Eq. 3.60}$$

$$\boldsymbol{s} = 2G\boldsymbol{e} \qquad \text{Eq. 3.61}$$

Note that for shear stress-shear strain relations in Voigt vector notation Eq. 3.61 should be evaluated as

$$\boldsymbol{\tau} = G\boldsymbol{\gamma} \qquad \text{Eq. 3.62}$$

This difference between the values in tensor and vector notations for shear strain components, i.e. $\gamma = 2\boldsymbol{e}$, in which $\boldsymbol{e}$ refers to the last three components of the six-dimensional deviatoric strain tensor. Thus, shear strains should be treated with caution in numerical calculations. By using Eq. 3.50, Eq. 3.60 and Eq. 3.61, ${f_{p,\sigma}}^{\mathrm{T}}\mathbf{E}g_{p,\boldsymbol{\sigma}}$ can be written alternatively as

$${f_{p_i,\boldsymbol{\sigma}}}^{\mathrm{T}}\mathbf{E}g_{p,\boldsymbol{\sigma}} = 3Kf_{p_i,\xi}g_{p_i,\xi} + 2Gf_{p_i,\rho}g_{p_i,\rho} + \frac{2G}{\rho^2}f_{p_i,\theta}g_{p_i,\theta}, \quad 0 < i \leq 2 \qquad \text{Eq. 3.63}$$

from which by substituting into Eq. 3.16, one obtains

$$\mathbf{A}^{(0)} = \begin{bmatrix} 3Kf^0_{p_1,\xi}g^0_{p_1,\xi} + 2Gf^0_{p_1,\rho}g^0_{p_1,\rho} + f^0_{p_1,\kappa_1}c^0_1 & 3Kf^0_{p_1,\xi}g^0_{p_2,\xi} + 2Gf^0_{p_1,\rho}g^0_{p_2,\rho} \\ 3Kf^0_{p_2,\xi}g^0_{p_1,\xi} + 2Gf^0_{p_2,\rho}g^0_{p_1,\rho} & 3Kf^0_{p_2,\xi}g^0_{p_2,\xi} + 2Gf^0_{p_2,\rho}g^0_{p_2,\rho} + f^0_{p_2,\kappa_2}c^0_2 \end{bmatrix} \qquad \text{Eq. 3.64}$$

where $g_{p_i,\theta} = 0$ for $0 < i \leq 2$ was used to eliminate the last term in Eq. 3.63. In Eq. 3.64, the superscript indicates the initial iteration, i.e., $(k) = 0$. Eq. 3.64 have been obtained for the initial iteration for the purpose of identifying the target yield surface. As it will be discussed next, in this algorithm the return surface have been selected at the initial iteration based on Eq. 3.64, after which the procedure explained in Section 3.3.1 above, is used to update the stresses. It should be noted that $f_{p,\sigma}$ and $g_{p,\boldsymbol{\sigma}}$ are generally tensors, however, all terms on the right-hand side of Eq. 3.63, e.g. $f_{p,\xi}$, are conveniently scalar quantities which are provided in Section 3.4.

3.4.Material Model Specifics

3.4.1. Menetrey-Willam Yield Surface for Compression

The yield surfaces are described in terms of Haigh-Westergaard in stress space. Haigh-Westergaard coordinates are (ξ, ρ, θ), where ξ is the hydrostatic stress invariant, ρ is the deviatoric stress invariant, θ is the deviatoric polar angle as described in Section 3.3.4. The yield surface proposed by Menetrey & Willam (1995) is given by the following equation:

$$f_{p_1}(\xi, \rho, \theta) = 1.5\left(\frac{\rho}{f_c}\right)^2 + q_h(\kappa_p) m \left(\frac{\rho}{f_c\sqrt{6}} r + \frac{\xi}{f_c\sqrt{3}}\right) - q_h(\kappa_p) q_s(\kappa_p) \leq 0 \qquad \text{Eq. 3.65}$$

where f_c is the uni-axial compressive strength. In Eq. 3.65, m is introduced as a measure of frictional strength in Menetrey & Willam (1995) and it can be written as

$$m = 3\frac{f_c^2 - f_t^2}{f_c f_t}\frac{e}{e+1} \qquad \text{Eq. 3.66}$$

in which f_t is the uniaxial tensile strength and e is called eccentricity which describes the out-of-roundness of the yield surface in the deviatoric plane (Figure 3-3).

$$e = \frac{1+\epsilon}{2-\epsilon} \qquad \text{Eq. 3.67}$$

Where

$$\epsilon = \frac{f_t}{f_b}\frac{f_b^2 - f_c^2}{f_c^2 - f_t^2} \qquad \text{Eq. 3.68}$$

In Eq. 3.65, r is the radius in the deviatoric plane which is a function of the deviatoric polar angle θ and the eccentricity e i.e.

$$r(\theta, e) = \frac{v(\theta, e)}{s(\theta, e) - t(\theta, e)} \qquad \text{Eq. 3.69}$$

Where

$$v(\theta, e) = 4(1 - e^2)\cos^2\theta + (2e - 1)^2 \qquad \text{Eq. 3.70}$$

$$s(\theta, e) = 2(1 - e^2)\cos\theta \qquad \text{Eq. 3.71}$$

$$t(\theta, e) = (2e - 1)[4(1 - e^2)\cos^2\theta + 5e^2 - 4e]^{1/2} \qquad \text{Eq. 3.72}$$

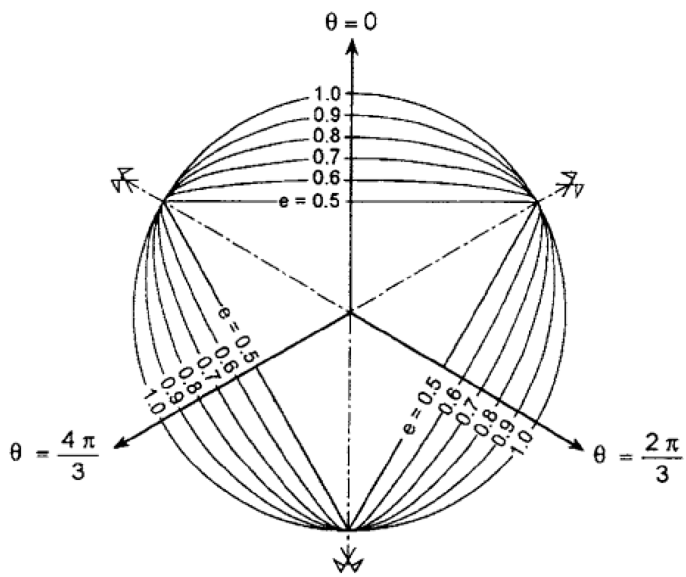


Figure 3-3. Deviatoric Plane Menetrey & Willam (1995)

Hardening and softening functions

An isotropic hardening law based on which hardening and softening functions is adopted, i.e., q_h and q_s respectively, only change the size of the yield surface, controlled by the hardening/softening parameter κ_{p_1}. Following Grassl et al. (2002), select the hardening parameter to be the plastic volumetric strain ε_v^p. i.e.

$$\dot{\kappa}_{p_1} = \dot{\varepsilon}_v^p = \dot{\lambda}_p \frac{\sqrt{3}}{q_h q_s} \qquad \text{Eq. 3.73}$$

where superimposed · indicates rate. The function q_h is active in the hardening region and it is unity beyond the peak strain whereas q_s is active in the softening region. According to the hardening law in Grassl et al. (2002), the hardening function in Eq. 3.65 can be written as

$$q_h(\kappa_{p_1}) = q_h(\varepsilon_v^p) = k_0 + (1 - k_0)\sqrt{1 - \left(\frac{\varepsilon_{v0}^p - \varepsilon_v^p}{\varepsilon_{v0}^p}\right)^2} \quad \text{Eq. 3.74}$$

Where

$$k_0 = \sigma_{c_0}/f_c \quad \text{Eq. 3.75}$$

in which σ_{c_0} is the uniaxial concrete stress at the onset of plastic flow. In Eq. 3.74, ε_{v0}^p is the threshold value for the volumetric plastic strain at uniaxial concrete strength, i.e.

$$\varepsilon_{v0}^p = \frac{f_c}{E_c}(1 - 2\upsilon_c) \quad \text{Eq. 3.76}$$

where E_c and υ_c are the Young's modulus and Poisson ratio for concrete, respectively.

$$q(\kappa_{p_1}) = q_h(\kappa_{p_1})q_s(\kappa_{p_1}) \quad \text{Eq. 3.77}$$

The softening function q_s is unity during the hardening range and its value is updated only beyond the peak compressive strain, i.e.

$$q_s(\kappa_{p_1}) = \left(\frac{1}{1 + \left(\frac{n_1 - 1}{n_2 - 1}\right)^2}\right)^2 \quad \text{Eq. 3.78}$$

Where

$$n_1 = \frac{\varepsilon_v^p}{\varepsilon_{v0}^p} \quad \text{Eq. 3.79}$$

And

$$n_2 = \frac{\varepsilon_{v0}^{p} + t_c}{\varepsilon_{v0}^{p}} \qquad \text{Eq. 3.80}$$

in which t_c is a calibrated parameter and considering MPa as the stress unit, it is recommended to use $t_c = f_c/15000$, (Papanikolaou & Kappos, 2007).

3.4.2. Potential Function for Compression

The linear potential function proposed in (Lee & Fenves, 1998) is adopted, which can be expressed in Haigh–Westergaard coordinates as

$$g_{p_1}(\xi, \rho) = -B\rho + \xi - a \qquad \text{Eq. 3.81}$$

where B controls the slope in Rendulic Plane and it is chosen to give proper dilatancy. Lee & Fenves (1998) suggested a value between -6.6 and -5 in their case studies, which is adopted herein. The effect of slope B will be shown in Chapter 5 Numerical Results. It should be noted that more sophisticated potential functions that describe the confined concrete behaviour more accurately were discussed by Grassl et al. (2002) and Papanikolaou & Kappos (2007), which may cause some differences in results when the concrete is confined. However, in our experience the linear potential function selected herein performs well in numerical simulations as will be shown in Chapter 5, while other alternatives may cause convergence issues especially when tensile stresses are involved. It should also be noted that as the gradient of the potential function is used and not the potential function value itself, the value of a in Eq. 3.81 has no influence in the derivation of equations and results. It is a constant introduced to adjust the position of the potential function to be meaningful, i.e., to meet with the point of current stress state.

3.4.3. Rankine Yield Surface for Tension Cut-off

In tensile region, non-associative flow rule is also adopted to be able to use a potential function that is independent of the polar angle θ, while using the Rankine yield surface to limit the maximum stress at the tensile strength. In Haigh–Westergaard coordinates the Rankine surface can be written as

$$f_{p_2}(\xi, \rho, \theta) = \sqrt{2}\rho\cos\theta + \xi - \sqrt{3}f_t \qquad \text{Eq. 3.82}$$

On the other hand, the potential function is obtained by removing the dependence to angle θ in Eq. 3.82 as

$$g_{p_2}(\xi,\rho) = \sqrt{2}\rho + \xi - b \quad \text{Eq. 3.83}$$

By adopting the potential function in Eq. 3.83, assure that the condition $g_{p_2,\theta} = 0$, which was used in the derivation of Eq. 3.64 is valid in the tension zone. Similar to the compressive potential surface constant a, the value of b in Eq. 3.83 has no influence in the derivation of the equations.

3.5. Solution of the Global Equilibrium Equations

3.5.1. Variational Form of the Equilibrium Equations

To refer to difference in the finite element solution, first start with the general equilibrium equations based on the principle of virtual work i.e.

$$\delta\mathbf{\Pi} = \delta\mathbf{W}^{int} - \delta\mathbf{W}^{ext} = 0 \quad \text{Eq. 3.84}$$

where $\delta\mathbf{W}^{int}$ is the variation of the internal work, i.e.,

$$\delta\mathbf{W}^{int} = \int_{\mathrm{V}} \delta\varepsilon^{\mathbf{T}}\boldsymbol{\sigma} dV \quad \text{Eq. 3.85}$$

And $\delta\mathbf{W}^{ext}$ is the virtual work done by the external loads, i.e.,

$$\delta\mathbf{W}^{ext} = \delta\mathrm{d}^{\mathbf{T}}\mathbf{P}^{ext} \quad \text{Eq. 3.86}$$

where $\mathbf{P}^{ext}$ is the vector of the external nodal forces and $\delta\mathbf{d}$ is the vector of the displacement variations. In the finite element form, refer to vector $\delta\mathbf{d}$ as the nodal displacement vector. A relation can be directly built between the variations of strains and the variations of nodal displacements in the form of

$$\delta\varepsilon = \mathbf{B}\delta\mathbf{d}_{\boldsymbol{e}} \quad \text{Eq. 3.87}$$

where $\mathbf{d}_{\boldsymbol{e}}$ is the element displacement vector and matrix **B** forms the element level discretized strain-displacement relations, which depends on the selected finite element interpolation field. For matrix **B** geometrically linear small-strain assumptions have been adopted.

3.5.2. Linearization of the Equilibrium Equations

Linearization of Eq. 3.84 produces

$$\delta \mathrm{d}.\nabla_d \delta\boldsymbol{\Pi} = \int_{\mathrm{V}} \mathbf{B}^{\mathrm{T}} \mathbf{C}_{ep} \mathbf{B} dV = \delta \mathbf{d}^{\mathbf{T}} \mathbf{K}_{Gt} \delta \mathbf{d} \quad \text{Eq. 3.88}$$

Conventional displacement has been adopted based finite element formulations with standard assemblage procedures. Therefore, the formation of the nodal displacement vector $\mathbf{d}$ as an assemblage of element displacements $\mathbf{d}_e$ and all the relevant procedures are standard. Transition from the element level matrix $\mathbf{B}$ to global level relations in Eq. 3.87 are not further elaborated herein and further details can be found in Robert et al., (2007). In Eq. 3.88, $\mathbf{K}_{Gt}$ denotes the tangent stiffness matrix and ∇_d is the gradient with respect to the nodal displacement vector. In Eq. 3.88, $\mathbf{C}_{ep}$ is the material level tangent modulus which can be written as

$$\mathbf{C}_{\mathrm{ep}} = \mathbf{E}[\mathrm{I} - \mathrm{m_b} \mathrm{A}^{-1} \mathrm{n_a}^{\mathrm{T}} \mathrm{E}] \quad \text{Eq. 3.89}$$

Where

$$\mathrm{n_a}^{\mathrm{T}} = \begin{Bmatrix} \mathrm{n}_1^{\mathrm{T}} \\ \mathrm{n}_2^{\mathrm{T}} \end{Bmatrix} \quad \text{Eq. 3.90}$$

$$\mathrm{m_b}^{\mathrm{T}} = \begin{Bmatrix} \mathrm{m}_1^{\mathrm{T}} \\ \mathrm{m}_2^{\mathrm{T}} \end{Bmatrix} \quad \text{Eq. 3.91}$$

were used. In deriving Eq. 3.89, the differential equations $d\boldsymbol{\lambda} = \mathbf{A}^{-1} \mathbf{n_a}^{\mathbf{T}} \mathbf{E} d\varepsilon$ and $d\varepsilon_p = \mathbf{m}_{\mathrm{b}}$ were substituted into $d\boldsymbol{\sigma} = \mathbf{E}(d\varepsilon - d\varepsilon_p)$. The Newton-Raphson solution of the non-linear equilibrium equation in Eq. 3.84 produces

$$\begin{bmatrix} \boldsymbol{K}_{Gt} & -\boldsymbol{P}^{ext} \\ \boldsymbol{a}^{\boldsymbol{T}(\mathrm{j})} & b^{(j)} \end{bmatrix} \begin{Bmatrix} \delta \boldsymbol{d}^{(j)} \\ \delta \boldsymbol{\Lambda}^{(j)} \end{Bmatrix} = - \begin{Bmatrix} \mathbf{r}_{\mathbf{d}}^{(j)} \\ c^{(j)} \end{Bmatrix} \quad \text{Eq. 3.92}$$

where $\boldsymbol{\Lambda}^{(j)}$ is a scaling factor that sets up the applied load level within each global iteration (j) and $\mathbf{r}_{\mathbf{d}}^{(j)}$ is the residual of the global equilibrium condition in Eq. 3.84 calculated at the end of each iteration. To solve the above augmented system of equations more efficiently the iterative displacement vector can be decomposed as

$$\delta d^{(j)} = \delta\boldsymbol{\Lambda}^{(j)}\delta\mathbf{d_p}^{(j)} + \delta\mathbf{d_r}^{(j)} \qquad \text{Eq. 3.93}$$

where $\delta\mathbf{d_p}^{(j)} = \mathbf{K}_{Gt}{}^{-1}\mathbf{P}^{\mathbf{ext}}$ and $\delta\mathbf{d_r}^{(j)} = \mathbf{K}_{Gt}{}^{-1}\boldsymbol{r}_d^{(j)}$ From the second row of the augmented equation in Eq. 3.93 and using the displacement components, one obtains

$$\delta\boldsymbol{\Lambda}^{(j)} = \frac{c^{(j)} - \mathbf{a}^{\mathbf{T}(j)}\boldsymbol{\delta}\mathbf{d_r}^{(j)}}{\mathbf{a}^{\mathbf{T}(j)}\boldsymbol{\delta}\mathbf{d_p}^{(j)}} \qquad \text{Eq. 3.94}$$

In Eq. 3.93 and Eq. 3.94, the vector $a^{(j)}$ and the constant $c^{(j)}$ enforces a constraint condition at each global iteration (j), which allows selection of alternative control parameters while keeping the load scaling factor $\boldsymbol{\Lambda}$ a variable. It should be noted that the equations is solved in an incremental-iterative manner, where a modified Newton-Raphson procedure is adopted and thus, update the stiffness matrix only at the beginning of the initial iteration. Therefore, $\mathbf{C}_{ep}$ and accordingly $\mathbf{K}_{Gt}$ are presented without any reference to iteration (j). However, they are updated after each converged increment. Adopted is the displacement control method to be able to trace the load-deflection curve beyond the peak strength. For the displacement-control method, the constraint conditions are such that the vector $a^{(j)}$ is composed of zero components except a unity at the controlled degree-of-freedom and the constant $c^{(j)}$ takes the prescribed displacement value. Further details on the displacement-control algorithm can be found in the literature of Batoz & Dhatt (1979).

3.5.3. Selected Finite Element Types

In the modeling process of the concrete bulk utilizing a 3D material model, the 8-node solid element featuring 6-degrees-of-freedom per node is used, including nodal rotations, as outlined by Ibrahimbegovic & Wilson (1991). The steel reinforcement bars and stirrups are frame element type with 6-degrees-of-freedom and are represented using 2-node 1D elements. The beam type elements incorporating both translational and rotational degrees-of-freedom are adopted to ensure compatibility between solid and re-bar elements.

3.5.4. Uni-axial Sugano Model for 1D Beam-Type Analysis

In the realm of structural engineering, plain concrete exhibits a brittle behavior when subjected to uniaxial compression. However, the deformability of concrete experiences enhancement when subjected to confinement. Confinement effectively enables concrete to endure higher strains at the peak load, often exhibiting minimal strength decay thereafter. The strain observed at peak stress is intricately tied to the effectiveness of the confinement mechanism. Building upon the work of previous researchers such as Saatcioglu and Razvi (1992) and Mander et al. (1988), an expression has been identified to yield accurate predictions of experimentally obtained strain values corresponding to peak stress ε_{cc}.

$$\varepsilon_{cc} = \varepsilon_{co}\left(1 + 5\left(\frac{f'_{cc}}{f'_{co}} - 1\right)\right) \qquad \text{Eq. 3.95}$$

Where

$$f'_{cc} = f'_{co} + \left(-1.254 + 2.254\sqrt{1 + 7.94\frac{f_l}{f'_{co}}} - 2\frac{f_l}{f'_{co}}\right) \qquad \text{Eq. 3.96}$$

It is imperative to note that ε_{co}, denoting the strain corresponding to peak stress of unconfined concrete, must be determined under the same rate of loading employed for the confined concrete. In instances where experimental data is lacking, a value of 0.002 may be deemed appropriate for ε_{co} under a slow rate of loading condition.

Eq. 3.96 denotes the compressive strength of confined concrete and was defined by Mander et al. (1988).

$$f_l = 0.5k_e\rho_c f_{yt} \qquad \text{Eq. 3.97}$$

f_l represents the effective lateral confining stress on the concrete (Saatcioglu & Razvi, 1992). $k_e = \frac{A_e}{A_{cc}}$ is the confinement effectiveness coefficient. f_{yt} denotes the yield strength of transverse reinforcement. $\rho_c = \frac{4A_{st}}{b_s s}$ is area ratio of transverse confinement reinforcement. A_{st} is the area of transverse reinforcement within spacing s.

$$f'_{co} = 0.85f_c \qquad \text{Eq. 3.98}$$

where

$$f_c = \frac{1}{\delta_f - 0.041}\left(0.127 f_{yt}\rho_c - 0.052\sigma_c\right) \qquad \text{Eq. 3.99}$$

In which δ_f is the ultimate displacement defined as the displacement angle at which 80% of the maximum strength is sustained in load versus displacement angle curve based on some experimental data carried out by Sugano (1997) thus Eq. 3.99 was acquired.

Chapter 4

Description of the finite element models

4.1.ABAQUS Model

4.1.1. Concrete model in ABAQUS

The values of said parameters were utilized in accordance with the specifications outlined in the experimental data. The finite element software ABAQUS was used for comparison purposes, in which a coupled plastic damage model for concrete is available. The concrete damage plasticity (CDP) constitutive model is employed by ABAQUS to represent inelastic behavior. The model under consideration takes into account two primary failure processes, namely tensile cracking and compressive crushing (ABAQUS, 2008).

The CDP model in ABAQUS is derived from plastic behavior, compressive behavior, and tensile behavior. The investigation of the compressive behavior of concrete necessitates the establishment of a correlation between the yield stress and inelastic strain. The CDP model primarily focuses on the development of reinforced concrete structures. Therefore, the implementation of a stress-strain model for concrete, specifically the design-oriented model proposed by Milad et al. (2017), was carried out.

In order to establish the plasticity model of concrete, it is necessary to determine certain key parameters. The parameters under consideration include the dilation angle (ψ), the plastic potential eccentricity (e), the ratio of the initial equibiaxial compressive yield stress to the initial uniaxial compressive yield stress fb_0/fc_0, the ratio of the second stress invariant on the tensile meridian which governs the shape of the yield surface (k_c), and the viscosity (u). The dilation angle was selected as 31 degrees based on the calibration process. Milad et al. (2017) provided definitions for the eccentricity (e), the ratio of the distance between the foci to the length of the major axis (fb_0/fc_0), the constant k_c, and the parameter (u). Specifically, the values assigned to these variables were 0.1, 1.16, 2/3, and zero, respectively.

4.1.2. Reinforcements in ABAQUS

The behavior of steel and FRP was modelled as elastic perfectly plastic model. The parameters which were used to define the model are modulus of elasticity, yield stress, and Poisson's ratio. Figure 4-1 illustrates the reinforcement arrangement for SW-1 in ABAQUS.

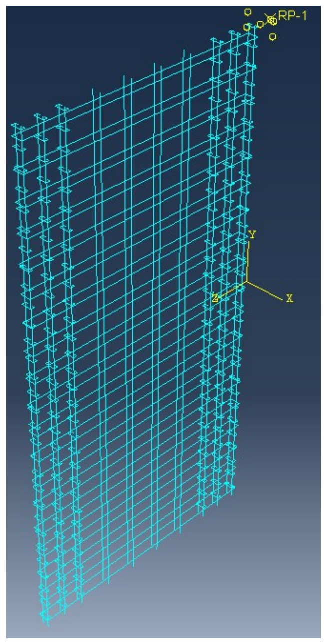


Figure 4-1. Reinforcement configuration in ABAQUS.

4.1.3. Finite Element Types and Meshing in ABAQUS

To effectively simulate the concrete column in ABAQUS, distinct element types have been employed to represent the various components of the beams and shear walls. The primary materials included in the model are concrete, steel, and fiber-reinforced polymer (FRP). The primary material used for the concrete is represented in the model as a homogeneous 8-node 3D brick element, specifically the C3D8R element. Additionally, the longitudinal and transverse steel and FRP materials are represented in the model as linear truss elements, namely the T3D2 element.

In order to simulate the interaction between the concrete and the reinforcement, a constraint is applied to the embedded region. The purpose of the embedded contact region is to ensure that the number of translational degrees of freedom (DOF) at a node on the embedded element is equivalent to the number of translational degrees of freedom at a node on the host element (referred to as Compatible DOF). The reinforcement was incorporated within the concrete, which is regarded as the host region. Hence, it can be observed that the concrete and reinforcement elements are interconnected at a common node, assuming an ideal link between them.

It is imperative that all elements possess a congruent degree of freedom and are interconnected via a common node. Consequently, in order to assure the accuracy of the results derived from the finite element model, all the utilized elements in the model were uniformly allocated the same mesh size. The model utilizes a mesh size of 25 mm in order to attain optimal outcomes while maintaining a suitable simulation pace.

4.1.4. Boundary Condition and Loading in ABAQUS

In the ABAQUS analysis, the shear walls were subjected to fixed boundary conditions at the bottom in all directions, while being freed at the top, except at the location where the load was applied. The beams, on the other hand, were supported using pinned connections (pin and roller). To determine the load-deflection characteristics of the simulated beams and shear walls, a static monotonic load was applied at the designated loading location. The displacement control approach was utilized to apply loading till failure. The displacement increments were modified to 1 millimeter for each successive step.

4.2.Model properties

4.2.1. Beams

Three reinforced concrete beams were modelled, D-C1 × 9, S-C1 × 9 and ISO30-1. D-C1 × 9 and S-C1 × 9 were 2800mm long; the total length includes two parts of 400 mm beyond supports providing an additional bond length for the intrados reinforcing bars. ISO30-1 was 3000mm long; 200mm × 300 mm (width × depth). The first specimen S-C1 × 9 had a shallow rectangular cross section 200mm × 100 mm (width × depth) as described in Figure 4-2 to Figure 4-4. The second beam D-C1 × 9 had a deep cross section 100 mm × 200 mm (width × depth) as between Figure 4-5 and Figure 4-7. Given cube concrete strength values were converted into cylindrical concrete strength values by multiplying them with 0.83 (Focacci et al. 2016). f_c= 66.6 MPa and the Modulus of elasticity of 38882 MPa are the material characteristics of deep and shallow beams. FRP reinforcements with d_b= 9 mm. Both the deep and shallow beams in ABAQUS were fixed in the bottom in all directions and released at the top except the top middle point where the load was applied.

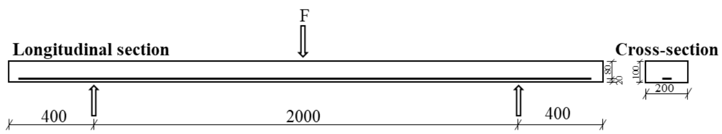


Figure 4-2. Shallow S-C1-9 beam test setup and dimensions (units in mm)

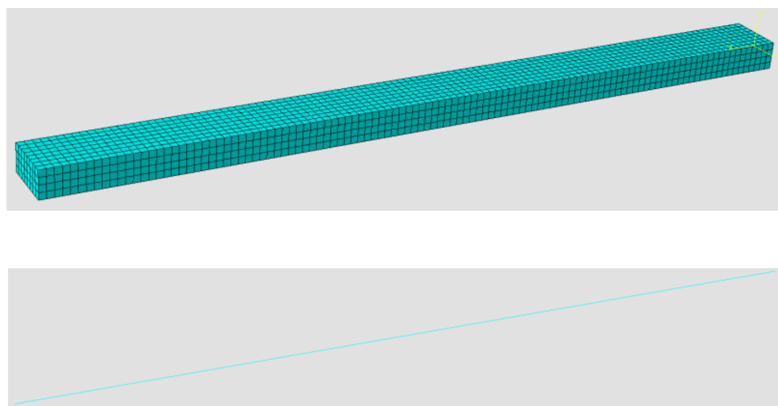


Figure 4-3. ABAQUS Depiction of S-C1-9 beam (top: meshed beam, bottom: reinforcement)

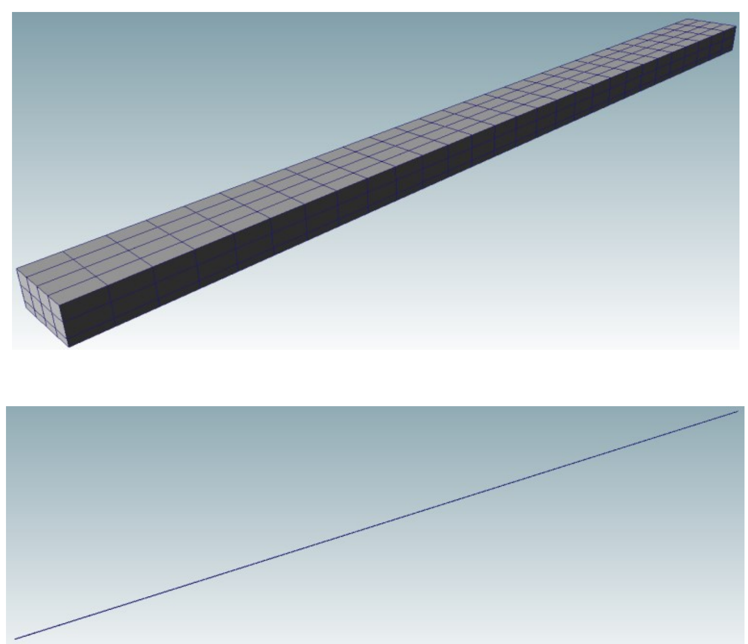


Figure 4-4. Shallow S-C1-9 beam FEAViewer configuration

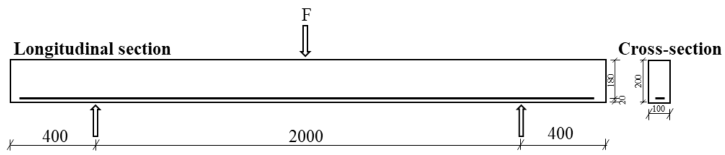
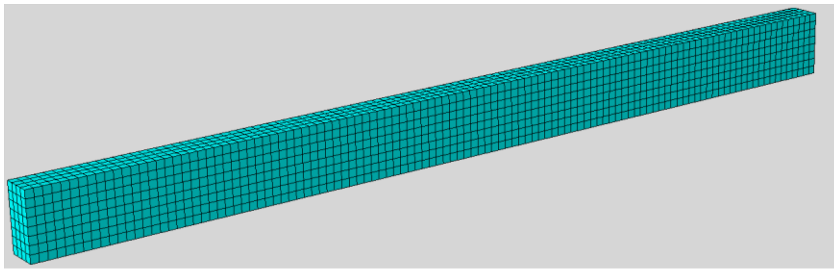


Figure 4-5. Deep D-C1-9 beam test setup and dimensions (units in mm)



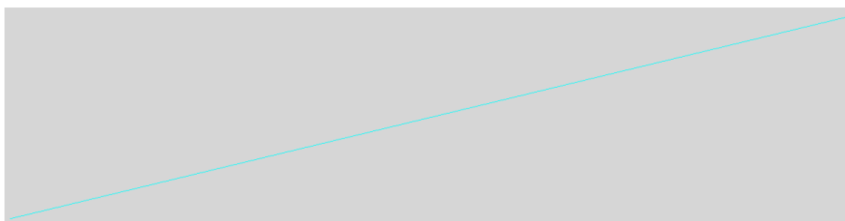
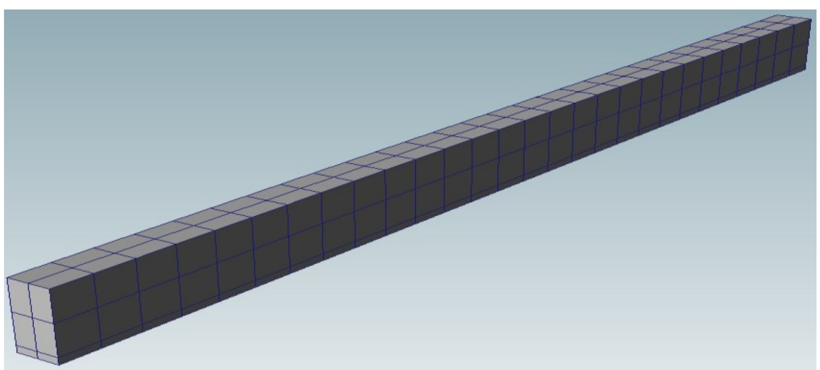


Figure 4-6. ABAQUS Depiction of D-C1-9 beam (top: meshed beam, bottom: reinforcement)



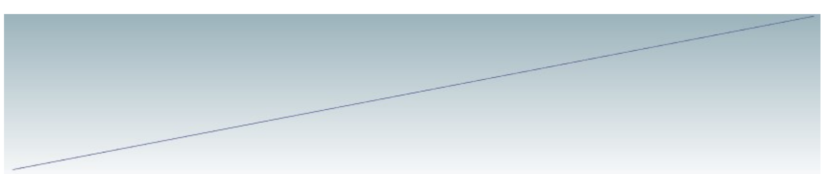


Figure 4-7. Deep D-C1-9 beam FEAViewer configuration

The third beam was 200 mm wide and 300 mm high Benmokrane et al. (1995). As shown in Figure 4-8 to Figure 4-10, it was simply supported on a span of 3000 mm and was subjected to two equal loads symmetrically placed about the mid-span. The modulus of elasticity of concrete was 32 GPa and f_c=44 MPa. Yielding stress for steel rebars was taken as 480 MPa, the ultimate strength was taken as 600 MPa and the modulus of elasticity was taken as 200 GPa. Conventional steel stirrups (10 mm diameter) were used in the non-constant moment zones, to prevent shear failure. The diameter of the reinforcement was maintained constant (19.1 mm diameter) and this beam was reinforced by two identical rebar as resumed in Figure 4-8.

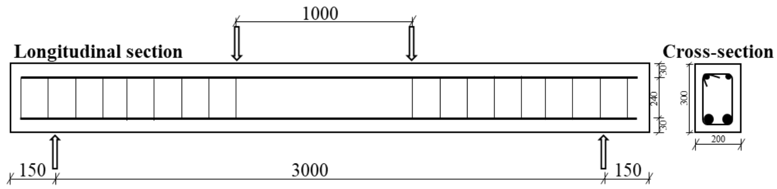


Figure 4-8. Reinforcement details of ISO30-1 beam (Benmokrane et al. (1995)

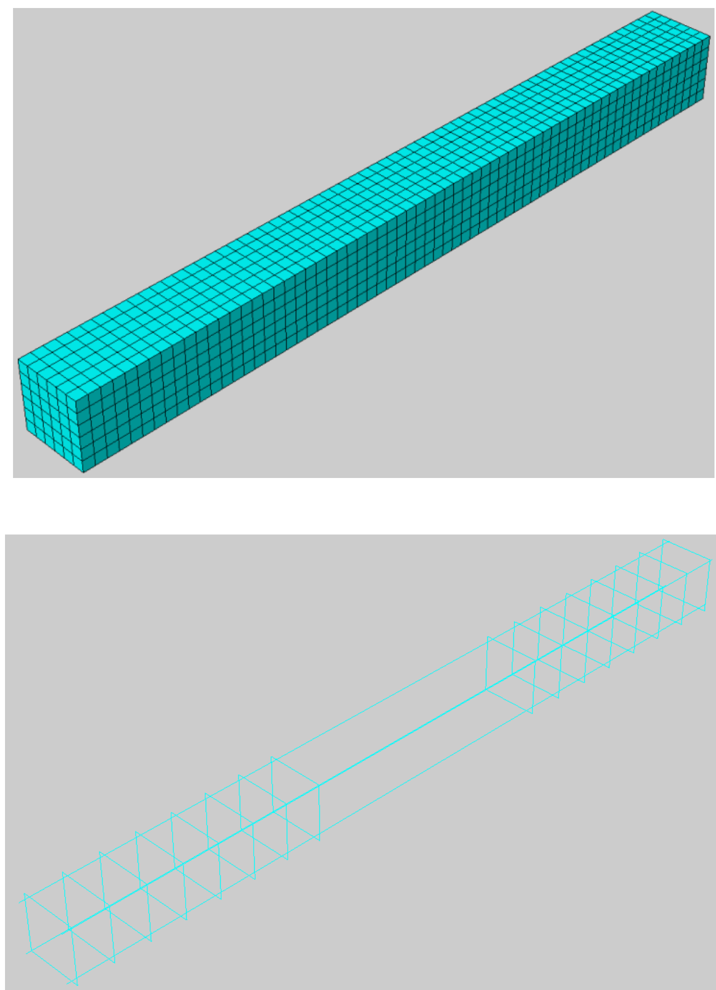


Figure 4-9. ABAQUS Depiction of ISO30-1 beam (top: meshed beam, bottom: reinforcement)

The elastic performance of concrete was determined based on the elastic modulus and Poisson's ratio. The values of those parameters were used as specified in the experimental data. For the inelastic behavior, ABAQUS uses the concrete damage plasticity (CDP) constitutive model. This model considers two main failure mechanisms, which are tensile cracking and compressive crushing ABAQUS (2008).

The CDP model in ABAQUS forms from plastic behavior, compressive behavior, and tensile behavior. The compressive behaviour of concrete requires determining the relationship between the yield stress and inelastic strain. The CDP model is primary developed for reinforced concrete structures. Thus, a design-oriented stress-strain model for concrete Lam & Teng (2003b) was implemented.

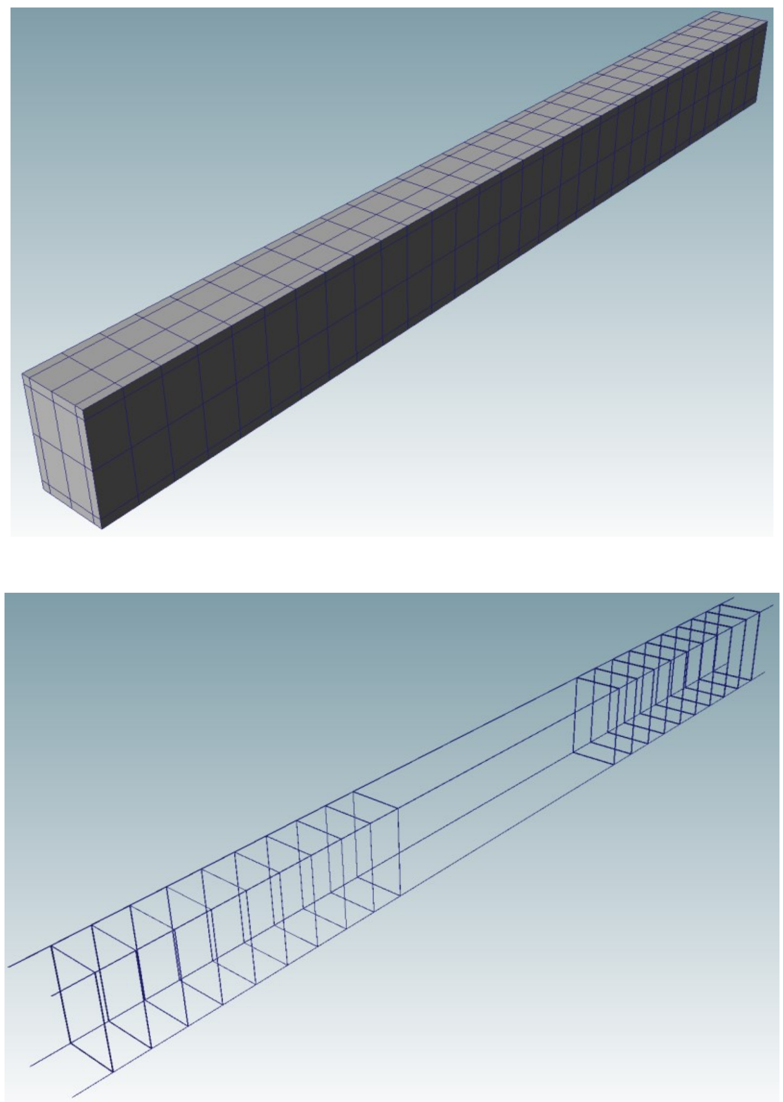


Figure 4-10. ISO30-1 beam FEAViewer configuration

4.2.2. Shear walls

Two rectangular shear wall was modeled from the study of Qian and Chen (2005) – SW-1and Mohamed et al. (2014) – G-15. The SW-1 wall by Qian and Chen (2005) was fixed at bottom and free at the top. The specimen had a height of 1900 mm and length of 1000 mm. The material properties of steel bars are listed in Table 4.1. welded hot-rolled steel bar (HRB400) fabrics, welded cold-rolled ribbed steel bar (CRB550) fabrics and CD, cold-drawn steel bar was used. The concrete cube compressive strength used 25.2 MPa, 774.4 kN as the axial load applied at top of specimen.

Table 4.1. Properties of SW-1 reinforcements

Grade of bar	Location	d: mm	f_y:MPa	f_u:MPa	E_s: GPa
HRB 400	Distributed reinforcements	6	451.7	631.7	200
HRB 335	Vertical reinforcements in boundary zones	10	395	595	194
CD	Hoops in boundary zones	4	631.7	671.7	209

Reinforcement details of shear walls are given below from Figure 4-11 and Figure 4-14, all units are in millimeters

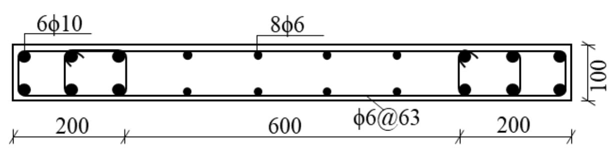


Figure 4-11. Top view dimensions and reinforcement details of SW-1

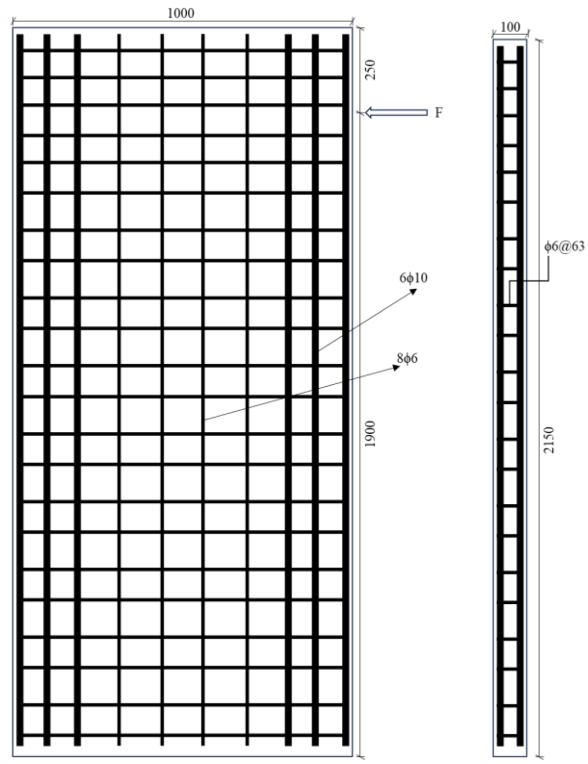


Figure 4-12. Elevation of SW-1

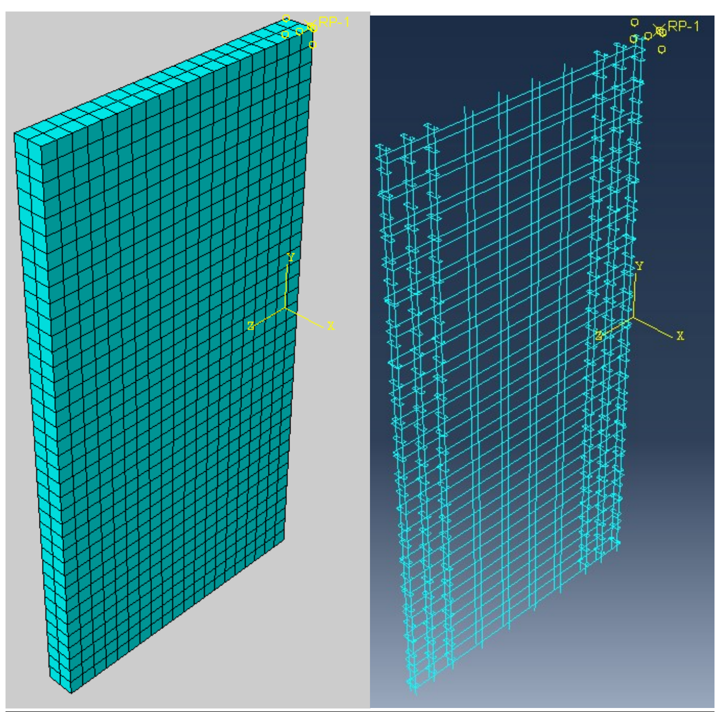


Figure 4-13. ABAQUS Depiction of SW1 shear wall (Left: meshed beam, Right: reinforcement)

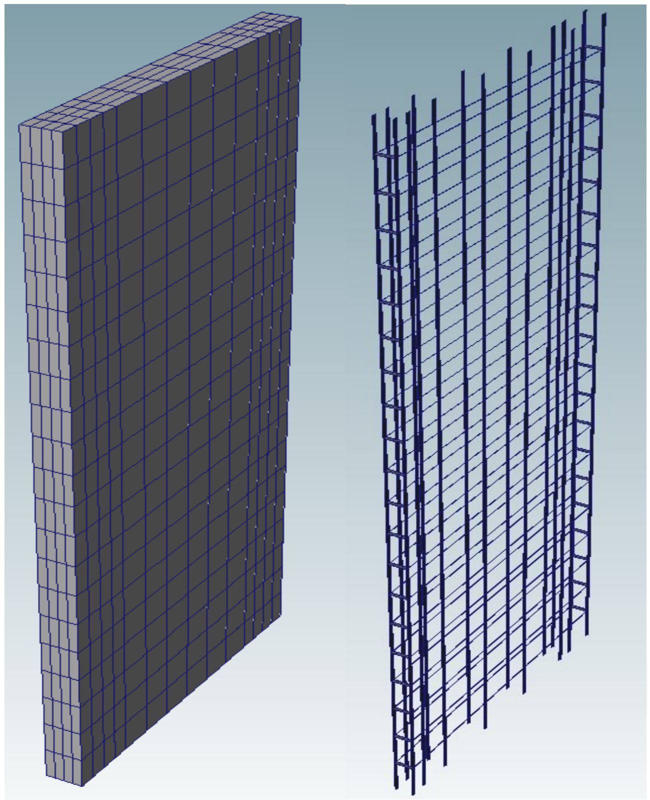
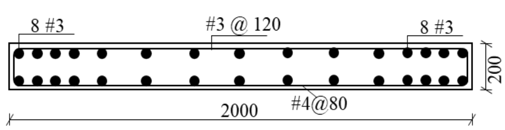


Figure 4-14. SW-1 Shear wall FEAViewer configuration

The specimen G-15 by Mohamed et al. (2015) represent a single shear wall complying with the special seismic requirements specified in CSA A23.3 (CAN/CSA 2004) and ACI 318 (ACI 2007) for the seismic-force resisting systems (SFRSs). The minimum thickness and reinforcement details were according to CSA S806 (CAN/CSA 2012) and ACI 440.1R-06 (ACI 2006) were applied for the GFRP-reinforced walls. The wall specimens were 3,500 mm in height, 200 mm thick and was 1,500 mm in length as shown in Figure 4-15. G-15 concrete dimensions and details of reinforcement configuration



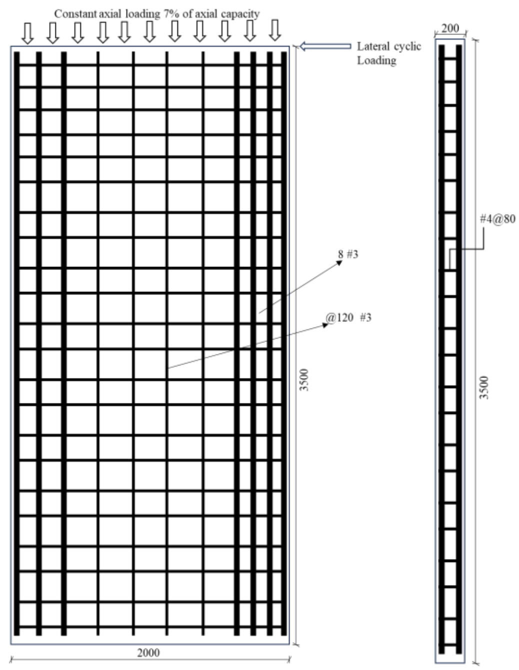


Figure 4-15. G-15 concrete dimensions and details of reinforcement configuration

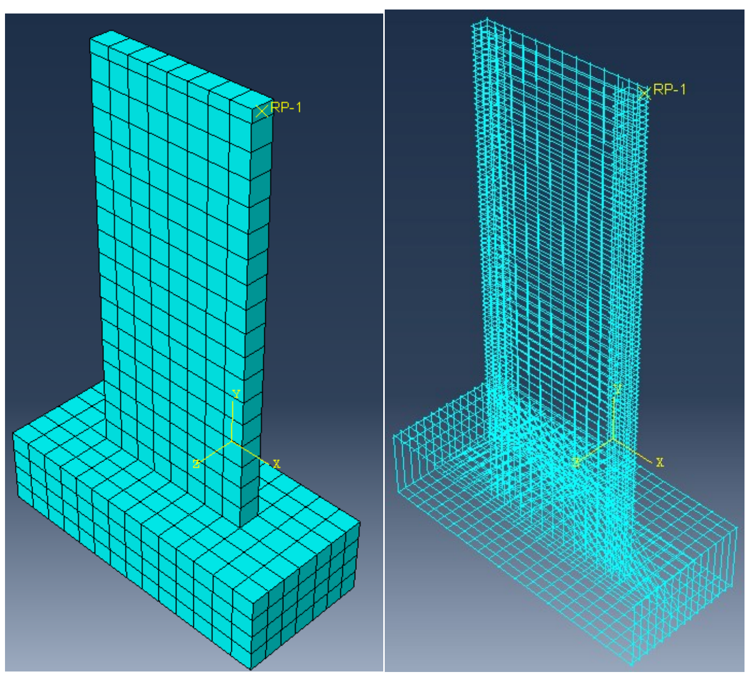


Figure 4-16. ABAQUS Depiction of shear wall G15 (Left: meshed version, Right: reinforcement)

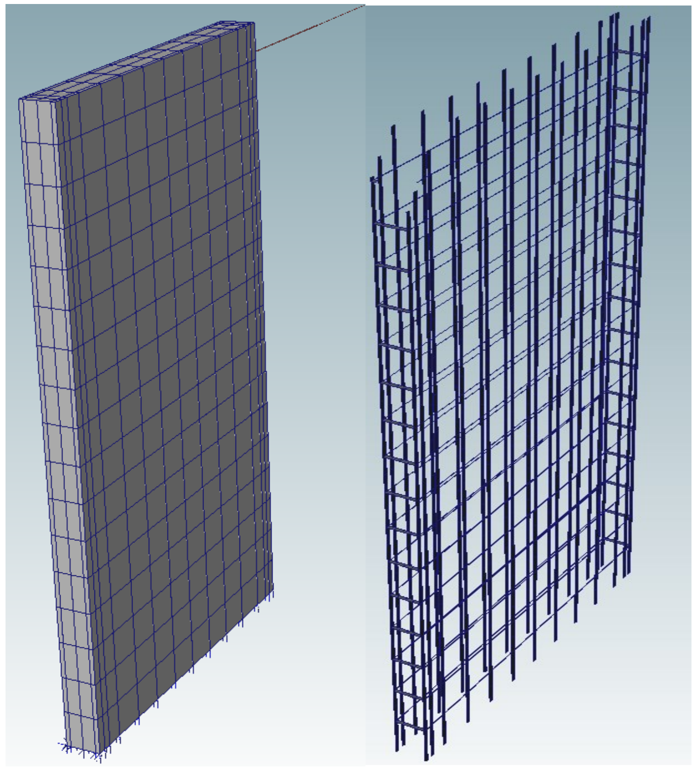


Figure 4-17. G15 Shear wall FEAViewer configuration

The nominal concrete compressive strength used for G15 was 40 MPa. An axial load of $0.07. b_w. l_w. f_c'$ was applied at the top of the wall. #3 for vertical bars ($f_{fu} = 1{,}412\ MPa, E_f = 66.9\ GPa, \varepsilon_{fu} = 2.11\%, A_f = 71.3\ mm^2$) and spiral ties (for straight portions $f_{fu} = 962\ MPa, E_f = 52\ GPa, \varepsilon_{fu} = 1.85\%, A_f = 71.3\ mm^2$; for bent portions: $f_{fu} = 500\ MPa$ and #4 for horizontal bars ($f_{fu} = 1{,}392\ MPa, E_f = 69.6\ GPa, \varepsilon_{fu} = 2\%, A_f = 126.7\ mm^2$).

Chapter 5

Numerical results

5.1.Introduction

The results of the Beam and Solid element based finite element models, as well as those based on ABAQUS and experimental results in literature are presented in this chapter. With the help of load-displacement curves, all the data are graphically shown. In the load-deflection figures, the vertical axis is for the load and the horizontal axis for the displacement. In Section 5.2, the validation studies of the developed numerical technique are presented and comparisons with ABAQUS and those of experimental results. In Section 5.3, results of members whose span is half of the original length and in Section 5.4, doubled the spans.

5.2.Validation of the Numerical Model

5.2.1. Beams

Figure 5-1 displays the force-displacement curves for a specimen of the ISOROD GFRP reinforced beam. The graphic clearly shows the good agreement between the results of the 1D and 3D material model, the experimental and ABAQUS models. The 1D and 3D model can therefore accurately reproduce the mechanical behavior of reinforced concrete columns.

The load-displacement curves for a deep section reinforced with one CFRP reinforcement in flexural and a shallow section reinforced with one CFRP beam are shown in Figures 5-2 and 5-3, respectively. The performance of the beams based on the 1D and 3D material models is well-aligned with the findings from ABAQUS and the experimental data. All approaches failed in flexural. The models behaved according to a load-displacement relationship consisting of two nearly linear branches representing the elastic uncracked phase and the elastic-cracked phase. Direct1DSugano was softer as it doesn’t consider shear stress effects. It can be seen that all the models present similar stiffness in the uncracked phase. Due to high tensile strength of the GFRP the concrete failed in compression before the failure of the FRPs.

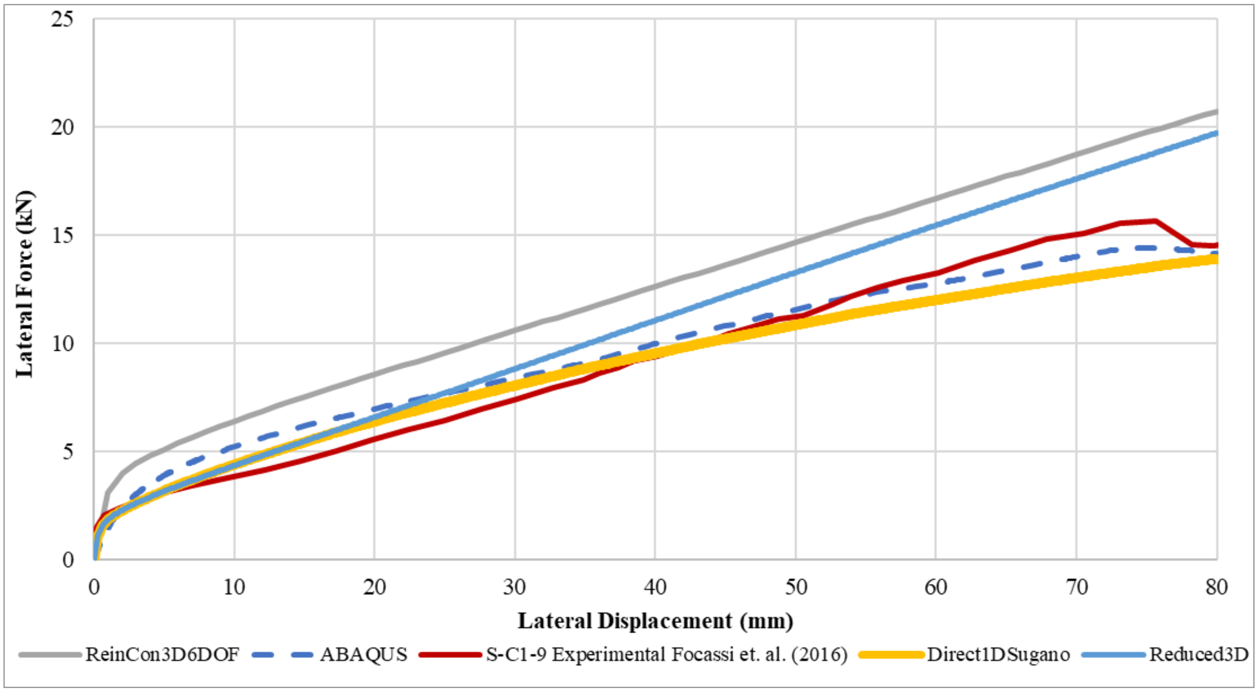


Figure 5-1. Force – Displacement curve for shallow CFRP beam (S-C1 × 9)

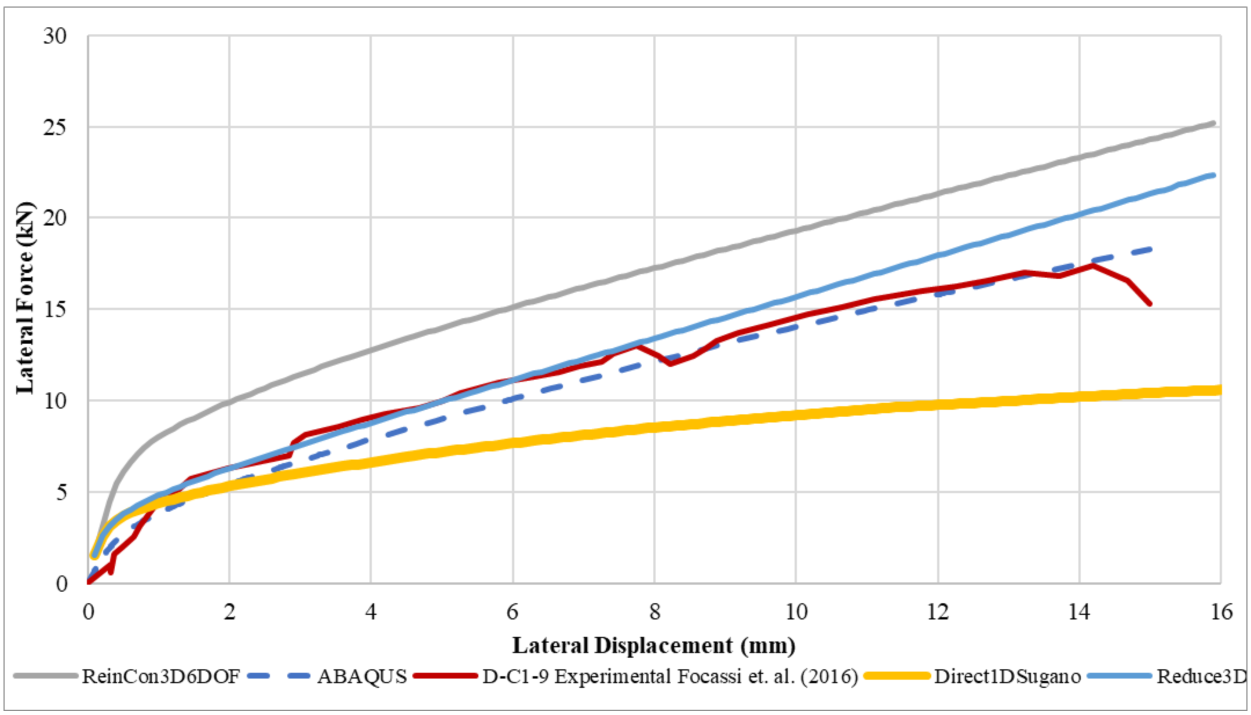


Figure 5-2. Force - Displacement curve for Deep CFRP beam (D-C1 × 9)

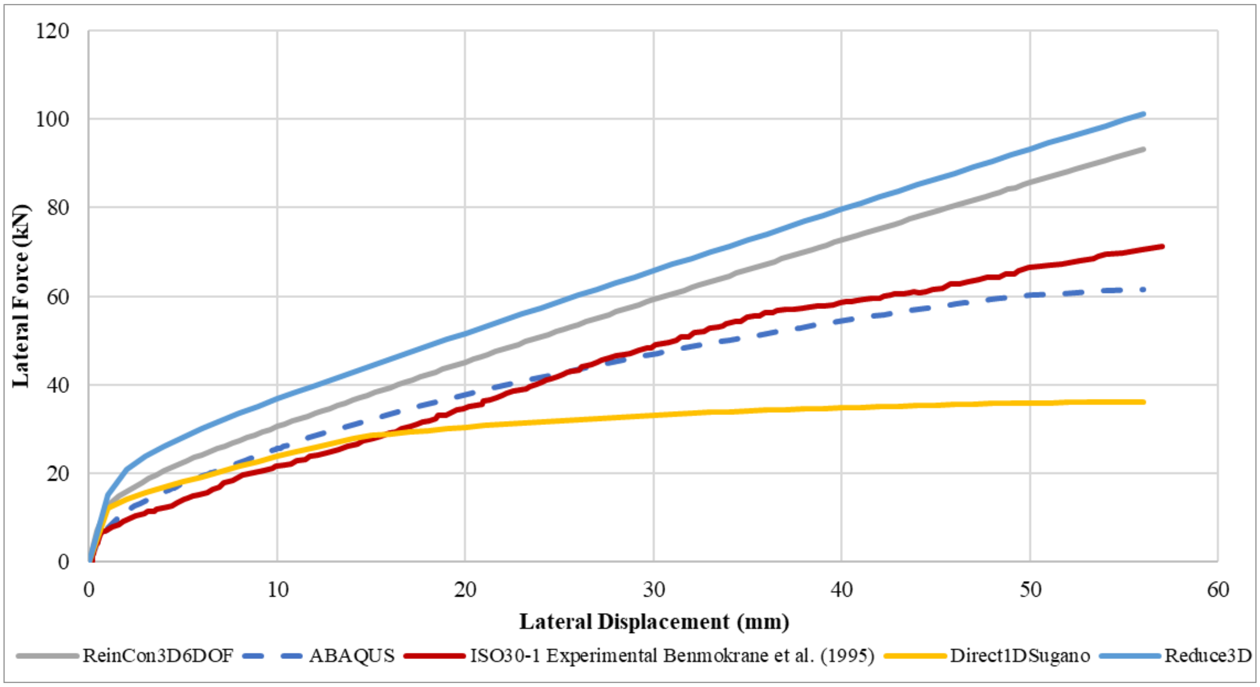


Figure 5-3. Force – Displacement for ISOROD GFRP beam (ISO30-1)

5.2.2. Shear walls

Figures 5-4 and 5-5 show the obtained monotonic curves of the lateral load against top lateral displacement of the shear walls. The 1D and 3D numerical models' performance are in good agreement with the results of the experiment and ABAQUS, which makes it evident from the data that it can accurately represent the behavior of reinforced walls. The initial stiffness until initial crack formation of G15 in the 3 proposed models is the same but higher than the literature and the ABAQUS. After the initial crack formation, there was a reduction of stiffness resulting in linear behavior until failure. For the SW-1, the 1D and literature were in good agreement up to the end unlike the fails earlier than the others. The 3D also fails before the other two though it behaved accordingly with the literature, ABAQUS and the 1D.

The use of several material models for concrete and various finite element types could account for any discrepancy in findings between the material model and ABAQUS.

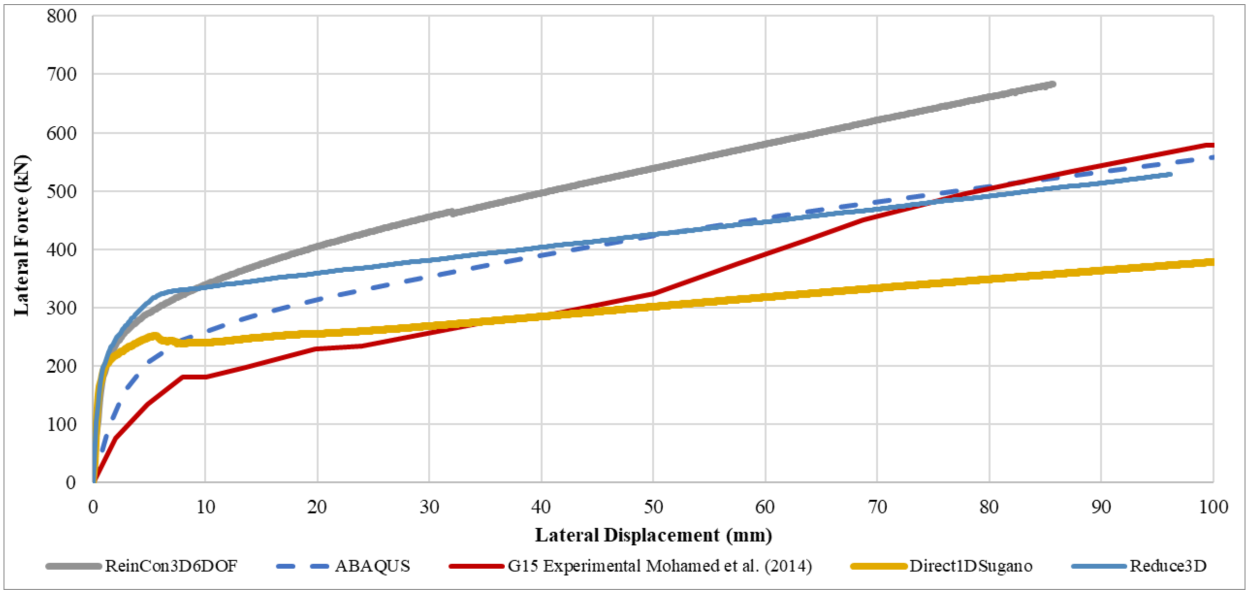


Figure 5-4. Force – Displacement curve for G15 shear wall

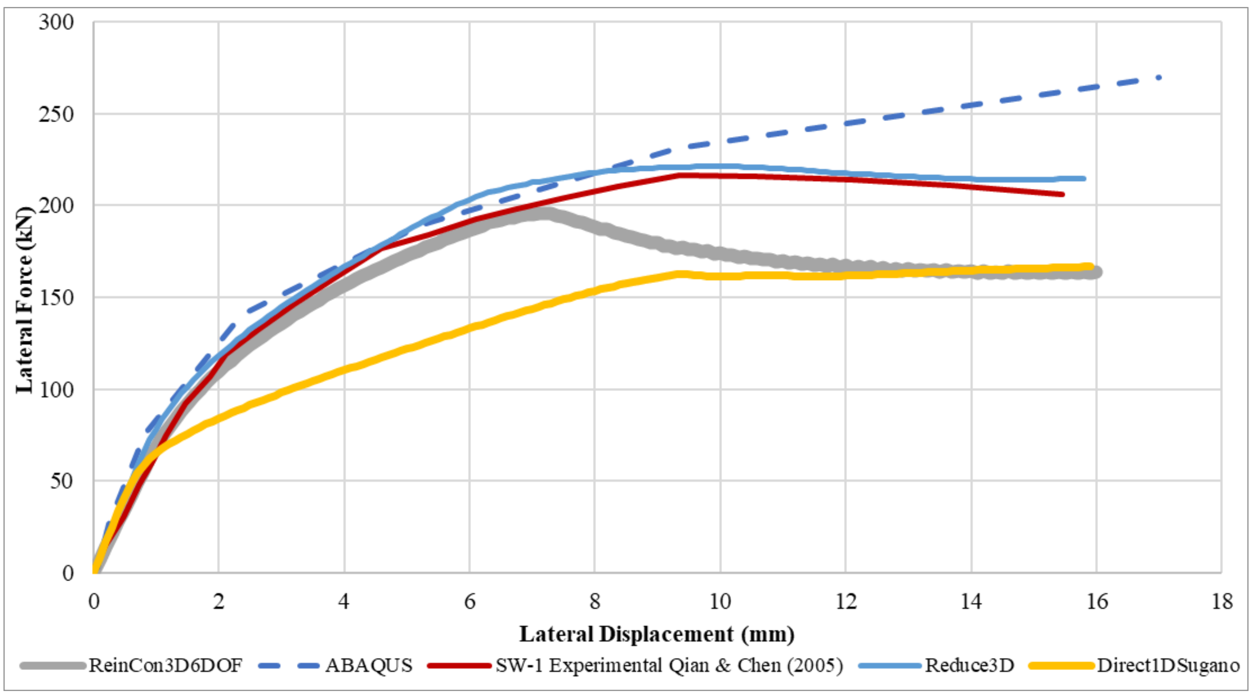


Figure 5-5. Force - Displacement curve for SW-1 shear wall

5.3.Parametric Studies on Shortened members

In this section, the above five cases used for validation purposes are changed by reducing the member sizes to half of their original length.

5.3.1. Beams

The beams analysed in Section 5.2.1 are re-analysed after reducing their spans to half to increase the effect of shear deformation.

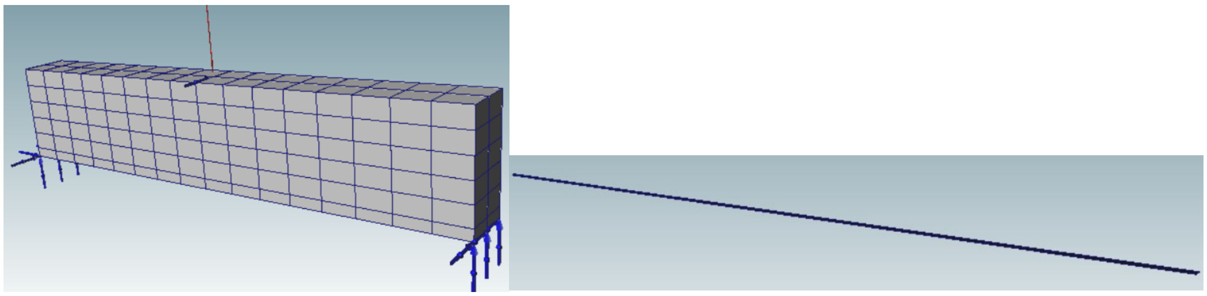


Figure 5-6. Depiction of the Shortened D-C1-9 (Right: meshed version, Left: reinforcement)

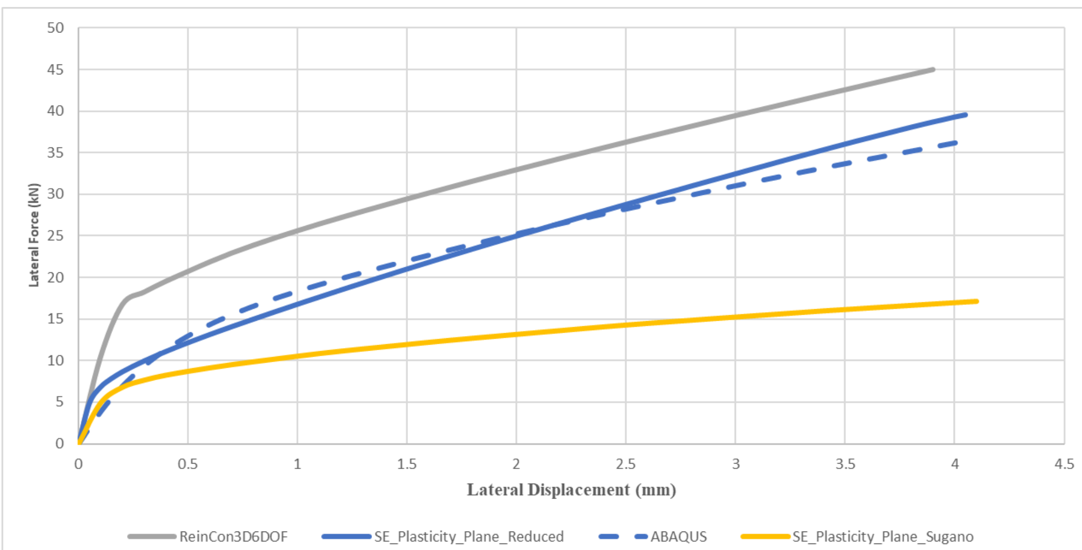


Figure 5-7. Load - deflection curve for the Shortened D-C1-9

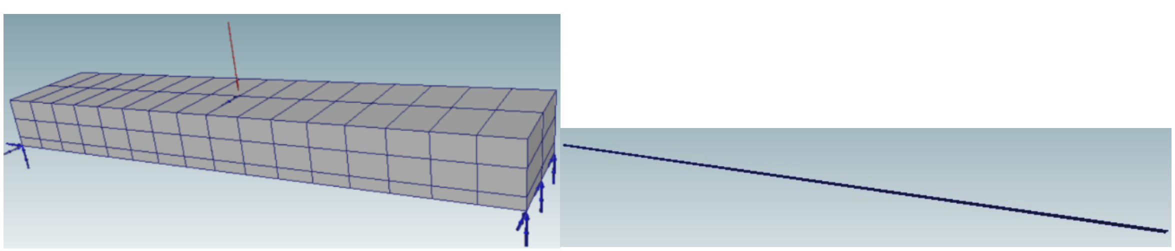


Figure 5-8. Depiction of Shortened S-C1-9 (Left: meshed version, Right: reinforcement)

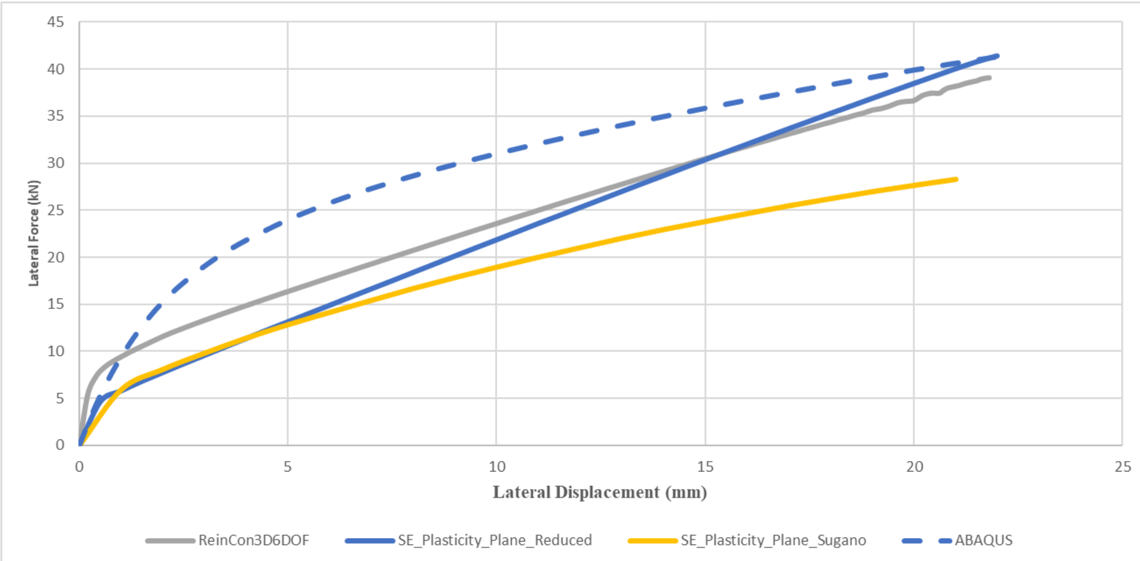


Figure 5-9. Load - deflection curve for the Shortened S-C1-9

5.3.2. Shear walls

In this example, the shear wall analysed in Section 5.2.2 are re-analysed after reducing their spans to half to increase the effect of shear deformation. When the spans of structural components are reduced, the 1D beam formulations become overly stiff compared to the 3D solid-element based formulation.

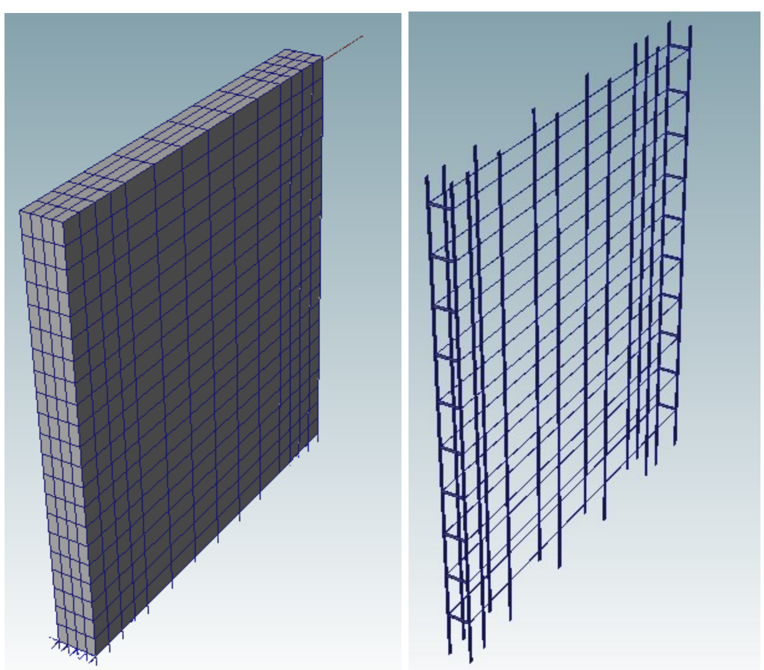


Figure 5-10. Depiction of the Shortened SW-1 (Left: meshed version, Right: reinforcements)

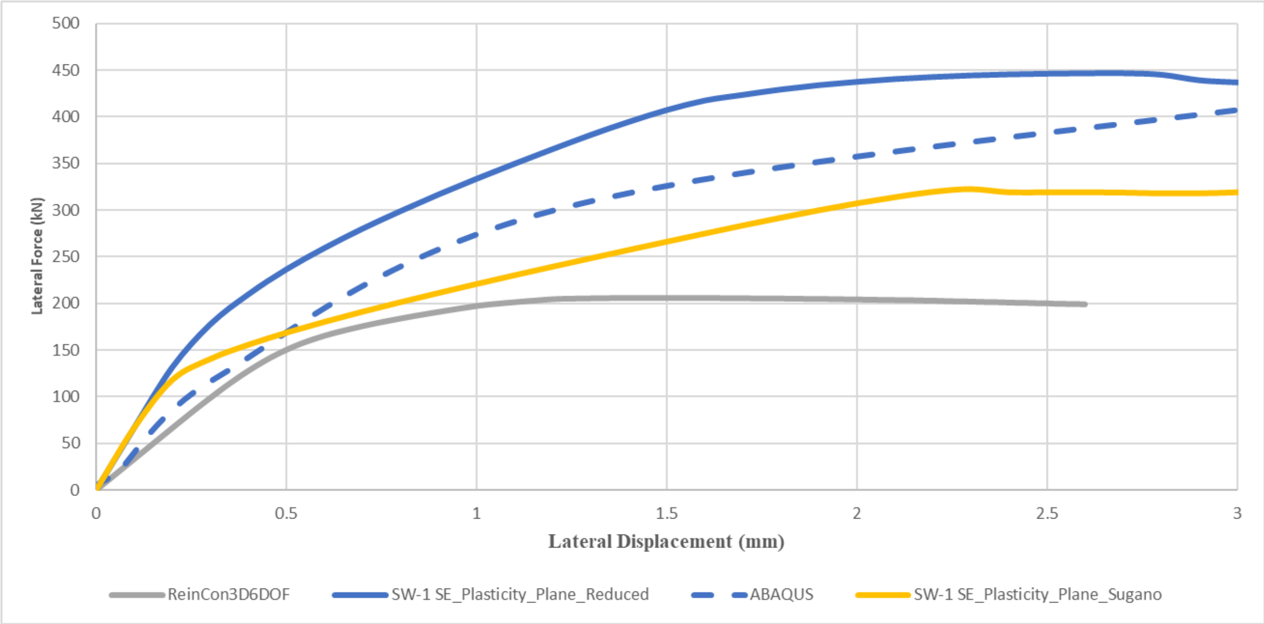


Figure 5-11. Load - deflection curve for the Shortened SW-1

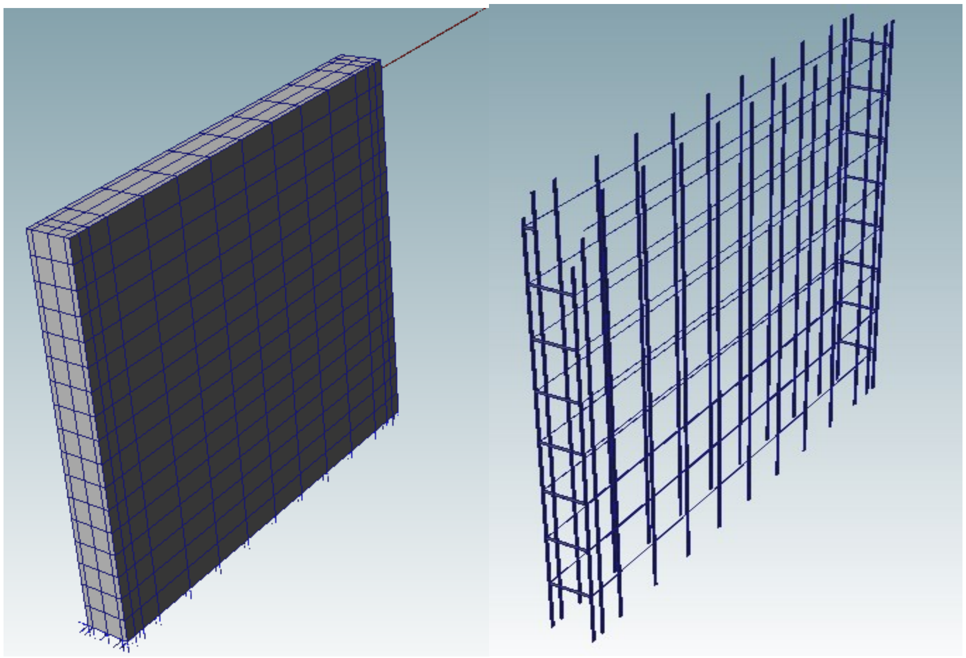


Figure 5-12. Depiction of the Shortened G15(Left: meshed version, Right: reinforcements)

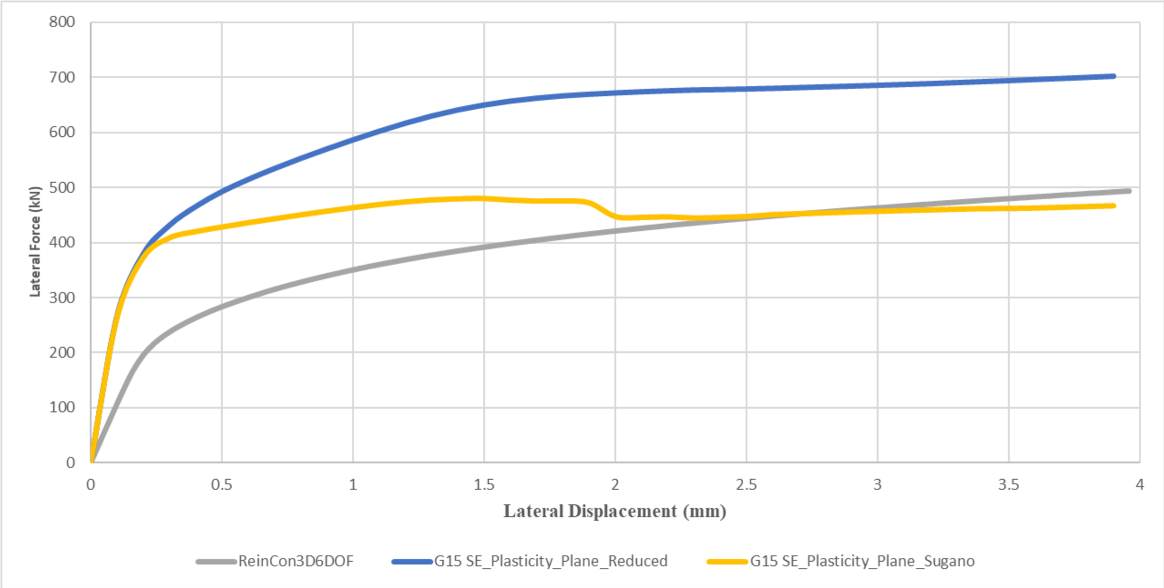


Figure 5-13. Load - deflection curve for the Shortened G15

5.4.Parametric Studies on Elongated members

5.4.1. Beams

The beams analysed in Section 5.2.1 are re-analysed after increasing their spans to double to decrease the effect of shear deformation.

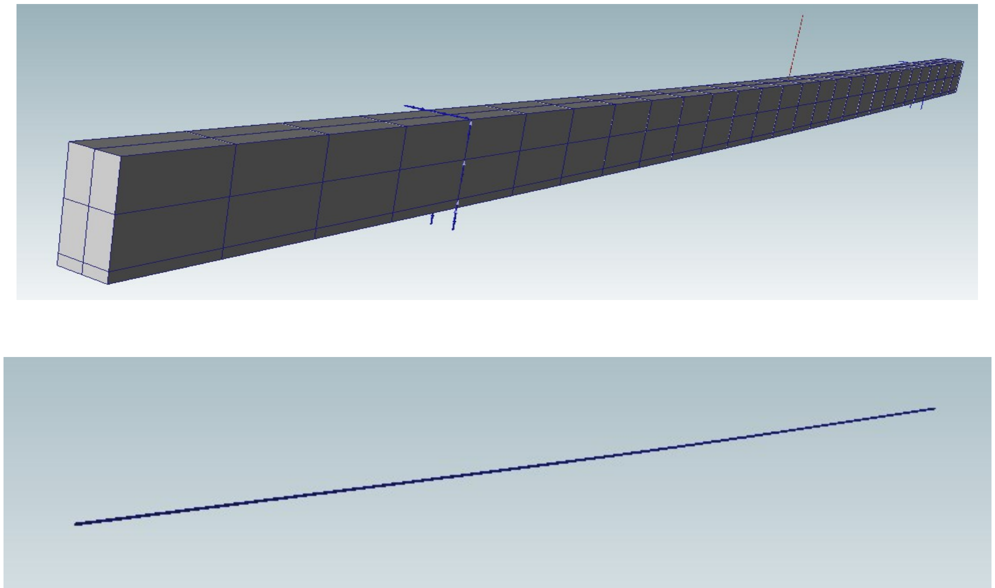


Figure 5-14. Depiction of the elongated D-C1-9 (Top: meshed version, Bottom: reinforcement)

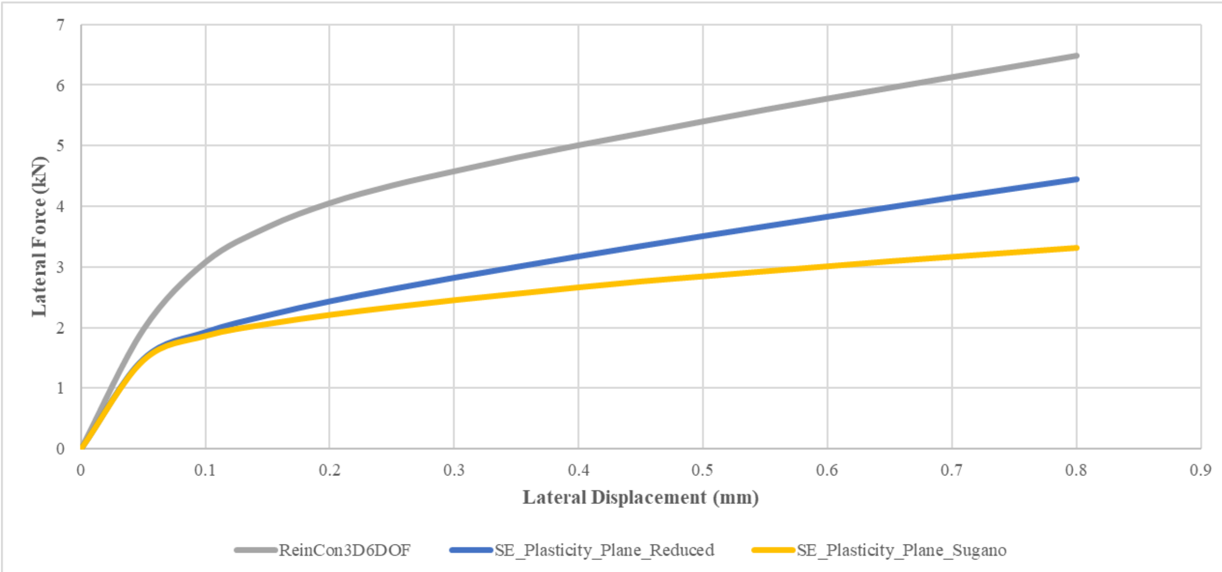


Figure 5-15. Load - deflection curve for the elongated D-C1-9

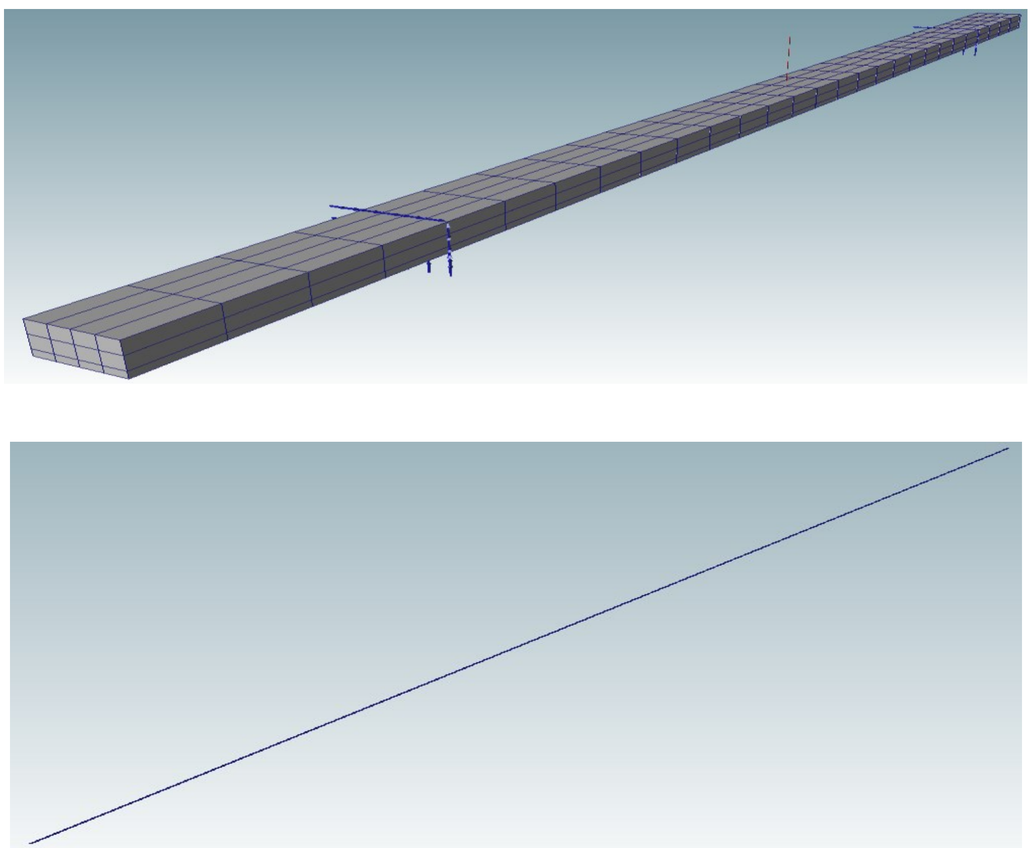


Figure 5-16. Depiction of elongated S-C1-9 (top: meshed version, bottom: reinforcement)

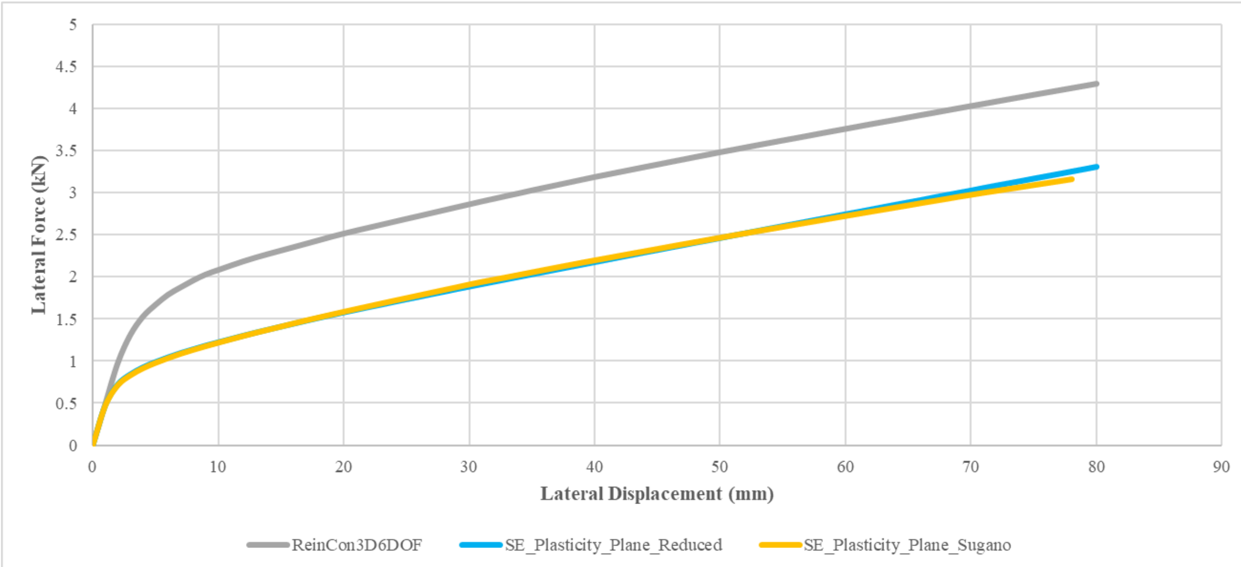


Figure 5-17. Load - deflection curve for the elongated S-C1-9

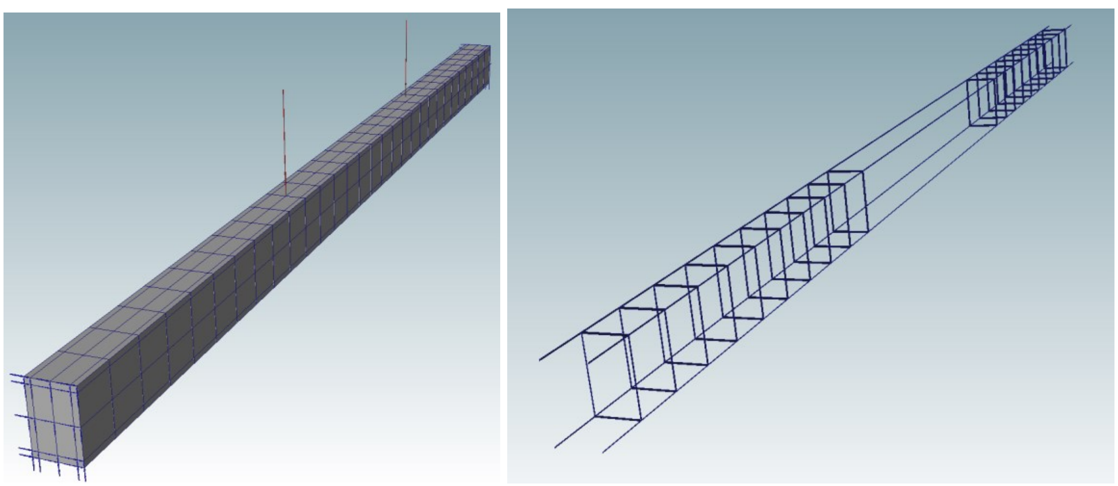


*Figure 5-18. Depiction of the elongated ISO*30-1*(Left: meshed version, Right: reinforcements)*

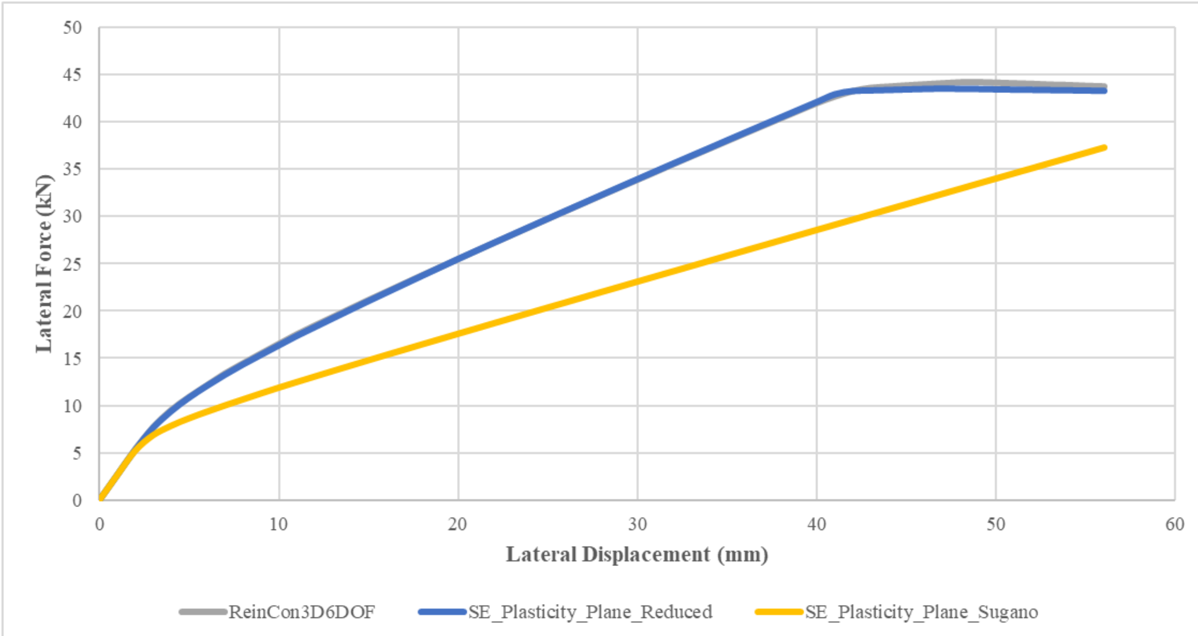


Figure 5-19. Load - deflection curve for the elongated ISO30-1

5.4.2. Shear walls

In this example, the shear wall analysed in Section 5.2.2 are re-analysed after increased their spans to double to decrease the effect of shear deformation.

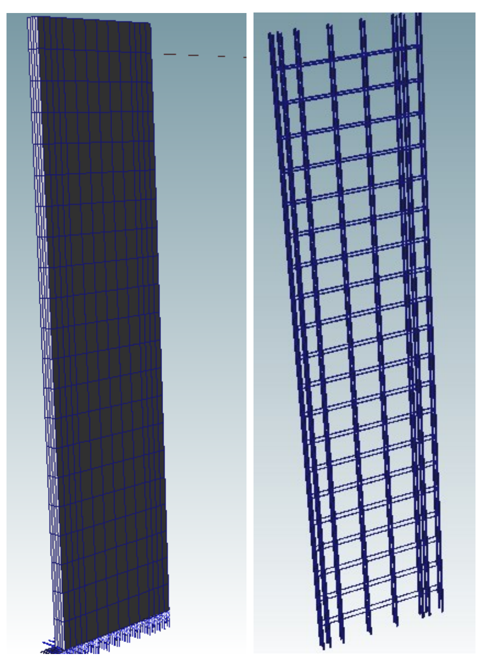


Figure 5-20. Depiction of the elongated SW-1 (Left: meshed version, Right: reinforcements)

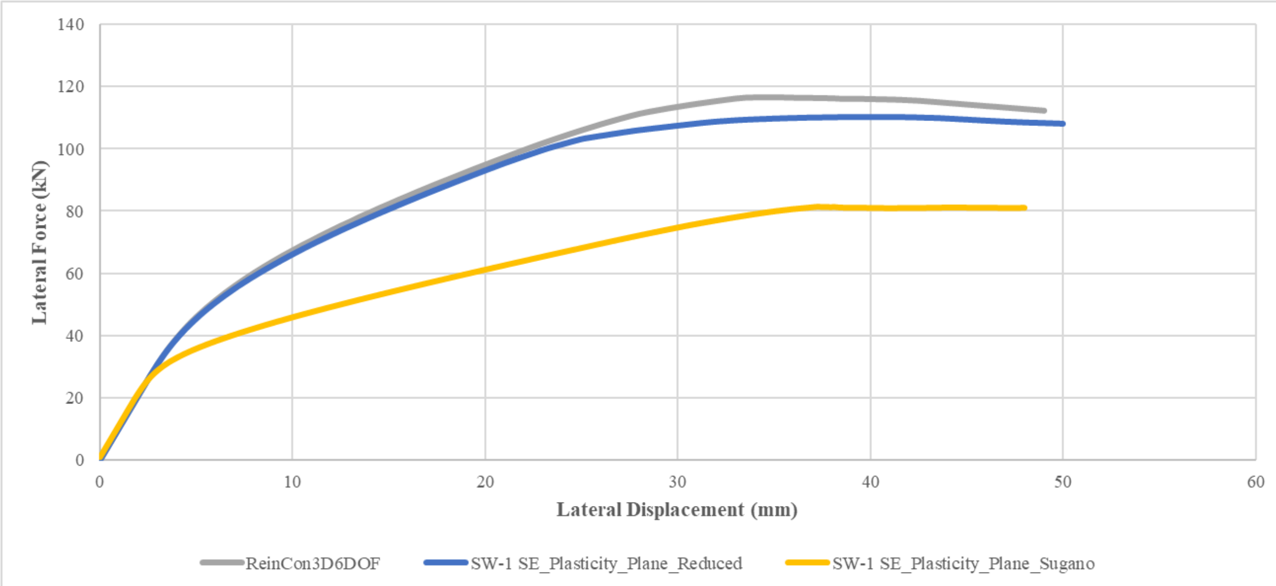


Figure 5-21. Load - deflection curve for the elongated SW-1

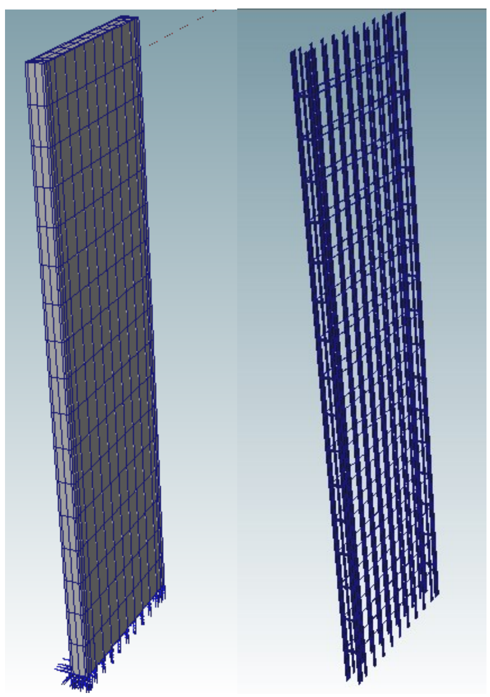


Figure 5-22. Depiction of the elongated G15(Left: meshed version, Right: reinforcements)

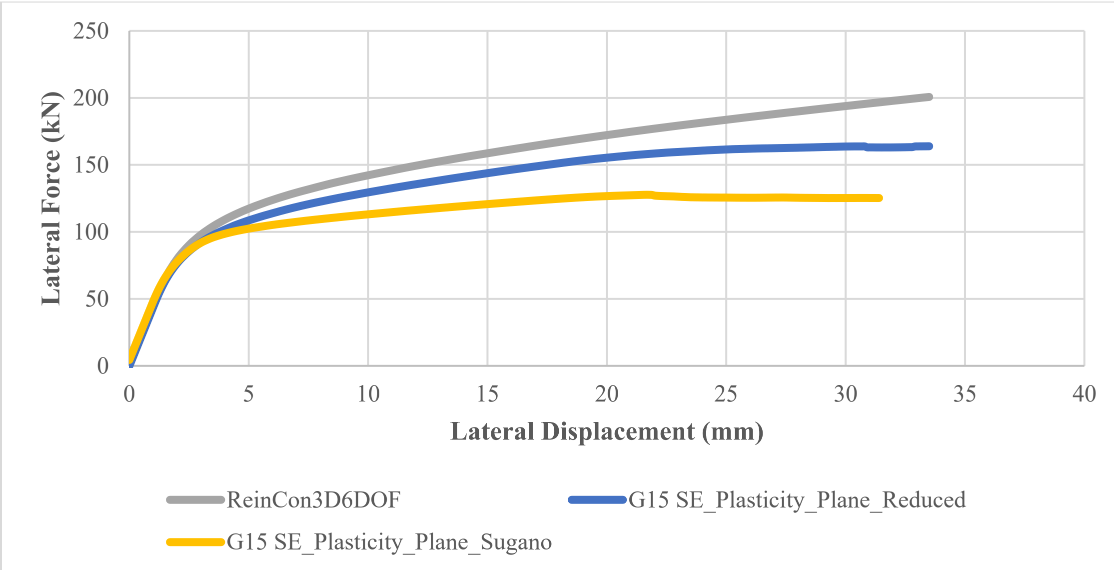


Figure 5-23. Load - deflection curve for the elongated G15

5.5.Limitations

As observed from section 5.2, the proposed modelling program has some limitation that need further investigation. calibration and sensitivity studies are needed to limit any discrepancy that was observed in this work.

Conclusions

Two nonlinear structural analysis tools were developed. The first one employs 3D solid-type Finite Elements whereas the second one employs 1D 2-node Finite Elements for modelling of structural components. The tool was equipped with easy model generation and graphical representation options in order to reduce the risk of modelling errors. The inelastic material behaviour of steel reinforcements bars has also been considered in the analysis. Details of a proposed multi-axial elasto-plastic material model that can be used for the simulation of the concrete material under both tension and compression were described. The formulation for the material is implemented in the context of a 3D solid-element and 1D beam-element based formulations. 1D beam formulation was implemented using two alternative material models. The reduced model is obtained by removing all 3D stresses except the beams axial and vertical shear stress acting on the cross-section. On the other hand, what is referred to as the Sugano model is a uni-axial model which only considers the axial stress-strain relations along the longitudinal fibre. The modelling approach was used for simulating the behaviour of shear walls and beams under static loading causing tension and compression in various parts of the structural components. The model predictions were compared with three experimental results from literature as well as models developed in ABAQUS commercial software. Good agreement between the results were observed between the alternative modelling approaches.

Future work recommendation

Future research work can be conducted in the following topics:

- **Alternative structural elements such as columns as well as stirrup and rebar arrangements can be tested to illustrate the performance of the developed tool.**
- **A sensitivity study on material parameters can be conducted to illustrate the effects on structural behaviour.**
- **Performance of alternative yield and potential surface types of the plasticity model can be tested.**
- **The elasto-plastic material model can be extended to include a damage component to be able to simulate structures under cyclic loads.**

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APPENDIX 1

SE_Plasticity_Plane User Guide

A1.1. Data entry and solutions

Program accepts a group of input data files with .TXT extension and creates another group of output files with. DAC extension.

A1.1.1. Input files for static 1D Beam-Type model

The input files required for the 1D Beam-Type model analyses are:

- **CoorBOUNDSE**
- **CoorLoadSE**
- **GEOSE**
- **PROPERTY_CONCRETE**
- **ReinforcementSE**
- **SEC**
- **Solution_ParameterSE**
- **Step_Guide**
- **SWITCHB**
- **Current_PlasticDamageParam**

A1.1.2. Output files for static 1D Beam-Type model

The output files created after the 1D Beam-Type model static analysis

- **DEP_X**
- **DEP_Y**
- **ELEM_MATRIX**
- **INPUT_CHECK**

- **Lamda**
- **ROT_Z**
- **STATIC_DISPLACEMENTS**
- **TRANS**

A1.2. Input files

- **CoorBOUNDSE.TXT: Support Information**

-EnterWithKeywords-

EnterNewBoundaryCoordinatesYorN: Y for a new boundary condition

BoundaryCoordinatesX-Y: Coordinates at which the support is applied

FixedDirection: 1 for horizontal and 2 for vertical

EnterNewBoundaryCoordinatesYorN: If there is no support information put N

- **CoorLoadSE.TXT**: Nodal loads

-EnterWithKeywords-

EnterNewLoadCoordinatesYorN: Y for a new load

LoadCoordinatesX-Y: Coordinate at which the node is applied

LoadDirection: Direction of the nodal loading (1 or 2)

LoadValue: Value of the nodal loading

EnterNewLoadCoordinatesYorN: If there is no loading information put N

- **GEOSE.TXT: Structural geometry information**

-EnterWithKeywords-

NumNodes:

NumElems:

NodeCoor: *X-Coordinate, Y-Coordinate*

ElemConnect:

- **PROPERTY_CONCRETE.TXT: Properties of the concrete bulk**

-EnterWithKeywords-

ConcreteElasticityModulus: Modulus of elasticity, E

ConcretePoissonRatio: Poisson ratio, μ

ConcreteCompressiveStress: Compressive Stress, f_c

OnsetRatioPlaticFlow:

CompressivePeakStrain:

ConcreteTensileStress:

TensionSofteningPower:

FactorIntersectTensionCompressionSurface:

PotentialSurfaceType:

SlopeLinearPotentialSurface:

TensionSurfaceType1Rankine_2Mixed:

CornerReturnTypeAssociative0orNon1:

DamageEvolutionFactorCompression:

DamageEvolutionFactorTension:

AnalysisTypeIsotropic0Anisotropic1:

ConfinementCoefficientXdirection:

ConfinementCoefficientYdirection:

ProducePlasticReturnGraphAtSpecificPointYorN:

- **ReinforcementSE.TXT: Properties of the reinforcements**

-EnterWithKeywords-

NumberOfRebarProperties:

NumberOfRebarsInTheGroup:

RebarElasticityModulusOfTheGroup:

RebarYieldStressOfTheGroup:

RebarHardeningModulusOfTheGroup:

RebarAreaAndLocationInEachGroup:

ApplyAllElementsYorN:

EnterStirrupsYorN:

ReportReinforcementPlasticReturn:

- **SEC.TXT: Cross section of the concrete bulk**

-EnterWithKeywords-

EnterWidthDepthEachElement: The width and depth of the bulk

- **Solution_ParameterSE.TXT: Parameters needed for running**

-EnterWithKeywords-

ElementType:

NumIntPoint:

SectionWidthIntegPoint:

SectionHeightIntegPoint:

AnalysisTypeNoShear0Shear1:

AnalysisTypeStatic1Dynamic2Both3:

ControlTypeLoad1Displacement2:

ControlNodeCoordinates:

ControlDirection:

StepSize:

StepNumberLimit:

HardeningType_1volum_2mixed:

HardeningUpdateLevel_1GlobalStep_2GlobalIteration_3PlasticIteration:

PlasticReturnType_1CuttingPlane_2CPP:

AlgorithmStabilizationYorN:

PlasticReturnIterationLimit:

ViscosityRate_0Independent_1ViscoPlastic_2ViscosRegularization:

GlobalAlgorithm_ErrorMargin:

PlasticityAlgorithm_ErrorMargin:

- **Step_Guide.TXT: Setting the number of cycles**

-EnterWithKeywords-

NumberOfCycles:

ControlType1or2:

NumberOfStepsEachCycle:

- **SWITCHB.TXT: Activating option to consider during analysis**

-EnterWithKeywords-

LoadGenerateUsingCoordinatesYorN:

BoundaryGenerateUsingCoordinatesYorN:

MassGenerateUsingCoordinatesYorN:

- **Current_PlasticDamageParam: Parameters of analysis**

-EnterWithKeywords-

MaterialModels_1Reduce3D_2Direct1DSugano_3Direct1DSaatchi:

DirectUniaxialModelPostpeakCalibrationFactor:

CurrentCompressionPlasticityParameter:

CurrentTensionPlasticityParameter:

CurrentCompressionDamageParameter:

CurrentTensionDamageParameter:

Solution_ParameterSE, *SWITCHB and Current_PlasticDamageParam.txt* files are analysis information needed to smoothly run the program. The analysis type, the choice of solution control, Step size, Step number limit and stabilization parameters are defined. We didn't need them in this work. NumIntPoint: the number of integration points refers to the discretization of an element into smaller segments for numerical computation. In this program, integration is defined along the length of the element and on the cross section of the element. Analysis Type: is whether the run will be shear or non-shear based. In this work, the analysis type chosen is shear based.

Displacement control was employed for the analysis of structural elements in this work. Control Node Coordinates or Control Node Number is the coordinates of interest. The program gives the outputs based on this coordinate. In SWITCHB, that's where commands are activated or disactivated. There were introduced to give options to the user on how to use the program. There is a choice of using coordinates or nodes to apply load, supports or mass (in case it is dynamic analysis).

A1.3. Example 1. Beam Analysis

The beam ISO30-1 is 200 mm wide and 300 mm high, as shown in Figure 4-8 to Figure 4-10, it is supported on a span of 3000 mm and is subjected to two equal loads symmetrically placed about the mid-span. The modulus of elasticity of concrete is 32 GPa and f_c=44 MPa. Yielding stress for steel rebars is taken as 480 MPa, the ultimate strength is taken as 600 MPa and the modulus of elasticity is taken as 200 GPa. Conventional steel stirrups (10 mm diameter) is used in the non-constant moment zones, to prevent shear failure. The diameter of the reinforcement is maintained constant (19.1 mm diameter) and this beam is reinforced by two identical rebar as resumed in Figure 4-8.

A1.3.1. Input files

GEOSE.TXT

The geometry of the member to be analyzed is defined. The number of nodes, number of elements and each nodes' coordinates. For the example given, the member is 3000mm and is divided in 30 members (31 nodes). ElemConnect stands for the connection of each node.

defined.

```
GEOSE
File    Edit    View
-EnterWithKeywords-
NumNodes:
   31
NumElems:
   30
NodeCoor:
        0.0000 ,      0.0000
        100.0000 ,    0.0000
        200.0000 ,    0.0000
        300.0000 ,    0.0000
        400.0000 ,    0.0000
        500.0000 ,    0.0000
        600.0000 ,    0.0000
        700.0000 ,    0.0000
        800.0000 ,    0.0000
        900.0000 ,    0.0000
        1000.0000 ,   0.0000
        1100.0000 ,   0.0000
        1200.0000 ,   0.0000
        1300.0000 ,   0.0000
        1400.0000 ,   0.0000
        1500.0000 ,   0.0000
        1600.0000 ,   0.0000
        1700.0000 ,   0.0000
        1800.0000 ,   0.0000
        1900.0000 ,   0.0000
        2000.0000 ,   0.0000
        2100.0000 ,   0.0000
        2200.0000 ,   0.0000
        2300.0000 ,   0.0000
        2400.0000 ,   0.0000
        2500.0000 ,   0.0000
        2600.0000 ,   0.0000
        2700.0000 ,   0.0000
        2800.0000 ,   0.0000
        2900.0000 ,   0.0000
        3000.0000 ,   0.0000
ElemConnect:
      1 ,     2
      2 ,     3
      3 ,     4
      4 ,     5
      5 ,     6
      6 ,     7
      7 ,     8
      8 ,     9
      9 ,    10
     10 ,    11
     11 ,    12
     12 ,    13
     13 ,    14
     14 ,    15
     15 ,    16
     16 ,    17
     17 ,    18
     18 ,    19
     19 ,    20
     20 ,    21
     21 ,    22
     22 ,    23
     23 ,    24
     24 ,    25
     25 ,    26
     26 ,    27
     27 ,    28
     28 ,    29
     29 ,    30
     30 ,    31
```

PROPERTY_CONCRETE.TXT

The solver requires the concrete material properties in order to analyze the system. Concrete Elasticity Modulus, Poisson Ratio, Compressive Stress, Tensile stress, peak strain and Onset ratio Plastic Flow are defined.

PROPERTY_CONCRETE

File Edit View

```
-EnterWithKeywords-
ConcreteElasticityModulus:
  32000.0000000000
ConcretePoissonRatio:
 0.150000000000000
ConcreteCompressiveStress:
 -46.0000000000000
OnsetRatioPlaticFlow:
 0.14
CompressivePeakStrain:
-0.0022
ConcreteTensileStress:
  2.0
TensionSofteningPower:
 0.27
FactorIntersectTensionCompressionSurface:
  1.50000000000000
PotentialSurfaceType:
           1
SlopeLinearPotentialSurface:
 0.150000000000000
TensionSurfaceType1Rankine_2Mixed:
XXX
CornerReturnTypeAssociative0orNon1:
XXX
DamageEvolutionFactorCompression:
XXX
DamageEvolutionFactorTension:
XXX
AnalysisTypeIsotropic0Anisotropic1:
XXX
ConfinementCoefficientXdirection:
XXX
ConfinementCoefficientYdirection:
XXX
ProducePlasticReturnGraphAtSpecificPointYorN:
XXX
```

CoorBOUNDSE.TXT

In order to analyse the system, the finite element solver requires boundary conditions to be defined. Boundary conditions should be able to provide equilibrium to the system. In this example, the beam is supported at each end in such a way that it can freely rotate and translate vertically, it cannot resist horizontal movement and. Y means Yes there is support at coordinate X-Y, 1 means it is fixed in global X-direction and 2 means fixed in global Y-direction.

```
CoorBOUNDSE
File    Edit    View

-EnterWithKeywords-
 EnterNewBoundaryCoordinatesYorN:
Y
 BoundaryCoordinatesX-Y:
    0.00,0.00
 FixedDirection:
    1
 EnterNewBoundaryCoordinatesYorN:
Y
 BoundaryCoordinatesX-Y:
    0.00,0.00
 FixedDirection:
    2
 EnterNewBoundaryCoordinatesYorN:
Y
 BoundaryCoordinatesX-Y:
    3000.00,0.00
 FixedDirection:
    2
 EnterNewBoundaryCoordinatesYorN:
N
```

CoorLoadSE.TXT

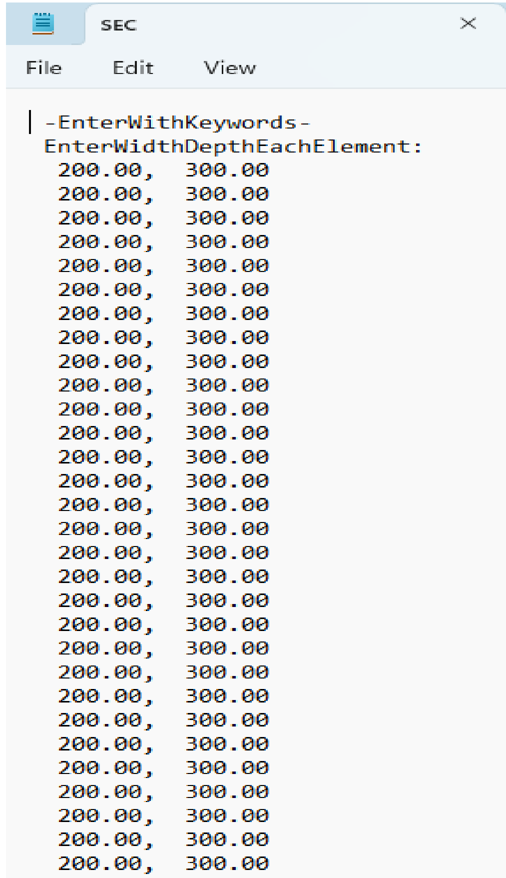
Nodal load data is inputted. As shown in below, the coordinate where the load is applied is defined and the direction of the load which is perpendicular to the direction of the member. The load value is in N. The program has also the capabilities to support multiple loading points.

```
CoorLoadSE
File    Edit    View

 -EnterWithKeywords-
 EnterNewLoadCoordinatesYorN:
Y
 LoadCoordinatesX-Y:
   1000.000000000000,0.00000000000
 LoadDirection:
     2
 LoadValue:
 -0.4000E+06
 EnterNewLoadCoordinatesYorN:
Y
 LoadCoordinatesX-Y:
   2000.000000000000,0.00000000000
 LoadDirection:
     2
 LoadValue:
 -0.4000E+06
 EnterNewLoadCoordinatesYorN:
N
```

Current_PlasticDamageParam.TXT

```
Current_PlasticDamageParam
File    Edit    View

-EnterWithKeywords-
MaterialModels_1Reduce3D_2Direct1DSugano_3Direct1DSaatchi:
2
DirectUniaxialModelPostpeakCalibrationFactor:
XXX
CurrentCompressionPlasticityParameter:
XXX
CurrentTensionPlasticityParameter:
XXX
CurrentCompressionDamageParameter:
XXX
CurrentTensionDamageParameter:
XXX
```

SEC.TXT



```
SEC
File    Edit    View

-EnterWithKeywords-
EnterWidthDepthEachElement:
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
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 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
 200.00,  300.00
```

ReinforcementSE.TXT

In this .TXT file longitudinal and transversal reinforcements are inputted.

Number of rebar properties stands for group of longitudinal reinforcements in the whole member, i.e. in the following figure, there is a specific property for reinforcements in compression zone that are different from what is in tension zone hence 2.

Number of rebars in the group is the number of rebars in a specific group of reinforcements with the same properties. The Elastic modulus, yield and hardening stress of the bars in this specific group are defined. The cross-sectional area of each bar in the group and its location in the cross section of the member are defined. This step should be repeated in respect to the number of rebar properties set previously. In case there is ties in the member, *EnterStirrupsYorN* is set to Y as shown in the **Error! Reference source not found.**. The average spacing between them is also defined and their cross-sectional area.

ReinforcementSE

File Edit View

```
-EnterWithKeywords-
NumberOfRebarProperties:
          2
NumberOfRebarsInTheGroup:
          2
RebarElasticityModulusOfTheGroup:
  42000
RebarYieldStressOfTheGroup:
  689.0
RebarHardeningModulusOfTheGroup:
 1000.0
RebarAreaAndLocationInEachGroup:
   286.4
 -75.00, -125.00
   286.4
  75.00, -125.00
NumberOfRebarsInTheGroup:
          2
RebarElasticityModulusOfTheGroup:
  200000.000000000
RebarYieldStressOfTheGroup:
  480.000000000000
RebarHardeningModulusOfTheGroup:
 600.0
RebarAreaAndLocationInEachGroup:
   78.5
 -75.00,  125.00
   78.5
  75.00,  125.00
ApplyAllElementsYorN:
Y
NumberOfRebarGroupsUsedInEachElement:
          1
RebarGroupNoForEachElement:
          1
EnterStirrupsYorN:
Y
AverageSpacingOfStirrups:
  100
AreaOfStrirrupsWithinEachSpacing:
   78.5
ReportReinforcementPlasticReturn:
N
```

Solution_ParameterSE.TXT

Solution_ParameterSE

File Edit View

```
-EnterWithKeywords-
ElementType:
           1
NumIntPoint:
           3
SectionWidthIntegPoint:
           3
SectionHeightIntegPoint:
          12
AnalysisTypeNoShear0Shear1:
           1
AnalysisTypeStatic1Dynamic2Both3:
           1
ControlTypeLoad1Displacement2:
           2
ControlNodeCoordinates:
 2000.00000000000000,0.00000000000
ControlNodeNumber:
          22
ControlDirection:
           2
StepSize:
-1.00000000000000
StepNumberLimit:
         56
PlasticReturnType_1CuttingPlane_2CPP:
           1
AlgorithmStabilizationYorN:
N
DenominatorAmplificationFactor:
  1.00000000000000
PenaltyFactorLagrangian:
 0.000000000000000E+000
PlasticReturnIterationLimit:
        1000
ViscosityRate_0Independent_1ViscoPlastic_2ViscosRegularization:
           0
ViscoPlasticRetardationTime:
 0.000000000000000E+000
ViscoPlasticTimeIncrement:
 0.000000000000000E+000
```

Step_Guide.TXT

Step_Guide

File Edit View

```
-EnterWithKeywords-
NumberOfCycles:
1
ControlType1or2:
1
NumberOfStepsEachCycle:
1000
ControlValuesEachCycle:
XXX
```

SWITCHB.TXT

SWITCHB

File Edit View

```
-EnterWithKeywords-
LoadGenerateUsingCoordinatesYorN:
Y
BoundaryGenerateUsingCoordinatesYorN:
Y
MassGenerateUsingCoordinatesYorN:
XXX
```

A1.3.2. Input check

INPUT_CHECK - Notepad

File Edit Format View Help

```
****************Start Time*******************
         17 :           57 :           56 :          534

-------------------------------------------------------------------------
     ***Enter the Names of Plasticity Related Output files***

***Choose from the below list of Possible Output files***

***List of Possible Output files***

to be addressed at ListOutputFileSE.txt

                   ---Lamda.DAC---
           ---STATIC_DISPLACEMENTS.DAC---
                   ---DEP_X.DAC---
                   ---DEP_Y.DAC---
                   ---ROT_Z.DAC---

           ---PLASTIC_RETURN_LOG_FILE.DAC---
               ---InstantDrawFiles---
             ---SURFACE_AND_RETURN.TXT---
            ---StressConvergenceChase---


-------------------------------------------------------------------------
Number of pieces along an element           3
Number of pieces along width b of the Cross-section            3
Number of pieces along height h of the Cross-section           12

COORDINATES OF NODES
        NOD       X(mm)              Y(mm)
         1       0.0000000        0.0000000
         2     100.0000000        0.0000000
         3     200.0000000        0.0000000
         4     300.0000000        0.0000000
         5     400.0000000        0.0000000
         6     500.0000000        0.0000000
         7     600.0000000        0.0000000
         8     700.0000000        0.0000000
         9     800.0000000        0.0000000
        10     900.0000000        0.0000000
        11    1000.0000000        0.0000000
        12    1100.0000000        0.0000000
        13    1200.0000000        0.0000000
        14    1300.0000000        0.0000000
        15    1400.0000000        0.0000000
        16    1500.0000000        0.0000000
        17    1600.0000000        0.0000000
        18    1700.0000000        0.0000000
        19    1800.0000000        0.0000000
        20    1900.0000000        0.0000000
        21    2000.0000000        0.0000000
        22    2100.0000000        0.0000000
        23    2200.0000000        0.0000000
        24    2300.0000000        0.0000000
        25    2400.0000000        0.0000000
        26    2500.0000000        0.0000000
        27    2600.0000000        0.0000000
        28    2700.0000000        0.0000000
        29    2800.0000000        0.0000000
        30    2900.0000000        0.0000000
        31    3000.0000000        0.0000000

      ELEMENT        I END          J END        LENGTH (mm)
         1              1              2       100.00000000
         2              2              3       100.00000000
         3              3              4       100.00000000
         4              4              5       100.00000000
         5              5              6       100.00000000
         6              6              7       100.00000000
         7              7              8       100.00000000
         8              8              9       100.00000000
         9              9             10       100.00000000
        10             10             11       100.00000000
        11             11             12       100.00000000
        12             12             13       100.00000000
        13             13             14       100.00000000
```

INPUT_CHECK - Notepad

File Edit Format View Help

```
       13              13              14       100.00000000
       14              14              15       100.00000000
       15              15              16       100.00000000
       16              16              17       100.00000000
       17              17              18       100.00000000
       18              18              19       100.00000000
       19              19              20       100.00000000
       20              20              21       100.00000000
       21              21              22       100.00000000
       22              22              23       100.00000000
       23              23              24       100.00000000
       24              24              25       100.00000000
       25              25              26       100.00000000
       26              26              27       100.00000000
       27              27              28       100.00000000
       28              28              29       100.00000000
       29              29              30       100.00000000
       30              30              31       100.00000000

 Loads are generated using Coordinates
      Load No      11            in direction     2          applied at    1000.00      0.00
      Load No      21            in direction     2          applied at    2000.00      0.00
 ----------------------------------------------

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

 Boundary Conditions are generated using Coordinates
          BC applied in direction    1   at      0.00      0.00
          BC applied in direction    2   at      0.00      0.00
          BC applied in direction    2   at   3000.00      0.00
 ----------------------------------------------

 Multiple-Point Constraints are imposed directly to nodes
 ----------------------------------------------

 FactorIntersectTensionCompressionSurface    1.50000000000000

 PROPERTIES OF SOLID

 Ec          nu         fc            ft         ko       eps_c     P_type   al_p
   N/mm2                  N/mm2         N/mm2
0.3200E+05   0.15   -46.0000    2.0000      0.1400   -0.002200     1    0.150

       Kbu                                  G
      N/mm2                              N/mm2
   15238.0952380952            13913.0434782609

 Factor to make sure Tension Surface and Mentrey-Willam Intersects
   1.50000000000000
  -------

 P_type=1 Linear | P_type=2 Higher order Potential func (al_p=2 Quadratic)
 T_type=1 Rankine surface | T_type=2 Mixed surface with Cut-off

 ----------------------------------------------------
 ------If T_Type =1 --------***Suggested numbers***----
 ksi_t0= 1.45*ft/afc | But we read si_to | So enter approximately  1.45
 ----------------------------------------------------
 ------If T_Type =2 --------***Suggested numbers***----
 ksi_m0=-2.5/afc     | But we read si_mo | So enter approximately -2.5
 ksi_t0= 1.45*ft/afc | But we read si_to | So enter approximately  1.45
 Ro_t0 =1.05 /afc    | But we read o_to  | So enter approximately  1.05
     0<mkf<1         |   rate_vkm<1
 ----------------------------------------------------
   T_type     ksi_m0    ksi_t0      Ro_t0       n3         Fdamc      Fdamt
  1      0.0000    0.0000    0.0000    0.2700     0.0000    0.000000

   Isotropic Analysis Type 0 | Anisotropic Analysis Type 1
   IA_type =            0


  gama1=   0.000000000000000E+000

  gama2=   0.000000000000000E+000
 ----------------------------------------------------

  Output NOT generated for any Plastic return scenario for the Concrete Beam
```

INPUT_CHECK - Notepad

File Edit Format View Help

```
 Output NOT generated for any Plastic return scenario for the Concrete Beam

----------
Number of Reinforcement Groups with different Properties           2
Number of Reinforcement Bars in Group           1 is           2
--------For the Reinforcement Group--------------
  Er  =   42000.0000000000
sig_y =   689.000000000000
  Hr  =   1000.00000000000

Number of Reinforcement Bars in Group           2 is           2
--------For the Reinforcement Group--------------
  Er  =   200000.000000000
sig_y =   480.000000000000
  Hr  =   600.000000000000

Number of total re-bars within the Cross-section           4
Properties of the Reinforcement
 Mem  =            1
Num  Location x   Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
---------------------------------------
 Mem  =            2
Num  Location x   Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
---------------------------------------
 Mem  =            3
Num  Location x   Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
---------------------------------------
 Mem  =            4
Num  Location x   Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
---------------------------------------
 Mem  =            5
Num  Location x   Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
---------------------------------------
 Mem  =            6
Num  Location x   Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
---------------------------------------
 Mem  =            7
Num  Location x   Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
---------------------------------------
 Mem  =            8
Num  Location x   Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
---------------------------------------
 Mem  =            9
Num  Location x   Location y Area
  1   -75.0000  -125.0000  .2864E+03
```

INPUT_CHECK - Notepad

File Edit Format View Help

```
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
 ---------------------------------------
  Mem   =           10
 Num  Location x    Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
 ---------------------------------------
  Mem   =           11
 Num  Location x    Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
 ---------------------------------------
  Mem   =           12
 Num  Location x    Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
 ---------------------------------------
  Mem   =           13
 Num  Location x    Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
 ---------------------------------------
  Mem   =           14
 Num  Location x    Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
 ---------------------------------------
  Mem   =           15
 Num  Location x    Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
 ---------------------------------------
  Mem   =           16
 Num  Location x    Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
 ---------------------------------------
  Mem   =           17
 Num  Location x    Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
 ---------------------------------------
  Mem   =           18
 Num  Location x    Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
 ---------------------------------------
  Mem   =           19
 Num  Location x    Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
 ---------------------------------------
  Mem   =           20
 Num  Location x    Location y Area
```

INPUT_CHECK - Notepad

File Edit Format View Help

```
Num  Location x   Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
 ----------------------------------------
 Mem  =           21
Num  Location x   Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
 ----------------------------------------
 Mem  =           22
Num  Location x   Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
 ----------------------------------------
 Mem  =           23
Num  Location x   Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
 ----------------------------------------
 Mem  =           24
Num  Location x   Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
 ----------------------------------------
 Mem  =           25
Num  Location x   Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
 ----------------------------------------
 Mem  =           26
Num  Location x   Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
 ----------------------------------------
 Mem  =           27
Num  Location x   Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
 ----------------------------------------
 Mem  =           28
Num  Location x   Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
 ----------------------------------------
 Mem  =           29
Num  Location x   Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
 ----------------------------------------
 Mem  =           30
Num  Location x   Location y Area
  1   -75.0000  -125.0000  .2864E+03
  2    75.0000  -125.0000  .2864E+03
  3   -75.0000   125.0000  .7850E+02
  4    75.0000   125.0000  .7850E+02
 ----------------------------------------
 _*************************************_
```

INPUT_CHECK - Notepad

File Edit Format View Help

```
 Output NOT generated for any Plastic return scenario for the Reinforcement

----------

CROSS-SECTIONAL PROPERTIES including Reinforcement
Mem       EA        EIx
         mm2        mm4

  1 .20E+10 .1517E+14
  2 .20E+10 .1517E+14
  3 .20E+10 .1517E+14
  4 .20E+10 .1517E+14
  5 .20E+10 .1517E+14
  6 .20E+10 .1517E+14
  7 .20E+10 .1517E+14
  8 .20E+10 .1517E+14
  9 .20E+10 .1517E+14
 10 .20E+10 .1517E+14
 11 .20E+10 .1517E+14
 12 .20E+10 .1517E+14
 13 .20E+10 .1517E+14
 14 .20E+10 .1517E+14
 15 .20E+10 .1517E+14
 16 .20E+10 .1517E+14
 17 .20E+10 .1517E+14
 18 .20E+10 .1517E+14
 19 .20E+10 .1517E+14
 20 .20E+10 .1517E+14
 21 .20E+10 .1517E+14
 22 .20E+10 .1517E+14
 23 .20E+10 .1517E+14
 24 .20E+10 .1517E+14
 25 .20E+10 .1517E+14
 26 .20E+10 .1517E+14
 27 .20E+10 .1517E+14
 28 .20E+10 .1517E+14
 29 .20E+10 .1517E+14
 30 .20E+10 .1517E+14

--------------------------------------
  BOUNDARY CONDITIONS
     FIXED NODE     FIXED DIRECTION
          1             GLOBAL X DIRECTION
          1             GLOBAL Y DIRECTION
         31             GLOBAL Y DIRECTION


 NODAL LOADS
NODE   LOADING TYPE          DIRECTION           P     M
                                                 N    Nmm
 11    CONCENTRATED P           GLOBAL Y -.4000E+06
 21    CONCENTRATED P           GLOBAL Y -.4000E+06

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

 CONSTANT NODAL LOADS
NODE   LOADING TYPE          DIRECTION          CP    CM
                                                N    Nmm

------------------------------
Analysis type: 0 for No Shear| 1 for Including Shear
S_type =           1 selected
----------------------------------------------------------

Analysis type: 1 for Static only| 2 for Dynamic only| 3 for Both
          1 selected
----------------------------------------------------------


  The results are produced for            0  number of files

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

MaterialModels_1Reduce3D_2Direct1DSugano_3Direct1DSaatchi            2
DirectUniaxialModelPostpeakCalibrationFactor    4.00000000000000
CurrentCompressionPlasticityParameter   0.0000000000000000E+000
```

```
Analysis type: 1 for Static only| 2 for Dynamic only| 3 for Both
          1 selected
-----------------------------------------------------------


  The results are produced for            0  number of files

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

MaterialModels_1Reduce3D_2Direct1DSugano_3Direct1DSaatchi            2
DirectUniaxialModelPostpeakCalibrationFactor    4.00000000000000
CurrentCompressionPlasticityParameter   0.000000000000000E+000
CurrentTensionPlasticityParameter   0.000000000000000E+000
CurrentCompressionDamageParameter   0.000000000000000E+000
CurrentTensionDamageParameter   0.000000000000000E+000

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

Analysis Control type: Enter 1 for Load Control or Enter 2 for Displacement Con
trol           2
The control node number           21

Enter the direction: Enter 1 for X  Enter 2 for Y  Enter 3 for Z Rot
Control direction =           2 selected
Enter the step increment size  -1.00000000000000
How many steps do you want to continue          56

-------------------------------------------------------------------
Plastic return type: 1 for Cutting_plane | 2 for Closest Point Projection | 3 f
or Premono-Willam           1

Iteration limit to terminate plastic return        1000

Enter| 0  rate-independent | 1 visco-plastic | 2 viscous regularization
          0

Enter GlobalAlgorithm_ErrorMargin  9.999999974752427E-007

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

Enter PlasticityAlgorithm_ErrorMargin  9.999999747378752E-005

Number of cycles           1
C_type=           1
****************End of Static Analysis********************
         17 :          58 :           5 :         614
```

A1.3.3. Output files

- DEP_X, DEP_Y records deflections values along x and y-axis of the node selected in Solution_Parameters at the end of each step.

- Lamda is the factor to describe the amount of force that was required to have a respective deflection. This is later multiplied by the nodal load to get the Force-displacement graph.

- ELEM_MATRIX, ROT_Z, STATIC_DISPLACEMENTS and TRANS are additional outputs that describe the behavior of each element at the end of each step in the program run.

DEP_X

DEP_X - Notepad

File Edit Format View Help

```
4.116360761585035E-002
0.281169969664856
0.475288304387282
0.660083511869108
0.849770900731120
1.04381453507716
1.25990743901444
1.44377342296885
1.63062470403253
1.81879036133263
2.00827489418673
2.19940612704558
2.39159662271163
2.58442776833779
2.77809747443275
3.02398472350313
3.21759855711076
3.41072775949631
3.60393982894572
3.79705520395285
3.99018975164665
4.18255284535900
4.37574775825882
4.56933888515711
4.76394860223566
4.95862031357919
5.15357591370966
5.34935805888747
5.54539436315886
5.74249395136966
5.93957526199708
6.13664574627503
6.33273039611004
6.52907005430857
6.72514164015284
6.92108211161198
7.11695990782442
7.31287644277021
7.50884339940883
7.70471492175009
7.90141222653260
8.07648945507242
8.00377464173763
8.09672455762467
8.21446570308397
8.34712346252341
8.48308350782568
8.63472553621486
8.79151523849347
8.94532580982648
9.08989554839292
9.17256684959701
9.31725612313173
9.47128992497105
9.62709548353896
9.78072772281064
```

DEP_Y

DEP_Y - Notepad

File Edit Format View Help

```
-1.00000000000000
-2.00000000000000
-3.00000000000000
-4.00000000000000
-5.00000000000000
-6.00000000000000
-7.00000000000000
-8.00000000000000
-9.00000000000000
-10.0000000000000
-11.0000000000000
-12.0000000000000
-13.0000000000000
-14.0000000000000
-15.0000000000000
-16.0000000000000
-17.0000000000000
-18.0000000000000
-19.0000000000000
-20.0000000000000
-21.0000000000000
-22.0000000000000
-23.0000000000000
-24.0000000000000
-25.0000000000000
-26.0000000000000
-27.0000000000000
-28.0000000000000
-29.0000000000000
-30.0000000000000
-31.0000000000000
-32.0000000000000
-33.0000000000000
-34.0000000000000
-35.0000000000000
-36.0000000000000
-37.0000000000000
-38.0000000000000
-39.0000000000000
-40.0000000000000
-41.0000000000000
-42.0000000000000
-43.0000000000000
-44.0000000000000
-45.0000000000000
-46.0000000000000
-47.0000000000000
-48.0000000000000
-49.0000000000000
-50.0000000000000
-51.0000000000000
-52.0000000000000
-53.0000000000000
-54.0000000000000
-55.0000000000000
-56.0000000000000
```

ELEM_MATRIX

ELEM_MATRIX - Notepad

File Edit Format View Help

```
 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
 0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
-0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
 0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
 0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
-0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
 0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
 0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
-0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
 0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
 0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
-0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
 0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
 0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
-0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
 0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
 0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
-0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
 0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
 0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
-0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
 0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
 0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
-0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
```

ELEM_MATRIX - Notepad

File Edit Format View Help

```
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
 0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
 0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
-0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
 0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
 0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
-0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
 0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
 0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
-0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
 0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
 0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
-0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
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 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
 0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
-0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
 0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
 0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
-0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
 0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
 0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
-0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
 0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
 0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
```

ELEM_MATRIX - Notepad

File Edit Format View Help

```
-0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
 0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
 0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
-0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
 0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
 0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
-0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
 0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
 0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
-0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
 0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
 0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
-0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
 0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
 0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
-0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
 0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
 0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
-0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
 0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
 0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
-0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
 0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
 0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
 ELEMENT MATRIX
 0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
 0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
```

ELEM_MATRIX - Notepad

File Edit Format View Help

```
  0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
 -0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
  0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
  0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
  ELEMENT MATRIX
  0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
  0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
  0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
 -0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
  0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
  0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
  ELEMENT MATRIX
  0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
  0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
  0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
 -0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
  0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
  0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
  ELEMENT MATRIX
  0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
  0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
  0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
 -0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
  0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
  0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
  ELEMENT MATRIX
  0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
  0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
  0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
 -0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
  0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
  0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
  ELEMENT MATRIX
  0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
  0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
  0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
 -0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
  0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
  0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
  ELEMENT MATRIX
  0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
  0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
  0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
 -0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
  0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
  0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
  ELEMENT MATRIX
  0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
  0.00E+00  0.79E+07  0.40E+09  0.00E+00 -0.79E+07  0.40E+09
  0.00E+00  0.40E+09  0.17E+12  0.00E+00 -0.40E+09 -0.13E+12
 -0.20E+08  0.00E+00  0.00E+00  0.40E+08  0.00E+00  0.00E+00
  0.00E+00 -0.79E+07 -0.40E+09  0.00E+00  0.16E+08 -0.18E-06
  0.00E+00  0.40E+09 -0.13E+12  0.00E+00 -0.18E-06  0.34E+12
  ELEMENT MATRIX
  0.20E+08  0.00E+00  0.00E+00 -0.20E+08  0.00E+00  0.00E+00
```

Lamda

Lamda - Notepad

File Edit Format View Help

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3.026151795936299E-002
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2.750770044120694E-002
3.117517606565595E-002
3.465216345500333E-002
3.507234575133015E-002
3.965969447371862E-002
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4.835264820132004E-002
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5.677747503316505E-002
6.088229844716924E-002
6.497551875164372E-002
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7.123012840642685E-002
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9.328723266437623E-002
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ROT_Z

ROT_Z - Notepad

File Edit Format View Help

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3.716582273811857E-003
4.335040023802476E-003
4.686985222349597E-003
5.276635414337285E-003
5.876572615792627E-003
6.478951396467797E-003
7.077916441224118E-003
7.670768764672552E-003
8.255695232728580E-003
8.834278181304490E-003
9.408448409411827E-003
9.763250968144101E-003
1.034388449189690E-002
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1.153116932107992E-002
1.212990080917528E-002
1.272955023949256E-002
1.332949114321517E-002
1.392921852520180E-002
1.452821746456425E-002
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1.572343189958957E-002
1.631951542883192E-002
1.691452646761788E-002
1.750875390073846E-002
1.810260274153054E-002
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1.988338019518126E-002
2.047800421574057E-002
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2.166914003147511E-002
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2.405581705768581E-002
2.465306458236774E-002
2.528177156295101E-002
2.664833960173943E-002
2.754906943941359E-002
2.847029829633195E-002
2.939127868871120E-002
3.010797935444333E-002
3.079431801019134E-002
3.145906998634029E-002
3.209374979635106E-002
3.267905539797734E-002
3.286993654740209E-002
3.344417269512690E-002
3.404347211767455E-002
3.464858846561663E-002
3.525107843537614E-002
```

STATIC_DISPLACEMENTS

STATIC_DISPLACEMENTS - Notepad

File Edit Format View Help

```
NODAL DISPLACEMENTS   STEP           1
 NODE            X          Y        rZ

     1     0.00E+00  0.00E+00 -0.11E-02
     2     0.19E-05 -0.11E+00 -0.11E-02
     3     0.75E-05 -0.23E+00 -0.11E-02
     4     0.17E-04 -0.34E+00 -0.11E-02
     5     0.30E-04 -0.45E+00 -0.11E-02
     6     0.47E-04 -0.55E+00 -0.10E-02
     7     0.81E-04 -0.66E+00 -0.98E-03
     8     0.27E-03 -0.75E+00 -0.92E-03
     9     0.97E-03 -0.84E+00 -0.85E-03
    10     0.26E-02 -0.93E+00 -0.76E-03
    11     0.54E-02 -0.10E+01 -0.64E-03
    12     0.90E-02 -0.11E+01 -0.52E-03
    13     0.13E-01 -0.11E+01 -0.39E-03
    14     0.16E-01 -0.11E+01 -0.26E-03
    15     0.20E-01 -0.12E+01 -0.13E-03
    16     0.23E-01 -0.12E+01  0.26E-17
    17     0.27E-01 -0.12E+01  0.13E-03
    18     0.30E-01 -0.11E+01  0.26E-03
    19     0.34E-01 -0.11E+01  0.39E-03
    20     0.38E-01 -0.11E+01  0.52E-03
    21     0.41E-01 -0.10E+01  0.64E-03
    22     0.44E-01 -0.93E+00  0.76E-03
    23     0.46E-01 -0.84E+00  0.85E-03
    24     0.46E-01 -0.75E+00  0.92E-03
    25     0.46E-01 -0.66E+00  0.98E-03
    26     0.47E-01 -0.55E+00  0.10E-02
    27     0.47E-01 -0.45E+00  0.11E-02
    28     0.47E-01 -0.34E+00  0.11E-02
    29     0.47E-01 -0.23E+00  0.11E-02
    30     0.47E-01 -0.11E+00  0.11E-02
    31     0.47E-01  0.00E+00  0.11E-02
----------------------------------------
NODAL DISPLACEMENTS   STEP           2
 NODE            X          Y        rZ

     1     0.00E+00  0.00E+00 -0.21E-02
     2     0.12E-05 -0.21E+00 -0.21E-02
     3     0.49E-05 -0.42E+00 -0.21E-02
     4     0.11E-04 -0.63E+00 -0.21E-02
     5     0.20E-04 -0.84E+00 -0.21E-02
     6     0.31E-04 -0.10E+01 -0.20E-02
     7     0.57E-04 -0.12E+01 -0.20E-02
     8     0.22E-03 -0.14E+01 -0.20E-02
     9     0.86E-03 -0.16E+01 -0.19E-02
    10     0.45E-02 -0.18E+01 -0.18E-02
    11     0.22E-01 -0.20E+01 -0.16E-02
    12     0.48E-01 -0.21E+01 -0.13E-02
    13     0.74E-01 -0.23E+01 -0.95E-03
    14     0.10E+00 -0.23E+01 -0.63E-03
    15     0.13E+00 -0.24E+01 -0.32E-03
    16     0.15E+00 -0.24E+01  0.71E-17
    17     0.18E+00 -0.24E+01  0.32E-03
    18     0.20E+00 -0.23E+01  0.63E-03
    19     0.23E+00 -0.23E+01  0.95E-03
    20     0.26E+00 -0.21E+01  0.13E-02
    21     0.28E+00 -0.20E+01  0.16E-02
    22     0.30E+00 -0.18E+01  0.18E-02
    23     0.30E+00 -0.16E+01  0.19E-02
    24     0.30E+00 -0.14E+01  0.20E-02
    25     0.30E+00 -0.12E+01  0.20E-02
    26     0.30E+00 -0.10E+01  0.20E-02
    27     0.30E+00 -0.84E+00  0.21E-02
    28     0.30E+00 -0.63E+00  0.21E-02
    29     0.30E+00 -0.42E+00  0.21E-02
    30     0.30E+00 -0.21E+00  0.21E-02
    31     0.30E+00  0.00E+00  0.21E-02
----------------------------------------
NODAL DISPLACEMENTS   STEP           3
```

STATIC_DISPLACEMENTS - Notepad

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```
NODAL DISPLACEMENTS   STEP           3
 NODE            X          Y        rZ

     1     0.00E+00  0.00E+00 -0.31E-02
     2     0.14E-05 -0.31E+00 -0.31E-02
     3     0.58E-05 -0.63E+00 -0.31E-02
     4     0.13E-04 -0.94E+00 -0.31E-02
     5     0.23E-04 -0.13E+01 -0.31E-02
     6     0.36E-04 -0.16E+01 -0.30E-02
     7     0.64E-04 -0.19E+01 -0.30E-02
     8     0.23E-03 -0.22E+01 -0.30E-02
     9     0.14E-02 -0.25E+01 -0.29E-02
    10     0.13E-01 -0.27E+01 -0.27E-02
    11     0.45E-01 -0.30E+01 -0.23E-02
    12     0.88E-01 -0.32E+01 -0.19E-02
    13     0.13E+00 -0.34E+01 -0.14E-02
    14     0.17E+00 -0.35E+01 -0.94E-03
    15     0.22E+00 -0.36E+01 -0.47E-03
    16     0.26E+00 -0.36E+01  0.10E-16
    17     0.30E+00 -0.36E+01  0.47E-03
    18     0.35E+00 -0.35E+01  0.94E-03
    19     0.39E+00 -0.34E+01  0.14E-02
    20     0.43E+00 -0.32E+01  0.19E-02
    21     0.48E+00 -0.30E+01  0.23E-02
    22     0.51E+00 -0.27E+01  0.27E-02
    23     0.52E+00 -0.25E+01  0.29E-02
    24     0.52E+00 -0.22E+01  0.30E-02
    25     0.52E+00 -0.19E+01  0.30E-02
    26     0.52E+00 -0.16E+01  0.30E-02
    27     0.52E+00 -0.13E+01  0.31E-02
    28     0.52E+00 -0.94E+00  0.31E-02
    29     0.52E+00 -0.63E+00  0.31E-02
    30     0.52E+00 -0.31E+00  0.31E-02
    31     0.52E+00  0.00E+00  0.31E-02
----------------------------------------
NODAL DISPLACEMENTS   STEP           4
 NODE            X          Y        rZ

     1     0.00E+00  0.00E+00 -0.42E-02
     2     0.17E-05 -0.42E+00 -0.42E-02
     3     0.68E-05 -0.84E+00 -0.42E-02
     4     0.15E-04 -0.13E+01 -0.41E-02
     5     0.27E-04 -0.17E+01 -0.41E-02
     6     0.42E-04 -0.21E+01 -0.41E-02
     7     0.94E-04 -0.25E+01 -0.40E-02
     8     0.62E-03 -0.29E+01 -0.40E-02
     9     0.49E-02 -0.33E+01 -0.39E-02
    10     0.28E-01 -0.37E+01 -0.36E-02
    11     0.76E-01 -0.40E+01 -0.31E-02
    12     0.13E+00 -0.43E+01 -0.24E-02
    13     0.19E+00 -0.45E+01 -0.18E-02
    14     0.25E+00 -0.46E+01 -0.12E-02
    15     0.31E+00 -0.47E+01 -0.61E-03
    16     0.37E+00 -0.48E+01  0.12E-16
    17     0.43E+00 -0.47E+01  0.61E-03
    18     0.48E+00 -0.46E+01  0.12E-02
    19     0.54E+00 -0.45E+01  0.18E-02
    20     0.60E+00 -0.43E+01  0.24E-02
    21     0.66E+00 -0.40E+01  0.31E-02
    22     0.71E+00 -0.37E+01  0.36E-02
    23     0.73E+00 -0.33E+01  0.39E-02
    24     0.74E+00 -0.29E+01  0.40E-02
    25     0.74E+00 -0.25E+01  0.40E-02
    26     0.74E+00 -0.21E+01  0.41E-02
    27     0.74E+00 -0.17E+01  0.41E-02
    28     0.74E+00 -0.13E+01  0.41E-02
    29     0.74E+00 -0.84E+00  0.42E-02
    30     0.74E+00 -0.42E+00  0.42E-02
    31     0.74E+00  0.00E+00  0.42E-02
----------------------------------------
NODAL DISPLACEMENTS   STEP           5
```

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NODAL DISPLACEMENTS STEP 5

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.52E-02
2	0.19E-05	-0.53E+00	-0.52E-02
3	0.77E-05	-0.11E+01	-0.52E-02
4	0.17E-04	-0.16E+01	-0.52E-02
5	0.31E-04	-0.21E+01	-0.52E-02
6	0.48E-04	-0.26E+01	-0.51E-02
7	0.25E-03	-0.31E+01	-0.51E-02
8	0.20E-02	-0.36E+01	-0.50E-02
9	0.13E-01	-0.41E+01	-0.48E-02
10	0.51E-01	-0.46E+01	-0.44E-02
11	0.11E+00	-0.50E+01	-0.37E-02
12	0.19E+00	-0.53E+01	-0.30E-02
13	0.26E+00	-0.56E+01	-0.22E-02
14	0.33E+00	-0.58E+01	-0.15E-02
15	0.41E+00	-0.59E+01	-0.74E-03
16	0.48E+00	-0.59E+01	0.12E-16
17	0.56E+00	-0.59E+01	0.74E-03
18	0.63E+00	-0.58E+01	0.15E-02
19	0.70E+00	-0.56E+01	0.22E-02
20	0.78E+00	-0.53E+01	0.30E-02
21	0.85E+00	-0.50E+01	0.37E-02
22	0.91E+00	-0.46E+01	0.44E-02
23	0.95E+00	-0.41E+01	0.48E-02
24	0.96E+00	-0.36E+01	0.50E-02
25	0.96E+00	-0.31E+01	0.51E-02
26	0.96E+00	-0.26E+01	0.51E-02
27	0.96E+00	-0.21E+01	0.52E-02
28	0.96E+00	-0.16E+01	0.52E-02
29	0.96E+00	-0.11E+01	0.52E-02
30	0.96E+00	-0.53E+00	0.52E-02
31	0.96E+00	0.00E+00	0.52E-02

NODAL DISPLACEMENTS STEP 6

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.63E-02
2	0.21E-05	-0.64E+00	-0.63E-02
3	0.85E-05	-0.13E+01	-0.63E-02
4	0.19E-04	-0.19E+01	-0.63E-02
5	0.34E-04	-0.25E+01	-0.63E-02
6	0.83E-04	-0.32E+01	-0.62E-02
7	0.67E-03	-0.38E+01	-0.62E-02
8	0.56E-02	-0.44E+01	-0.60E-02
9	0.30E-01	-0.50E+01	-0.57E-02
10	0.84E-01	-0.55E+01	-0.51E-02
11	0.16E+00	-0.60E+01	-0.43E-02
12	0.25E+00	-0.64E+01	-0.35E-02
13	0.34E+00	-0.67E+01	-0.26E-02
14	0.43E+00	-0.69E+01	-0.17E-02
15	0.51E+00	-0.70E+01	-0.87E-03
16	0.60E+00	-0.71E+01	0.13E-16
17	0.69E+00	-0.70E+01	0.87E-03
18	0.78E+00	-0.69E+01	0.17E-02
19	0.87E+00	-0.67E+01	0.26E-02
20	0.96E+00	-0.64E+01	0.35E-02
21	0.10E+01	-0.60E+01	0.43E-02
22	0.11E+01	-0.55E+01	0.51E-02
23	0.12E+01	-0.50E+01	0.57E-02
24	0.12E+01	-0.44E+01	0.60E-02
25	0.12E+01	-0.38E+01	0.62E-02
26	0.12E+01	-0.32E+01	0.62E-02
27	0.12E+01	-0.25E+01	0.63E-02
28	0.12E+01	-0.19E+01	0.63E-02
29	0.12E+01	-0.13E+01	0.63E-02
30	0.12E+01	-0.64E+00	0.63E-02
31	0.12E+01	0.00E+00	0.63E-02

NODAL DISPLACEMENTS STEP 7

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NODAL DISPLACEMENTS STEP 7

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.75E-02
2	0.22E-05	-0.76E+00	-0.75E-02
3	0.86E-05	-0.15E+01	-0.75E-02
4	0.19E-04	-0.23E+01	-0.75E-02
5	0.34E-04	-0.30E+01	-0.75E-02
6	0.14E-03	-0.38E+01	-0.74E-02
7	0.23E-02	-0.45E+01	-0.73E-02
8	0.37E-01	-0.52E+01	-0.69E-02
9	0.99E-01	-0.59E+01	-0.63E-02
10	0.18E+00	-0.65E+01	-0.56E-02
11	0.27E+00	-0.70E+01	-0.47E-02
12	0.37E+00	-0.74E+01	-0.37E-02
13	0.47E+00	-0.77E+01	-0.28E-02
14	0.57E+00	-0.80E+01	-0.19E-02
15	0.67E+00	-0.81E+01	-0.94E-03
16	0.76E+00	-0.82E+01	0.74E-17
17	0.86E+00	-0.81E+01	0.94E-03
18	0.96E+00	-0.80E+01	0.19E-02
19	0.11E+01	-0.77E+01	0.28E-02
20	0.12E+01	-0.74E+01	0.37E-02
21	0.13E+01	-0.70E+01	0.47E-02
22	0.14E+01	-0.65E+01	0.56E-02
23	0.14E+01	-0.59E+01	0.63E-02
24	0.15E+01	-0.52E+01	0.69E-02
25	0.15E+01	-0.45E+01	0.73E-02
26	0.15E+01	-0.38E+01	0.74E-02
27	0.15E+01	-0.30E+01	0.75E-02
28	0.15E+01	-0.23E+01	0.75E-02
29	0.15E+01	-0.15E+01	0.75E-02
30	0.15E+01	-0.76E+00	0.75E-02
31	0.15E+01	0.00E+00	0.75E-02

NODAL DISPLACEMENTS STEP 8

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.87E-02
2	0.24E-05	-0.87E+00	-0.87E-02
3	0.97E-05	-0.17E+01	-0.86E-02
4	0.22E-04	-0.26E+01	-0.86E-02
5	0.39E-04	-0.35E+01	-0.86E-02
6	0.32E-03	-0.43E+01	-0.85E-02
7	0.56E-02	-0.52E+01	-0.84E-02
8	0.54E-01	-0.60E+01	-0.79E-02
9	0.13E+00	-0.67E+01	-0.71E-02
10	0.22E+00	-0.74E+01	-0.63E-02
11	0.33E+00	-0.80E+01	-0.53E-02
12	0.44E+00	-0.85E+01	-0.42E-02
13	0.55E+00	-0.88E+01	-0.32E-02
14	0.66E+00	-0.91E+01	-0.21E-02
15	0.77E+00	-0.93E+01	-0.11E-02
16	0.88E+00	-0.93E+01	0.12E-16
17	0.10E+01	-0.93E+01	0.11E-02
18	0.11E+01	-0.91E+01	0.21E-02
19	0.12E+01	-0.88E+01	0.32E-02
20	0.13E+01	-0.85E+01	0.42E-02
21	0.14E+01	-0.80E+01	0.53E-02
22	0.15E+01	-0.74E+01	0.63E-02
23	0.16E+01	-0.67E+01	0.71E-02
24	0.17E+01	-0.60E+01	0.79E-02
25	0.18E+01	-0.52E+01	0.84E-02
26	0.18E+01	-0.43E+01	0.85E-02
27	0.18E+01	-0.35E+01	0.86E-02
28	0.18E+01	-0.26E+01	0.86E-02
29	0.18E+01	-0.17E+01	0.86E-02
30	0.18E+01	-0.87E+00	0.87E-02
31	0.18E+01	0.00E+00	0.87E-02

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NODAL DISPLACEMENTS STEP 9

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.98E-02
2	0.27E-05	-0.98E+00	-0.98E-02
3	0.11E-04	-0.20E+01	-0.98E-02
4	0.24E-04	-0.29E+01	-0.97E-02
5	0.65E-04	-0.39E+01	-0.97E-02
6	0.72E-03	-0.49E+01	-0.96E-02
7	0.11E-01	-0.58E+01	-0.94E-02
8	0.72E-01	-0.68E+01	-0.88E-02
9	0.16E+00	-0.76E+01	-0.80E-02
10	0.26E+00	-0.84E+01	-0.70E-02
11	0.38E+00	-0.90E+01	-0.59E-02
12	0.51E+00	-0.95E+01	-0.47E-02
13	0.63E+00	-0.99E+01	-0.35E-02
14	0.76E+00	-0.10E+02	-0.24E-02
15	0.88E+00	-0.10E+02	-0.12E-02
16	0.10E+01	-0.10E+02	0.15E-16
17	0.11E+01	-0.10E+02	0.12E-02
18	0.13E+01	-0.10E+02	0.24E-02
19	0.14E+01	-0.99E+01	0.35E-02
20	0.15E+01	-0.95E+01	0.47E-02
21	0.16E+01	-0.90E+01	0.59E-02
22	0.17E+01	-0.84E+01	0.70E-02
23	0.19E+01	-0.76E+01	0.80E-02
24	0.19E+01	-0.68E+01	0.88E-02
25	0.20E+01	-0.58E+01	0.94E-02
26	0.20E+01	-0.49E+01	0.96E-02
27	0.20E+01	-0.39E+01	0.97E-02
28	0.20E+01	-0.29E+01	0.97E-02
29	0.20E+01	-0.20E+01	0.98E-02
30	0.20E+01	-0.98E+00	0.98E-02
31	0.20E+01	0.00E+00	0.98E-02

NODAL DISPLACEMENTS STEP 10

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.11E-01
2	0.30E-05	-0.11E+01	-0.11E-01
3	0.12E-04	-0.22E+01	-0.11E-01
4	0.27E-04	-0.33E+01	-0.11E-01
5	0.12E-03	-0.44E+01	-0.11E-01
6	0.16E-02	-0.55E+01	-0.11E-01
7	0.20E-01	-0.65E+01	-0.10E-01
8	0.92E-01	-0.75E+01	-0.97E-02
9	0.19E+00	-0.85E+01	-0.88E-02
10	0.30E+00	-0.93E+01	-0.77E-02
11	0.44E+00	-0.10E+02	-0.65E-02
12	0.57E+00	-0.11E+02	-0.52E-02
13	0.71E+00	-0.11E+02	-0.39E-02
14	0.85E+00	-0.11E+02	-0.26E-02
15	0.99E+00	-0.12E+02	-0.13E-02
16	0.11E+01	-0.12E+02	0.19E-16
17	0.13E+01	-0.12E+02	0.13E-02
18	0.14E+01	-0.11E+02	0.26E-02
19	0.15E+01	-0.11E+02	0.39E-02
20	0.17E+01	-0.11E+02	0.52E-02
21	0.18E+01	-0.10E+02	0.65E-02
22	0.19E+01	-0.93E+01	0.77E-02
23	0.21E+01	-0.85E+01	0.88E-02
24	0.22E+01	-0.75E+01	0.97E-02
25	0.22E+01	-0.65E+01	0.10E-01
26	0.23E+01	-0.55E+01	0.11E-01
27	0.23E+01	-0.44E+01	0.11E-01
28	0.23E+01	-0.33E+01	0.11E-01
29	0.23E+01	-0.22E+01	0.11E-01
30	0.23E+01	-0.11E+01	0.11E-01
31	0.23E+01	0.00E+00	0.11E-01

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NODAL DISPLACEMENTS STEP 11

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.12E-01
2	0.32E-05	-0.12E+01	-0.12E-01
3	0.13E-04	-0.24E+01	-0.12E-01
4	0.29E-04	-0.36E+01	-0.12E-01
5	0.23E-03	-0.48E+01	-0.12E-01
6	0.34E-02	-0.60E+01	-0.12E-01
7	0.32E-01	-0.72E+01	-0.11E-01
8	0.11E+00	-0.83E+01	-0.11E-01
9	0.22E+00	-0.93E+01	-0.96E-02
10	0.35E+00	-0.10E+02	-0.84E-02
11	0.49E+00	-0.11E+02	-0.71E-02
12	0.64E+00	-0.12E+02	-0.57E-02
13	0.80E+00	-0.12E+02	-0.42E-02
14	0.95E+00	-0.12E+02	-0.28E-02
15	0.11E+01	-0.13E+02	-0.14E-02
16	0.13E+01	-0.13E+02	0.18E-16
17	0.14E+01	-0.13E+02	0.14E-02
18	0.16E+01	-0.12E+02	0.28E-02
19	0.17E+01	-0.12E+02	0.42E-02
20	0.19E+01	-0.12E+02	0.57E-02
21	0.20E+01	-0.11E+02	0.71E-02
22	0.22E+01	-0.10E+02	0.84E-02
23	0.23E+01	-0.93E+01	0.96E-02
24	0.24E+01	-0.83E+01	0.11E-01
25	0.25E+01	-0.72E+01	0.11E-01
26	0.25E+01	-0.60E+01	0.12E-01
27	0.25E+01	-0.48E+01	0.12E-01
28	0.25E+01	-0.36E+01	0.12E-01
29	0.25E+01	-0.24E+01	0.12E-01
30	0.25E+01	-0.12E+01	0.12E-01
31	0.25E+01	0.00E+00	0.12E-01

NODAL DISPLACEMENTS STEP 12

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.13E-01
2	0.35E-05	-0.13E+01	-0.13E-01
3	0.14E-04	-0.26E+01	-0.13E-01
4	0.38E-04	-0.40E+01	-0.13E-01
5	0.45E-03	-0.53E+01	-0.13E-01
6	0.69E-02	-0.66E+01	-0.13E-01
7	0.47E-01	-0.79E+01	-0.12E-01
8	0.14E+00	-0.91E+01	-0.12E-01
9	0.26E+00	-0.10E+02	-0.10E-01
10	0.40E+00	-0.11E+02	-0.91E-02
11	0.55E+00	-0.12E+02	-0.77E-02
12	0.72E+00	-0.13E+02	-0.61E-02
13	0.88E+00	-0.13E+02	-0.46E-02
14	0.10E+01	-0.14E+02	-0.31E-02
15	0.12E+01	-0.14E+02	-0.15E-02
16	0.14E+01	-0.14E+02	0.18E-16
17	0.15E+01	-0.14E+02	0.15E-02
18	0.17E+01	-0.14E+02	0.31E-02
19	0.19E+01	-0.13E+02	0.46E-02
20	0.20E+01	-0.13E+02	0.61E-02
21	0.22E+01	-0.12E+02	0.77E-02
22	0.24E+01	-0.11E+02	0.91E-02
23	0.25E+01	-0.10E+02	0.10E-01
24	0.26E+01	-0.91E+01	0.12E-01
25	0.27E+01	-0.79E+01	0.12E-01
26	0.27E+01	-0.66E+01	0.13E-01
27	0.28E+01	-0.53E+01	0.13E-01
28	0.28E+01	-0.40E+01	0.13E-01
29	0.28E+01	-0.26E+01	0.13E-01
30	0.28E+01	-0.13E+01	0.13E-01
31	0.28E+01	0.00E+00	0.13E-01

NODAL DISPLACEMENTS STEP 13

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NODAL DISPLACEMENTS STEP 13

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.14E-01
2	0.37E-05	-0.14E+01	-0.14E-01
3	0.15E-04	-0.29E+01	-0.14E-01
4	0.58E-04	-0.43E+01	-0.14E-01
5	0.86E-03	-0.58E+01	-0.14E-01
6	0.13E-01	-0.72E+01	-0.14E-01
7	0.66E-01	-0.85E+01	-0.13E-01
8	0.17E+00	-0.98E+01	-0.12E-01
9	0.30E+00	-0.11E+02	-0.11E-01
10	0.45E+00	-0.12E+02	-0.98E-02
11	0.62E+00	-0.13E+02	-0.83E-02
12	0.79E+00	-0.14E+02	-0.66E-02
13	0.97E+00	-0.14E+02	-0.50E-02
14	0.11E+01	-0.15E+02	-0.33E-02
15	0.13E+01	-0.15E+02	-0.17E-02
16	0.15E+01	-0.15E+02	0.17E-16
17	0.17E+01	-0.15E+02	0.17E-02
18	0.19E+01	-0.15E+02	0.33E-02
19	0.20E+01	-0.14E+02	0.50E-02
20	0.22E+01	-0.14E+02	0.66E-02
21	0.24E+01	-0.13E+02	0.83E-02
22	0.26E+01	-0.12E+02	0.98E-02
23	0.27E+01	-0.11E+02	0.11E-01
24	0.28E+01	-0.98E+01	0.12E-01
25	0.29E+01	-0.85E+01	0.13E-01
26	0.30E+01	-0.72E+01	0.14E-01
27	0.30E+01	-0.58E+01	0.14E-01
28	0.30E+01	-0.43E+01	0.14E-01
29	0.30E+01	-0.29E+01	0.14E-01
30	0.30E+01	-0.14E+01	0.14E-01
31	0.30E+01	0.00E+00	0.14E-01

NODAL DISPLACEMENTS STEP 14

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.16E-01
2	0.40E-05	-0.16E+01	-0.16E-01
3	0.16E-04	-0.31E+01	-0.16E-01
4	0.80E-04	-0.47E+01	-0.15E-01
5	0.16E-02	-0.62E+01	-0.15E-01
6	0.22E-01	-0.78E+01	-0.15E-01
7	0.89E-01	-0.92E+01	-0.14E-01
8	0.20E+00	-0.11E+02	-0.13E-01
9	0.34E+00	-0.12E+02	-0.12E-01
10	0.50E+00	-0.13E+02	-0.11E-01
11	0.68E+00	-0.14E+02	-0.88E-02
12	0.87E+00	-0.15E+02	-0.71E-02
13	0.11E+01	-0.15E+02	-0.53E-02
14	0.13E+01	-0.16E+02	-0.35E-02
15	0.14E+01	-0.16E+02	-0.18E-02
16	0.16E+01	-0.16E+02	0.16E-16
17	0.18E+01	-0.16E+02	0.18E-02
18	0.20E+01	-0.16E+02	0.35E-02
19	0.22E+01	-0.15E+02	0.53E-02
20	0.24E+01	-0.15E+02	0.71E-02
21	0.26E+01	-0.14E+02	0.88E-02
22	0.28E+01	-0.13E+02	0.11E-01
23	0.29E+01	-0.12E+02	0.12E-01
24	0.31E+01	-0.11E+02	0.13E-01
25	0.32E+01	-0.92E+01	0.14E-01
26	0.32E+01	-0.78E+01	0.15E-01
27	0.33E+01	-0.62E+01	0.15E-01
28	0.33E+01	-0.47E+01	0.15E-01
29	0.33E+01	-0.31E+01	0.16E-01
30	0.33E+01	-0.16E+01	0.16E-01
31	0.33E+01	0.00E+00	0.16E-01

NODAL DISPLACEMENTS STEP 15

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.17E-01
2	0.42E-05	-0.17E+01	-0.17E-01
3	0.17E-04	-0.34E+01	-0.17E-01
4	0.14E-03	-0.50E+01	-0.17E-01
5	0.30E-02	-0.67E+01	-0.17E-01
6	0.35E-01	-0.83E+01	-0.16E-01
7	0.11E+00	-0.99E+01	-0.15E-01
8	0.23E+00	-0.11E+02	-0.14E-01
9	0.38E+00	-0.13E+02	-0.13E-01
10	0.55E+00	-0.14E+02	-0.11E-01
11	0.75E+00	-0.15E+02	-0.94E-02
12	0.95E+00	-0.16E+02	-0.75E-02
13	0.12E+01	-0.17E+02	-0.56E-02
14	0.14E+01	-0.17E+02	-0.38E-02
15	0.16E+01	-0.17E+02	-0.19E-02
16	0.18E+01	-0.17E+02	0.15E-16
17	0.20E+01	-0.17E+02	0.19E-02
18	0.22E+01	-0.17E+02	0.38E-02
19	0.24E+01	-0.17E+02	0.56E-02
20	0.26E+01	-0.16E+02	0.75E-02
21	0.28E+01	-0.15E+02	0.94E-02
22	0.30E+01	-0.14E+02	0.11E-01
23	0.31E+01	-0.13E+02	0.13E-01
24	0.33E+01	-0.11E+02	0.14E-01
25	0.34E+01	-0.99E+01	0.15E-01
26	0.35E+01	-0.83E+01	0.16E-01

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-----------------------------------------------
NODAL DISPLACEMENTS   STEP          16
 NODE            X            Y          rZ

    1      0.00E+00  0.00E+00 -0.18E-01
    2      0.44E-05 -0.18E+01 -0.18E-01
    3      0.17E-04 -0.37E+01 -0.18E-01
    4      0.24E-03 -0.55E+01 -0.18E-01
    5      0.40E-01 -0.73E+01 -0.18E-01
    6      0.13E+00 -0.91E+01 -0.17E-01
    7      0.24E+00 -0.11E+02 -0.16E-01
    8      0.37E+00 -0.12E+02 -0.15E-01
    9      0.53E+00 -0.14E+02 -0.13E-01
   10      0.71E+00 -0.15E+02 -0.12E-01
   11      0.91E+00 -0.16E+02 -0.98E-02
   12      0.11E+01 -0.17E+02 -0.78E-02
   13      0.13E+01 -0.18E+02 -0.59E-02
   14      0.15E+01 -0.18E+02 -0.39E-02
   15      0.18E+01 -0.18E+02 -0.20E-02
   16      0.20E+01 -0.18E+02  0.18E-13
   17      0.22E+01 -0.18E+02  0.20E-02
   18      0.24E+01 -0.18E+02  0.39E-02
   19      0.26E+01 -0.18E+02  0.59E-02
   20      0.28E+01 -0.17E+02  0.78E-02
   21      0.30E+01 -0.16E+02  0.98E-02
   22      0.32E+01 -0.15E+02  0.12E-01
   23      0.34E+01 -0.14E+02  0.13E-01
   24      0.36E+01 -0.12E+02  0.15E-01
   25      0.37E+01 -0.11E+02  0.16E-01
   26      0.38E+01 -0.91E+01  0.17E-01
   27      0.39E+01 -0.73E+01  0.18E-01
   28      0.39E+01 -0.55E+01  0.18E-01
   29      0.39E+01 -0.37E+01  0.18E-01
   30      0.39E+01 -0.18E+01  0.18E-01
   31      0.39E+01  0.00E+00  0.18E-01
-----------------------------------------------
NODAL DISPLACEMENTS   STEP          17
 NODE            X            Y          rZ

    1      0.00E+00  0.00E+00 -0.20E-01
    2      0.46E-05 -0.20E+01 -0.20E-01
    3      0.19E-04 -0.39E+01 -0.20E-01
    4      0.36E-03 -0.59E+01 -0.19E-01
    5      0.52E-01 -0.78E+01 -0.19E-01
    6      0.15E+00 -0.97E+01 -0.18E-01
    7      0.27E+00 -0.11E+02 -0.17E-01
    8      0.41E+00 -0.13E+02 -0.16E-01
    9      0.57E+00 -0.15E+02 -0.14E-01
   10      0.76E+00 -0.16E+02 -0.12E-01
   11      0.98E+00 -0.17E+02 -0.10E-01
   12      0.12E+01 -0.18E+02 -0.83E-02
   13      0.14E+01 -0.19E+02 -0.62E-02
   14      0.16E+01 -0.19E+02 -0.41E-02
   15      0.19E+01 -0.19E+02 -0.21E-02
   16      0.21E+01 -0.20E+02 -0.14E-13
   17      0.23E+01 -0.19E+02  0.21E-02
   18      0.25E+01 -0.19E+02  0.41E-02
   19      0.28E+01 -0.19E+02  0.62E-02
   20      0.30E+01 -0.18E+02  0.83E-02
   21      0.32E+01 -0.17E+02  0.10E-01
   22      0.34E+01 -0.16E+02  0.12E-01
   23      0.36E+01 -0.15E+02  0.14E-01
   24      0.38E+01 -0.13E+02  0.16E-01
   25      0.39E+01 -0.11E+02  0.17E-01
   26      0.40E+01 -0.97E+01  0.18E-01
   27      0.41E+01 -0.78E+01  0.19E-01
   28      0.42E+01 -0.59E+01  0.19E-01
   29      0.42E+01 -0.39E+01  0.20E-01
   30      0.42E+01 -0.20E+01  0.20E-01
   31      0.42E+01  0.00E+00  0.20E-01
-----------------------------------------------
NODAL DISPLACEMENTS   STEP          18
 NODE            X            Y          rZ

    1      0.00E+00  0.00E+00 -0.21E-01
    2      0.49E-05 -0.21E+01 -0.21E-01
    3      0.20E-04 -0.42E+01 -0.21E-01
    4      0.53E-03 -0.62E+01 -0.21E-01
    5      0.60E-01 -0.83E+01 -0.20E-01
    6      0.16E+00 -0.10E+02 -0.19E-01
    7      0.29E+00 -0.12E+02 -0.18E-01
    8      0.44E+00 -0.14E+02 -0.16E-01
    9      0.62E+00 -0.15E+02 -0.15E-01
   10      0.82E+00 -0.17E+02 -0.13E-01
   11      0.10E+01 -0.18E+02 -0.11E-01
   12      0.13E+01 -0.19E+02 -0.87E-02
   13      0.15E+01 -0.20E+02 -0.66E-02
   14      0.18E+01 -0.20E+02 -0.44E-02
   15      0.20E+01 -0.21E+02 -0.22E-02
   16      0.22E+01 -0.21E+02 -0.70E-14
   17      0.25E+01 -0.21E+02  0.22E-02
   18      0.27E+01 -0.20E+02  0.44E-02
   19      0.29E+01 -0.20E+02  0.66E-02
   20      0.32E+01 -0.19E+02  0.87E-02
   21      0.34E+01 -0.18E+02  0.11E-01
   22      0.36E+01 -0.17E+02  0.13E-01
   23      0.38E+01 -0.15E+02  0.15E-01
   24      0.40E+01 -0.14E+02  0.16E-01
   25      0.42E+01 -0.12E+02  0.18E-01
   26      0.43E+01 -0.10E+02  0.19E-01
```

STATIC_DISPLACEMENTS - Notepad

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```
-----------------------------------------------
NODAL DISPLACEMENTS   STEP          19
 NODE            X            Y          rZ

    1      0.00E+00  0.00E+00 -0.22E-01
    2      0.52E-05 -0.22E+01 -0.22E-01
    3      0.21E-04 -0.44E+01 -0.22E-01
    4      0.81E-03 -0.66E+01 -0.22E-01
    5      0.67E-01 -0.87E+01 -0.21E-01
    6      0.18E+00 -0.11E+02 -0.20E-01
    7      0.31E+00 -0.13E+02 -0.19E-01
    8      0.47E+00 -0.15E+02 -0.17E-01
    9      0.65E+00 -0.16E+02 -0.16E-01
   10      0.87E+00 -0.18E+02 -0.14E-01
   11      0.11E+01 -0.19E+02 -0.12E-01
   12      0.14E+01 -0.20E+02 -0.92E-02
   13      0.16E+01 -0.21E+02 -0.69E-02
   14      0.19E+01 -0.21E+02 -0.46E-02
   15      0.21E+01 -0.22E+02 -0.23E-02
   16      0.24E+01 -0.22E+02 -0.33E-14
   17      0.26E+01 -0.22E+02  0.23E-02
   18      0.29E+01 -0.21E+02  0.46E-02
   19      0.31E+01 -0.21E+02  0.69E-02
   20      0.34E+01 -0.20E+02  0.92E-02
   21      0.36E+01 -0.19E+02  0.12E-01
   22      0.38E+01 -0.18E+02  0.14E-01
   23      0.41E+01 -0.16E+02  0.16E-01
   24      0.42E+01 -0.15E+02  0.17E-01
   25      0.44E+01 -0.13E+02  0.19E-01
   26      0.45E+01 -0.11E+02  0.20E-01
   27      0.46E+01 -0.87E+01  0.21E-01
   28      0.47E+01 -0.66E+01  0.22E-01
   29      0.47E+01 -0.44E+01  0.22E-01
   30      0.47E+01 -0.22E+01  0.22E-01
   31      0.47E+01  0.00E+00  0.22E-01
-----------------------------------------------
NODAL DISPLACEMENTS   STEP          20
 NODE            X            Y          rZ

    1      0.00E+00  0.00E+00 -0.23E-01
    2      0.55E-05 -0.23E+01 -0.23E-01
    3      0.34E-04 -0.46E+01 -0.23E-01
    4      0.12E-02 -0.69E+01 -0.23E-01
    5      0.73E-01 -0.92E+01 -0.22E-01
    6      0.19E+00 -0.11E+02 -0.21E-01
    7      0.33E+00 -0.13E+02 -0.20E-01
    8      0.50E+00 -0.15E+02 -0.18E-01
    9      0.69E+00 -0.17E+02 -0.16E-01
   10      0.92E+00 -0.19E+02 -0.14E-01
   11      0.12E+01 -0.20E+02 -0.12E-01
   12      0.14E+01 -0.21E+02 -0.97E-02
   13      0.17E+01 -0.22E+02 -0.73E-02
   14      0.20E+01 -0.23E+02 -0.49E-02
   15      0.22E+01 -0.23E+02 -0.24E-02
   16      0.25E+01 -0.23E+02 -0.15E-14
   17      0.27E+01 -0.23E+02  0.24E-02
   18      0.30E+01 -0.23E+02  0.49E-02
   19      0.33E+01 -0.22E+02  0.73E-02
   20      0.35E+01 -0.21E+02  0.97E-02
   21      0.38E+01 -0.20E+02  0.12E-01
   22      0.40E+01 -0.19E+02  0.14E-01
   23      0.43E+01 -0.17E+02  0.16E-01
   24      0.45E+01 -0.15E+02  0.18E-01
   25      0.46E+01 -0.13E+02  0.20E-01
   26      0.48E+01 -0.11E+02  0.21E-01
   27      0.49E+01 -0.92E+01  0.22E-01
   28      0.50E+01 -0.69E+01  0.23E-01
   29      0.50E+01 -0.46E+01  0.23E-01
   30      0.50E+01 -0.23E+01  0.23E-01
   31      0.50E+01  0.00E+00  0.23E-01
-----------------------------------------------
NODAL DISPLACEMENTS   STEP          21
 NODE            X            Y          rZ

    1      0.00E+00  0.00E+00 -0.24E-01
    2      0.57E-05 -0.24E+01 -0.24E-01
    3      0.48E-04 -0.49E+01 -0.24E-01
    4      0.19E-02 -0.73E+01 -0.24E-01
    5      0.80E-01 -0.97E+01 -0.23E-01
    6      0.20E+00 -0.12E+02 -0.22E-01
    7      0.35E+00 -0.14E+02 -0.21E-01
    8      0.53E+00 -0.16E+02 -0.19E-01
    9      0.73E+00 -0.18E+02 -0.17E-01
   10      0.97E+00 -0.20E+02 -0.15E-01
   11      0.12E+01 -0.21E+02 -0.13E-01
   12      0.15E+01 -0.22E+02 -0.10E-01
   13      0.18E+01 -0.23E+02 -0.76E-02
   14      0.21E+01 -0.24E+02 -0.51E-02
   15      0.23E+01 -0.24E+02 -0.25E-02
   16      0.26E+01 -0.24E+02 -0.44E-15
   17      0.29E+01 -0.24E+02  0.25E-02
   18      0.32E+01 -0.24E+02  0.51E-02
   19      0.34E+01 -0.23E+02  0.76E-02
   20      0.37E+01 -0.22E+02  0.10E-01
   21      0.40E+01 -0.21E+02  0.13E-01
   22      0.43E+01 -0.20E+02  0.15E-01
   23      0.45E+01 -0.18E+02  0.17E-01
   24      0.47E+01 -0.16E+02  0.19E-01
   25      0.49E+01 -0.14E+02  0.21E-01
   26      0.50E+01 -0.12E+02  0.22E-01
```

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NODAL DISPLACEMENTS STEP 22

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.25E-01
2	0.60E-05	-0.26E+01	-0.25E-01
3	0.61E-04	-0.51E+01	-0.25E-01
4	0.29E-02	-0.76E+01	-0.25E-01
5	0.86E-01	-0.10E+02	-0.24E-01
6	0.21E+00	-0.13E+02	-0.23E-01
7	0.37E+00	-0.15E+02	-0.22E-01
8	0.56E+00	-0.17E+02	-0.20E-01
9	0.77E+00	-0.19E+02	-0.18E-01
10	0.10E+01	-0.21E+02	-0.16E-01
11	0.13E+01	-0.22E+02	-0.13E-01
12	0.16E+01	-0.23E+02	-0.11E-01
13	0.19E+01	-0.24E+02	-0.80E-02
14	0.22E+01	-0.25E+02	-0.53E-02
15	0.24E+01	-0.25E+02	-0.27E-02
16	0.27E+01	-0.25E+02	0.13E-15
17	0.30E+01	-0.25E+02	0.27E-02
18	0.33E+01	-0.25E+02	0.53E-02
19	0.36E+01	-0.24E+02	0.80E-02
20	0.39E+01	-0.23E+02	0.11E-01
21	0.42E+01	-0.22E+02	0.13E-01
22	0.45E+01	-0.21E+02	0.16E-01
23	0.47E+01	-0.19E+02	0.18E-01
24	0.49E+01	-0.17E+02	0.20E-01
25	0.51E+01	-0.15E+02	0.22E-01
26	0.53E+01	-0.13E+02	0.23E-01
27	0.54E+01	-0.10E+02	0.24E-01
28	0.55E+01	-0.76E+01	0.25E-01
29	0.55E+01	-0.51E+01	0.25E-01
30	0.55E+01	-0.26E+01	0.25E-01
31	0.55E+01	0.00E+00	0.25E-01

NODAL DISPLACEMENTS STEP 23

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.27E-01
2	0.63E-05	-0.27E+01	-0.27E-01
3	0.77E-04	-0.53E+01	-0.27E-01
4	0.43E-02	-0.80E+01	-0.26E-01
5	0.93E-01	-0.11E+02	-0.26E-01
6	0.23E+00	-0.13E+02	-0.24E-01
7	0.39E+00	-0.15E+02	-0.23E-01
8	0.58E+00	-0.18E+02	-0.21E-01
9	0.81E+00	-0.20E+02	-0.19E-01
10	0.11E+01	-0.21E+02	-0.17E-01
11	0.14E+01	-0.23E+02	-0.14E-01
12	0.17E+01	-0.24E+02	-0.11E-01
13	0.20E+01	-0.25E+02	-0.84E-02
14	0.23E+01	-0.26E+02	-0.56E-02
15	0.26E+01	-0.26E+02	-0.28E-02
16	0.29E+01	-0.26E+02	0.47E-15
17	0.32E+01	-0.26E+02	0.28E-02
18	0.35E+01	-0.26E+02	0.56E-02
19	0.38E+01	-0.25E+02	0.84E-02
20	0.41E+01	-0.24E+02	0.11E-01
21	0.44E+01	-0.23E+02	0.14E-01
22	0.47E+01	-0.21E+02	0.17E-01
23	0.49E+01	-0.20E+02	0.19E-01
24	0.51E+01	-0.18E+02	0.21E-01
25	0.53E+01	-0.15E+02	0.23E-01
26	0.55E+01	-0.13E+02	0.24E-01
27	0.56E+01	-0.11E+02	0.26E-01
28	0.57E+01	-0.80E+01	0.26E-01
29	0.57E+01	-0.53E+01	0.27E-01
30	0.57E+01	-0.27E+01	0.27E-01
31	0.57E+01	0.00E+00	0.27E-01

NODAL DISPLACEMENTS STEP 24

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.28E-01
2	0.65E-05	-0.28E+01	-0.28E-01
3	0.10E-03	-0.56E+01	-0.28E-01
4	0.64E-02	-0.84E+01	-0.28E-01
5	0.10E+00	-0.11E+02	-0.27E-01
6	0.24E+00	-0.14E+02	-0.25E-01
7	0.41E+00	-0.16E+02	-0.24E-01
8	0.61E+00	-0.18E+02	-0.22E-01
9	0.85E+00	-0.21E+02	-0.20E-01
10	0.11E+01	-0.22E+02	-0.17E-01
11	0.14E+01	-0.24E+02	-0.15E-01
12	0.17E+01	-0.25E+02	-0.12E-01
13	0.20E+01	-0.26E+02	-0.87E-02
14	0.24E+01	-0.27E+02	-0.58E-02
15	0.27E+01	-0.27E+02	-0.29E-02
16	0.30E+01	-0.28E+02	0.68E-15
17	0.33E+01	-0.27E+02	0.29E-02
18	0.36E+01	-0.27E+02	0.58E-02
19	0.39E+01	-0.26E+02	0.87E-02
20	0.43E+01	-0.25E+02	0.12E-01
21	0.46E+01	-0.24E+02	0.15E-01
22	0.49E+01	-0.22E+02	0.17E-01
23	0.51E+01	-0.21E+02	0.20E-01
24	0.54E+01	-0.18E+02	0.22E-01
25	0.56E+01	-0.16E+02	0.24E-01
26	0.57E+01	-0.14E+02	0.25E-01

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NODAL DISPLACEMENTS STEP 25

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.29E-01
2	0.68E-05	-0.29E+01	-0.29E-01
3	0.14E-03	-0.58E+01	-0.29E-01
4	0.91E-02	-0.87E+01	-0.29E-01
5	0.11E+00	-0.12E+02	-0.28E-01
6	0.25E+00	-0.14E+02	-0.26E-01
7	0.43E+00	-0.17E+02	-0.25E-01
8	0.64E+00	-0.19E+02	-0.23E-01
9	0.89E+00	-0.21E+02	-0.21E-01
10	0.12E+01	-0.23E+02	-0.18E-01
11	0.15E+01	-0.25E+02	-0.15E-01
12	0.18E+01	-0.26E+02	-0.12E-01
13	0.21E+01	-0.27E+02	-0.91E-02
14	0.25E+01	-0.28E+02	-0.61E-02
15	0.28E+01	-0.29E+02	-0.30E-02
16	0.31E+01	-0.29E+02	0.79E-15
17	0.34E+01	-0.29E+02	0.30E-02
18	0.38E+01	-0.28E+02	0.61E-02
19	0.41E+01	-0.27E+02	0.91E-02
20	0.44E+01	-0.26E+02	0.12E-01
21	0.48E+01	-0.25E+02	0.15E-01
22	0.51E+01	-0.23E+02	0.18E-01
23	0.54E+01	-0.21E+02	0.21E-01
24	0.56E+01	-0.19E+02	0.23E-01
25	0.58E+01	-0.17E+02	0.25E-01
26	0.60E+01	-0.14E+02	0.26E-01
27	0.61E+01	-0.12E+02	0.28E-01
28	0.62E+01	-0.87E+01	0.29E-01
29	0.62E+01	-0.58E+01	0.29E-01
30	0.62E+01	-0.29E+01	0.29E-01
31	0.62E+01	0.00E+00	0.29E-01

NODAL DISPLACEMENTS STEP 26

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.30E-01
2	0.71E-05	-0.30E+01	-0.30E-01
3	0.18E-03	-0.61E+01	-0.30E-01
4	0.13E-01	-0.91E+01	-0.30E-01
5	0.12E+00	-0.12E+02	-0.29E-01
6	0.27E+00	-0.15E+02	-0.27E-01
7	0.45E+00	-0.18E+02	-0.26E-01
8	0.67E+00	-0.20E+02	-0.24E-01
9	0.93E+00	-0.22E+02	-0.21E-01
10	0.12E+01	-0.24E+02	-0.19E-01
11	0.15E+01	-0.26E+02	-0.16E-01
12	0.19E+01	-0.27E+02	-0.13E-01
13	0.22E+01	-0.29E+02	-0.94E-02
14	0.26E+01	-0.29E+02	-0.63E-02
15	0.29E+01	-0.30E+02	-0.31E-02
16	0.33E+01	-0.30E+02	0.86E-15
17	0.36E+01	-0.30E+02	0.31E-02
18	0.39E+01	-0.29E+02	0.63E-02
19	0.43E+01	-0.29E+02	0.94E-02
20	0.46E+01	-0.27E+02	0.13E-01
21	0.50E+01	-0.26E+02	0.16E-01
22	0.53E+01	-0.24E+02	0.19E-01
23	0.56E+01	-0.22E+02	0.21E-01
24	0.58E+01	-0.20E+02	0.24E-01
25	0.60E+01	-0.18E+02	0.26E-01
26	0.62E+01	-0.15E+02	0.27E-01
27	0.64E+01	-0.12E+02	0.29E-01
28	0.65E+01	-0.91E+01	0.30E-01
29	0.65E+01	-0.61E+01	0.30E-01
30	0.65E+01	-0.30E+01	0.30E-01
31	0.65E+01	0.00E+00	0.30E-01

NODAL DISPLACEMENTS STEP 27

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.31E-01
2	0.73E-05	-0.31E+01	-0.31E-01
3	0.22E-03	-0.63E+01	-0.31E-01
4	0.18E-01	-0.94E+01	-0.31E-01
5	0.13E+00	-0.12E+02	-0.30E-01
6	0.28E+00	-0.15E+02	-0.29E-01
7	0.48E+00	-0.18E+02	-0.27E-01
8	0.71E+00	-0.21E+02	-0.25E-01
9	0.97E+00	-0.23E+02	-0.22E-01
10	0.13E+01	-0.25E+02	-0.19E-01
11	0.16E+01	-0.27E+02	-0.16E-01
12	0.20E+01	-0.28E+02	-0.13E-01
13	0.23E+01	-0.30E+02	-0.98E-02
14	0.27E+01	-0.30E+02	-0.65E-02
15	0.30E+01	-0.31E+02	-0.33E-02
16	0.34E+01	-0.31E+02	0.88E-15
17	0.37E+01	-0.31E+02	0.33E-02
18	0.41E+01	-0.30E+02	0.65E-02
19	0.44E+01	-0.30E+02	0.98E-02
20	0.48E+01	-0.28E+02	0.13E-01
21	0.52E+01	-0.27E+02	0.16E-01
22	0.55E+01	-0.25E+02	0.19E-01
23	0.58E+01	-0.23E+02	0.22E-01
24	0.61E+01	-0.21E+02	0.25E-01
25	0.63E+01	-0.18E+02	0.27E-01
26	0.65E+01	-0.15E+02	0.29E-01

STATIC_DISPLACEMENTS - Notepad

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NODAL DISPLACEMENTS STEP 28

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.33E-01
2	0.76E-05	-0.33E+01	-0.33E-01
3	0.27E-03	-0.65E+01	-0.33E-01
4	0.23E-01	-0.98E+01	-0.32E-01
5	0.14E+00	-0.13E+02	-0.31E-01
6	0.30E+00	-0.16E+02	-0.30E-01
7	0.50E+00	-0.19E+02	-0.28E-01
8	0.74E+00	-0.22E+02	-0.26E-01
9	0.10E+01	-0.24E+02	-0.23E-01
10	0.13E+01	-0.26E+02	-0.20E-01
11	0.17E+01	-0.28E+02	-0.17E-01
12	0.20E+01	-0.30E+02	-0.14E-01
13	0.24E+01	-0.31E+02	-0.10E-01
14	0.28E+01	-0.32E+02	-0.68E-02
15	0.31E+01	-0.32E+02	-0.34E-02
16	0.35E+01	-0.32E+02	0.89E-15
17	0.39E+01	-0.32E+02	0.34E-02
18	0.42E+01	-0.32E+02	0.68E-02
19	0.46E+01	-0.31E+02	0.10E-01
20	0.50E+01	-0.30E+02	0.14E-01
21	0.53E+01	-0.28E+02	0.17E-01
22	0.57E+01	-0.26E+02	0.20E-01
23	0.60E+01	-0.24E+02	0.23E-01
24	0.63E+01	-0.22E+02	0.26E-01
25	0.65E+01	-0.19E+02	0.28E-01
26	0.67E+01	-0.16E+02	0.30E-01
27	0.69E+01	-0.13E+02	0.31E-01
28	0.70E+01	-0.98E+01	0.32E-01
29	0.70E+01	-0.65E+01	0.33E-01
30	0.70E+01	-0.33E+01	0.33E-01
31	0.70E+01	0.00E+00	0.33E-01

NODAL DISPLACEMENTS STEP 29

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.34E-01
2	0.78E-05	-0.34E+01	-0.34E-01
3	0.35E-03	-0.68E+01	-0.34E-01
4	0.30E-01	-0.10E+02	-0.33E-01
5	0.15E+00	-0.13E+02	-0.32E-01
6	0.32E+00	-0.17E+02	-0.31E-01
7	0.53E+00	-0.20E+02	-0.29E-01
8	0.77E+00	-0.22E+02	-0.26E-01
9	0.11E+01	-0.25E+02	-0.24E-01
10	0.14E+01	-0.27E+02	-0.21E-01
11	0.17E+01	-0.29E+02	-0.18E-01
12	0.21E+01	-0.31E+02	-0.14E-01
13	0.25E+01	-0.32E+02	-0.11E-01
14	0.29E+01	-0.33E+02	-0.70E-02
15	0.33E+01	-0.33E+02	-0.35E-02
16	0.36E+01	-0.33E+02	0.24E-13
17	0.40E+01	-0.33E+02	0.35E-02
18	0.44E+01	-0.33E+02	0.70E-02
19	0.48E+01	-0.32E+02	0.11E-01
20	0.52E+01	-0.31E+02	0.14E-01
21	0.55E+01	-0.29E+02	0.18E-01
22	0.59E+01	-0.27E+02	0.21E-01
23	0.62E+01	-0.25E+02	0.24E-01
24	0.65E+01	-0.22E+02	0.26E-01
25	0.68E+01	-0.20E+02	0.29E-01
26	0.70E+01	-0.17E+02	0.31E-01
27	0.71E+01	-0.13E+02	0.32E-01
28	0.73E+01	-0.10E+02	0.33E-01
29	0.73E+01	-0.68E+01	0.34E-01
30	0.73E+01	-0.34E+01	0.34E-01
31	0.73E+01	0.00E+00	0.34E-01

NODAL DISPLACEMENTS STEP 30

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.35E-01
2	0.81E-05	-0.35E+01	-0.35E-01
3	0.43E-03	-0.70E+01	-0.35E-01
4	0.37E-01	-0.10E+02	-0.34E-01
5	0.16E+00	-0.14E+02	-0.33E-01
6	0.34E+00	-0.17E+02	-0.32E-01
7	0.55E+00	-0.20E+02	-0.30E-01
8	0.80E+00	-0.23E+02	-0.27E-01
9	0.11E+01	-0.26E+02	-0.25E-01
10	0.14E+01	-0.28E+02	-0.22E-01
11	0.18E+01	-0.30E+02	-0.18E-01
12	0.22E+01	-0.32E+02	-0.14E-01
13	0.26E+01	-0.33E+02	-0.11E-01
14	0.30E+01	-0.34E+02	-0.72E-02
15	0.34E+01	-0.34E+02	-0.36E-02
16	0.38E+01	-0.35E+02	-0.11E-13
17	0.42E+01	-0.34E+02	0.36E-02
18	0.46E+01	-0.34E+02	0.72E-02
19	0.50E+01	-0.33E+02	0.11E-01
20	0.53E+01	-0.32E+02	0.14E-01
21	0.57E+01	-0.30E+02	0.18E-01
22	0.61E+01	-0.28E+02	0.22E-01
23	0.65E+01	-0.26E+02	0.25E-01
24	0.67E+01	-0.23E+02	0.27E-01
25	0.70E+01	-0.20E+02	0.30E-01
26	0.72E+01	-0.17E+02	0.32E-01
27	0.74E+01	-0.14E+02	0.33E-01

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NODAL DISPLACEMENTS STEP 31

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.36E-01
2	0.84E-05	-0.36E+01	-0.36E-01
3	0.53E-03	-0.73E+01	-0.36E-01
4	0.45E-01	-0.11E+02	-0.36E-01
5	0.17E+00	-0.14E+02	-0.34E-01
6	0.36E+00	-0.18E+02	-0.33E-01
7	0.58E+00	-0.21E+02	-0.31E-01
8	0.84E+00	-0.24E+02	-0.28E-01
9	0.11E+01	-0.27E+02	-0.25E-01
10	0.15E+01	-0.29E+02	-0.22E-01
11	0.19E+01	-0.31E+02	-0.19E-01
12	0.23E+01	-0.33E+02	-0.15E-01
13	0.27E+01	-0.34E+02	-0.11E-01
14	0.31E+01	-0.35E+02	-0.75E-02
15	0.35E+01	-0.35E+02	-0.37E-02
16	0.39E+01	-0.36E+02	0.20E-13
17	0.43E+01	-0.35E+02	0.37E-02
18	0.47E+01	-0.35E+02	0.75E-02
19	0.51E+01	-0.34E+02	0.11E-01
20	0.55E+01	-0.33E+02	0.15E-01
21	0.59E+01	-0.31E+02	0.19E-01
22	0.63E+01	-0.29E+02	0.22E-01
23	0.67E+01	-0.27E+02	0.25E-01
24	0.70E+01	-0.24E+02	0.28E-01
25	0.72E+01	-0.21E+02	0.31E-01
26	0.75E+01	-0.18E+02	0.33E-01
27	0.76E+01	-0.14E+02	0.34E-01
28	0.78E+01	-0.11E+02	0.36E-01
29	0.78E+01	-0.73E+01	0.36E-01
30	0.78E+01	-0.36E+01	0.36E-01
31	0.78E+01	0.00E+00	0.36E-01

NODAL DISPLACEMENTS STEP 32

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.37E-01
2	0.86E-05	-0.38E+01	-0.37E-01
3	0.64E-03	-0.75E+01	-0.37E-01
4	0.53E-01	-0.11E+02	-0.37E-01
5	0.19E+00	-0.15E+02	-0.35E-01
6	0.37E+00	-0.18E+02	-0.34E-01
7	0.60E+00	-0.22E+02	-0.32E-01
8	0.87E+00	-0.25E+02	-0.29E-01
9	0.12E+01	-0.27E+02	-0.26E-01
10	0.15E+01	-0.30E+02	-0.23E-01
11	0.19E+01	-0.32E+02	-0.19E-01
12	0.24E+01	-0.34E+02	-0.15E-01
13	0.28E+01	-0.35E+02	-0.12E-01
14	0.32E+01	-0.36E+02	-0.77E-02
15	0.36E+01	-0.37E+02	-0.39E-02
16	0.40E+01	-0.37E+02	-0.13E-13
17	0.45E+01	-0.37E+02	0.39E-02
18	0.49E+01	-0.36E+02	0.77E-02
19	0.53E+01	-0.35E+02	0.12E-01
20	0.57E+01	-0.34E+02	0.15E-01
21	0.61E+01	-0.32E+02	0.19E-01
22	0.65E+01	-0.30E+02	0.23E-01
23	0.69E+01	-0.27E+02	0.26E-01
24	0.72E+01	-0.25E+02	0.29E-01
25	0.75E+01	-0.22E+02	0.32E-01
26	0.77E+01	-0.18E+02	0.34E-01
27	0.79E+01	-0.15E+02	0.35E-01
28	0.80E+01	-0.11E+02	0.37E-01
29	0.81E+01	-0.75E+01	0.37E-01
30	0.81E+01	-0.38E+01	0.37E-01
31	0.81E+01	0.00E+00	0.37E-01

NODAL DISPLACEMENTS STEP 33

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.39E-01
2	0.89E-05	-0.39E+01	-0.39E-01
3	0.82E-03	-0.77E+01	-0.39E-01
4	0.60E-01	-0.12E+02	-0.38E-01
5	0.20E+00	-0.15E+02	-0.37E-01
6	0.39E+00	-0.19E+02	-0.35E-01
7	0.63E+00	-0.22E+02	-0.33E-01
8	0.91E+00	-0.25E+02	-0.30E-01
9	0.12E+01	-0.28E+02	-0.27E-01
10	0.16E+01	-0.31E+02	-0.24E-01
11	0.20E+01	-0.33E+02	-0.20E-01
12	0.24E+01	-0.35E+02	-0.16E-01
13	0.29E+01	-0.36E+02	-0.12E-01
14	0.33E+01	-0.37E+02	-0.80E-02
15	0.37E+01	-0.38E+02	-0.40E-02
16	0.42E+01	-0.38E+02	0.14E-13
17	0.46E+01	-0.38E+02	0.40E-02
18	0.50E+01	-0.37E+02	0.80E-02
19	0.55E+01	-0.36E+02	0.12E-01
20	0.59E+01	-0.35E+02	0.16E-01
21	0.63E+01	-0.33E+02	0.20E-01
22	0.67E+01	-0.31E+02	0.24E-01
23	0.71E+01	-0.28E+02	0.27E-01
24	0.74E+01	-0.25E+02	0.30E-01
25	0.77E+01	-0.22E+02	0.33E-01
26	0.79E+01	-0.19E+02	0.35E-01
27	0.81E+01	-0.15E+02	0.37E-01

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NODAL DISPLACEMENTS STEP 34

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.40E-01
2	0.92E-05	-0.40E+01	-0.40E-01
3	0.10E-02	-0.80E+01	-0.40E-01
4	0.67E-01	-0.12E+02	-0.39E-01
5	0.21E+00	-0.16E+02	-0.38E-01
6	0.41E+00	-0.19E+02	-0.36E-01
7	0.65E+00	-0.23E+02	-0.34E-01
8	0.94E+00	-0.26E+02	-0.31E-01
9	0.13E+01	-0.29E+02	-0.28E-01
10	0.17E+01	-0.32E+02	-0.24E-01
11	0.21E+01	-0.34E+02	-0.20E-01
12	0.25E+01	-0.36E+02	-0.16E-01
13	0.30E+01	-0.37E+02	-0.12E-01
14	0.34E+01	-0.38E+02	-0.82E-02
15	0.39E+01	-0.39E+02	-0.41E-02
16	0.43E+01	-0.39E+02	-0.83E-14
17	0.47E+01	-0.39E+02	0.41E-02
18	0.52E+01	-0.38E+02	0.82E-02
19	0.56E+01	-0.37E+02	0.12E-01
20	0.61E+01	-0.36E+02	0.16E-01
21	0.65E+01	-0.34E+02	0.20E-01
22	0.70E+01	-0.32E+02	0.24E-01
23	0.73E+01	-0.29E+02	0.28E-01
24	0.77E+01	-0.26E+02	0.31E-01
25	0.79E+01	-0.23E+02	0.34E-01
26	0.82E+01	-0.19E+02	0.36E-01
27	0.84E+01	-0.16E+02	0.38E-01
28	0.85E+01	-0.12E+02	0.39E-01
29	0.86E+01	-0.80E+01	0.40E-01
30	0.86E+01	-0.40E+01	0.40E-01
31	0.86E+01	0.00E+00	0.40E-01

NODAL DISPLACEMENTS STEP 35

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.41E-01
2	0.94E-05	-0.41E+01	-0.41E-01
3	0.13E-02	-0.82E+01	-0.41E-01
4	0.74E-01	-0.12E+02	-0.40E-01
5	0.22E+00	-0.16E+02	-0.39E-01
6	0.43E+00	-0.20E+02	-0.37E-01
7	0.68E+00	-0.24E+02	-0.35E-01
8	0.97E+00	-0.27E+02	-0.32E-01
9	0.13E+01	-0.30E+02	-0.29E-01
10	0.17E+01	-0.33E+02	-0.25E-01
11	0.21E+01	-0.35E+02	-0.21E-01
12	0.26E+01	-0.37E+02	-0.17E-01
13	0.31E+01	-0.38E+02	-0.13E-01
14	0.35E+01	-0.39E+02	-0.84E-02
15	0.40E+01	-0.40E+02	-0.42E-02
16	0.44E+01	-0.40E+02	0.77E-14
17	0.49E+01	-0.40E+02	0.42E-02
18	0.53E+01	-0.39E+02	0.84E-02
19	0.58E+01	-0.38E+02	0.13E-01
20	0.63E+01	-0.37E+02	0.17E-01
21	0.67E+01	-0.35E+02	0.21E-01
22	0.72E+01	-0.33E+02	0.25E-01
23	0.75E+01	-0.30E+02	0.29E-01
24	0.79E+01	-0.27E+02	0.32E-01
25	0.82E+01	-0.24E+02	0.35E-01
26	0.84E+01	-0.20E+02	0.37E-01
27	0.86E+01	-0.16E+02	0.39E-01
28	0.88E+01	-0.12E+02	0.40E-01
29	0.89E+01	-0.82E+01	0.41E-01
30	0.89E+01	-0.41E+01	0.41E-01
31	0.89E+01	0.00E+00	0.41E-01

NODAL DISPLACEMENTS STEP 36

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.42E-01
2	0.97E-05	-0.42E+01	-0.42E-01
3	0.17E-02	-0.85E+01	-0.42E-01
4	0.80E-01	-0.13E+02	-0.41E-01
5	0.23E+00	-0.17E+02	-0.40E-01
6	0.44E+00	-0.21E+02	-0.38E-01
7	0.70E+00	-0.24E+02	-0.36E-01
8	0.10E+01	-0.28E+02	-0.33E-01
9	0.14E+01	-0.31E+02	-0.29E-01
10	0.18E+01	-0.34E+02	-0.26E-01
11	0.22E+01	-0.36E+02	-0.22E-01
12	0.27E+01	-0.38E+02	-0.17E-01
13	0.31E+01	-0.39E+02	-0.13E-01
14	0.36E+01	-0.41E+02	-0.87E-02
15	0.41E+01	-0.41E+02	-0.43E-02
16	0.46E+01	-0.41E+02	-0.33E-14
17	0.50E+01	-0.41E+02	0.43E-02
18	0.55E+01	-0.41E+02	0.87E-02
19	0.60E+01	-0.39E+02	0.13E-01
20	0.64E+01	-0.38E+02	0.17E-01
21	0.69E+01	-0.36E+02	0.22E-01
22	0.74E+01	-0.34E+02	0.26E-01
23	0.78E+01	-0.31E+02	0.29E-01
24	0.81E+01	-0.28E+02	0.33E-01
25	0.84E+01	-0.24E+02	0.36E-01
26	0.87E+01	-0.21E+02	0.38E-01

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NODAL DISPLACEMENTS STEP 37

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.43E-01
2	0.10E-04	-0.44E+01	-0.43E-01
3	0.21E-02	-0.87E+01	-0.43E-01
4	0.87E-01	-0.13E+02	-0.42E-01
5	0.25E+00	-0.17E+02	-0.41E-01
6	0.46E+00	-0.21E+02	-0.39E-01
7	0.73E+00	-0.25E+02	-0.36E-01
8	0.10E+01	-0.28E+02	-0.34E-01
9	0.14E+01	-0.32E+02	-0.30E-01
10	0.18E+01	-0.35E+02	-0.26E-01
11	0.23E+01	-0.37E+02	-0.22E-01
12	0.28E+01	-0.39E+02	-0.18E-01
13	0.32E+01	-0.41E+02	-0.13E-01
14	0.37E+01	-0.42E+02	-0.89E-02
15	0.42E+01	-0.42E+02	-0.45E-02
16	0.47E+01	-0.43E+02	0.32E-14
17	0.52E+01	-0.42E+02	0.45E-02
18	0.57E+01	-0.42E+02	0.89E-02
19	0.61E+01	-0.41E+02	0.13E-01
20	0.66E+01	-0.39E+02	0.18E-01
21	0.71E+01	-0.37E+02	0.22E-01
22	0.76E+01	-0.35E+02	0.26E-01
23	0.80E+01	-0.32E+02	0.30E-01
24	0.84E+01	-0.28E+02	0.34E-01
25	0.87E+01	-0.25E+02	0.36E-01
26	0.89E+01	-0.21E+02	0.39E-01
27	0.91E+01	-0.17E+02	0.41E-01
28	0.93E+01	-0.13E+02	0.42E-01
29	0.94E+01	-0.87E+01	0.43E-01
30	0.94E+01	-0.44E+01	0.43E-01
31	0.94E+01	0.00E+00	0.43E-01

NODAL DISPLACEMENTS STEP 38

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.45E-01
2	0.10E-04	-0.45E+01	-0.45E-01
3	0.28E-02	-0.89E+01	-0.45E-01
4	0.93E-01	-0.13E+02	-0.44E-01
5	0.26E+00	-0.18E+02	-0.42E-01
6	0.48E+00	-0.22E+02	-0.40E-01
7	0.75E+00	-0.26E+02	-0.37E-01
8	0.11E+01	-0.29E+02	-0.35E-01
9	0.14E+01	-0.33E+02	-0.31E-01
10	0.19E+01	-0.35E+02	-0.27E-01
11	0.23E+01	-0.38E+02	-0.23E-01
12	0.28E+01	-0.40E+02	-0.18E-01
13	0.33E+01	-0.42E+02	-0.14E-01
14	0.38E+01	-0.43E+02	-0.91E-02
15	0.43E+01	-0.43E+02	-0.46E-02
16	0.48E+01	-0.44E+02	-0.61E-15
17	0.53E+01	-0.43E+02	0.46E-02
18	0.58E+01	-0.43E+02	0.91E-02
19	0.63E+01	-0.42E+02	0.14E-01
20	0.68E+01	-0.40E+02	0.18E-01
21	0.73E+01	-0.38E+02	0.23E-01
22	0.78E+01	-0.35E+02	0.27E-01
23	0.82E+01	-0.33E+02	0.31E-01
24	0.86E+01	-0.29E+02	0.35E-01
25	0.89E+01	-0.26E+02	0.37E-01
26	0.92E+01	-0.22E+02	0.40E-01
27	0.94E+01	-0.18E+02	0.42E-01
28	0.96E+01	-0.13E+02	0.44E-01
29	0.96E+01	-0.89E+01	0.45E-01
30	0.97E+01	-0.45E+01	0.45E-01
31	0.97E+01	0.00E+00	0.45E-01

NODAL DISPLACEMENTS STEP 39

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.46E-01
2	0.11E-04	-0.46E+01	-0.46E-01
3	0.36E-02	-0.92E+01	-0.46E-01
4	0.99E-01	-0.14E+02	-0.45E-01
5	0.27E+00	-0.18E+02	-0.43E-01
6	0.50E+00	-0.22E+02	-0.41E-01
7	0.77E+00	-0.26E+02	-0.38E-01
8	0.11E+01	-0.30E+02	-0.35E-01
9	0.15E+01	-0.33E+02	-0.32E-01
10	0.19E+01	-0.36E+02	-0.28E-01
11	0.24E+01	-0.39E+02	-0.23E-01
12	0.29E+01	-0.41E+02	-0.19E-01
13	0.34E+01	-0.43E+02	-0.14E-01
14	0.39E+01	-0.44E+02	-0.94E-02
15	0.44E+01	-0.45E+02	-0.47E-02
16	0.50E+01	-0.45E+02	0.13E-14
17	0.55E+01	-0.45E+02	0.47E-02
18	0.60E+01	-0.44E+02	0.94E-02
19	0.65E+01	-0.43E+02	0.14E-01
20	0.70E+01	-0.41E+02	0.19E-01
21	0.75E+01	-0.39E+02	0.23E-01
22	0.80E+01	-0.36E+02	0.28E-01
23	0.84E+01	-0.33E+02	0.32E-01
24	0.88E+01	-0.30E+02	0.35E-01
25	0.91E+01	-0.26E+02	0.38E-01
26	0.94E+01	-0.22E+02	0.41E-01
27	0.96E+01	-0.18E+02	0.43E-01

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NODAL DISPLACEMENTS STEP 40

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.47E-01
2	0.16E-04	-0.47E+01	-0.47E-01
3	0.46E-02	-0.94E+01	-0.47E-01
4	0.11E+00	-0.14E+02	-0.46E-01
5	0.28E+00	-0.19E+02	-0.44E-01
6	0.51E+00	-0.23E+02	-0.42E-01
7	0.80E+00	-0.27E+02	-0.39E-01
8	0.11E+01	-0.31E+02	-0.36E-01
9	0.15E+01	-0.34E+02	-0.33E-01
10	0.20E+01	-0.37E+02	-0.29E-01
11	0.25E+01	-0.40E+02	-0.24E-01
12	0.30E+01	-0.42E+02	-0.19E-01
13	0.35E+01	-0.44E+02	-0.14E-01
14	0.40E+01	-0.45E+02	-0.96E-02
15	0.46E+01	-0.46E+02	-0.48E-02
16	0.51E+01	-0.46E+02	0.28E-15
17	0.56E+01	-0.46E+02	0.48E-02
18	0.61E+01	-0.45E+02	0.96E-02
19	0.67E+01	-0.44E+02	0.14E-01
20	0.72E+01	-0.42E+02	0.19E-01
21	0.77E+01	-0.40E+02	0.24E-01
22	0.82E+01	-0.37E+02	0.29E-01
23	0.86E+01	-0.34E+02	0.33E-01
24	0.90E+01	-0.31E+02	0.36E-01
25	0.94E+01	-0.27E+02	0.39E-01
26	0.97E+01	-0.23E+02	0.42E-01
27	0.99E+01	-0.19E+02	0.44E-01
28	0.10E+02	-0.14E+02	0.46E-01
29	0.10E+02	-0.94E+01	0.47E-01
30	0.10E+02	-0.47E+01	0.47E-01
31	0.10E+02	0.00E+00	0.47E-01

NODAL DISPLACEMENTS STEP 41

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.48E-01
2	0.22E-04	-0.48E+01	-0.48E-01
3	0.60E-02	-0.97E+01	-0.48E-01
4	0.11E+00	-0.14E+02	-0.47E-01
5	0.29E+00	-0.19E+02	-0.45E-01
6	0.53E+00	-0.23E+02	-0.43E-01
7	0.82E+00	-0.28E+02	-0.40E-01
8	0.12E+01	-0.32E+02	-0.37E-01
9	0.16E+01	-0.35E+02	-0.34E-01
10	0.20E+01	-0.38E+02	-0.29E-01
11	0.25E+01	-0.41E+02	-0.25E-01
12	0.31E+01	-0.43E+02	-0.20E-01
13	0.36E+01	-0.45E+02	-0.15E-01
14	0.41E+01	-0.46E+02	-0.99E-02
15	0.47E+01	-0.47E+02	-0.49E-02
16	0.52E+01	-0.47E+02	0.70E-15
17	0.58E+01	-0.47E+02	0.49E-02
18	0.63E+01	-0.46E+02	0.99E-02
19	0.68E+01	-0.45E+02	0.15E-01
20	0.74E+01	-0.43E+02	0.20E-01
21	0.79E+01	-0.41E+02	0.25E-01
22	0.84E+01	-0.38E+02	0.29E-01
23	0.89E+01	-0.35E+02	0.34E-01
24	0.93E+01	-0.32E+02	0.37E-01
25	0.96E+01	-0.28E+02	0.40E-01
26	0.99E+01	-0.23E+02	0.43E-01
27	0.10E+02	-0.19E+02	0.45E-01
28	0.10E+02	-0.14E+02	0.47E-01
29	0.10E+02	-0.97E+01	0.48E-01
30	0.10E+02	-0.48E+01	0.48E-01
31	0.10E+02	0.00E+00	0.48E-01

NODAL DISPLACEMENTS STEP 42

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.49E-01
2	0.28E-04	-0.50E+01	-0.49E-01
3	0.76E-02	-0.99E+01	-0.49E-01
4	0.12E+00	-0.15E+02	-0.48E-01
5	0.30E+00	-0.20E+02	-0.46E-01
6	0.54E+00	-0.24E+02	-0.44E-01
7	0.85E+00	-0.28E+02	-0.41E-01
8	0.12E+01	-0.32E+02	-0.38E-01
9	0.16E+01	-0.36E+02	-0.34E-01
10	0.21E+01	-0.39E+02	-0.30E-01
11	0.26E+01	-0.42E+02	-0.25E-01
12	0.31E+01	-0.44E+02	-0.20E-01
13	0.37E+01	-0.46E+02	-0.15E-01
14	0.42E+01	-0.47E+02	-0.10E-01
15	0.48E+01	-0.48E+02	-0.51E-02
16	0.53E+01	-0.48E+02	0.48E-15
17	0.59E+01	-0.48E+02	0.51E-02
18	0.64E+01	-0.47E+02	0.10E-01
19	0.70E+01	-0.46E+02	0.15E-01
20	0.75E+01	-0.44E+02	0.20E-01
21	0.81E+01	-0.42E+02	0.25E-01
22	0.86E+01	-0.39E+02	0.30E-01
23	0.91E+01	-0.36E+02	0.34E-01
24	0.95E+01	-0.32E+02	0.38E-01
25	0.98E+01	-0.28E+02	0.41E-01
26	0.10E+02	-0.24E+02	0.44E-01
27	0.10E+02	-0.20E+02	0.46E-01

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NODAL DISPLACEMENTS STEP 43

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.50E-01
2	0.26E-04	-0.50E+01	-0.50E-01
3	0.76E-02	-0.10E+02	-0.50E-01
4	0.12E+00	-0.15E+02	-0.49E-01
5	0.30E+00	-0.20E+02	-0.47E-01
6	0.55E+00	-0.25E+02	-0.45E-01
7	0.85E+00	-0.29E+02	-0.42E-01
8	0.12E+01	-0.33E+02	-0.39E-01
9	0.16E+01	-0.37E+02	-0.36E-01
10	0.21E+01	-0.40E+02	-0.31E-01
11	0.26E+01	-0.43E+02	-0.27E-01
12	0.31E+01	-0.45E+02	-0.21E-01
13	0.37E+01	-0.47E+02	-0.16E-01
14	0.42E+01	-0.49E+02	-0.11E-01
15	0.48E+01	-0.49E+02	-0.53E-02
16	0.53E+01	-0.50E+02	0.51E-15
17	0.58E+01	-0.49E+02	0.53E-02
18	0.64E+01	-0.49E+02	0.11E-01
19	0.69E+01	-0.47E+02	0.16E-01
20	0.75E+01	-0.45E+02	0.21E-01
21	0.80E+01	-0.43E+02	0.27E-01
22	0.85E+01	-0.40E+02	0.31E-01
23	0.90E+01	-0.37E+02	0.36E-01
24	0.94E+01	-0.33E+02	0.39E-01
25	0.98E+01	-0.29E+02	0.42E-01
26	0.10E+02	-0.25E+02	0.45E-01
27	0.10E+02	-0.20E+02	0.47E-01
28	0.10E+02	-0.15E+02	0.49E-01
29	0.11E+02	-0.10E+02	0.50E-01
30	0.11E+02	-0.50E+01	0.50E-01
31	0.11E+02	0.00E+00	0.50E-01

NODAL DISPLACEMENTS STEP 44

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.51E-01
2	0.26E-04	-0.51E+01	-0.51E-01
3	0.76E-02	-0.10E+02	-0.51E-01
4	0.12E+00	-0.15E+02	-0.50E-01
5	0.30E+00	-0.20E+02	-0.48E-01
6	0.55E+00	-0.25E+02	-0.46E-01
7	0.85E+00	-0.30E+02	-0.43E-01
8	0.12E+01	-0.34E+02	-0.40E-01
9	0.16E+01	-0.38E+02	-0.36E-01
10	0.21E+01	-0.41E+02	-0.32E-01
11	0.26E+01	-0.44E+02	-0.28E-01
12	0.32E+01	-0.46E+02	-0.22E-01
13	0.37E+01	-0.48E+02	-0.17E-01
14	0.43E+01	-0.50E+02	-0.11E-01
15	0.48E+01	-0.51E+02	-0.55E-02
16	0.54E+01	-0.51E+02	0.49E-15
17	0.59E+01	-0.51E+02	0.55E-02
18	0.65E+01	-0.50E+02	0.11E-01
19	0.70E+01	-0.48E+02	0.17E-01
20	0.75E+01	-0.46E+02	0.22E-01
21	0.81E+01	-0.44E+02	0.28E-01
22	0.86E+01	-0.41E+02	0.32E-01
23	0.91E+01	-0.38E+02	0.36E-01
24	0.95E+01	-0.34E+02	0.40E-01
25	0.99E+01	-0.30E+02	0.43E-01
26	0.10E+02	-0.25E+02	0.46E-01
27	0.10E+02	-0.20E+02	0.48E-01
28	0.11E+02	-0.15E+02	0.50E-01
29	0.11E+02	-0.10E+02	0.51E-01
30	0.11E+02	-0.51E+01	0.51E-01
31	0.11E+02	0.00E+00	0.51E-01

NODAL DISPLACEMENTS STEP 45

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.52E-01
2	0.27E-04	-0.52E+01	-0.52E-01
3	0.77E-02	-0.10E+02	-0.52E-01
4	0.12E+00	-0.16E+02	-0.51E-01
5	0.30E+00	-0.21E+02	-0.49E-01
6	0.55E+00	-0.26E+02	-0.47E-01
7	0.85E+00	-0.30E+02	-0.44E-01
8	0.12E+01	-0.34E+02	-0.41E-01
9	0.16E+01	-0.38E+02	-0.37E-01
10	0.21E+01	-0.42E+02	-0.33E-01
11	0.26E+01	-0.45E+02	-0.28E-01
12	0.32E+01	-0.48E+02	-0.23E-01
13	0.37E+01	-0.50E+02	-0.17E-01
14	0.43E+01	-0.51E+02	-0.11E-01
15	0.49E+01	-0.52E+02	-0.57E-02
16	0.54E+01	-0.52E+02	0.49E-15
17	0.60E+01	-0.52E+02	0.57E-02
18	0.65E+01	-0.51E+02	0.11E-01
19	0.71E+01	-0.50E+02	0.17E-01
20	0.77E+01	-0.48E+02	0.23E-01
21	0.82E+01	-0.45E+02	0.28E-01
22	0.87E+01	-0.42E+02	0.33E-01
23	0.92E+01	-0.38E+02	0.37E-01
24	0.96E+01	-0.34E+02	0.41E-01
25	0.10E+02	-0.30E+02	0.44E-01
26	0.10E+02	-0.26E+02	0.47E-01

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NODAL DISPLACEMENTS STEP 46

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.53E-01
2	0.27E-04	-0.54E+01	-0.53E-01
3	0.89E-02	-0.11E+02	-0.53E-01
4	0.12E+00	-0.16E+02	-0.52E-01
5	0.31E+00	-0.21E+02	-0.50E-01
6	0.55E+00	-0.26E+02	-0.48E-01
7	0.85E+00	-0.31E+02	-0.45E-01
8	0.12E+01	-0.35E+02	-0.42E-01
9	0.16E+01	-0.39E+02	-0.38E-01
10	0.21E+01	-0.43E+02	-0.34E-01
11	0.26E+01	-0.46E+02	-0.29E-01
12	0.32E+01	-0.49E+02	-0.24E-01
13	0.38E+01	-0.51E+02	-0.18E-01
14	0.43E+01	-0.52E+02	-0.12E-01
15	0.49E+01	-0.53E+02	-0.59E-02
16	0.55E+01	-0.53E+02	0.50E-15
17	0.61E+01	-0.53E+02	0.59E-02
18	0.66E+01	-0.52E+02	0.12E-01
19	0.72E+01	-0.51E+02	0.18E-01
20	0.78E+01	-0.49E+02	0.24E-01
21	0.83E+01	-0.46E+02	0.29E-01
22	0.89E+01	-0.43E+02	0.34E-01
23	0.93E+01	-0.39E+02	0.38E-01
24	0.98E+01	-0.35E+02	0.42E-01
25	0.10E+02	-0.31E+02	0.45E-01
26	0.10E+02	-0.26E+02	0.48E-01
27	0.11E+02	-0.21E+02	0.50E-01
28	0.11E+02	-0.16E+02	0.52E-01
29	0.11E+02	-0.11E+02	0.53E-01
30	0.11E+02	-0.54E+01	0.53E-01
31	0.11E+02	0.00E+00	0.53E-01

NODAL DISPLACEMENTS STEP 47

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.55E-01
2	0.29E-04	-0.55E+01	-0.55E-01
3	0.11E-01	-0.11E+02	-0.54E-01
4	0.13E+00	-0.16E+02	-0.53E-01
5	0.31E+00	-0.22E+02	-0.51E-01
6	0.56E+00	-0.27E+02	-0.49E-01
7	0.87E+00	-0.31E+02	-0.46E-01
8	0.12E+01	-0.36E+02	-0.43E-01
9	0.16E+01	-0.40E+02	-0.39E-01
10	0.21E+01	-0.44E+02	-0.35E-01
11	0.27E+01	-0.47E+02	-0.30E-01
12	0.32E+01	-0.50E+02	-0.24E-01
13	0.38E+01	-0.52E+02	-0.18E-01
14	0.44E+01	-0.53E+02	-0.12E-01
15	0.50E+01	-0.54E+02	-0.60E-02
16	0.56E+01	-0.55E+02	0.50E-15
17	0.61E+01	-0.54E+02	0.60E-02
18	0.67E+01	-0.53E+02	0.12E-01
19	0.73E+01	-0.52E+02	0.18E-01
20	0.79E+01	-0.50E+02	0.24E-01
21	0.85E+01	-0.47E+02	0.30E-01
22	0.90E+01	-0.44E+02	0.35E-01
23	0.95E+01	-0.40E+02	0.39E-01
24	0.99E+01	-0.36E+02	0.43E-01
25	0.10E+02	-0.31E+02	0.46E-01
26	0.11E+02	-0.27E+02	0.49E-01
27	0.11E+02	-0.22E+02	0.51E-01
28	0.11E+02	-0.16E+02	0.53E-01
29	0.11E+02	-0.11E+02	0.54E-01
30	0.11E+02	-0.55E+01	0.55E-01
31	0.11E+02	0.00E+00	0.55E-01

NODAL DISPLACEMENTS STEP 48

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.56E-01
2	0.35E-04	-0.56E+01	-0.56E-01
3	0.13E-01	-0.11E+02	-0.55E-01
4	0.13E+00	-0.17E+02	-0.54E-01
5	0.32E+00	-0.22E+02	-0.53E-01
6	0.57E+00	-0.27E+02	-0.50E-01
7	0.88E+00	-0.32E+02	-0.47E-01
8	0.13E+01	-0.37E+02	-0.44E-01
9	0.17E+01	-0.41E+02	-0.40E-01
10	0.22E+01	-0.45E+02	-0.36E-01
11	0.27E+01	-0.48E+02	-0.31E-01
12	0.33E+01	-0.51E+02	-0.25E-01
13	0.39E+01	-0.53E+02	-0.18E-01
14	0.45E+01	-0.54E+02	-0.12E-01
15	0.51E+01	-0.55E+02	-0.62E-02
16	0.57E+01	-0.56E+02	0.50E-15
17	0.63E+01	-0.55E+02	0.62E-02
18	0.69E+01	-0.54E+02	0.12E-01
19	0.74E+01	-0.53E+02	0.18E-01
20	0.80E+01	-0.51E+02	0.25E-01
21	0.86E+01	-0.48E+02	0.31E-01
22	0.92E+01	-0.45E+02	0.36E-01
23	0.97E+01	-0.41E+02	0.40E-01
24	0.10E+02	-0.37E+02	0.44E-01
25	0.10E+02	-0.32E+02	0.47E-01
26	0.11E+02	-0.27E+02	0.50E-01
27	0.11E+02	-0.22E+02	0.53E-01

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NODAL DISPLACEMENTS STEP 49

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.57E-01
2	0.41E-04	-0.57E+01	-0.57E-01
3	0.15E-01	-0.11E+02	-0.57E-01
4	0.14E+00	-0.17E+02	-0.55E-01
5	0.33E+00	-0.22E+02	-0.54E-01
6	0.59E+00	-0.28E+02	-0.51E-01
7	0.90E+00	-0.33E+02	-0.48E-01
8	0.13E+01	-0.37E+02	-0.45E-01
9	0.17E+01	-0.42E+02	-0.41E-01
10	0.22E+01	-0.46E+02	-0.36E-01
11	0.27E+01	-0.49E+02	-0.31E-01
12	0.33E+01	-0.52E+02	-0.25E-01
13	0.40E+01	-0.54E+02	-0.19E-01
14	0.46E+01	-0.56E+02	-0.13E-01
15	0.52E+01	-0.57E+02	-0.63E-02
16	0.58E+01	-0.57E+02	0.49E-15
17	0.64E+01	-0.57E+02	0.63E-02
18	0.70E+01	-0.56E+02	0.13E-01
19	0.76E+01	-0.54E+02	0.19E-01
20	0.82E+01	-0.52E+02	0.25E-01
21	0.88E+01	-0.49E+02	0.31E-01
22	0.93E+01	-0.46E+02	0.36E-01
23	0.98E+01	-0.42E+02	0.41E-01
24	0.10E+02	-0.37E+02	0.45E-01
25	0.11E+02	-0.33E+02	0.48E-01
26	0.11E+02	-0.28E+02	0.51E-01
27	0.11E+02	-0.22E+02	0.54E-01
28	0.11E+02	-0.17E+02	0.55E-01
29	0.12E+02	-0.11E+02	0.57E-01
30	0.12E+02	-0.57E+01	0.57E-01
31	0.12E+02	0.00E+00	0.57E-01

NODAL DISPLACEMENTS STEP 50

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.58E-01
2	0.46E-04	-0.58E+01	-0.58E-01
3	0.17E-01	-0.12E+02	-0.58E-01
4	0.14E+00	-0.17E+02	-0.57E-01
5	0.34E+00	-0.23E+02	-0.55E-01
6	0.60E+00	-0.28E+02	-0.52E-01
7	0.92E+00	-0.33E+02	-0.49E-01
8	0.13E+01	-0.38E+02	-0.46E-01
9	0.17E+01	-0.43E+02	-0.42E-01
10	0.22E+01	-0.47E+02	-0.37E-01
11	0.28E+01	-0.50E+02	-0.32E-01
12	0.34E+01	-0.53E+02	-0.26E-01
13	0.40E+01	-0.55E+02	-0.19E-01
14	0.46E+01	-0.57E+02	-0.13E-01
15	0.53E+01	-0.58E+02	-0.64E-02
16	0.59E+01	-0.58E+02	0.45E-15
17	0.65E+01	-0.58E+02	0.64E-02
18	0.71E+01	-0.57E+02	0.13E-01
19	0.77E+01	-0.55E+02	0.19E-01
20	0.83E+01	-0.53E+02	0.26E-01
21	0.89E+01	-0.50E+02	0.32E-01
22	0.95E+01	-0.47E+02	0.37E-01
23	0.10E+02	-0.43E+02	0.42E-01
24	0.10E+02	-0.38E+02	0.46E-01
25	0.11E+02	-0.33E+02	0.49E-01
26	0.11E+02	-0.28E+02	0.52E-01
27	0.11E+02	-0.23E+02	0.55E-01
28	0.12E+02	-0.17E+02	0.57E-01
29	0.12E+02	-0.12E+02	0.58E-01
30	0.12E+02	-0.58E+01	0.58E-01
31	0.12E+02	0.00E+00	0.58E-01

NODAL DISPLACEMENTS STEP 51

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.59E-01
2	0.51E-04	-0.59E+01	-0.59E-01
3	0.19E-01	-0.12E+02	-0.59E-01
4	0.15E+00	-0.18E+02	-0.58E-01
5	0.35E+00	-0.23E+02	-0.56E-01
6	0.61E+00	-0.29E+02	-0.53E-01
7	0.94E+00	-0.34E+02	-0.50E-01
8	0.13E+01	-0.39E+02	-0.47E-01
9	0.18E+01	-0.43E+02	-0.43E-01
10	0.23E+01	-0.47E+02	-0.38E-01
11	0.28E+01	-0.51E+02	-0.33E-01
12	0.35E+01	-0.54E+02	-0.26E-01
13	0.41E+01	-0.56E+02	-0.20E-01
14	0.47E+01	-0.58E+02	-0.13E-01
15	0.53E+01	-0.59E+02	-0.65E-02
16	0.60E+01	-0.59E+02	0.48E-15
17	0.66E+01	-0.59E+02	0.65E-02
18	0.72E+01	-0.58E+02	0.13E-01
19	0.78E+01	-0.56E+02	0.20E-01
20	0.85E+01	-0.54E+02	0.26E-01
21	0.91E+01	-0.51E+02	0.33E-01
22	0.97E+01	-0.47E+02	0.38E-01
23	0.10E+02	-0.43E+02	0.43E-01
24	0.11E+02	-0.39E+02	0.47E-01
25	0.11E+02	-0.34E+02	0.50E-01
26	0.11E+02	-0.29E+02	0.53E-01

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NODAL DISPLACEMENTS STEP 52

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.60E-01
2	0.53E-04	-0.60E+01	-0.60E-01
3	0.24E-01	-0.12E+02	-0.60E-01
4	0.15E+00	-0.18E+02	-0.59E-01
5	0.36E+00	-0.24E+02	-0.57E-01
6	0.63E+00	-0.29E+02	-0.54E-01
7	0.95E+00	-0.35E+02	-0.51E-01
8	0.13E+01	-0.40E+02	-0.48E-01
9	0.18E+01	-0.44E+02	-0.44E-01
10	0.23E+01	-0.48E+02	-0.39E-01
11	0.29E+01	-0.52E+02	-0.33E-01
12	0.35E+01	-0.55E+02	-0.26E-01
13	0.41E+01	-0.57E+02	-0.20E-01
14	0.48E+01	-0.59E+02	-0.13E-01
15	0.54E+01	-0.60E+02	-0.66E-02
16	0.60E+01	-0.60E+02	0.47E-15
17	0.67E+01	-0.60E+02	0.66E-02
18	0.73E+01	-0.59E+02	0.13E-01
19	0.79E+01	-0.57E+02	0.20E-01
20	0.85E+01	-0.55E+02	0.26E-01
21	0.92E+01	-0.52E+02	0.33E-01
22	0.98E+01	-0.48E+02	0.39E-01
23	0.10E+02	-0.44E+02	0.44E-01
24	0.11E+02	-0.40E+02	0.48E-01
25	0.11E+02	-0.35E+02	0.51E-01
26	0.11E+02	-0.29E+02	0.54E-01
27	0.12E+02	-0.24E+02	0.57E-01
28	0.12E+02	-0.18E+02	0.59E-01
29	0.12E+02	-0.12E+02	0.60E-01
30	0.12E+02	-0.60E+01	0.60E-01
31	0.12E+02	0.00E+00	0.60E-01

NODAL DISPLACEMENTS STEP 53

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.62E-01
2	0.59E-04	-0.62E+01	-0.61E-01
3	0.27E-01	-0.12E+02	-0.61E-01
4	0.16E+00	-0.18E+02	-0.60E-01
5	0.37E+00	-0.24E+02	-0.58E-01
6	0.64E+00	-0.30E+02	-0.55E-01
7	0.97E+00	-0.35E+02	-0.52E-01
8	0.14E+01	-0.40E+02	-0.49E-01
9	0.18E+01	-0.45E+02	-0.44E-01
10	0.23E+01	-0.49E+02	-0.40E-01
11	0.29E+01	-0.53E+02	-0.33E-01
12	0.36E+01	-0.56E+02	-0.27E-01
13	0.42E+01	-0.58E+02	-0.20E-01
14	0.49E+01	-0.60E+02	-0.13E-01
15	0.55E+01	-0.61E+02	-0.67E-02
16	0.61E+01	-0.61E+02	0.47E-15
17	0.68E+01	-0.61E+02	0.67E-02
18	0.74E+01	-0.60E+02	0.13E-01
19	0.80E+01	-0.58E+02	0.20E-01
20	0.87E+01	-0.56E+02	0.27E-01
21	0.93E+01	-0.53E+02	0.33E-01
22	0.99E+01	-0.49E+02	0.40E-01
23	0.10E+02	-0.45E+02	0.44E-01
24	0.11E+02	-0.40E+02	0.49E-01
25	0.11E+02	-0.35E+02	0.52E-01
26	0.12E+02	-0.30E+02	0.55E-01
27	0.12E+02	-0.24E+02	0.58E-01
28	0.12E+02	-0.18E+02	0.60E-01
29	0.12E+02	-0.12E+02	0.61E-01
30	0.12E+02	-0.62E+01	0.61E-01
31	0.12E+02	0.00E+00	0.62E-01

NODAL DISPLACEMENTS STEP 54

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.63E-01
2	0.68E-04	-0.63E+01	-0.63E-01
3	0.31E-01	-0.13E+02	-0.62E-01
4	0.17E+00	-0.19E+02	-0.61E-01
5	0.38E+00	-0.25E+02	-0.59E-01
6	0.65E+00	-0.31E+02	-0.56E-01
7	0.10E+01	-0.36E+02	-0.53E-01
8	0.14E+01	-0.41E+02	-0.50E-01
9	0.19E+01	-0.46E+02	-0.45E-01
10	0.24E+01	-0.50E+02	-0.40E-01
11	0.30E+01	-0.54E+02	-0.34E-01
12	0.37E+01	-0.57E+02	-0.27E-01
13	0.43E+01	-0.59E+02	-0.20E-01
14	0.49E+01	-0.61E+02	-0.14E-01
15	0.56E+01	-0.62E+02	-0.68E-02
16	0.62E+01	-0.63E+02	0.46E-15
17	0.69E+01	-0.62E+02	0.68E-02
18	0.75E+01	-0.61E+02	0.14E-01
19	0.82E+01	-0.59E+02	0.20E-01
20	0.88E+01	-0.57E+02	0.27E-01
21	0.95E+01	-0.54E+02	0.34E-01
22	0.10E+02	-0.50E+02	0.40E-01
23	0.11E+02	-0.46E+02	0.45E-01
24	0.11E+02	-0.41E+02	0.50E-01
25	0.11E+02	-0.36E+02	0.53E-01
26	0.12E+02	-0.31E+02	0.56E-01
27	0.12E+02	-0.25E+02	0.59E-01

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NODE	X	Y	rZ
5	0.38E+00	-0.25E+02	-0.59E-01
6	0.65E+00	-0.31E+02	-0.56E-01
7	0.10E+01	-0.36E+02	-0.53E-01
8	0.14E+01	-0.41E+02	-0.50E-01
9	0.19E+01	-0.46E+02	-0.45E-01
10	0.24E+01	-0.50E+02	-0.40E-01
11	0.30E+01	-0.54E+02	-0.34E-01
12	0.37E+01	-0.57E+02	-0.27E-01
13	0.43E+01	-0.59E+02	-0.20E-01
14	0.49E+01	-0.61E+02	-0.14E-01
15	0.56E+01	-0.62E+02	-0.68E-02
16	0.62E+01	-0.63E+02	0.46E-15
17	0.69E+01	-0.62E+02	0.68E-02
18	0.75E+01	-0.61E+02	0.14E-01
19	0.82E+01	-0.59E+02	0.20E-01
20	0.88E+01	-0.57E+02	0.27E-01
21	0.95E+01	-0.54E+02	0.34E-01
22	0.10E+02	-0.50E+02	0.40E-01
23	0.11E+02	-0.46E+02	0.45E-01
24	0.11E+02	-0.41E+02	0.50E-01
25	0.11E+02	-0.36E+02	0.53E-01
26	0.12E+02	-0.31E+02	0.56E-01
27	0.12E+02	-0.25E+02	0.59E-01
28	0.12E+02	-0.19E+02	0.61E-01
29	0.12E+02	-0.13E+02	0.62E-01
30	0.12E+02	-0.63E+01	0.63E-01
31	0.12E+02	0.00E+00	0.63E-01

NODAL DISPLACEMENTS STEP 55

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.64E-01
2	0.79E-04	-0.64E+01	-0.64E-01
3	0.34E-01	-0.13E+02	-0.63E-01
4	0.17E+00	-0.19E+02	-0.62E-01
5	0.39E+00	-0.25E+02	-0.60E-01
6	0.67E+00	-0.31E+02	-0.57E-01
7	0.10E+01	-0.37E+02	-0.54E-01
8	0.14E+01	-0.42E+02	-0.51E-01
9	0.19E+01	-0.47E+02	-0.46E-01
10	0.24E+01	-0.51E+02	-0.41E-01
11	0.31E+01	-0.55E+02	-0.35E-01
12	0.37E+01	-0.58E+02	-0.28E-01
13	0.44E+01	-0.61E+02	-0.21E-01
14	0.50E+01	-0.62E+02	-0.14E-01
15	0.57E+01	-0.63E+02	-0.69E-02
16	0.63E+01	-0.64E+02	0.45E-15
17	0.70E+01	-0.63E+02	0.69E-02
18	0.77E+01	-0.62E+02	0.14E-01
19	0.83E+01	-0.61E+02	0.21E-01
20	0.90E+01	-0.58E+02	0.28E-01
21	0.96E+01	-0.55E+02	0.35E-01
22	0.10E+02	-0.51E+02	0.41E-01
23	0.11E+02	-0.47E+02	0.46E-01
24	0.11E+02	-0.42E+02	0.51E-01
25	0.12E+02	-0.37E+02	0.54E-01
26	0.12E+02	-0.31E+02	0.57E-01
27	0.12E+02	-0.25E+02	0.60E-01
28	0.13E+02	-0.19E+02	0.62E-01
29	0.13E+02	-0.13E+02	0.63E-01
30	0.13E+02	-0.64E+01	0.64E-01
31	0.13E+02	0.00E+00	0.64E-01

NODAL DISPLACEMENTS STEP 56

NODE	X	Y	rZ
1	0.00E+00	0.00E+00	-0.65E-01
2	0.90E-04	-0.65E+01	-0.65E-01
3	0.38E-01	-0.13E+02	-0.65E-01
4	0.18E+00	-0.19E+02	-0.63E-01
5	0.40E+00	-0.26E+02	-0.61E-01
6	0.69E+00	-0.32E+02	-0.59E-01
7	0.10E+01	-0.37E+02	-0.55E-01
8	0.15E+01	-0.43E+02	-0.51E-01
9	0.19E+01	-0.48E+02	-0.47E-01
10	0.25E+01	-0.52E+02	-0.42E-01
11	0.31E+01	-0.56E+02	-0.35E-01
12	0.38E+01	-0.59E+02	-0.28E-01
13	0.45E+01	-0.62E+02	-0.21E-01
14	0.51E+01	-0.63E+02	-0.14E-01
15	0.58E+01	-0.64E+02	-0.71E-02
16	0.65E+01	-0.65E+02	0.45E-15
17	0.71E+01	-0.64E+02	0.71E-02
18	0.78E+01	-0.63E+02	0.14E-01
19	0.84E+01	-0.62E+02	0.21E-01
20	0.91E+01	-0.59E+02	0.28E-01
21	0.98E+01	-0.56E+02	0.35E-01
22	0.10E+02	-0.52E+02	0.42E-01
23	0.11E+02	-0.48E+02	0.47E-01
24	0.11E+02	-0.43E+02	0.51E-01
25	0.12E+02	-0.37E+02	0.55E-01
26	0.12E+02	-0.32E+02	0.59E-01
27	0.13E+02	-0.26E+02	0.61E-01
28	0.13E+02	-0.19E+02	0.63E-01
29	0.13E+02	-0.13E+02	0.65E-01
30	0.13E+02	-0.65E+01	0.65E-01
31	0.13E+02	0.00E+00	0.65E-01

TRANS

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```
TRANS MATRIX
0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
TRANS MATRIX
0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
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0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
TRANS MATRIX
0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
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0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
TRANS MATRIX
0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
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0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
TRANS MATRIX
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0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
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0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
TRANS MATRIX
0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
TRANS MATRIX
0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00
0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
TRANS MATRIX
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TRANS MATRIX
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TRANS MATRIX
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0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
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TRANS MATRIX
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*TRANS - Notepad

File Edit Format View Help

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0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
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TRANS MATRIX
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*TRANS - Notepad

File Edit Format View Help

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0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00
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TRANS MATRIX
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TRANS MATRIX
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0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
TRANS MATRIX
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```

A1.4. Example 2. Shear Wall Analysis

The specimen G-15 represent a single shear wall. The wall specimens were 3,500 mm in height, 200 mm thick and was 1,500 mm in length as shown in Figure 4-15. G-15 concrete dimensions and details of reinforcement configuration The nominal concrete compressive strength used for G15 was 40 MPa. An axial load of $0.07. b_w. l_w. f_c'$ was applied at the top of the wall. #3 for vertical bars ($f_{fu} = 1{,}412\ MPa, E_f = 66.9\ GPa, \varepsilon_{fu} = 2.11\%, A_f = 71.3\ mm^2$) and spiral ties (for straight portions $f_{fu} = 962\ MPa, E_f = 52\ GPa, \varepsilon_{fu} = 1.85\%, A_f = 71.3\ mm^2$; for bent portions: $f_{fu} = 500\ MPa$ and #4 for horizontal bars ($f_{fu} = 1{,}392\ MPa, E_f = 69.6\ GPa, \varepsilon_{fu} = 2\%, A_f = 126.7\ mm^2$).

A1.4.1. Input files

GEOSE.TXT

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-EnterWithKeywords-
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  35
NumElems:
  34
NodeCoor:
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      0.0000 ,    100.0000
      0.0000 ,    200.0000
      0.0000 ,    300.0000
      0.0000 ,    400.0000
      0.0000 ,    500.0000
      0.0000 ,    600.0000
      0.0000 ,    700.0000
      0.0000 ,    800.0000
      0.0000 ,    900.0000
      0.0000 ,   1000.0000
      0.0000 ,   1100.0000
      0.0000 ,   1200.0000
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      0.0000 ,   1500.0000
      0.0000 ,   1600.0000
      0.0000 ,   1700.0000
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      0.0000 ,   2100.0000
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      0.0000 ,   2800.0000
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*GEOSE - Notepad
File  Edit  Format  View  Help
ElemConnect:
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     2 ,     3
     3 ,     4
     4 ,     5
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     7 ,     8
     8 ,     9
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    21 ,    22
    22 ,    23
    23 ,    24
    24 ,    25
    25 ,    26
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    27 ,    28
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    29 ,    30
    30 ,    31
    31 ,    32
    32 ,    33
    33 ,    34
    34 ,    35
```

PROPERTY_CONCRETE.TXT

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PROPERTY_CONCRETE - Notepad
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-EnterWithKeywords-
ConcreteElasticityModulus:
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ConcretePoissonRatio:
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ConcreteCompressiveStress:
-39.9000000000000
OnsetRatioPlaticFlow:
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CompressivePeakStrain:
-2.200000000000000E-002
ConcreteTensileStress:
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TensionSofteningPower:
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FactorIntersectTensionCompressionSurface:
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SlopeLinearPotentialSurface:
0.150000000000000
TensionSurfaceType1Rankine_2Mixed:
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CornerReturnType:
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DamageEvolutionFactorCompression:
XXX
DamageEvolutionFactorTension:
XXX
AnalysisTypeIsotropic0Anisotropic1:
XXX
ConfinementCoefficientXdirection:
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ConfinementCoefficientYdirection:
0.600000000000000
ProducePlasticReturnGraphAtSpecificPointYorN:
XXX
```

Current_PlasticDamageParam.TXT

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Current_PlasticDamageParam
File  Edit  View
-EnterWithKeywords-
MaterialModels_1Reduce3D_2Direct1DSugano_3Direct1DSaatchi:
2
DirectUniaxialModelPostpeakCalibrationFactor:
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CurrentCompressionPlasticityParameter:
XXX
CurrentTensionPlasticityParameter:
XXX
CurrentCompressionDamageParameter:
XXX
CurrentTensionDamageParameter:
XXX
```

CoorLoadSE.TXT

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 -EnterWithKeywords-
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Y
 LoadCoordinatesX-Y:
  0.000000000000        3200.00000000000
 LoadDirection:
    1
 LoadValue:
 -1.000E+06
 EnterNewLoadCoordinatesYorN:
N
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CoorBOUNDSE.TXT

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CoorBOUNDSE - Notepad
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 -EnterWithKeywords-
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Y
 BoundaryCoordinatesX-Y:
    0.00    0.00
 FixedDirection:
    1
 EnterNewBoundaryCoordinatesYorN:
Y
 BoundaryCoordinatesX-Y:
    0.00    0.00
 FixedDirection:
    2
 EnterNewBoundaryCoordinatesYorN:
Y
 BoundaryCoordinatesX-Y:
    0.00    0.00
 FixedDirection:
    3
 EnterNewBoundaryCoordinatesYorN:
N
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SEC.TXT

SEC - Notepad

File Edit Format View Help

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 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
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 200.00, 2000.00
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 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
 200.00, 2000.00
```

ReinforcementSE.TXT

*ReinforcementSE - Notepad

File Edit Format View Help

```
-EnterWithKeywords-
NumberOfRebarProperties:
          1
NumberOfRebarsInTheGroup:
         32
RebarElasticityModulusOfTheGroup:
  66900
RebarYieldStressOfTheGroup:
  250.0
RebarHardeningModulusOfTheGroup:
 12000.0
RebarAreaAndLocationInEachGroup:
    71.3
 -75.00, -950.00
    71.3000
  75.00, -950.00
    71.3000
 -75.00, -900.00
    71.3000
  75.00, -900.00
    71.3000
 -75.00, -850.00
    71.3000
  75.00, -850.00
    71.3000
 -75.00, -800.00
    71.3000
  75.00, -800.00
    71.3000
 -75.00, -600.00
    71.3000
  75.00, -600.00
    71.3000
 -75.00, -400.00
    71.3000
  75.00, -400.00
    71.3000
 -75.00, -200.00
    71.3000
  75.00, -200.00
    71.3000
 -75.00, -100.00
    71.3000
  75.00, -100.00
    71.3000
```

*ReinforcementSE - Notepad

File Edit Format View Help

```
 -75.00,    0.00
    71.3000
  75.00,    0.00
    71.3000
 -75.00,  200.00
    71.3000
  75.00,  200.00
    71.3000
 -75.00,  400.00
    71.3000
  75.00,  400.00
    71.3000
 -75.00,  600.00
    71.3000
  75.00,  600.00
    71.3000
 -75.00,  800.00
    71.3000
  75.00,  800.00
    71.3000
 -75.00,  850.00
    71.3000
  75.00,  850.00
    71.3000
 -75.00,  900.00
    71.3000
  75.00,  900.00
    71.3000
 -75.00,  950.00
    71.3000
  75.00,  950.00
 ApplyAllElementsYorN:
Y
 NumberOfRebarGroupsUsedInEachElement:
          1
 RebarGroupNoForEachElement:
          1
 EnterStirrupsYorN:
 Y
 AverageSpacingOfStirrups:
   200.0
 AreaOfStrirrupsWithinEachSpacing:
    50.0
 ReportReinforcementPlasticReturn:
 N
```

Solution_ParameterSE.TXT

Solution_ParameterSE - Notepad

File Edit Format View Help

```
-EnterWithKeywords-
ElementType:
          1
NumIntPoint:
          3
SectionWidthIntegPoint:
          3
SectionHeightIntegPoint:
         12
AnalysisTypeNoShear0Shear1:
          0
AnalysisTypeStatic1Dynamic2Both3:
          1
ControlTypeLoad1Displacement2:
          2
ControlNodeCoordinates:
 0.000000000000000E+000,3200.00000000000
ControlNodeNumber:
         33
ControlDirection:
          1
StepSize:
-1.00000000000000
StepNumberLimit:
       110
PlasticReturnType_1CuttingPlane_2CPP:
          1
AlgorithmStabilizationYorN:
N
DenominatorAmplificationFactor:
  1.00000000000000
PenaltyFactorLagrangian:
 0.000000000000000E+000
PlasticReturnIterationLimit:
       1000
ViscosityRate_0Independent_1ViscoPlastic_2ViscosRegularization:
          0
ViscoPlasticRetardationTime:
 0.000000000000000E+000
ViscoPlasticTimeIncrement:
 0.000000000000000E+000
```

Step_Guide.TXT

```
-EnterWithKeywords-
NumberOfCycles:
1
ControlType1or2:
1
NumberOfStepsEachCycle:
1000
ControlValuesEachCycle:
XXX
```

SWITCHB.TXT

```
-EnterWithKeywords-
LoadGenerateUsingCoordinatesYorN:
Y
BoundaryGenerateUsingCoordinatesYorN:
Y
MassGenerateUsingCoordinatesYorN:
XXX
```

A1.3.2. Input check

INPUT_CHECK - Notepad

File Edit Format View Help

```
****************Start Time********************
        15 :          5 :          17 :         740

------------------------------------------------------------------------
     ***Enter the Names of Plasticity Related Output files***

***Choose from the below list of Possible Output files***

***List of Possible Output files***

to be addressed at ListOutputFileSE.txt

                   ---Lamda.DAC---
           ---STATIC_DISPLACEMENTS.DAC---
                   ---DEP_X.DAC---
                   ---DEP_Y.DAC---
                   ---ROT_Z.DAC---

           ---PLASTIC_RETURN_LOG_FILE.DAC---
               ---InstantDrawFiles---
             ---SURFACE_AND_RETURN.TXT---
            ---StressConvergenceChase---

 Warning list mostly in 153
- Warning - No Intersection  Rankine M-W
- Modification introduced to return to M-W directly

- Warning - No Intersection  Rankine M-W
- Modification introduced to to shift the Rankine surface with factor

- Warning - ro<epsilon
- In the M-W  return algorithm Fp=0 is assigned directly

- Warning - ro<epsilon
- In the Rankine return algorithm Rankinep=0 is assigned directly

- Warning - ro<epsilon
- In the Corner return algorithm Fp = Rankinep=0 is assigned directly

 Warning - ro<=epsilon
---- dFp_dro =0 is assigned -----

 Warning - ro<=epsilon
---- dRanFpA_dro =0 is assigned -----

 Warning - K=dFp_dqp*dqp_dkapa*dkapa_dlam<0 for M-W
----K=0 is assigned -----

 Warning - K_RanA= -dRanFpA_dqp*dqp_dkapa*dkapa_dlam<-100 for Rankine
---- K_RanA=-100 is assigned -----

 WARNING - it_limit exceeded


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



------------------------------------------------------------------------
Number of pieces along an element           3
Number of pieces along width b of the Cross-section           3
Number of pieces along height h of the Cross-section          12

COORDINATES OF NODES
        NOD      X(mm)            Y(mm)
         1     0.0000000       0.0000000
         2     0.0000000     100.0000000
         3     0.0000000     200.0000000
         4     0.0000000     300.0000000
         5     0.0000000     400.0000000
         6     0.0000000     500.0000000
         7     0.0000000     600.0000000
         8     0.0000000     700.0000000
         9     0.0000000     800.0000000
        10     0.0000000     900.0000000
        11     0.0000000    1000.0000000
        12     0.0000000    1100.0000000
        13     0.0000000    1200.0000000
```

INPUT_CHECK - Notepad

File Edit Format View Help

```
        14     0.0000000    1300.0000000
        15     0.0000000    1400.0000000
        16     0.0000000    1500.0000000
        17     0.0000000    1600.0000000
        18     0.0000000    1700.0000000
        19     0.0000000    1800.0000000
        20     0.0000000    1900.0000000
        21     0.0000000    2000.0000000
        22     0.0000000    2100.0000000
        23     0.0000000    2200.0000000
        24     0.0000000    2300.0000000
        25     0.0000000    2400.0000000
        26     0.0000000    2500.0000000
        27     0.0000000    2600.0000000
        28     0.0000000    2700.0000000
        29     0.0000000    2800.0000000
        30     0.0000000    2900.0000000
        31     0.0000000    3000.0000000
        32     0.0000000    3100.0000000
        33     0.0000000    3200.0000000
        34     0.0000000    3300.0000000
        35     0.0000000    3400.0000000

     ELEMENT       I END         J END       LENGTH (mm)
         1           1             2      100.00000000
         2           2             3      100.00000000
         3           3             4      100.00000000
         4           4             5      100.00000000
         5           5             6      100.00000000
         6           6             7      100.00000000
         7           7             8      100.00000000
         8           8             9      100.00000000
         9           9            10      100.00000000
        10          10            11      100.00000000
        11          11            12      100.00000000
        12          12            13      100.00000000
        13          13            14      100.00000000
        14          14            15      100.00000000
        15          15            16      100.00000000
        16          16            17      100.00000000
        17          17            18      100.00000000
        18          18            19      100.00000000
        19          19            20      100.00000000
        20          20            21      100.00000000
        21          21            22      100.00000000
        22          22            23      100.00000000
        23          23            24      100.00000000
        24          24            25      100.00000000
        25          25            26      100.00000000
        26          26            27      100.00000000
        27          27            28      100.00000000
        28          28            29      100.00000000
        29          29            30      100.00000000
        30          30            31      100.00000000
        31          31            32      100.00000000
        32          32            33      100.00000000
        33          33            34      100.00000000
        34          34            35      100.00000000

 Loads are generated using Coordinates
     Load No     33            in direction    1          applied at      0.00   3200.00
----------------------------------------------


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

 Boundary Conditions are generated using Coordinates
          BC applied in direction    1   at      0.00      0.00
          BC applied in direction    2   at      0.00      0.00
          BC applied in direction    3   at      0.00      0.00
----------------------------------------------

 Multiple-Point Constraints are imposed directly to nodes
----------------------------------------------

FactorIntersectTensionCompressionSurface    1.50000000000000

PROPERTIES OF SOLID
```

INPUT_CHECK - Notepad

File Edit Format View Help

```
 PROPERTIES OF SOLID

 Ec          nu         fc           ft         ko      eps_c    P_type   al_p
   N/mm2                  N/mm2        N/mm2
0.2842E+05   0.15   -39.9000    0.5000     0.2000   -0.022000     1    0.150

      Kbu                                      G
     N/mm2                                  N/mm2
   13535.7142857143             12358.6956521739

 Factor to make sure Tension Surface and Mentrey-Willam Intersects
   1.50000000000000
  -------

 P_type=1 Linear | P_type=2 Higher order Potential func (al_p=2 Quadratic)
 T_type=1 Rankine surface | T_type=2 Mixed surface with Cut-off

 ----------------------------------------------------
 ------If T_Type =1 --------***Suggested numbers***----
 ksi_t0= 1.45*ft/afc | But we read si_to | So enter approximately  1.45
 ----------------------------------------------------
 ------If T_Type =2 --------***Suggested numbers***----
 ksi_m0=-2.5/afc     | But we read si_mo | So enter approximately -2.5
 ksi_t0= 1.45*ft/afc | But we read si_to | So enter approximately  1.45
 Ro_t0 =1.05 /afc    | But we read o_to  | So enter approximately  1.05
     0<mkf<1         |   rate_vkm<1
 ----------------------------------------------------
   T_type    ksi_m0   ksi_t0     Ro_t0       n3        Fdamc     Fdamt
  1     0.0000    0.0000    0.0000    0.2700     0.0000    0.000000

        If  ( TP_T>=0) then
             mcir = 0.1 * TP_T   !The intersection tolerance
        End If


        If      ( QI==0 ) then   ! No modification needed
          QI=0
           modif_qst = 1.0
        else if ( QI==1 .and. TP_T==0 ) then ! It is Ok to have no intersection
 - Return to Mentrey - Willam
          QI=1
          modif_qst = 1.0
        else if ( QI==1 .and. TP_T>0 ) then   !   It is Ok to shift the Rankine
 surface
          QI=0
          modif_qst = modif_qst2
        End If


   Isotropic Analysis Type 0 | Anisotropic Analysis Type 1
   IA_type =            0


  gama1=   0.600000000000000

  gama2=   0.600000000000000
 ----------------------------------------------------

  Output NOT generated for any Plastic return scenario for the Concrete Beam

 ----------
 Number of Reinforcement Groups with different Properties           1
 Number of Reinforcement Bars in Group           1 is          32
 --------For the Reinforcement Group--------------
   Er  =   66900.0000000000
 sig_y =   250.000000000000
   Hr  =   12000.0000000000

 Number of total re-bars within the Cross-section          32
 Properties of the Reinforcement
  Mem  =           1
 Num  Location x    Location y Area
   1   -75.0000  -950.0000  .7130E+02
   2    75.0000  -950.0000  .7130E+02
   3   -75.0000  -900.0000  .7130E+02
   4    75.0000  -900.0000  .7130E+02
   5   -75.0000  -850.0000  .7130E+02
```

INPUT_CHECK - Notepad

File Edit Format View Help

```
   6    75.0000  -850.0000  .7130E+02
   7   -75.0000  -800.0000  .7130E+02
   8    75.0000  -800.0000  .7130E+02
   9   -75.0000  -600.0000  .7130E+02
  10    75.0000  -600.0000  .7130E+02
  11   -75.0000  -400.0000  .7130E+02
  12    75.0000  -400.0000  .7130E+02
  13   -75.0000  -200.0000  .7130E+02
  14    75.0000  -200.0000  .7130E+02
  15   -75.0000  -100.0000  .7130E+02
  16    75.0000  -100.0000  .7130E+02
  17   -75.0000     0.0000  .7130E+02
  18    75.0000     0.0000  .7130E+02
  19   -75.0000   200.0000  .7130E+02
  20    75.0000   200.0000  .7130E+02
  21   -75.0000   400.0000  .7130E+02
  22    75.0000   400.0000  .7130E+02
  23   -75.0000   600.0000  .7130E+02
  24    75.0000   600.0000  .7130E+02
  25   -75.0000   800.0000  .7130E+02
  26    75.0000   800.0000  .7130E+02
  27   -75.0000   850.0000  .7130E+02
  28    75.0000   850.0000  .7130E+02
  29   -75.0000   900.0000  .7130E+02
  30    75.0000   900.0000  .7130E+02
  31   -75.0000   950.0000  .7130E+02
  32    75.0000   950.0000  .7130E+02
 ---------------------------------------
  Mem  =           2
 Num  Location x    Location y Area
   1   -75.0000  -950.0000  .7130E+02
   2    75.0000  -950.0000  .7130E+02
   3   -75.0000  -900.0000  .7130E+02
   4    75.0000  -900.0000  .7130E+02
   5   -75.0000  -850.0000  .7130E+02
   6    75.0000  -850.0000  .7130E+02
   7   -75.0000  -800.0000  .7130E+02
   8    75.0000  -800.0000  .7130E+02
   9   -75.0000  -600.0000  .7130E+02
  10    75.0000  -600.0000  .7130E+02
  11   -75.0000  -400.0000  .7130E+02
  12    75.0000  -400.0000  .7130E+02
  13   -75.0000  -200.0000  .7130E+02
  14    75.0000  -200.0000  .7130E+02
  15   -75.0000  -100.0000  .7130E+02
  16    75.0000  -100.0000  .7130E+02
  17   -75.0000     0.0000  .7130E+02
  18    75.0000     0.0000  .7130E+02
  19   -75.0000   200.0000  .7130E+02
  20    75.0000   200.0000  .7130E+02
  21   -75.0000   400.0000  .7130E+02
  22    75.0000   400.0000  .7130E+02
  23   -75.0000   600.0000  .7130E+02
  24    75.0000   600.0000  .7130E+02
  25   -75.0000   800.0000  .7130E+02
  26    75.0000   800.0000  .7130E+02
  27   -75.0000   850.0000  .7130E+02
  28    75.0000   850.0000  .7130E+02
  29   -75.0000   900.0000  .7130E+02
  30    75.0000   900.0000  .7130E+02
  31   -75.0000   950.0000  .7130E+02
  32    75.0000   950.0000  .7130E+02
 ---------------------------------------
  Mem  =           3
 Num  Location x    Location y Area
   1   -75.0000  -950.0000  .7130E+02
   2    75.0000  -950.0000  .7130E+02
   3   -75.0000  -900.0000  .7130E+02
   4    75.0000  -900.0000  .7130E+02
   5   -75.0000  -850.0000  .7130E+02
   6    75.0000  -850.0000  .7130E+02
   7   -75.0000  -800.0000  .7130E+02
   8    75.0000  -800.0000  .7130E+02
   9   -75.0000  -600.0000  .7130E+02
  10    75.0000  -600.0000  .7130E+02
  11   -75.0000  -400.0000  .7130E+02
  12    75.0000  -400.0000  .7130E+02
```

INPUT_CHECK - Notepad

File Edit Format View Help

```
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
--------------------------------------
 Mem  =           4
Num  Location x   Location y Area
  1   -75.0000  -950.0000  .7130E+02
  2    75.0000  -950.0000  .7130E+02
  3   -75.0000  -900.0000  .7130E+02
  4    75.0000  -900.0000  .7130E+02
  5   -75.0000  -850.0000  .7130E+02
  6    75.0000  -850.0000  .7130E+02
  7   -75.0000  -800.0000  .7130E+02
  8    75.0000  -800.0000  .7130E+02
  9   -75.0000  -600.0000  .7130E+02
 10    75.0000  -600.0000  .7130E+02
 11   -75.0000  -400.0000  .7130E+02
 12    75.0000  -400.0000  .7130E+02
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
--------------------------------------
 Mem  =           5
Num  Location x   Location y Area
  1   -75.0000  -950.0000  .7130E+02
  2    75.0000  -950.0000  .7130E+02
  3   -75.0000  -900.0000  .7130E+02
  4    75.0000  -900.0000  .7130E+02
  5   -75.0000  -850.0000  .7130E+02
  6    75.0000  -850.0000  .7130E+02
  7   -75.0000  -800.0000  .7130E+02
  8    75.0000  -800.0000  .7130E+02
  9   -75.0000  -600.0000  .7130E+02
 10    75.0000  -600.0000  .7130E+02
 11   -75.0000  -400.0000  .7130E+02
 12    75.0000  -400.0000  .7130E+02
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
```

INPUT_CHECK - Notepad

File Edit Format View Help

```
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
--------------------------------------
 Mem  =           6
Num  Location x   Location y Area
  1   -75.0000  -950.0000  .7130E+02
  2    75.0000  -950.0000  .7130E+02
  3   -75.0000  -900.0000  .7130E+02
  4    75.0000  -900.0000  .7130E+02
  5   -75.0000  -850.0000  .7130E+02
  6    75.0000  -850.0000  .7130E+02
  7   -75.0000  -800.0000  .7130E+02
  8    75.0000  -800.0000  .7130E+02
  9   -75.0000  -600.0000  .7130E+02
 10    75.0000  -600.0000  .7130E+02
 11   -75.0000  -400.0000  .7130E+02
 12    75.0000  -400.0000  .7130E+02
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
--------------------------------------
 Mem  =           7
Num  Location x   Location y Area
  1   -75.0000  -950.0000  .7130E+02
  2    75.0000  -950.0000  .7130E+02
  3   -75.0000  -900.0000  .7130E+02
  4    75.0000  -900.0000  .7130E+02
  5   -75.0000  -850.0000  .7130E+02
  6    75.0000  -850.0000  .7130E+02
  7   -75.0000  -800.0000  .7130E+02
  8    75.0000  -800.0000  .7130E+02
  9   -75.0000  -600.0000  .7130E+02
 10    75.0000  -600.0000  .7130E+02
 11   -75.0000  -400.0000  .7130E+02
 12    75.0000  -400.0000  .7130E+02
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
```

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```
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
--------------------------------------
 Mem  =           8
Num  Location x   Location y Area
  1   -75.0000  -950.0000  .7130E+02
  2    75.0000  -950.0000  .7130E+02
  3   -75.0000  -900.0000  .7130E+02
  4    75.0000  -900.0000  .7130E+02
  5   -75.0000  -850.0000  .7130E+02
  6    75.0000  -850.0000  .7130E+02
  7   -75.0000  -800.0000  .7130E+02
  8    75.0000  -800.0000  .7130E+02
  9   -75.0000  -600.0000  .7130E+02
 10    75.0000  -600.0000  .7130E+02
 11   -75.0000  -400.0000  .7130E+02
 12    75.0000  -400.0000  .7130E+02
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
--------------------------------------
 Mem  =           9
Num  Location x   Location y Area
  1   -75.0000  -950.0000  .7130E+02
  2    75.0000  -950.0000  .7130E+02
  3   -75.0000  -900.0000  .7130E+02
  4    75.0000  -900.0000  .7130E+02
  5   -75.0000  -850.0000  .7130E+02
  6    75.0000  -850.0000  .7130E+02
  7   -75.0000  -800.0000  .7130E+02
  8    75.0000  -800.0000  .7130E+02
  9   -75.0000  -600.0000  .7130E+02
 10    75.0000  -600.0000  .7130E+02
 11   -75.0000  -400.0000  .7130E+02
 12    75.0000  -400.0000  .7130E+02
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
```

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```
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
 ------------------------------------
  Mem  =           10
 Num  Location x   Location y Area
  1   -75.0000  -950.0000  .7130E+02
  2    75.0000  -950.0000  .7130E+02
  3   -75.0000  -900.0000  .7130E+02
  4    75.0000  -900.0000  .7130E+02
  5   -75.0000  -850.0000  .7130E+02
  6    75.0000  -850.0000  .7130E+02
  7   -75.0000  -800.0000  .7130E+02
  8    75.0000  -800.0000  .7130E+02
  9   -75.0000  -600.0000  .7130E+02
 10    75.0000  -600.0000  .7130E+02
 11   -75.0000  -400.0000  .7130E+02
 12    75.0000  -400.0000  .7130E+02
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
 ------------------------------------
  Mem  =           11
 Num  Location x   Location y Area
  1   -75.0000  -950.0000  .7130E+02
  2    75.0000  -950.0000  .7130E+02
  3   -75.0000  -900.0000  .7130E+02
  4    75.0000  -900.0000  .7130E+02
  5   -75.0000  -850.0000  .7130E+02
  6    75.0000  -850.0000  .7130E+02
  7   -75.0000  -800.0000  .7130E+02
  8    75.0000  -800.0000  .7130E+02
  9   -75.0000  -600.0000  .7130E+02
 10    75.0000  -600.0000  .7130E+02
 11   -75.0000  -400.0000  .7130E+02
 12    75.0000  -400.0000  .7130E+02
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
 ------------------------------------
  Mem  =           12
 Num  Location x   Location y Area
  1   -75.0000  -950.0000  .7130E+02
  2    75.0000  -950.0000  .7130E+02
```

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```
  3   -75.0000  -900.0000  .7130E+02
  4    75.0000  -900.0000  .7130E+02
  5   -75.0000  -850.0000  .7130E+02
  6    75.0000  -850.0000  .7130E+02
  7   -75.0000  -800.0000  .7130E+02
  8    75.0000  -800.0000  .7130E+02
  9   -75.0000  -600.0000  .7130E+02
 10    75.0000  -600.0000  .7130E+02
 11   -75.0000  -400.0000  .7130E+02
 12    75.0000  -400.0000  .7130E+02
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
 ------------------------------------
  Mem  =           13
 Num  Location x   Location y Area
  1   -75.0000  -950.0000  .7130E+02
  2    75.0000  -950.0000  .7130E+02
  3   -75.0000  -900.0000  .7130E+02
  4    75.0000  -900.0000  .7130E+02
  5   -75.0000  -850.0000  .7130E+02
  6    75.0000  -850.0000  .7130E+02
  7   -75.0000  -800.0000  .7130E+02
  8    75.0000  -800.0000  .7130E+02
  9   -75.0000  -600.0000  .7130E+02
 10    75.0000  -600.0000  .7130E+02
 11   -75.0000  -400.0000  .7130E+02
 12    75.0000  -400.0000  .7130E+02
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
 ------------------------------------
  Mem  =           14
 Num  Location x   Location y Area
  1   -75.0000  -950.0000  .7130E+02
  2    75.0000  -950.0000  .7130E+02
  3   -75.0000  -900.0000  .7130E+02
  4    75.0000  -900.0000  .7130E+02
  5   -75.0000  -850.0000  .7130E+02
  6    75.0000  -850.0000  .7130E+02
  7   -75.0000  -800.0000  .7130E+02
  8    75.0000  -800.0000  .7130E+02
  9   -75.0000  -600.0000  .7130E+02
```

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```
 10    75.0000  -600.0000  .7130E+02
 11   -75.0000  -400.0000  .7130E+02
 12    75.0000  -400.0000  .7130E+02
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
 ------------------------------------
  Mem  =           15
 Num  Location x   Location y Area
  1   -75.0000  -950.0000  .7130E+02
  2    75.0000  -950.0000  .7130E+02
  3   -75.0000  -900.0000  .7130E+02
  4    75.0000  -900.0000  .7130E+02
  5   -75.0000  -850.0000  .7130E+02
  6    75.0000  -850.0000  .7130E+02
  7   -75.0000  -800.0000  .7130E+02
  8    75.0000  -800.0000  .7130E+02
  9   -75.0000  -600.0000  .7130E+02
 10    75.0000  -600.0000  .7130E+02
 11   -75.0000  -400.0000  .7130E+02
 12    75.0000  -400.0000  .7130E+02
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
 ------------------------------------
  Mem  =           16
 Num  Location x   Location y Area
  1   -75.0000  -950.0000  .7130E+02
  2    75.0000  -950.0000  .7130E+02
  3   -75.0000  -900.0000  .7130E+02
  4    75.0000  -900.0000  .7130E+02
  5   -75.0000  -850.0000  .7130E+02
  6    75.0000  -850.0000  .7130E+02
  7   -75.0000  -800.0000  .7130E+02
  8    75.0000  -800.0000  .7130E+02
  9   -75.0000  -600.0000  .7130E+02
 10    75.0000  -600.0000  .7130E+02
 11   -75.0000  -400.0000  .7130E+02
 12    75.0000  -400.0000  .7130E+02
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
```

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```
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
 ------------------------------------------
 Mem  =          17
Num  Location x   Location y Area
  1   -75.0000  -950.0000  .7130E+02
  2    75.0000  -950.0000  .7130E+02
  3   -75.0000  -900.0000  .7130E+02
  4    75.0000  -900.0000  .7130E+02
  5   -75.0000  -850.0000  .7130E+02
  6    75.0000  -850.0000  .7130E+02
  7   -75.0000  -800.0000  .7130E+02
  8    75.0000  -800.0000  .7130E+02
  9   -75.0000  -600.0000  .7130E+02
 10    75.0000  -600.0000  .7130E+02
 11   -75.0000  -400.0000  .7130E+02
 12    75.0000  -400.0000  .7130E+02
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
 ------------------------------------------
 Mem  =          18
Num  Location x   Location y Area
  1   -75.0000  -950.0000  .7130E+02
  2    75.0000  -950.0000  .7130E+02
  3   -75.0000  -900.0000  .7130E+02
  4    75.0000  -900.0000  .7130E+02
  5   -75.0000  -850.0000  .7130E+02
  6    75.0000  -850.0000  .7130E+02
  7   -75.0000  -800.0000  .7130E+02
  8    75.0000  -800.0000  .7130E+02
  9   -75.0000  -600.0000  .7130E+02
 10    75.0000  -600.0000  .7130E+02
 11   -75.0000  -400.0000  .7130E+02
 12    75.0000  -400.0000  .7130E+02
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
```

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```
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
 ------------------------------------------
 Mem  =          19
Num  Location x   Location y Area
  1   -75.0000  -950.0000  .7130E+02
  2    75.0000  -950.0000  .7130E+02
  3   -75.0000  -900.0000  .7130E+02
  4    75.0000  -900.0000  .7130E+02
  5   -75.0000  -850.0000  .7130E+02
  6    75.0000  -850.0000  .7130E+02
  7   -75.0000  -800.0000  .7130E+02
  8    75.0000  -800.0000  .7130E+02
  9   -75.0000  -600.0000  .7130E+02
 10    75.0000  -600.0000  .7130E+02
 11   -75.0000  -400.0000  .7130E+02
 12    75.0000  -400.0000  .7130E+02
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
 ------------------------------------------
 Mem  =          20
Num  Location x   Location y Area
  1   -75.0000  -950.0000  .7130E+02
  2    75.0000  -950.0000  .7130E+02
  3   -75.0000  -900.0000  .7130E+02
  4    75.0000  -900.0000  .7130E+02
  5   -75.0000  -850.0000  .7130E+02
  6    75.0000  -850.0000  .7130E+02
  7   -75.0000  -800.0000  .7130E+02
  8    75.0000  -800.0000  .7130E+02
  9   -75.0000  -600.0000  .7130E+02
 10    75.0000  -600.0000  .7130E+02
 11   -75.0000  -400.0000  .7130E+02
 12    75.0000  -400.0000  .7130E+02
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
```

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```
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
 ------------------------------------------
 Mem  =          21
Num  Location x   Location y Area
  1   -75.0000  -950.0000  .7130E+02
  2    75.0000  -950.0000  .7130E+02
  3   -75.0000  -900.0000  .7130E+02
  4    75.0000  -900.0000  .7130E+02
  5   -75.0000  -850.0000  .7130E+02
  6    75.0000  -850.0000  .7130E+02
  7   -75.0000  -800.0000  .7130E+02
  8    75.0000  -800.0000  .7130E+02
  9   -75.0000  -600.0000  .7130E+02
 10    75.0000  -600.0000  .7130E+02
 11   -75.0000  -400.0000  .7130E+02
 12    75.0000  -400.0000  .7130E+02
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
 ------------------------------------------
 Mem  =          22
Num  Location x   Location y Area
  1   -75.0000  -950.0000  .7130E+02
  2    75.0000  -950.0000  .7130E+02
  3   -75.0000  -900.0000  .7130E+02
  4    75.0000  -900.0000  .7130E+02
  5   -75.0000  -850.0000  .7130E+02
  6    75.0000  -850.0000  .7130E+02
  7   -75.0000  -800.0000  .7130E+02
  8    75.0000  -800.0000  .7130E+02
  9   -75.0000  -600.0000  .7130E+02
 10    75.0000  -600.0000  .7130E+02
 11   -75.0000  -400.0000  .7130E+02
 12    75.0000  -400.0000  .7130E+02
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
 ------------------------------------------
 Mem  =          23
Num  Location x   Location y Area
```

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```
 Mem  =          23
Num  Location x   Location y Area
  1   -75.0000 -950.0000  .7130E+02
  2    75.0000 -950.0000  .7130E+02
  3   -75.0000 -900.0000  .7130E+02
  4    75.0000 -900.0000  .7130E+02
  5   -75.0000 -850.0000  .7130E+02
  6    75.0000 -850.0000  .7130E+02
  7   -75.0000 -800.0000  .7130E+02
  8    75.0000 -800.0000  .7130E+02
  9   -75.0000 -600.0000  .7130E+02
 10    75.0000 -600.0000  .7130E+02
 11   -75.0000 -400.0000  .7130E+02
 12    75.0000 -400.0000  .7130E+02
 13   -75.0000 -200.0000  .7130E+02
 14    75.0000 -200.0000  .7130E+02
 15   -75.0000 -100.0000  .7130E+02
 16    75.0000 -100.0000  .7130E+02
 17   -75.0000    0.0000  .7130E+02
 18    75.0000    0.0000  .7130E+02
 19   -75.0000  200.0000  .7130E+02
 20    75.0000  200.0000  .7130E+02
 21   -75.0000  400.0000  .7130E+02
 22    75.0000  400.0000  .7130E+02
 23   -75.0000  600.0000  .7130E+02
 24    75.0000  600.0000  .7130E+02
 25   -75.0000  800.0000  .7130E+02
 26    75.0000  800.0000  .7130E+02
 27   -75.0000  850.0000  .7130E+02
 28    75.0000  850.0000  .7130E+02
 29   -75.0000  900.0000  .7130E+02
 30    75.0000  900.0000  .7130E+02
 31   -75.0000  950.0000  .7130E+02
 32    75.0000  950.0000  .7130E+02
----------------------------------------
 Mem  =          24
Num  Location x   Location y Area
  1   -75.0000 -950.0000  .7130E+02
  2    75.0000 -950.0000  .7130E+02
  3   -75.0000 -900.0000  .7130E+02
  4    75.0000 -900.0000  .7130E+02
  5   -75.0000 -850.0000  .7130E+02
  6    75.0000 -850.0000  .7130E+02
  7   -75.0000 -800.0000  .7130E+02
  8    75.0000 -800.0000  .7130E+02
  9   -75.0000 -600.0000  .7130E+02
 10    75.0000 -600.0000  .7130E+02
 11   -75.0000 -400.0000  .7130E+02
 12    75.0000 -400.0000  .7130E+02
 13   -75.0000 -200.0000  .7130E+02
 14    75.0000 -200.0000  .7130E+02
 15   -75.0000 -100.0000  .7130E+02
 16    75.0000 -100.0000  .7130E+02
 17   -75.0000    0.0000  .7130E+02
 18    75.0000    0.0000  .7130E+02
 19   -75.0000  200.0000  .7130E+02
 20    75.0000  200.0000  .7130E+02
 21   -75.0000  400.0000  .7130E+02
 22    75.0000  400.0000  .7130E+02
 23   -75.0000  600.0000  .7130E+02
 24    75.0000  600.0000  .7130E+02
 25   -75.0000  800.0000  .7130E+02
 26    75.0000  800.0000  .7130E+02
 27   -75.0000  850.0000  .7130E+02
 28    75.0000  850.0000  .7130E+02
 29   -75.0000  900.0000  .7130E+02
 30    75.0000  900.0000  .7130E+02
 31   -75.0000  950.0000  .7130E+02
 32    75.0000  950.0000  .7130E+02
----------------------------------------
 Mem  =          25
Num  Location x   Location y Area
  1   -75.0000 -950.0000  .7130E+02
  2    75.0000 -950.0000  .7130E+02
  3   -75.0000 -900.0000  .7130E+02
  4    75.0000 -900.0000  .7130E+02
  5   -75.0000 -850.0000  .7130E+02
```

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```
  5   -75.0000 -850.0000  .7130E+02
  6    75.0000 -850.0000  .7130E+02
  7   -75.0000 -800.0000  .7130E+02
  8    75.0000 -800.0000  .7130E+02
  9   -75.0000 -600.0000  .7130E+02
 10    75.0000 -600.0000  .7130E+02
 11   -75.0000 -400.0000  .7130E+02
 12    75.0000 -400.0000  .7130E+02
 13   -75.0000 -200.0000  .7130E+02
 14    75.0000 -200.0000  .7130E+02
 15   -75.0000 -100.0000  .7130E+02
 16    75.0000 -100.0000  .7130E+02
 17   -75.0000    0.0000  .7130E+02
 18    75.0000    0.0000  .7130E+02
 19   -75.0000  200.0000  .7130E+02
 20    75.0000  200.0000  .7130E+02
 21   -75.0000  400.0000  .7130E+02
 22    75.0000  400.0000  .7130E+02
 23   -75.0000  600.0000  .7130E+02
 24    75.0000  600.0000  .7130E+02
 25   -75.0000  800.0000  .7130E+02
 26    75.0000  800.0000  .7130E+02
 27   -75.0000  850.0000  .7130E+02
 28    75.0000  850.0000  .7130E+02
 29   -75.0000  900.0000  .7130E+02
 30    75.0000  900.0000  .7130E+02
 31   -75.0000  950.0000  .7130E+02
 32    75.0000  950.0000  .7130E+02
----------------------------------------
 Mem  =          26
Num  Location x   Location y Area
  1   -75.0000 -950.0000  .7130E+02
  2    75.0000 -950.0000  .7130E+02
  3   -75.0000 -900.0000  .7130E+02
  4    75.0000 -900.0000  .7130E+02
  5   -75.0000 -850.0000  .7130E+02
  6    75.0000 -850.0000  .7130E+02
  7   -75.0000 -800.0000  .7130E+02
  8    75.0000 -800.0000  .7130E+02
  9   -75.0000 -600.0000  .7130E+02
 10    75.0000 -600.0000  .7130E+02
 11   -75.0000 -400.0000  .7130E+02
 12    75.0000 -400.0000  .7130E+02
 13   -75.0000 -200.0000  .7130E+02
 14    75.0000 -200.0000  .7130E+02
 15   -75.0000 -100.0000  .7130E+02
 16    75.0000 -100.0000  .7130E+02
 17   -75.0000    0.0000  .7130E+02
 18    75.0000    0.0000  .7130E+02
 19   -75.0000  200.0000  .7130E+02
 20    75.0000  200.0000  .7130E+02
 21   -75.0000  400.0000  .7130E+02
 22    75.0000  400.0000  .7130E+02
 23   -75.0000  600.0000  .7130E+02
 24    75.0000  600.0000  .7130E+02
 25   -75.0000  800.0000  .7130E+02
 26    75.0000  800.0000  .7130E+02
 27   -75.0000  850.0000  .7130E+02
 28    75.0000  850.0000  .7130E+02
 29   -75.0000  900.0000  .7130E+02
 30    75.0000  900.0000  .7130E+02
 31   -75.0000  950.0000  .7130E+02
 32    75.0000  950.0000  .7130E+02
----------------------------------------
 Mem  =          27
Num  Location x   Location y Area
  1   -75.0000 -950.0000  .7130E+02
  2    75.0000 -950.0000  .7130E+02
  3   -75.0000 -900.0000  .7130E+02
  4    75.0000 -900.0000  .7130E+02
  5   -75.0000 -850.0000  .7130E+02
  6    75.0000 -850.0000  .7130E+02
  7   -75.0000 -800.0000  .7130E+02
  8    75.0000 -800.0000  .7130E+02
  9   -75.0000 -600.0000  .7130E+02
 10    75.0000 -600.0000  .7130E+02
 11   -75.0000 -400.0000  .7130E+02
```

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```
 11   -75.0000 -400.0000  .7130E+02
 12    75.0000 -400.0000  .7130E+02
 13   -75.0000 -200.0000  .7130E+02
 14    75.0000 -200.0000  .7130E+02
 15   -75.0000 -100.0000  .7130E+02
 16    75.0000 -100.0000  .7130E+02
 17   -75.0000    0.0000  .7130E+02
 18    75.0000    0.0000  .7130E+02
 19   -75.0000  200.0000  .7130E+02
 20    75.0000  200.0000  .7130E+02
 21   -75.0000  400.0000  .7130E+02
 22    75.0000  400.0000  .7130E+02
 23   -75.0000  600.0000  .7130E+02
 24    75.0000  600.0000  .7130E+02
 25   -75.0000  800.0000  .7130E+02
 26    75.0000  800.0000  .7130E+02
 27   -75.0000  850.0000  .7130E+02
 28    75.0000  850.0000  .7130E+02
 29   -75.0000  900.0000  .7130E+02
 30    75.0000  900.0000  .7130E+02
 31   -75.0000  950.0000  .7130E+02
 32    75.0000  950.0000  .7130E+02
----------------------------------------
 Mem  =          28
Num  Location x   Location y Area
  1   -75.0000 -950.0000  .7130E+02
  2    75.0000 -950.0000  .7130E+02
  3   -75.0000 -900.0000  .7130E+02
  4    75.0000 -900.0000  .7130E+02
  5   -75.0000 -850.0000  .7130E+02
  6    75.0000 -850.0000  .7130E+02
  7   -75.0000 -800.0000  .7130E+02
  8    75.0000 -800.0000  .7130E+02
  9   -75.0000 -600.0000  .7130E+02
 10    75.0000 -600.0000  .7130E+02
 11   -75.0000 -400.0000  .7130E+02
 12    75.0000 -400.0000  .7130E+02
 13   -75.0000 -200.0000  .7130E+02
 14    75.0000 -200.0000  .7130E+02
 15   -75.0000 -100.0000  .7130E+02
 16    75.0000 -100.0000  .7130E+02
 17   -75.0000    0.0000  .7130E+02
 18    75.0000    0.0000  .7130E+02
 19   -75.0000  200.0000  .7130E+02
 20    75.0000  200.0000  .7130E+02
 21   -75.0000  400.0000  .7130E+02
 22    75.0000  400.0000  .7130E+02
 23   -75.0000  600.0000  .7130E+02
 24    75.0000  600.0000  .7130E+02
 25   -75.0000  800.0000  .7130E+02
 26    75.0000  800.0000  .7130E+02
 27   -75.0000  850.0000  .7130E+02
 28    75.0000  850.0000  .7130E+02
 29   -75.0000  900.0000  .7130E+02
 30    75.0000  900.0000  .7130E+02
 31   -75.0000  950.0000  .7130E+02
 32    75.0000  950.0000  .7130E+02
----------------------------------------
 Mem  =          29
Num  Location x   Location y Area
  1   -75.0000 -950.0000  .7130E+02
  2    75.0000 -950.0000  .7130E+02
  3   -75.0000 -900.0000  .7130E+02
  4    75.0000 -900.0000  .7130E+02
  5   -75.0000 -850.0000  .7130E+02
  6    75.0000 -850.0000  .7130E+02
  7   -75.0000 -800.0000  .7130E+02
  8    75.0000 -800.0000  .7130E+02
  9   -75.0000 -600.0000  .7130E+02
 10    75.0000 -600.0000  .7130E+02
 11   -75.0000 -400.0000  .7130E+02
 12    75.0000 -400.0000  .7130E+02
 13   -75.0000 -200.0000  .7130E+02
 14    75.0000 -200.0000  .7130E+02
 15   -75.0000 -100.0000  .7130E+02
 16    75.0000 -100.0000  .7130E+02
 17   -75.0000    0.0000  .7130E+02
```

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```
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
---------------------------------------
 Mem  =           30
Num  Location x    Location y Area
  1   -75.0000  -950.0000  .7130E+02
  2    75.0000  -950.0000  .7130E+02
  3   -75.0000  -900.0000  .7130E+02
  4    75.0000  -900.0000  .7130E+02
  5   -75.0000  -850.0000  .7130E+02
  6    75.0000  -850.0000  .7130E+02
  7   -75.0000  -800.0000  .7130E+02
  8    75.0000  -800.0000  .7130E+02
  9   -75.0000  -600.0000  .7130E+02
 10    75.0000  -600.0000  .7130E+02
 11   -75.0000  -400.0000  .7130E+02
 12    75.0000  -400.0000  .7130E+02
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
---------------------------------------
 Mem  =           31
Num  Location x    Location y Area
  1   -75.0000  -950.0000  .7130E+02
  2    75.0000  -950.0000  .7130E+02
  3   -75.0000  -900.0000  .7130E+02
  4    75.0000  -900.0000  .7130E+02
  5   -75.0000  -850.0000  .7130E+02
  6    75.0000  -850.0000  .7130E+02
  7   -75.0000  -800.0000  .7130E+02
  8    75.0000  -800.0000  .7130E+02
  9   -75.0000  -600.0000  .7130E+02
 10    75.0000  -600.0000  .7130E+02
 11   -75.0000  -400.0000  .7130E+02
 12    75.0000  -400.0000  .7130E+02
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
```

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```
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
---------------------------------------
 Mem  =           32
Num  Location x    Location y Area
  1   -75.0000  -950.0000  .7130E+02
  2    75.0000  -950.0000  .7130E+02
  3   -75.0000  -900.0000  .7130E+02
  4    75.0000  -900.0000  .7130E+02
  5   -75.0000  -850.0000  .7130E+02
  6    75.0000  -850.0000  .7130E+02
  7   -75.0000  -800.0000  .7130E+02
  8    75.0000  -800.0000  .7130E+02
  9   -75.0000  -600.0000  .7130E+02
 10    75.0000  -600.0000  .7130E+02
 11   -75.0000  -400.0000  .7130E+02
 12    75.0000  -400.0000  .7130E+02
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
 30    75.0000   900.0000  .7130E+02
 31   -75.0000   950.0000  .7130E+02
 32    75.0000   950.0000  .7130E+02
---------------------------------------
 Mem  =           33
Num  Location x    Location y Area
  1   -75.0000  -950.0000  .7130E+02
  2    75.0000  -950.0000  .7130E+02
  3   -75.0000  -900.0000  .7130E+02
  4    75.0000  -900.0000  .7130E+02
  5   -75.0000  -850.0000  .7130E+02
  6    75.0000  -850.0000  .7130E+02
  7   -75.0000  -800.0000  .7130E+02
  8    75.0000  -800.0000  .7130E+02
  9   -75.0000  -600.0000  .7130E+02
 10    75.0000  -600.0000  .7130E+02
 11   -75.0000  -400.0000  .7130E+02
 12    75.0000  -400.0000  .7130E+02
 13   -75.0000  -200.0000  .7130E+02
 14    75.0000  -200.0000  .7130E+02
 15   -75.0000  -100.0000  .7130E+02
 16    75.0000  -100.0000  .7130E+02
 17   -75.0000     0.0000  .7130E+02
 18    75.0000     0.0000  .7130E+02
 19   -75.0000   200.0000  .7130E+02
 20    75.0000   200.0000  .7130E+02
 21   -75.0000   400.0000  .7130E+02
 22    75.0000   400.0000  .7130E+02
 23   -75.0000   600.0000  .7130E+02
 24    75.0000   600.0000  .7130E+02
 25   -75.0000   800.0000  .7130E+02
 26    75.0000   800.0000  .7130E+02
 27   -75.0000   850.0000  .7130E+02
 28    75.0000   850.0000  .7130E+02
 29   -75.0000   900.0000  .7130E+02
```

```
INPUT_CHECK - Notepad
File  Edit  Format  View  Help
  29   -75.0000   900.0000  .7130E+02
  30    75.0000   900.0000  .7130E+02
  31   -75.0000   950.0000  .7130E+02
  32    75.0000   950.0000  .7130E+02
 --------------------------------------
  Mem  =          34
 Num  Location x    Location y Area
   1   -75.0000  -950.0000  .7130E+02
   2    75.0000  -950.0000  .7130E+02
   3   -75.0000  -900.0000  .7130E+02
   4    75.0000  -900.0000  .7130E+02
   5   -75.0000  -850.0000  .7130E+02
   6    75.0000  -850.0000  .7130E+02
   7   -75.0000  -800.0000  .7130E+02
   8    75.0000  -800.0000  .7130E+02
   9   -75.0000  -600.0000  .7130E+02
  10    75.0000  -600.0000  .7130E+02
  11   -75.0000  -400.0000  .7130E+02
  12    75.0000  -400.0000  .7130E+02
  13   -75.0000  -200.0000  .7130E+02
  14    75.0000  -200.0000  .7130E+02
  15   -75.0000  -100.0000  .7130E+02
  16    75.0000  -100.0000  .7130E+02
  17   -75.0000     0.0000  .7130E+02
  18    75.0000     0.0000  .7130E+02
  19   -75.0000   200.0000  .7130E+02
  20    75.0000   200.0000  .7130E+02
  21   -75.0000   400.0000  .7130E+02
  22    75.0000   400.0000  .7130E+02
  23   -75.0000   600.0000  .7130E+02
  24    75.0000   600.0000  .7130E+02
  25   -75.0000   800.0000  .7130E+02
  26    75.0000   800.0000  .7130E+02
  27   -75.0000   850.0000  .7130E+02
  28    75.0000   850.0000  .7130E+02
  29   -75.0000   900.0000  .7130E+02
  30    75.0000   900.0000  .7130E+02
  31   -75.0000   950.0000  .7130E+02
  32    75.0000   950.0000  .7130E+02
 --------------------------------------
 _************************************_

  Output NOT generated for any Plastic return scenario for the Reinforcement

 ----------

 CROSS-SECTIONAL PROPERTIES including Reinforcement
 Mem       EA        EIx
          mm2        mm4

   1 .12E+11 .3833E+16
   2 .12E+11 .3833E+16
   3 .12E+11 .3833E+16
   4 .12E+11 .3833E+16
   5 .12E+11 .3833E+16
   6 .12E+11 .3833E+16
   7 .12E+11 .3833E+16
   8 .12E+11 .3833E+16
   9 .12E+11 .3833E+16
  10 .12E+11 .3833E+16
  11 .12E+11 .3833E+16
  12 .12E+11 .3833E+16
  13 .12E+11 .3833E+16
  14 .12E+11 .3833E+16
  15 .12E+11 .3833E+16
  16 .12E+11 .3833E+16
  17 .12E+11 .3833E+16
  18 .12E+11 .3833E+16
  19 .12E+11 .3833E+16
  20 .12E+11 .3833E+16
  21 .12E+11 .3833E+16
  22 .12E+11 .3833E+16
  23 .12E+11 .3833E+16
  24 .12E+11 .3833E+16
  25 .12E+11 .3833E+16
  26 .12E+11 .3833E+16
  27 .12E+11 .3833E+16
```

```
INPUT_CHECK - Notepad
File  Edit  Format  View  Help
  28 .12E+11 .3833E+16
  29 .12E+11 .3833E+16
  30 .12E+11 .3833E+16
  31 .12E+11 .3833E+16
  32 .12E+11 .3833E+16
  33 .12E+11 .3833E+16
  34 .12E+11 .3833E+16

 -------------------------------------
   BOUNDARY CONDITIONS
      FIXED NODE    FIXED DIRECTION
           1            GLOBAL X DIRECTION
           1            GLOBAL Y DIRECTION
           1            GLOBAL AROUND Z


  NODAL LOADS
 NODE   LOADING TYPE          DIRECTION           P     M
                                                  N     Nmm
  33    CONCENTRATED P           GLOBAL X -.1000E+07

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

  CONSTANT NODAL LOADS
 NODE   LOADING TYPE          DIRECTION          CP    CM
                                                 N     Nmm
  36    CONCENTRATED P           GLOBAL X -.7744E+07

 -----------------------------
 Analysis type: 0 for No Shear| 1 for Including Shear
 S_type =           0 selected
 --------------------------------------------------------

 Analysis type: 1 for Static only| 2 for Dynamic only| 3 for Both
           1 selected
 --------------------------------------------------------


   The results are produced for            0  number of files

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

 MaterialModels_1Reduce3D_2Direct1DSugano_3Direct1DSaatchi           2
 DirectUniaxialModelPostpeakCalibrationFactor    4.00000000000000
 CurrentCompressionPlasticityParameter   0.000000000000000E+000
 CurrentTensionPlasticityParameter   0.000000000000000E+000
 CurrentCompressionDamageParameter   0.000000000000000E+000
 CurrentTensionDamageParameter    0.000000000000000E+000

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

 Analysis Control type: Enter 1 for Load Control or Enter 2 for Displacement Con
 trol          2
 The control node number           33

 Enter the direction: Enter 1 for X  Enter 2 for Y  Enter 3 for Z Rot
 Control direction =           1 selected
 Enter the step increment size  -1.00000000000000
 How many steps do you want to continue         110

 ------------------------------------------------------------------
 Plastic return type: 1 for Cutting_plane | 2 for Closest Point Projection | 3 f
 or Premono-Willam          1

 Iteration limit to terminate plastic return        1000

 Enter| 0  rate-independent | 1 visco-plastic | 2 viscous regularization
           0

 Enter GlobalAlgorithm_ErrorMargin  9.999999974752427E-007

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

 Enter PlasticityAlgorithm_ErrorMargin  9.999999747378752E-005

 Identify First Point of Yield Yes or No NNNNNNN
```

A1.3.3. Output files

DEP_X

DEP_X - Notepad

File Edit Format View Help

```
-1.00000000000000
-2.00000000000000
-3.00000000000000
-4.00000000000000
-5.00000000000000
-6.00000000000000
-7.00000000000000
-8.00000000000000
-9.00000000000000
-10.0000000000000
-11.0000000000000
-12.0000000000000
-13.0000000000000
-14.0000000000000
-15.0000000000000
-16.0000000000000
-17.0000000000000
-18.0000000000000
-19.0000000000000
-20.0000000000000
-21.0000000000000
-22.0000000000000
-23.0000000000000
-24.0000000000000
-25.0000000000000
-26.0000000000000
-27.0000000000000
-28.0000000000000
-29.0000000000000
-30.0000000000000
-31.0000000000000
-32.0000000000000
-33.0000000000000
-34.0000000000000
-35.0000000000000
-36.0000000000000
-37.0000000000000
-38.0000000000000
-39.0000000000000
-40.0000000000000
-41.0000000000000
-42.0000000000000
-43.0000000000000
-44.0000000000000
-45.0000000000000
-46.0000000000000
-47.0000000000000
-48.0000000000000
-49.0000000000000
-50.0000000000000
-51.0000000000000
-52.0000000000000
-53.0000000000000
-54.0000000000000
-55.0000000000000
```

DEP_X - Notepad

File Edit Format View Help

```
-56.0000000000000
-57.0000000000000
-58.0000000000000
-59.0000000000000
-60.0000000000000
-61.0000000000000
-62.0000000000000
-63.0000000000000
-64.0000000000000
-65.0000000000000
-66.0000000000000
-67.0000000000000
-68.0000000000000
-69.0000000000000
-70.0000000000000
-71.0000000000000
-72.0000000000000
-73.0000000000000
-74.0000000000000
-75.0000000000000
-76.0000000000000
-77.0000000000000
-78.0000000000000
-79.0000000000000
-80.0000000000000
-81.0000000000000
-82.0000000000000
-83.0000000000000
-84.0000000000000
-85.0000000000000
-86.0000000000000
-87.0000000000000
-88.0000000000000
-89.0000000000000
-90.0000000000000
-91.0000000000000
-92.0000000000000
-93.0000000000000
-94.0000000000000
-95.0000000000000
-96.0000000000000
-97.0000000000000
-98.0000000000000
-99.0000000000000
-100.000000000000
-101.000000000000
-102.000000000000
-103.000000000000
-104.000000000000
-105.000000000000
-106.000000000000
-107.000000000000
-108.000000000000
-109.000000000000
-110.000000000000
```

DEP_Y

DEP_Y - Notepad

File Edit Format View Help

```
0.218519680305488
0.518898208538416
0.834691946124427
1.16423269520403
1.50687942655538
1.91245850377095
2.26190277792058
2.61122513802492
2.96064108167956
3.31221653529996
3.66714240848648
4.02244673853188
4.37674478602862
4.72959997356000
5.08086005290600
5.42947337669351
5.77537458941942
6.11900269237763
6.46213924042944
6.80679077870283
7.15305990987902
7.49909763373337
7.84503672467597
8.19053213519114
8.53670881293302
8.88271513145134
9.22937795744367
9.57704335299749
9.92546854505216
10.2751046913317
10.6266273411891
10.9794374357234
11.3337445878683
11.6895708082919
12.0465593644482
12.4034055169366
12.7608740901255
13.1193561935343
13.4783267673234
13.8372974400300
14.1967652570996
14.5565627955638
14.9173358718584
15.2788812801688
15.6411307292984
16.0037167933535
16.3669246475697
16.7304067802865
17.0946781979885
17.4599837066177
17.8257694529631
18.1921632020512
18.5590270293273
18.9261276269649
19.2939037319713
```

DEP_Y - Notepad

File Edit Format View Help

```
19.6621067396785
20.0310249912512
20.4006837286345
20.7709738895640
21.1419320792486
21.5133136206663
21.8850352341584
22.2575355001006
22.6307303866503
23.0042016706845
23.3785348946866
23.7537331768058
24.1293767170414
24.5055128412899
24.8822902755629
25.2597014412948
25.6374149575646
26.0153189477945
26.3934026469557
26.7716556261095
27.1501194528335
27.5289887922537
27.9085639274088
28.2883969023304
28.6684911192073
29.0489299342776
29.4297204585102
29.8108283972329
30.1922141754196
30.5742802295096
30.9565047936304
31.3388436410433
31.7213559187849
32.1041452644031
32.4871893953242
32.8705937119761
33.2543470980973
33.6383970895862
34.0227062294655
34.4073720798893
34.7923677187577
35.1775166859781
35.5635131809629
35.9490859453659
36.3353191807010
36.7217641345933
37.1084707044926
37.4954419826592
37.8827115157613
38.2702434492033
38.6580123447799
39.0460120527855
39.4342529137323
39.8227109536175
40.2114048816135
```

ELEM_MATRIX

ELEM_MATRIX - Notepad

File Edit Format View Help

```
 ELEMENT MATRIX
 0.41E+11  0.00E+00 -0.20E+13 -0.41E+11  0.00E+00 -0.20E+13
 0.00E+00  0.12E+09  0.00E+00  0.00E+00 -0.12E+09  0.00E+00
-0.20E+13  0.00E+00  0.14E+15  0.20E+13  0.00E+00  0.64E+14
-0.41E+11  0.00E+00  0.20E+13  0.82E+11  0.00E+00  0.73E-03
 0.00E+00 -0.12E+09  0.00E+00  0.00E+00  0.23E+09  0.00E+00
-0.20E+13  0.00E+00  0.64E+14  0.24E-03  0.00E+00  0.28E+15
 ELEMENT MATRIX
 0.41E+11  0.00E+00 -0.20E+13 -0.41E+11  0.00E+00 -0.20E+13
 0.00E+00  0.12E+09  0.00E+00  0.00E+00 -0.12E+09  0.00E+00
-0.20E+13  0.00E+00  0.14E+15  0.20E+13  0.00E+00  0.64E+14
-0.41E+11  0.00E+00  0.20E+13  0.82E+11  0.00E+00  0.73E-03
 0.00E+00 -0.12E+09  0.00E+00  0.00E+00  0.23E+09  0.00E+00
-0.20E+13  0.00E+00  0.64E+14  0.24E-03  0.00E+00  0.28E+15
 ELEMENT MATRIX
 0.41E+11  0.00E+00 -0.20E+13 -0.41E+11  0.00E+00 -0.20E+13
 0.00E+00  0.12E+09  0.00E+00  0.00E+00 -0.12E+09  0.00E+00
-0.20E+13  0.00E+00  0.14E+15  0.20E+13  0.00E+00  0.64E+14
-0.41E+11  0.00E+00  0.20E+13  0.82E+11  0.00E+00  0.73E-03
 0.00E+00 -0.12E+09  0.00E+00  0.00E+00  0.23E+09  0.00E+00
-0.20E+13  0.00E+00  0.64E+14  0.24E-03  0.00E+00  0.28E+15
 ELEMENT MATRIX
 0.41E+11  0.00E+00 -0.20E+13 -0.41E+11  0.00E+00 -0.20E+13
 0.00E+00  0.12E+09  0.00E+00  0.00E+00 -0.12E+09  0.00E+00
-0.20E+13  0.00E+00  0.14E+15  0.20E+13  0.00E+00  0.64E+14
-0.41E+11  0.00E+00  0.20E+13  0.82E+11  0.00E+00  0.73E-03
 0.00E+00 -0.12E+09  0.00E+00  0.00E+00  0.23E+09  0.00E+00
-0.20E+13  0.00E+00  0.64E+14  0.24E-03  0.00E+00  0.28E+15
 ELEMENT MATRIX
 0.41E+11  0.00E+00 -0.20E+13 -0.41E+11  0.00E+00 -0.20E+13
 0.00E+00  0.12E+09  0.00E+00  0.00E+00 -0.12E+09  0.00E+00
-0.20E+13  0.00E+00  0.14E+15  0.20E+13  0.00E+00  0.64E+14
-0.41E+11  0.00E+00  0.20E+13  0.82E+11  0.00E+00  0.73E-03
 0.00E+00 -0.12E+09  0.00E+00  0.00E+00  0.23E+09  0.00E+00
-0.20E+13  0.00E+00  0.64E+14  0.24E-03  0.00E+00  0.28E+15
 ELEMENT MATRIX
 0.41E+11  0.00E+00 -0.20E+13 -0.41E+11  0.00E+00 -0.20E+13
 0.00E+00  0.12E+09  0.00E+00  0.00E+00 -0.12E+09  0.00E+00
-0.20E+13  0.00E+00  0.14E+15  0.20E+13  0.00E+00  0.64E+14
-0.41E+11  0.00E+00  0.20E+13  0.82E+11  0.00E+00  0.73E-03
 0.00E+00 -0.12E+09  0.00E+00  0.00E+00  0.23E+09  0.00E+00
-0.20E+13  0.00E+00  0.64E+14  0.24E-03  0.00E+00  0.28E+15
 ELEMENT MATRIX
 0.41E+11  0.00E+00 -0.20E+13 -0.41E+11  0.00E+00 -0.20E+13
 0.00E+00  0.12E+09  0.00E+00  0.00E+00 -0.12E+09  0.00E+00
-0.20E+13  0.00E+00  0.14E+15  0.20E+13  0.00E+00  0.64E+14
-0.41E+11  0.00E+00  0.20E+13  0.82E+11  0.00E+00  0.73E-03
 0.00E+00 -0.12E+09  0.00E+00  0.00E+00  0.23E+09  0.00E+00
-0.20E+13  0.00E+00  0.64E+14  0.24E-03  0.00E+00  0.28E+15
 ELEMENT MATRIX
 0.41E+11  0.00E+00 -0.20E+13 -0.41E+11  0.00E+00 -0.20E+13
 0.00E+00  0.12E+09  0.00E+00  0.00E+00 -0.12E+09  0.00E+00
-0.20E+13  0.00E+00  0.14E+15  0.20E+13  0.00E+00  0.64E+14
-0.41E+11  0.00E+00  0.20E+13  0.82E+11  0.00E+00  0.73E-03
 0.00E+00 -0.12E+09  0.00E+00  0.00E+00  0.23E+09  0.00E+00
```


ELEM_MATRIX - Notepad

File Edit Format View Help

```
 ELEMENT MATRIX
 0.41E+11  0.00E+00 -0.20E+13 -0.41E+11  0.00E+00 -0.20E+13
 0.00E+00  0.12E+09  0.00E+00  0.00E+00 -0.12E+09  0.00E+00
-0.20E+13  0.00E+00  0.14E+15  0.20E+13  0.00E+00  0.64E+14
-0.41E+11  0.00E+00  0.20E+13  0.82E+11  0.00E+00  0.73E-03
 0.00E+00 -0.12E+09  0.00E+00  0.00E+00  0.23E+09  0.00E+00
-0.20E+13  0.00E+00  0.64E+14  0.24E-03  0.00E+00  0.28E+15
 ELEMENT MATRIX
 0.41E+11  0.00E+00 -0.20E+13 -0.41E+11  0.00E+00 -0.20E+13
 0.00E+00  0.12E+09  0.00E+00  0.00E+00 -0.12E+09  0.00E+00
-0.20E+13  0.00E+00  0.14E+15  0.20E+13  0.00E+00  0.64E+14
-0.41E+11  0.00E+00  0.20E+13  0.82E+11  0.00E+00  0.73E-03
 0.00E+00 -0.12E+09  0.00E+00  0.00E+00  0.23E+09  0.00E+00
-0.20E+13  0.00E+00  0.64E+14  0.24E-03  0.00E+00  0.28E+15
 ELEMENT MATRIX
 0.41E+11  0.00E+00 -0.20E+13 -0.41E+11  0.00E+00 -0.20E+13
 0.00E+00  0.12E+09  0.00E+00  0.00E+00 -0.12E+09  0.00E+00
-0.20E+13  0.00E+00  0.14E+15  0.20E+13  0.00E+00  0.64E+14
-0.41E+11  0.00E+00  0.20E+13  0.82E+11  0.00E+00  0.73E-03
 0.00E+00 -0.12E+09  0.00E+00  0.00E+00  0.23E+09  0.00E+00
-0.20E+13  0.00E+00  0.64E+14  0.24E-03  0.00E+00  0.28E+15
 ELEMENT MATRIX
 0.41E+11  0.00E+00 -0.20E+13 -0.41E+11  0.00E+00 -0.20E+13
 0.00E+00  0.12E+09  0.00E+00  0.00E+00 -0.12E+09  0.00E+00
-0.20E+13  0.00E+00  0.14E+15  0.20E+13  0.00E+00  0.64E+14
-0.41E+11  0.00E+00  0.20E+13  0.82E+11  0.00E+00  0.73E-03
 0.00E+00 -0.12E+09  0.00E+00  0.00E+00  0.23E+09  0.00E+00
-0.20E+13  0.00E+00  0.64E+14  0.24E-03  0.00E+00  0.28E+15
 ELEMENT MATRIX
 0.41E+11  0.00E+00 -0.20E+13 -0.41E+11  0.00E+00 -0.20E+13
 0.00E+00  0.12E+09  0.00E+00  0.00E+00 -0.12E+09  0.00E+00
-0.20E+13  0.00E+00  0.14E+15  0.20E+13  0.00E+00  0.64E+14
-0.41E+11  0.00E+00  0.20E+13  0.82E+11  0.00E+00  0.73E-03
 0.00E+00 -0.12E+09  0.00E+00  0.00E+00  0.23E+09  0.00E+00
-0.20E+13  0.00E+00  0.64E+14  0.24E-03  0.00E+00  0.28E+15
 ELEMENT MATRIX
 0.41E+11  0.00E+00 -0.20E+13 -0.41E+11  0.00E+00 -0.20E+13
 0.00E+00  0.12E+09  0.00E+00  0.00E+00 -0.12E+09  0.00E+00
-0.20E+13  0.00E+00  0.14E+15  0.20E+13  0.00E+00  0.64E+14
-0.41E+11  0.00E+00  0.20E+13  0.82E+11  0.00E+00  0.73E-03
 0.00E+00 -0.12E+09  0.00E+00  0.00E+00  0.23E+09  0.00E+00
-0.20E+13  0.00E+00  0.64E+14  0.24E-03  0.00E+00  0.28E+15
 ELEMENT MATRIX
 0.41E+11  0.00E+00 -0.20E+13 -0.41E+11  0.00E+00 -0.20E+13
 0.00E+00  0.12E+09  0.00E+00  0.00E+00 -0.12E+09  0.00E+00
-0.20E+13  0.00E+00  0.14E+15  0.20E+13  0.00E+00  0.64E+14
-0.41E+11  0.00E+00  0.20E+13  0.82E+11  0.00E+00  0.73E-03
 0.00E+00 -0.12E+09  0.00E+00  0.00E+00  0.23E+09  0.00E+00
-0.20E+13  0.00E+00  0.64E+14  0.24E-03  0.00E+00  0.28E+15
 ELEMENT MATRIX
 0.41E+11  0.00E+00 -0.20E+13 -0.41E+11  0.00E+00 -0.20E+13
 0.00E+00  0.12E+09  0.00E+00  0.00E+00 -0.12E+09  0.00E+00
-0.20E+13  0.00E+00  0.14E+15  0.20E+13  0.00E+00  0.64E+14
-0.41E+11  0.00E+00  0.20E+13  0.82E+11  0.00E+00  0.73E-03
 0.00E+00 -0.12E+09  0.00E+00  0.00E+00  0.23E+09  0.00E+00
```

Lamda

Lamda - Notepad

File Edit Format View Help

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Lamda - Notepad

File Edit Format View Help

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ROT_Z

ROT_Z - Notepad

File Edit Format View Help

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ROT_Z - Notepad

File Edit Format View Help

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4.605362782293029E-002
4.649237171425984E-002

STATIC_DISPLACEMENTS

STATIC_DISPLACEMENTS - Notepad

File Edit Format View Help

```
 NODAL DISPLACEMENTS  STEP          1
  NODE           X           Y          rZ

     1   0.00E+00  0.00E+00  0.00E+00
     2  -0.23E-02  0.31E-01  0.47E-04
     3  -0.92E-02  0.60E-01  0.90E-04
     4  -0.20E-01  0.87E-01  0.13E-03
     5  -0.35E-01  0.11E+00  0.17E-03
     6  -0.54E-01  0.13E+00  0.20E-03
     7  -0.76E-01  0.15E+00  0.23E-03
     8  -0.10E+00  0.17E+00  0.26E-03
     9  -0.13E+00  0.18E+00  0.29E-03
    10  -0.16E+00  0.20E+00  0.31E-03
    11  -0.19E+00  0.20E+00  0.32E-03
    12  -0.22E+00  0.21E+00  0.34E-03
    13  -0.26E+00  0.22E+00  0.35E-03
    14  -0.29E+00  0.22E+00  0.35E-03
    15  -0.33E+00  0.22E+00  0.36E-03
    16  -0.36E+00  0.22E+00  0.36E-03
    17  -0.40E+00  0.22E+00  0.36E-03
    18  -0.44E+00  0.22E+00  0.37E-03
    19  -0.47E+00  0.22E+00  0.37E-03
    20  -0.51E+00  0.22E+00  0.37E-03
    21  -0.55E+00  0.22E+00  0.37E-03
    22  -0.58E+00  0.22E+00  0.37E-03
    23  -0.62E+00  0.22E+00  0.37E-03
    24  -0.66E+00  0.22E+00  0.38E-03
    25  -0.70E+00  0.22E+00  0.38E-03
    26  -0.73E+00  0.22E+00  0.38E-03
    27  -0.77E+00  0.22E+00  0.38E-03
    28  -0.81E+00  0.22E+00  0.38E-03
    29  -0.85E+00  0.22E+00  0.38E-03
    30  -0.89E+00  0.22E+00  0.38E-03
    31  -0.92E+00  0.22E+00  0.38E-03
    32  -0.96E+00  0.22E+00  0.38E-03
    33  -0.10E+01  0.22E+00  0.38E-03
    34  -0.10E+01  0.22E+00  0.38E-03
    35  -0.11E+01  0.22E+00  0.38E-03
-------------------------------------------
 NODAL DISPLACEMENTS  STEP          2
  NODE           X           Y          rZ

     1   0.00E+00  0.00E+00  0.00E+00
     2  -0.41E-02  0.59E-01  0.81E-04
     3  -0.16E-01  0.12E+00  0.16E-03
     4  -0.35E-01  0.17E+00  0.23E-03
     5  -0.62E-01  0.22E+00  0.30E-03
     6  -0.95E-01  0.26E+00  0.37E-03
     7  -0.13E+00  0.31E+00  0.43E-03
     8  -0.18E+00  0.35E+00  0.48E-03
     9  -0.23E+00  0.38E+00  0.53E-03
    10  -0.29E+00  0.41E+00  0.58E-03
    11  -0.35E+00  0.44E+00  0.62E-03
    12  -0.41E+00  0.46E+00  0.66E-03
    13  -0.48E+00  0.48E+00  0.69E-03
    14  -0.55E+00  0.50E+00  0.71E-03
    15  -0.62E+00  0.51E+00  0.73E-03
    16  -0.69E+00  0.51E+00  0.74E-03
    17  -0.77E+00  0.52E+00  0.75E-03
    18  -0.84E+00  0.52E+00  0.76E-03
    19  -0.92E+00  0.52E+00  0.76E-03
    20  -0.10E+01  0.52E+00  0.76E-03
    21  -0.11E+01  0.52E+00  0.77E-03
    22  -0.11E+01  0.52E+00  0.77E-03
    23  -0.12E+01  0.52E+00  0.77E-03
    24  -0.13E+01  0.52E+00  0.77E-03
    25  -0.14E+01  0.52E+00  0.77E-03
    26  -0.15E+01  0.52E+00  0.77E-03
    27  -0.15E+01  0.52E+00  0.77E-03
    28  -0.16E+01  0.52E+00  0.78E-03
    29  -0.17E+01  0.52E+00  0.78E-03
```

STATIC_DISPLACEMENTS - Notepad

File Edit Format View Help

```
    29  -0.17E+01  0.52E+00  0.78E-03
    30  -0.18E+01  0.52E+00  0.78E-03
    31  -0.18E+01  0.52E+00  0.78E-03
    32  -0.19E+01  0.52E+00  0.78E-03
    33  -0.20E+01  0.52E+00  0.78E-03
    34  -0.21E+01  0.52E+00  0.78E-03
    35  -0.22E+01  0.52E+00  0.78E-03
-------------------------------------------
 NODAL DISPLACEMENTS  STEP          3
  NODE           X           Y          rZ

     1   0.00E+00  0.00E+00  0.00E+00
     2  -0.55E-02  0.83E-01  0.11E-03
     3  -0.22E-01  0.16E+00  0.22E-03
     4  -0.49E-01  0.24E+00  0.32E-03
     5  -0.85E-01  0.31E+00  0.42E-03
     6  -0.13E+00  0.38E+00  0.51E-03
     7  -0.19E+00  0.44E+00  0.59E-03
     8  -0.25E+00  0.50E+00  0.68E-03
     9  -0.32E+00  0.56E+00  0.75E-03
    10  -0.40E+00  0.61E+00  0.82E-03
    11  -0.49E+00  0.65E+00  0.89E-03
    12  -0.58E+00  0.69E+00  0.95E-03
    13  -0.67E+00  0.73E+00  0.10E-02
    14  -0.78E+00  0.76E+00  0.10E-02
    15  -0.88E+00  0.78E+00  0.11E-02
    16  -0.99E+00  0.80E+00  0.11E-02
    17  -0.11E+01  0.82E+00  0.11E-02
    18  -0.12E+01  0.83E+00  0.12E-02
    19  -0.13E+01  0.83E+00  0.12E-02
    20  -0.15E+01  0.83E+00  0.12E-02
    21  -0.16E+01  0.83E+00  0.12E-02
    22  -0.17E+01  0.83E+00  0.12E-02
    23  -0.18E+01  0.83E+00  0.12E-02
    24  -0.19E+01  0.83E+00  0.12E-02
    25  -0.20E+01  0.83E+00  0.12E-02
    26  -0.22E+01  0.83E+00  0.12E-02
    27  -0.23E+01  0.83E+00  0.12E-02
    28  -0.24E+01  0.83E+00  0.12E-02
    29  -0.25E+01  0.83E+00  0.12E-02
    30  -0.26E+01  0.83E+00  0.12E-02
    31  -0.28E+01  0.83E+00  0.12E-02
    32  -0.29E+01  0.83E+00  0.12E-02
    33  -0.30E+01  0.83E+00  0.12E-02
    34  -0.31E+01  0.83E+00  0.12E-02
    35  -0.32E+01  0.83E+00  0.12E-02
-------------------------------------------
 NODAL DISPLACEMENTS  STEP          4
  NODE           X           Y          rZ

     1   0.00E+00  0.00E+00  0.00E+00
     2  -0.69E-02  0.10E+00  0.14E-03
     3  -0.27E-01  0.20E+00  0.27E-03
     4  -0.61E-01  0.30E+00  0.40E-03
     5  -0.11E+00  0.39E+00  0.52E-03
     6  -0.17E+00  0.48E+00  0.64E-03
     7  -0.23E+00  0.56E+00  0.75E-03
     8  -0.32E+00  0.64E+00  0.86E-03
     9  -0.41E+00  0.72E+00  0.96E-03
    10  -0.51E+00  0.78E+00  0.11E-02
    11  -0.62E+00  0.85E+00  0.11E-02
    12  -0.73E+00  0.91E+00  0.12E-02
    13  -0.86E+00  0.96E+00  0.13E-02
    14  -0.99E+00  0.10E+01  0.14E-02
    15  -0.11E+01  0.10E+01  0.14E-02
    16  -0.13E+01  0.11E+01  0.15E-02
    17  -0.14E+01  0.11E+01  0.15E-02
    18  -0.16E+01  0.11E+01  0.15E-02
    19  -0.17E+01  0.11E+01  0.16E-02
    20  -0.19E+01  0.12E+01  0.16E-02
    21  -0.21E+01  0.12E+01  0.16E-02
```

STATIC_DISPLACEMENTS - Notepad

File Edit Format View Help

```
    22  -0.22E+01  0.12E+01  0.16E-02
    23  -0.24E+01  0.12E+01  0.16E-02
    24  -0.25E+01  0.12E+01  0.16E-02
    25  -0.27E+01  0.12E+01  0.16E-02
    26  -0.29E+01  0.12E+01  0.16E-02
    27  -0.30E+01  0.12E+01  0.16E-02
    28  -0.32E+01  0.12E+01  0.16E-02
    29  -0.33E+01  0.12E+01  0.16E-02
    30  -0.35E+01  0.12E+01  0.16E-02
    31  -0.37E+01  0.12E+01  0.16E-02
    32  -0.38E+01  0.12E+01  0.16E-02
    33  -0.40E+01  0.12E+01  0.16E-02
    34  -0.42E+01  0.12E+01  0.16E-02
    35  -0.43E+01  0.12E+01  0.16E-02
-------------------------------------------
 NODAL DISPLACEMENTS  STEP          5
  NODE           X           Y          rZ

     1   0.00E+00  0.00E+00  0.00E+00
     2  -0.83E-02  0.12E+00  0.17E-03
     3  -0.33E-01  0.24E+00  0.32E-03
     4  -0.73E-01  0.36E+00  0.48E-03
     5  -0.13E+00  0.47E+00  0.63E-03
     6  -0.20E+00  0.58E+00  0.77E-03
     7  -0.28E+00  0.68E+00  0.90E-03
     8  -0.38E+00  0.78E+00  0.10E-02
     9  -0.49E+00  0.87E+00  0.12E-02
    10  -0.61E+00  0.95E+00  0.13E-02
    11  -0.74E+00  0.10E+01  0.14E-02
    12  -0.88E+00  0.11E+01  0.15E-02
    13  -0.10E+01  0.12E+01  0.16E-02
    14  -0.12E+01  0.12E+01  0.17E-02
    15  -0.14E+01  0.13E+01  0.17E-02
    16  -0.15E+01  0.14E+01  0.18E-02
    17  -0.17E+01  0.14E+01  0.19E-02
    18  -0.19E+01  0.14E+01  0.19E-02
    19  -0.21E+01  0.15E+01  0.20E-02
    20  -0.23E+01  0.15E+01  0.20E-02
    21  -0.25E+01  0.15E+01  0.20E-02
    22  -0.27E+01  0.15E+01  0.20E-02
    23  -0.29E+01  0.15E+01  0.21E-02
    24  -0.31E+01  0.15E+01  0.21E-02
    25  -0.33E+01  0.15E+01  0.21E-02
    26  -0.35E+01  0.15E+01  0.21E-02
    27  -0.38E+01  0.15E+01  0.21E-02
    28  -0.40E+01  0.15E+01  0.21E-02
    29  -0.42E+01  0.15E+01  0.21E-02
    30  -0.44E+01  0.15E+01  0.21E-02
    31  -0.46E+01  0.15E+01  0.21E-02
    32  -0.48E+01  0.15E+01  0.21E-02
    33  -0.50E+01  0.15E+01  0.21E-02
    34  -0.52E+01  0.15E+01  0.21E-02
    35  -0.54E+01  0.15E+01  0.21E-02
-------------------------------------------
 NODAL DISPLACEMENTS  STEP          6
  NODE           X           Y          rZ

     1   0.00E+00  0.00E+00  0.00E+00
     2  -0.93E-02  0.14E+00  0.19E-03
     3  -0.37E-01  0.28E+00  0.36E-03
     4  -0.82E-01  0.41E+00  0.54E-03
     5  -0.14E+00  0.53E+00  0.70E-03
     6  -0.22E+00  0.65E+00  0.86E-03
     7  -0.32E+00  0.77E+00  0.10E-02
     8  -0.43E+00  0.88E+00  0.12E-02
     9  -0.55E+00  0.99E+00  0.13E-02
    10  -0.69E+00  0.11E+01  0.14E-02
    11  -0.84E+00  0.12E+01  0.16E-02
    12  -0.10E+01  0.13E+01  0.17E-02
    13  -0.12E+01  0.14E+01  0.18E-02
    14  -0.14E+01  0.15E+01  0.19E-02
```

STATIC_DISPLACEMENTS - Notepad

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```
     14    -0.14E+01  0.15E+01  0.19E-02
     15    -0.16E+01  0.15E+01  0.20E-02
     16    -0.18E+01  0.16E+01  0.21E-02
     17    -0.20E+01  0.17E+01  0.22E-02
     18    -0.22E+01  0.17E+01  0.23E-02
     19    -0.24E+01  0.18E+01  0.24E-02
     20    -0.27E+01  0.18E+01  0.24E-02
     21    -0.29E+01  0.19E+01  0.25E-02
     22    -0.32E+01  0.19E+01  0.25E-02
     23    -0.34E+01  0.19E+01  0.25E-02
     24    -0.37E+01  0.19E+01  0.26E-02
     25    -0.39E+01  0.19E+01  0.26E-02
     26    -0.42E+01  0.19E+01  0.26E-02
     27    -0.45E+01  0.19E+01  0.26E-02
     28    -0.47E+01  0.19E+01  0.26E-02
     29    -0.50E+01  0.19E+01  0.26E-02
     30    -0.52E+01  0.19E+01  0.26E-02
     31    -0.55E+01  0.19E+01  0.26E-02
     32    -0.57E+01  0.19E+01  0.26E-02
     33    -0.60E+01  0.19E+01  0.26E-02
     34    -0.63E+01  0.19E+01  0.26E-02
     35    -0.65E+01  0.19E+01  0.26E-02
 -----------------------------------------
 NODAL DISPLACEMENTS   STEP          7
  NODE            X          Y         rZ

      1     0.00E+00  0.00E+00  0.00E+00
      2    -0.11E-01  0.16E+00  0.21E-03
      3    -0.42E-01  0.32E+00  0.42E-03
      4    -0.94E-01  0.47E+00  0.62E-03
      5    -0.17E+00  0.61E+00  0.81E-03
      6    -0.26E+00  0.75E+00  0.99E-03
      7    -0.36E+00  0.89E+00  0.12E-02
      8    -0.49E+00  0.10E+01  0.13E-02
      9    -0.63E+00  0.11E+01  0.15E-02
     10    -0.79E+00  0.13E+01  0.17E-02
     11    -0.96E+00  0.14E+01  0.18E-02
     12    -0.12E+01  0.15E+01  0.20E-02
     13    -0.14E+01  0.16E+01  0.21E-02
     14    -0.16E+01  0.17E+01  0.22E-02
     15    -0.18E+01  0.18E+01  0.23E-02
     16    -0.20E+01  0.18E+01  0.24E-02
     17    -0.23E+01  0.19E+01  0.26E-02
     18    -0.25E+01  0.20E+01  0.26E-02
     19    -0.28E+01  0.21E+01  0.27E-02
     20    -0.31E+01  0.21E+01  0.28E-02
     21    -0.34E+01  0.22E+01  0.29E-02
     22    -0.37E+01  0.22E+01  0.29E-02
     23    -0.40E+01  0.22E+01  0.30E-02
     24    -0.43E+01  0.23E+01  0.30E-02
     25    -0.46E+01  0.23E+01  0.30E-02
     26    -0.49E+01  0.23E+01  0.30E-02
     27    -0.52E+01  0.23E+01  0.30E-02
     28    -0.55E+01  0.23E+01  0.30E-02
     29    -0.58E+01  0.23E+01  0.30E-02
     30    -0.61E+01  0.23E+01  0.30E-02
     31    -0.64E+01  0.23E+01  0.30E-02
     32    -0.67E+01  0.23E+01  0.30E-02
     33    -0.70E+01  0.23E+01  0.30E-02
     34    -0.73E+01  0.23E+01  0.30E-02
     35    -0.76E+01  0.23E+01  0.30E-02
 -----------------------------------------
 NODAL DISPLACEMENTS   STEP          8
  NODE            X          Y         rZ

      1     0.00E+00  0.00E+00  0.00E+00
      2    -0.12E-01  0.18E+00  0.24E-03
      3    -0.48E-01  0.36E+00  0.48E-03
      4    -0.11E+00  0.53E+00  0.70E-03
      5    -0.19E+00  0.69E+00  0.92E-03
      6    -0.29E+00  0.85E+00  0.11E-02
```

STATIC_DISPLACEMENTS - Notepad

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```
      7    -0.41E+00  0.10E+01  0.13E-02
      8    -0.56E+00  0.12E+01  0.15E-02
      9    -0.72E+00  0.13E+01  0.17E-02
     10    -0.90E+00  0.14E+01  0.19E-02
     11    -0.11E+01  0.16E+01  0.21E-02
     12    -0.13E+01  0.17E+01  0.22E-02
     13    -0.15E+01  0.18E+01  0.24E-02
     14    -0.18E+01  0.19E+01  0.25E-02
     15    -0.20E+01  0.20E+01  0.27E-02
     16    -0.23E+01  0.21E+01  0.28E-02
     17    -0.26E+01  0.22E+01  0.29E-02
     18    -0.29E+01  0.23E+01  0.30E-02
     19    -0.32E+01  0.23E+01  0.31E-02
     20    -0.35E+01  0.24E+01  0.32E-02
     21    -0.38E+01  0.25E+01  0.33E-02
     22    -0.42E+01  0.25E+01  0.34E-02
     23    -0.45E+01  0.26E+01  0.34E-02
     24    -0.49E+01  0.26E+01  0.35E-02
     25    -0.52E+01  0.26E+01  0.35E-02
     26    -0.56E+01  0.26E+01  0.35E-02
     27    -0.59E+01  0.26E+01  0.35E-02
     28    -0.62E+01  0.26E+01  0.35E-02
     29    -0.66E+01  0.26E+01  0.35E-02
     30    -0.69E+01  0.26E+01  0.35E-02
     31    -0.73E+01  0.26E+01  0.35E-02
     32    -0.76E+01  0.26E+01  0.35E-02
     33    -0.80E+01  0.26E+01  0.35E-02
     34    -0.84E+01  0.26E+01  0.35E-02
     35    -0.87E+01  0.26E+01  0.35E-02
 -----------------------------------------
 NODAL DISPLACEMENTS   STEP          9
  NODE            X          Y         rZ

      1     0.00E+00  0.00E+00  0.00E+00
      2    -0.14E-01  0.21E+00  0.28E-03
      3    -0.55E-01  0.41E+00  0.54E-03
      4    -0.12E+00  0.60E+00  0.79E-03
      5    -0.21E+00  0.79E+00  0.10E-02
      6    -0.33E+00  0.96E+00  0.13E-02
      7    -0.47E+00  0.11E+01  0.15E-02
      8    -0.63E+00  0.13E+01  0.17E-02
      9    -0.81E+00  0.15E+01  0.19E-02
     10    -0.10E+01  0.16E+01  0.21E-02
     11    -0.12E+01  0.17E+01  0.23E-02
     12    -0.15E+01  0.19E+01  0.25E-02
     13    -0.17E+01  0.20E+01  0.27E-02
     14    -0.20E+01  0.21E+01  0.28E-02
     15    -0.23E+01  0.22E+01  0.30E-02
     16    -0.26E+01  0.24E+01  0.31E-02
     17    -0.29E+01  0.25E+01  0.32E-02
     18    -0.32E+01  0.26E+01  0.34E-02
     19    -0.36E+01  0.26E+01  0.35E-02
     20    -0.39E+01  0.27E+01  0.36E-02
     21    -0.43E+01  0.28E+01  0.37E-02
     22    -0.47E+01  0.29E+01  0.38E-02
     23    -0.51E+01  0.29E+01  0.39E-02
     24    -0.54E+01  0.29E+01  0.39E-02
     25    -0.58E+01  0.30E+01  0.39E-02
     26    -0.62E+01  0.30E+01  0.39E-02
     27    -0.66E+01  0.30E+01  0.39E-02
     28    -0.70E+01  0.30E+01  0.40E-02
     29    -0.74E+01  0.30E+01  0.40E-02
     30    -0.78E+01  0.30E+01  0.40E-02
     31    -0.82E+01  0.30E+01  0.40E-02
     32    -0.86E+01  0.30E+01  0.40E-02
     33    -0.90E+01  0.30E+01  0.40E-02
     34    -0.94E+01  0.30E+01  0.40E-02
     35    -0.98E+01  0.30E+01  0.40E-02
 -----------------------------------------
 NODAL DISPLACEMENTS   STEP         10
  NODE            X          Y         rZ
```

STATIC_DISPLACEMENTS - Notepad

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```
      1     0.00E+00  0.00E+00  0.00E+00
      2    -0.16E-01  0.24E+00  0.31E-03
      3    -0.62E-01  0.47E+00  0.61E-03
      4    -0.14E+00  0.68E+00  0.89E-03
      5    -0.24E+00  0.89E+00  0.12E-02
      6    -0.37E+00  0.11E+01  0.14E-02
      7    -0.52E+00  0.13E+01  0.17E-02
      8    -0.70E+00  0.15E+01  0.19E-02
      9    -0.91E+00  0.16E+01  0.21E-02
     10    -0.11E+01  0.18E+01  0.23E-02
     11    -0.14E+01  0.19E+01  0.26E-02
     12    -0.16E+01  0.21E+01  0.28E-02
     13    -0.19E+01  0.22E+01  0.29E-02
     14    -0.22E+01  0.24E+01  0.31E-02
     15    -0.25E+01  0.25E+01  0.33E-02
     16    -0.29E+01  0.26E+01  0.34E-02
     17    -0.32E+01  0.27E+01  0.36E-02
     18    -0.36E+01  0.28E+01  0.37E-02
     19    -0.40E+01  0.29E+01  0.39E-02
     20    -0.44E+01  0.30E+01  0.40E-02
     21    -0.48E+01  0.31E+01  0.41E-02
     22    -0.52E+01  0.32E+01  0.42E-02
     23    -0.56E+01  0.32E+01  0.43E-02
     24    -0.60E+01  0.33E+01  0.43E-02
     25    -0.65E+01  0.33E+01  0.44E-02
     26    -0.69E+01  0.33E+01  0.44E-02
     27    -0.74E+01  0.33E+01  0.44E-02
     28    -0.78E+01  0.33E+01  0.44E-02
     29    -0.82E+01  0.33E+01  0.44E-02
     30    -0.87E+01  0.33E+01  0.44E-02
     31    -0.91E+01  0.33E+01  0.44E-02
     32    -0.96E+01  0.33E+01  0.44E-02
     33    -0.10E+02  0.33E+01  0.44E-02
     34    -0.10E+02  0.33E+01  0.44E-02
     35    -0.11E+02  0.33E+01  0.44E-02
 -----------------------------------------
 NODAL DISPLACEMENTS   STEP         11
  NODE            X          Y         rZ

      1     0.00E+00  0.00E+00  0.00E+00
      2    -0.18E-01  0.27E+00  0.35E-03
      3    -0.69E-01  0.53E+00  0.69E-03
      4    -0.15E+00  0.77E+00  0.10E-02
      5    -0.27E+00  0.10E+01  0.13E-02
      6    -0.41E+00  0.12E+01  0.16E-02
      7    -0.59E+00  0.14E+01  0.19E-02
      8    -0.79E+00  0.16E+01  0.21E-02
      9    -0.10E+01  0.18E+01  0.24E-02
     10    -0.13E+01  0.20E+01  0.26E-02
     11    -0.15E+01  0.22E+01  0.28E-02
     12    -0.18E+01  0.23E+01  0.30E-02
     13    -0.21E+01  0.25E+01  0.32E-02
     14    -0.25E+01  0.26E+01  0.34E-02
     15    -0.28E+01  0.28E+01  0.36E-02
     16    -0.32E+01  0.29E+01  0.38E-02
     17    -0.36E+01  0.30E+01  0.39E-02
     18    -0.40E+01  0.31E+01  0.41E-02
     19    -0.44E+01  0.32E+01  0.42E-02
     20    -0.48E+01  0.33E+01  0.44E-02
     21    -0.53E+01  0.34E+01  0.45E-02
     22    -0.57E+01  0.35E+01  0.46E-02
     23    -0.62E+01  0.36E+01  0.47E-02
     24    -0.67E+01  0.36E+01  0.47E-02
     25    -0.71E+01  0.36E+01  0.48E-02
     26    -0.76E+01  0.37E+01  0.48E-02
     27    -0.81E+01  0.37E+01  0.48E-02
     28    -0.86E+01  0.37E+01  0.48E-02
     29    -0.91E+01  0.37E+01  0.48E-02
     30    -0.95E+01  0.37E+01  0.48E-02
     31    -0.10E+02  0.37E+01  0.48E-02
     32    -0.11E+02  0.37E+01  0.48E-02
```

STATIC_DISPLACEMENTS - Notepad

File Edit Format View Help

```
     19     -0.44E+02  0.35E+02  0.41E-01
     20     -0.48E+02  0.36E+02  0.41E-01
     21     -0.53E+02  0.37E+02  0.42E-01
     22     -0.57E+02  0.37E+02  0.43E-01
     23     -0.61E+02  0.37E+02  0.43E-01
     24     -0.65E+02  0.37E+02  0.43E-01
     25     -0.70E+02  0.38E+02  0.43E-01
     26     -0.74E+02  0.38E+02  0.44E-01
     27     -0.78E+02  0.38E+02  0.44E-01
     28     -0.83E+02  0.38E+02  0.44E-01
     29     -0.87E+02  0.38E+02  0.44E-01
     30     -0.92E+02  0.38E+02  0.44E-01
     31     -0.96E+02  0.38E+02  0.44E-01
     32     -0.10E+03  0.38E+02  0.44E-01
     33     -0.10E+03  0.38E+02  0.44E-01
     34     -0.11E+03  0.38E+02  0.44E-01
     35     -0.11E+03  0.38E+02  0.44E-01
-------------------------------------------
NODAL DISPLACEMENTS  STEP          106
 NODE            X          Y         rZ

      1      0.00E+00  0.00E+00  0.00E+00
      2     -0.18E+00  0.32E+01  0.37E-02
      3     -0.72E+00  0.63E+01  0.71E-02
      4     -0.16E+01  0.92E+01  0.10E-01
      5     -0.28E+01  0.12E+02  0.14E-01
      6     -0.43E+01  0.15E+02  0.17E-01
      7     -0.61E+01  0.17E+02  0.19E-01
      8     -0.82E+01  0.19E+02  0.22E-01
      9     -0.11E+02  0.22E+02  0.25E-01
     10     -0.13E+02  0.24E+02  0.27E-01
     11     -0.16E+02  0.26E+02  0.29E-01
     12     -0.19E+02  0.27E+02  0.31E-01
     13     -0.22E+02  0.29E+02  0.33E-01
     14     -0.26E+02  0.30E+02  0.35E-01
     15     -0.29E+02  0.32E+02  0.36E-01
     16     -0.33E+02  0.33E+02  0.38E-01
     17     -0.37E+02  0.34E+02  0.39E-01
     18     -0.41E+02  0.35E+02  0.40E-01
     19     -0.45E+02  0.36E+02  0.41E-01
     20     -0.49E+02  0.36E+02  0.42E-01
     21     -0.53E+02  0.37E+02  0.42E-01
     22     -0.57E+02  0.37E+02  0.43E-01
     23     -0.62E+02  0.38E+02  0.43E-01
     24     -0.66E+02  0.38E+02  0.44E-01
     25     -0.70E+02  0.38E+02  0.44E-01
     26     -0.75E+02  0.38E+02  0.44E-01
     27     -0.79E+02  0.38E+02  0.44E-01
     28     -0.84E+02  0.38E+02  0.44E-01
     29     -0.88E+02  0.39E+02  0.45E-01
     30     -0.93E+02  0.39E+02  0.45E-01
     31     -0.97E+02  0.39E+02  0.45E-01
     32     -0.10E+03  0.39E+02  0.45E-01
     33     -0.11E+03  0.39E+02  0.45E-01
     34     -0.11E+03  0.39E+02  0.45E-01
     35     -0.11E+03  0.39E+02  0.45E-01
-------------------------------------------
NODAL DISPLACEMENTS  STEP          107
 NODE            X          Y         rZ

      1      0.00E+00  0.00E+00  0.00E+00
      2     -0.18E+00  0.32E+01  0.37E-02
      3     -0.73E+00  0.63E+01  0.72E-02
      4     -0.16E+01  0.93E+01  0.11E-01
      5     -0.28E+01  0.12E+02  0.14E-01
      6     -0.44E+01  0.15E+02  0.17E-01
      7     -0.62E+01  0.17E+02  0.20E-01
      8     -0.83E+01  0.20E+02  0.22E-01
      9     -0.11E+02  0.22E+02  0.25E-01
     10     -0.13E+02  0.24E+02  0.27E-01
     11     -0.16E+02  0.26E+02  0.30E-01
```

STATIC_DISPLACEMENTS - Notepad

File Edit Format View Help

```
     12     -0.19E+02  0.28E+02  0.32E-01
     13     -0.22E+02  0.29E+02  0.33E-01
     14     -0.26E+02  0.31E+02  0.35E-01
     15     -0.29E+02  0.32E+02  0.37E-01
     16     -0.33E+02  0.33E+02  0.38E-01
     17     -0.37E+02  0.34E+02  0.39E-01
     18     -0.41E+02  0.35E+02  0.40E-01
     19     -0.45E+02  0.36E+02  0.41E-01
     20     -0.49E+02  0.37E+02  0.42E-01
     21     -0.54E+02  0.37E+02  0.43E-01
     22     -0.58E+02  0.38E+02  0.43E-01
     23     -0.62E+02  0.38E+02  0.44E-01
     24     -0.67E+02  0.38E+02  0.44E-01
     25     -0.71E+02  0.38E+02  0.44E-01
     26     -0.76E+02  0.39E+02  0.45E-01
     27     -0.80E+02  0.39E+02  0.45E-01
     28     -0.84E+02  0.39E+02  0.45E-01
     29     -0.89E+02  0.39E+02  0.45E-01
     30     -0.93E+02  0.39E+02  0.45E-01
     31     -0.98E+02  0.39E+02  0.45E-01
     32     -0.10E+03  0.39E+02  0.45E-01
     33     -0.11E+03  0.39E+02  0.45E-01
     34     -0.11E+03  0.39E+02  0.45E-01
     35     -0.12E+03  0.39E+02  0.45E-01
-------------------------------------------
NODAL DISPLACEMENTS  STEP          108
 NODE            X          Y         rZ

      1      0.00E+00  0.00E+00  0.00E+00
      2     -0.19E+00  0.33E+01  0.37E-02
      3     -0.73E+00  0.64E+01  0.73E-02
      4     -0.16E+01  0.93E+01  0.11E-01
      5     -0.29E+01  0.12E+02  0.14E-01
      6     -0.44E+01  0.15E+02  0.17E-01
      7     -0.62E+01  0.17E+02  0.20E-01
      8     -0.84E+01  0.20E+02  0.23E-01
      9     -0.11E+02  0.22E+02  0.25E-01
     10     -0.13E+02  0.24E+02  0.28E-01
     11     -0.16E+02  0.26E+02  0.30E-01
     12     -0.19E+02  0.28E+02  0.32E-01
     13     -0.23E+02  0.29E+02  0.34E-01
     14     -0.26E+02  0.31E+02  0.35E-01
     15     -0.30E+02  0.32E+02  0.37E-01
     16     -0.33E+02  0.34E+02  0.39E-01
     17     -0.37E+02  0.35E+02  0.40E-01
     18     -0.41E+02  0.36E+02  0.41E-01
     19     -0.46E+02  0.36E+02  0.42E-01
     20     -0.50E+02  0.37E+02  0.43E-01
     21     -0.54E+02  0.38E+02  0.43E-01
     22     -0.58E+02  0.38E+02  0.44E-01
     23     -0.63E+02  0.38E+02  0.44E-01
     24     -0.67E+02  0.39E+02  0.45E-01
     25     -0.72E+02  0.39E+02  0.45E-01
     26     -0.76E+02  0.39E+02  0.45E-01
     27     -0.81E+02  0.39E+02  0.45E-01
     28     -0.85E+02  0.39E+02  0.45E-01
     29     -0.90E+02  0.39E+02  0.45E-01
     30     -0.94E+02  0.39E+02  0.46E-01
     31     -0.99E+02  0.39E+02  0.46E-01
     32     -0.10E+03  0.39E+02  0.46E-01
     33     -0.11E+03  0.39E+02  0.46E-01
     34     -0.11E+03  0.39E+02  0.46E-01
     35     -0.12E+03  0.39E+02  0.46E-01
-------------------------------------------
NODAL DISPLACEMENTS  STEP          109
 NODE            X          Y         rZ

      1      0.00E+00  0.00E+00  0.00E+00
      2     -0.19E+00  0.33E+01  0.37E-02
      3     -0.74E+00  0.64E+01  0.73E-02
      4     -0.16E+01  0.94E+01  0.11E-01
```

STATIC_DISPLACEMENTS - Notepad

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```
      5     -0.29E+01  0.12E+02  0.14E-01
      6     -0.44E+01  0.15E+02  0.17E-01
      7     -0.63E+01  0.18E+02  0.20E-01
      8     -0.84E+01  0.20E+02  0.23E-01
      9     -0.11E+02  0.22E+02  0.25E-01
     10     -0.13E+02  0.24E+02  0.28E-01
     11     -0.16E+02  0.26E+02  0.30E-01
     12     -0.19E+02  0.28E+02  0.32E-01
     13     -0.23E+02  0.30E+02  0.34E-01
     14     -0.26E+02  0.31E+02  0.36E-01
     15     -0.30E+02  0.33E+02  0.37E-01
     16     -0.34E+02  0.34E+02  0.39E-01
     17     -0.38E+02  0.35E+02  0.40E-01
     18     -0.42E+02  0.36E+02  0.41E-01
     19     -0.46E+02  0.37E+02  0.42E-01
     20     -0.50E+02  0.37E+02  0.43E-01
     21     -0.55E+02  0.38E+02  0.44E-01
     22     -0.59E+02  0.38E+02  0.44E-01
     23     -0.63E+02  0.39E+02  0.45E-01
     24     -0.68E+02  0.39E+02  0.45E-01
     25     -0.72E+02  0.39E+02  0.45E-01
     26     -0.77E+02  0.39E+02  0.45E-01
     27     -0.81E+02  0.39E+02  0.46E-01
     28     -0.86E+02  0.40E+02  0.46E-01
     29     -0.91E+02  0.40E+02  0.46E-01
     30     -0.95E+02  0.40E+02  0.46E-01
     31     -0.10E+03  0.40E+02  0.46E-01
     32     -0.10E+03  0.40E+02  0.46E-01
     33     -0.11E+03  0.40E+02  0.46E-01
     34     -0.11E+03  0.40E+02  0.46E-01
     35     -0.12E+03  0.40E+02  0.46E-01
-------------------------------------------
NODAL DISPLACEMENTS  STEP          110
 NODE            X          Y         rZ

      1      0.00E+00  0.00E+00  0.00E+00
      2     -0.19E+00  0.33E+01  0.38E-02
      3     -0.75E+00  0.65E+01  0.74E-02
      4     -0.17E+01  0.95E+01  0.11E-01
      5     -0.29E+01  0.12E+02  0.14E-01
      6     -0.45E+01  0.15E+02  0.17E-01
      7     -0.63E+01  0.18E+02  0.20E-01
      8     -0.85E+01  0.20E+02  0.23E-01
      9     -0.11E+02  0.22E+02  0.26E-01
     10     -0.14E+02  0.24E+02  0.28E-01
     11     -0.17E+02  0.26E+02  0.30E-01
     12     -0.20E+02  0.28E+02  0.32E-01
     13     -0.23E+02  0.30E+02  0.34E-01
     14     -0.26E+02  0.32E+02  0.36E-01
     15     -0.30E+02  0.33E+02  0.38E-01
     16     -0.34E+02  0.34E+02  0.39E-01
     17     -0.38E+02  0.35E+02  0.40E-01
     18     -0.42E+02  0.36E+02  0.42E-01
     19     -0.46E+02  0.37E+02  0.43E-01
     20     -0.51E+02  0.38E+02  0.43E-01
     21     -0.55E+02  0.38E+02  0.44E-01
     22     -0.59E+02  0.39E+02  0.45E-01
     23     -0.64E+02  0.39E+02  0.45E-01
     24     -0.68E+02  0.39E+02  0.45E-01
     25     -0.73E+02  0.40E+02  0.46E-01
     26     -0.78E+02  0.40E+02  0.46E-01
     27     -0.82E+02  0.40E+02  0.46E-01
     28     -0.87E+02  0.40E+02  0.46E-01
     29     -0.91E+02  0.40E+02  0.46E-01
     30     -0.96E+02  0.40E+02  0.46E-01
     31     -0.10E+03  0.40E+02  0.46E-01
     32     -0.11E+03  0.40E+02  0.46E-01
     33     -0.11E+03  0.40E+02  0.46E-01
     34     -0.11E+03  0.40E+02  0.46E-01
     35     -0.12E+03  0.40E+02  0.46E-01
-------------------------------------------
```

TRANS

TRANS - Notepad

File Edit Format View Help

```
 TRANS MATRIX
 0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
 TRANS MATRIX
 0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
 TRANS MATRIX
 0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
 TRANS MATRIX
 0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
 TRANS MATRIX
 0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
 TRANS MATRIX
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-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
 TRANS MATRIX
 0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
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 0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
 TRANS MATRIX
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-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
```

*TRANS - Notepad

File Edit Format View Help

```
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
  TRANS MATRIX
  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 -0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
  TRANS MATRIX
  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 -0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
  TRANS MATRIX
  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 -0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
  TRANS MATRIX
  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 -0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
  TRANS MATRIX
  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
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  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
  TRANS MATRIX
  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 -0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
  TRANS MATRIX
  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 -0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
  TRANS MATRIX
  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 -0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
```

*TRANS - Notepad

File Edit Format View Help

```
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
 TRANS MATRIX
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-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
 TRANS MATRIX
 0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
 TRANS MATRIX
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-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
 TRANS MATRIX
 0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
 TRANS MATRIX
 0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
 TRANS MATRIX
 0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
 TRANS MATRIX
 0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
 TRANS MATRIX
 0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
```

*TRANS - Notepad

File Edit Format View Help

```
 TRANS MATRIX
 0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
 TRANS MATRIX
 0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
 TRANS MATRIX
 0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
 TRANS MATRIX
 0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
 TRANS MATRIX
 0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
 TRANS MATRIX
 0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
 TRANS MATRIX
 0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01
 TRANS MATRIX
 0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
-0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.1000E+01  0.0000E+00
 0.0000E+00  0.0000E+00  0.0000E+00 -0.1000E+01  0.0000E+00  0.0000E+00
```

APPENDIX 2

ReinCon3D6DOF User Guide

A2.1. Data entry and solutions

Program accepts a group of input data files with .TXT extension and creates another group of output files with. DAC extension.

A2.1.1. Input files for static 3D model

The input files required for the 3D model analyses are:

- **Auto_Mesh_SOLID**
- **Auto_Mesh_STIRRUP**
- **coorGEO_BAR**
- **PROPERTY_CONCRETE**
- **CoorLoad**
- **DirectEndConditions**
- **PROPERTY_BAR**
- **PROPERTY_SOLID**
- **SEC_BAR**
- **Solution_Parameters**
- **Step_Guide**
- **SWITCH_A**
- **SWITCH_B**

Longitudinal reinforcements are defined in coorGEO_BAR by specifying the coordinates at both ends of the rebar while the stirrups (Auto_Mesh_STIRRUPS) are are defined by the spacing between them. It is possible to define regions of stirrups. The dimensions of the reinforcements are inputted in SEC_BAR. Note that while inputting the rebars are registered and after comes the stirrups.

NumberOfBarsWithFollowingSection(Ordered) means the total number of one group of reinforcements in all the elements.

A2.1.2. Output files for static 3D model

The output files created after the 3D model static analysis

- **Bar_Coor_Ini**
- **Bar_Strain**
- **Bar_Stress**
- **file1**
- **file2**
- **fileline1**
- **hile1**
- **hloads**
- **hnodes**
- **hsupports**
- **Solid_Coor_Ini**
- **Solid_StrainXX, Solid_StrainXY, Solid_StrainXZ, Solid_StrainYY, Solid_StrainYZ, Solid_StrainZZ**
- **INPUT_CHECK**
- **Lamda**
- **U_Y**

A2.2. Input files

- **DirectEndConditions: Support Information**

-EnterWithKeywords-

FirstEnd_0Free_1Fixed_2Pinned_3Roller_4Sliding:

SecondEnd_0Free_1Fixed_2Pinned_3Roller_4Sliding:

EnterNewPlaneRestraintYorN:

EnterNewLineRestraintYorN:

EnterNewPlaneConstraintYorN:

EnterNewLineConstraintYorN:

LineConstraint-X-Y-Z-CoordinatesAtBothEnds:

LineConstraintDirection:

LineConstraintMasterX-Y-Z-Coordinates:

EnterNewLineConstraintYorN:

- **CoorLoad.TXT**: Nodal loads

-EnterWithKeywords-

EnterNewLoadCoordinatesYorN: Y for a new load

LoadCoordinatesX-Y-Z: Coordinate at which the node is applied

LoadDirection: Direction of the nodal loading (1 or 2)

LoadValue: Value of the nodal loading

EnterNewLoadCoordinatesYorN: If there is no loading information put N

- **Auto_Mesh_SOLID.TXT: Structural geometry information**

-EnterWithKeywords-

NumberOfPiecesSeperatesWidthX:

EnterWidthsX:

NumberOfSeperationsEachWidthX:

NumberOfPiecesSeperatesWidthY:

EnterWidthsY:

NumberOfSeperationsEachWidthY:

NumberOfPiecesSeperatesWidthZ:

EnterWidthsZ:

NumberOfSeperationsEachWidthZ:

CrossSectionTrim_YorN:

CoverTrim_YorN:

- **Auto_Mesh_STIRRUP.TXT: Stirrup geometry information**

-EnterWithKeywords-

NumberOfStirrupRegions:

BeginningHeightToEndHeightEachRegion:

LowerBoundOfSpacingEachRegion:

- **PROPERTY_SOLID.TXT: Properties of the concrete bulk**

-EnterWithKeywords-

ConcreteElasticityModulus:

ConcretePoissonRatio:

ConcreteCompressiveStress:

OnsetRatioPlaticFlow:

CompressivePeakStrain:

ConcreteTensileStress:

TensionSofteningPower:

FactorIntersectTensionCompressionSurface:

PotentialSurfaceType:

SlopeLinearPotentialSurface:

TensionSurfaceType1Rankine_2Mixed:

CornerReturnType:

DamageEvolutionFactorCompression:

DamageEvolutionFactorTension:

AnalysisTypeIsotropic0Anisotropic1:

ProducePlasticReturnGraphAtSpecificPointYorN:

- **PROPERTY_BAR.TXT: Properties of the reinforcements**

-EnterWithKeywords-

NumberOfBarsWithFollowingProperty(Ordered):

BarElasticityModulus:

BarYieldStressLimit:

BarHardeningModulus:

NumberOfBarsWithFollowingProperty(Ordered):

BarElasticityModulus:

BarYieldStressLimit:

BarHardeningModulus:

- **SEC_BAR.TXT: Cross section of the reinforcements**

-EnterWithKeywords-

NumberOfBarsWithFollowingSection(Ordered):

WidthAndHeight:

NumberOfBarsWithFollowingSection(Ordered):

WidthAndHeight:

- **Step_Guide.TXT: Setting the number of cycles**

-EnterWithKeywords-

NumberOfCycles:

ControlType1or2:

NumberOfStepsEachCycle:

- **SWITCH_A.TXT: Activating option to consider during analysis**

-EnterWithKeywords-

AutoGenerateSolidMeshYorN:

AutoWrapYorN(RequiresAutoGenerateSolid):

ConnectRebarsUsingCoordinatesYorN:

AutoStirrupYorN(RequiresAutoGenerateSolid):

- **SWITCH_B.TXT: Activating option to consider during analysis**

-EnterWithKeywords-

LoadGenerateUsingCoordinatesYorN:

BoundaryGenerateUsingCoordinatesYorN:

MPCGenerateUsingCoordinatesYorN:

DirectEndConditionsYorN:

- **Solution_ParameterSE.TXT: Parameters needed for running**

-EnterWithKeywords-

ElementType:

PrevRunYorNorS:

NumberOfIntegrationPointsSolid:

NumberOfIntegrationPointsReinforcement:

NumberOfIntegrationPointsWrap:

ControlTypeLoad1Displacement2:

ControlNodeCoordinates:

ControlDirection:

StepSize:

StepNumberLimit:

HardeningType_1volum_2mixed:

HardeningUpdateLevel_1GlobalStep_2GlobalIteration_3PlasticIteration:

PlasticReturnType_1CuttingPlane_2CPP:

TangentModulusType_0Elastic_1Plastic:

AlgorithmStabilizationYorN:

PlasticReturnIterationLimit:

ViscosityRate_0Independent_1ViscoPlastic_2ViscosRegularization:

NumberOfStepsExtractGraphicalOutput:

AmplificationFactorForGraphicalOutput:

NumberOfCollectedOutputFiles:

CollectedOutputFileNames:

GlobalAlgorithm_ErrorMargin:

PlasticityAlgorithm_ErrorMargin:

IdentifyFirstPointofYieldYorN:

A2.3. Example 1. Beam Analysis

The beam ISO30-1 is 200 mm wide and 300 mm high, as shown in Figure 4-8 to Figure 4-10, it is supported on a span of 3000 mm and is subjected to two equal loads symmetrically placed about the mid-span. The modulus of elasticity of concrete is 32 GPa and f_c=44 MPa. Yielding stress for steel rebars is taken as 480 MPa, the ultimate strength is taken as 600 MPa and the modulus of elasticity is taken as 200 GPa. Conventional steel stirrups (10 mm diameter) is used in the non-constant moment zones, to prevent shear failure. The diameter of the reinforcement is maintained constant (19.1 mm diameter) and this beam is reinforced by two identical rebar as resumed in Figure 4-8.

A1.3.1. Input files

Auto_Mesh_SOLID.TXT

Auto_Mesh_SOLID - Notepad

File Edit Format View Help

```
-EnterWithKeywords-
NumberOfPiecesSeperatesWidthX:
4
EnterWidthsX:
25.0,75.0,75.0,25.0
NumberOfSeperationsEachWidthX:
1,1,1,1
NumberOfPiecesSeperatesWidthY:
4
EnterWidthsY:
25.0,125.0,125.0,25.0
NumberOfSeperationsEachWidthY:
1,1,1,1
NumberOfPiecesSeperatesWidthZ:
1
EnterWidthsZ:
3000.0
NumberOfSeperationsEachWidthZ:
30
CrossSectionTrim_YorN:
XXX
CrossSectionTrimRadiusXYplane:
XXX
CoverTrim_YorN:
XXX
CoverTrimRadiusXYplane:
XXX
```

Auto_Mesh_STIRRUP.TXT

Auto_Mesh_STIRRUP - Notepad

File Edit Format View Help

```
-EnterWithKeywords-
NumberOfStirrupRegions:
2
BeginningHeightToEndHeightEachRegion:
100.0,1000.0
2000.0,2900.0
LowerBoundOfSpacingEachRegion:
100.0
100.0
```

CoorLoad.TXT

```
CoorLoadSE
File   Edit   View

-EnterWithKeywords-
 EnterNewLoadCoordinatesYorN:
Y
 LoadCoordinatesX-Y:
   1000.000000000000,0.00000000000
 LoadDirection:
    2
 LoadValue:
 -0.4000E+06
 EnterNewLoadCoordinatesYorN:
Y
 LoadCoordinatesX-Y:
   2000.000000000000,0.00000000000
 LoadDirection:
    2
 LoadValue:
 -0.4000E+06
 EnterNewLoadCoordinatesYorN:
N
```

SWITCH_A.TXT

```
SWITCH_A - Notepad
File  Edit  Format  View  Help
-EnterWithKeywords-
AutoGenerateSolidMeshYorN:
Y
AutoWrapYorN(RequiresAutoGenerateSolid):
N
ConnectRebarsUsingCoordinatesYorN:
Y
AutoStirrupYorN(RequiresAutoGenerateSolid):
Y
```

SWITCH_B.TXT

```
SWITCH_B - Notepad
File  Edit  Format  View  Help
-EnterWithKeywords-
LoadGenerateUsingCoordinatesYorN:
Y
BoundaryGenerateUsingCoordinatesYorN:
XXX
MPCGenerateUsingCoordinatesYorN:
XXX
DirectEndConditionsYorN:
Y
```

DirectEndConditions.TXT

In order to analyze the system, the finite element solver requires boundary conditions to be defined. Boundary conditions should be able to provide equilibrium to the system. Additional to the conventional boundary conditions, an option to plane restrain the structure was introduced to be able to extend the member beyond supports providing an additional bond length. In this example, a constraint was used too to distribute the load between the nodes. This was done after it was constated that the tip load was causing stress concentration around a node hence convergence issues. The load node was the master coordinate the slave being a plane or line around it.

DirectEndConditions - Notepad

File Edit Format View Help

```
 -EnterWithKeywords-
 FirstEnd_1Fixed_2Pinned:
 XXX
 SecondEnd_0Free_1Fixed_2Sliding_3Roller:
 XXX
 EnterNewPlaneRestraintYorN:
Y
 ApplyPlaneRestraint_NormalAxis_1X_2Y_3Z:
3
 CoordinateOfRestraintPlaneOnSelectedAxis:
0
 PlaneRestraintDirection:
1
 EnterNewPlaneRestraintYorN:
Y
 ApplyPlaneRestraint_NormalAxis_1X_2Y_3Z:
3
 CoordinateOfRestraintPlaneOnSelectedAxis:
0
 PlaneRestraintDirection:
2
 EnterNewPlaneRestraintYorN:
Y
 ApplyPlaneRestraint_NormalAxis_1X_2Y_3Z:
```

DirectEndConditions - Notepad

File Edit Format View Help

```
 ApplyPlaneRestraint_NormalAxis_1X_2Y_3Z:
3
 CoordinateOfRestraintPlaneOnSelectedAxis:
3000
 PlaneRestraintDirection:
2
 EnterNewLineRestraintYorN:
Y
 LineRestraint-X-Y-Z-CoordinatesAtBothEnds:
0.0,150.0,0.0,200.0,150.0,0.0
 LineRestraintDirection:
3
 EnterNewPlaneConstraintYorN:
Y
 ApplyPlaneConstraint_NormalAxis_1X_2Y_3Z:
3
 CoordinateOfConstraintPlaneOnSelectedAxis:
1000.0
 PlaneConstraintDirection:
2
 PlaneConstraintMasterX-Y-Z-Coordinates:
 100.0,300.0,1000.0
 EnterNewPlaneConstraintYorN:
Y
 ApplyPlaneConstraint_NormalAxis_1X_2Y_3Z:
3
 CoordinateOfConstraintPlaneOnSelectedAxis:
2000.0
 PlaneConstraintDirection:
2
 PlaneConstraintMasterX-Y-Z-Coordinates:
 100.0,300.0,2000.0
 EnterNewLineConstraintYorN:
 XXX
 LineConstraint-X-Y-Z-CoordinatesAtBothEnds:
 XXX
 LineConstraintDirection:
 XXX
 LineConstraintMasterX-Y-Z-Coordinates:
 XXX
```

PROPERTY_SOLID.TXT

PROPERTY_SOLID - Notepad

File Edit Format View Help

```
-EnterWithKeywords-
ConcreteElasticityModulus:
32.000E+03
ConcretePoissonRatio:
0.15
ConcreteCompressiveStress:
-46.0
OnsetRatioPlaticFlow:
0.005
CompressivePeakStrain:
-0.0022
ConcreteTensileStress:
2.0
TensionSofteningPower:
0.27
FactorIntersectTensionCompressionSurface:
1.5
PotentialSurfaceType:
1
SlopeLinearPotentialSurface:
0.15
OrderNonlinearPotentialSurface:
XXX
LimitVolumetricStressRatioForLinearKinkPotentialSurface:
XXX
ReductionRatePotentialSurfaceCoefA:
XXX
ReductionRatePotentialSurfaceCoefB:
XXX
SlopeBilinearPotentialSurface:
XXX
ReductionRatePotentialSurfaceCoefB:
XXX
LimitVolumetricStressRatioForLinearKinkPotentialSurface:
XXX
OrderNonlinearPotentialSurface:
XXX
ReductionRatePotentialSurfaceCoefB:
XXX
LimitVolumetricStressRatioForLinearKinkPotentialSurface:
XXX
TensionSurfaceType1Rankine_2Mixed:
XXX
MixedSurfaceCornerControlwith1KsiOr2Ro:
XXX
MixedSurfaceVolumetricStressLimit:
XXX
MixedSurfaceDeviatoricStressLimit:
XXX
TensionCornerVolumetricStressLimit:
XXX
TensionCornerDeviatoricStressLimit:
XXX
MixedSurfaceTetaAtCornerDeviatoricStressLimit:
XXX
CornerReturnTypeAssociative0orNon1:
XXX
DamageEvolutionFactorCompression:
XXX
DamageEvolutionFactorTension:
XXX
AnalysisTypeIsotropic0Anisotropic1:
XXX
SixAnisotropicDamageCoefficients:
XXX
ConfinementCoefficientYdirection:
XXX
ConfinementCoefficientZdirection:
XXX
ProducePlasticReturnGraphAtSpecificPointYorN:
XXX
Teta_select1:
XXX
Teta_select2:
XXX
ksi_select:
XXX
ShowIterationsInStressReturnYorN:
XXX
NumberOfGraphs:
XXX
ProducePlasticReturnGraphAtSpecificTimeYorN:
XXX
GlobalAnalysisStepNo:
XXX
```

coorGEO_BAR.TXT

coorGEO_BAR - Notepad

File Edit Format View Help

```
-EnterWithKeywords-
EnterNewBarCoordinatesYorN:
Y
ConnectionType_0Direct_1Continuous:
1
X-Y-Z-CoordinatesAtBothEnds:
25.0,25.0,0.0,25.0,25.0,3000.0
EnterNewBarCoordinatesYorN:
Y
ConnectionType_0Direct_1Continuous:
1
X-Y-Z-CoordinatesAtBothEnds:
175.0,25.0,0.0,175.0,25.0,3000.0
EnterNewBarCoordinatesYorN:
Y
ConnectionType_0Direct_1Continuous:
1
X-Y-Z-CoordinatesAtBothEnds:
25.0,275.0,0.0,25.0,275.0,3000.0
EnterNewBarCoordinatesYorN:
Y
ConnectionType_0Direct_1Continuous:
1
X-Y-Z-CoordinatesAtBothEnds:
175.0,275.0,0.0,175.0,275.0,3000.0
EnterNewBarCoordinatesYorN:
N
```

SEC_BAR.TXT

SEC_BAR - Notepad

File Edit Format View Help

```
-EnterWithKeywords-
NumberOfBarsWithFollowingSection(Ordered):
60
WidthAndHeight:
17.0,17.0
NumberOfBarsWithFollowingSection(Ordered):
60
WidthAndHeight:
8.90,8.90
NumberOfBarsWithFollowingSection(Ordered):
160
WidthAndHeight:
8.90,8.90
```

PROPERTY_BAR.TXT

PROPERTY_BAR - Notepad

File Edit Format View Help

```
-EnterWithKeywords-
NumberOfBarsWithFollowingProperty(Ordered):
60
BarElasticityModulus:
42.0E+03
BarYieldStressLimit:
689.0
BarHardeningModulus:
1000.0
NumberOfBarsWithFollowingProperty(Ordered):
60
BarElasticityModulus:
42.0E+03
BarYieldStressLimit:
689.0
BarHardeningModulus:
1000.0
NumberOfBarsWithFollowingProperty(Ordered):
160
BarElasticityModulus:
200.0E+03
BarYieldStressLimit:
480.0
BarHardeningModulus:
600.0
GraphPlasticReturnReinforcementYorN:
XXX
NumberOfGraphsBar:
XXX
ElementNoBar:
XXX
IntegrationPointAlong:
XXX
GlobalAnalysisStepNoBar:
XXX
GlobalAnalysisIterationNoBar:
XXX
```

Step_Guide.TXT

Step_Guide

File Edit View

```
-EnterWithKeywords-
NumberOfCycles:
1
ControlType1or2:
1
NumberOfStepsEachCycle:
1000
ControlValuesEachCycle:
XXX
```

Solution_Parameter.TXT

Solution_Parameters - Notepad

File Edit Format View Help

```
 -EnterWithKeywords-
 ElementType:
1
 MeshGeneratedAutomaticallyYorN:
Y
 PrevRunYorNorS:
N
 LoadStepToStructureUpdate:
10
 NumberOfIntegrationPointsSolid:
3
 NumberOfIntegrationPointsReinforcement:
2
 NumberOfIntegrationPointsWrap:
2
 ControlTypeLoad1Displacement2:
2
 ControlNodeCoordinates:
 100.0,300.0,1000.0
 ControlNodeNumber:
 XXX
 ControlDirection:
2
 StepSize:
-0.4
 StepNumberLimit:
140
 HardeningType_1volum_2mixed:
1
 HardeningUpdateLevel_1GlobalStep_2GlobalIteration_3PlasticIteration:
1
```

Solution_Parameters - Notepad

File Edit Format View Help

```
 PlasticReturnType_1CuttingPlane_2CPP:
1
 TangentModulusType_0Elastic_1Plastic:
1
 AlgorithmStabilizationYorN:
N
 DenominatorAmplificationFactor:
 XXX
 PenaltyFactorLagrangian:
 XXX
 WeightinFactorForGeneralizedMidPointIntegration:
 XXX
 PlasticReturnIterationLimit:
1000
 ViscosityRate_0Independent_1ViscoPlastic_2ViscosRegularization:
0
 ViscoPlasticRetardationTime:
 XXX
 ViscoPlasticTimeIncrement:
 XXX
 ViscosRegularizationGlobalAlgorithmIterationLimit:
 XXX
 NumberOfStepsExtractGraphicalOutput:
10
 AmplificationFactorForGraphicalOutput:
100.0
 NumberOfCollectedOutputFiles:
2
 CollectedOutputFileNames:
Lamda.DAC
U_Y.DAC
```

A1.3.2. Input check

INPUT_CHECK - Notepad

File Edit Format View Help

```
ReinCon3D6DOF - Version - 01-03-2024

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

***List of Possible Output files***

to be addressed at the end of Solution_Parameters.txt

---Lamda.DAC---
---DISPLACEMENTS.DAC---
---U_X.DAC---
---U_Y.DAC---
---U_Z.DAC---
---R_X.DAC---
---R_Y.DAC---
---R_Z.DAC---
---Concrete_Strain.DAC---
---Concrete_Stress.DAC---
---Reinforcement_bar_Strain.DAC---
---Reinforcement_bar_Stress.DAC---
---FRP_Wrap_Strain.DAC---
---FRP_Wrap_Stress.DAC---
---Concrete_Damage_compression.DAC---
---Concrete_Damage_tension.DAC---
---Concrete_Plastic_Strain_compression.DAC---
---Concrete_Plastic_Strain_tension.DAC---
---Reinforcement_Bar_Plastic_Strain.DAC---
---Concrete_Stress_Point.DAC---
---Concrete_Strain_Point.DAC---
---Reinforcement_Bar_Stress_Point.DAC---
---Reinforcement_Bar_Strain_Point.DAC---
---Concrete_Damage_point.DAC---
---Concrete_Plastic_Strain_point.DAC---
---Reinforcement_Bar_Plastic_Strain_point.DAC---
           ---PLASTIC_RETURN_LOG_FILE.DAC---
               ---InstantDrawFiles---
              ---SURFACE_AND_RETURN---
            ---StressConvergenceChase---



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

New Mesh for Solid is generated
```

INPUT_CHECK - Notepad

File Edit Format View Help

```
 Mesh-size limit =    7.74193548387097
 ---------------------------------------------

 Mesh-size limit =    3.87096774193548
  Connectivity of Reinforcement beams using Coordinates
                                 Element Connected between Nodes    7                     and    32
                                 Element Connected between Nodes   32                     and    57
                                 Element Connected between Nodes   57                     and    82
                                 Element Connected between Nodes   82                     and   107
                                 Element Connected between Nodes  107                     and   132
                                 Element Connected between Nodes  132                     and   157
                                 Element Connected between Nodes  157                     and   182
                                 Element Connected between Nodes  182                     and   207
                                 Element Connected between Nodes  207                     and   232
                                 Element Connected between Nodes  232                     and   257
                                 Element Connected between Nodes  257                     and   282
                                 Element Connected between Nodes  282                     and   307
                                 Element Connected between Nodes  307                     and   332
                                 Element Connected between Nodes  332                     and   357
                                 Element Connected between Nodes  357                     and   382
                                 Element Connected between Nodes  382                     and   407
                                 Element Connected between Nodes  407                     and   432
                                 Element Connected between Nodes  432                     and   457
                                 Element Connected between Nodes  457                     and   482
                                 Element Connected between Nodes  482                     and   507
                                 Element Connected between Nodes  507                     and   532
                                 Element Connected between Nodes  532                     and   557
                                 Element Connected between Nodes  557                     and   582
                                 Element Connected between Nodes  582                     and   607
                                 Element Connected between Nodes  607                     and   632
                                 Element Connected between Nodes  632                     and   657
                                 Element Connected between Nodes  657                     and   682
                                 Element Connected between Nodes  682                     and   707
                                 Element Connected between Nodes  707                     and   732
                                 Element Connected between Nodes  732                     and   757
                                 Element Connected between Nodes    9                     and    34
                                 Element Connected between Nodes   34                     and    59
                                 Element Connected between Nodes   59                     and    84
                                 Element Connected between Nodes   84                     and   109
                                 Element Connected between Nodes  109                     and   134
                                 Element Connected between Nodes  134                     and   159
                                 Element Connected between Nodes  159                     and   184
                                 Element Connected between Nodes  184                     and   209
                                 Element Connected between Nodes  209                     and   234
                                 Element Connected between Nodes  234                     and   259
                                 Element Connected between Nodes  259                     and   284
                                 Element Connected between Nodes  284                     and   309
                                 Element Connected between Nodes  309                     and   334
                                 Element Connected between Nodes  334                     and   359
                                 Element Connected between Nodes  359                     and   384
                                 Element Connected between Nodes  384                     and   409
                                 Element Connected between Nodes  409                     and   434
                                 Element Connected between Nodes  434                     and   459
                                 Element Connected between Nodes  459                     and   484
```

INPUT_CHECK - Notepad

File Edit Format View Help

```
Element Connected between Nodes 484     and 509
Element Connected between Nodes 509     and 534
Element Connected between Nodes 534     and 559
Element Connected between Nodes 559     and 584
Element Connected between Nodes 584     and 609
Element Connected between Nodes 609     and 634
Element Connected between Nodes 634     and 659
Element Connected between Nodes 659     and 684
Element Connected between Nodes 684     and 709
Element Connected between Nodes 709     and 734
Element Connected between Nodes 734     and 759
Element Connected between Nodes  17     and  42
Element Connected between Nodes  42     and  67
Element Connected between Nodes  67     and  92
Element Connected between Nodes  92     and 117
Element Connected between Nodes 117     and 142
Element Connected between Nodes 142     and 167
Element Connected between Nodes 167     and 192
Element Connected between Nodes 192     and 217
Element Connected between Nodes 217     and 242
Element Connected between Nodes 242     and 267
Element Connected between Nodes 267     and 292
Element Connected between Nodes 292     and 317
Element Connected between Nodes 317     and 342
Element Connected between Nodes 342     and 367
Element Connected between Nodes 367     and 392
Element Connected between Nodes 392     and 417
Element Connected between Nodes 417     and 442
Element Connected between Nodes 442     and 467
Element Connected between Nodes 467     and 492
Element Connected between Nodes 492     and 517
Element Connected between Nodes 517     and 542
Element Connected between Nodes 542     and 567
Element Connected between Nodes 567     and 592
Element Connected between Nodes 592     and 617
Element Connected between Nodes 617     and 642
Element Connected between Nodes 642     and 667
Element Connected between Nodes 667     and 692
Element Connected between Nodes 692     and 717
Element Connected between Nodes 717     and 742
Element Connected between Nodes 742     and 767
Element Connected between Nodes  19     and  44
Element Connected between Nodes  44     and  69
Element Connected between Nodes  69     and  94
Element Connected between Nodes  94     and 119
Element Connected between Nodes 119     and 144
Element Connected between Nodes 144     and 169
Element Connected between Nodes 169     and 194
Element Connected between Nodes 194     and 219
Element Connected between Nodes 219     and 244
Element Connected between Nodes 244     and 269
Element Connected between Nodes 269     and 294
Element Connected between Nodes 294     and 319
Element Connected between Nodes 319     and 344
Element Connected between Nodes 344     and 369
```

INPUT_CHECK - Notepad

File Edit Format View Help

```
                                  Element Connected between Nodes  369                        and   394
                                  Element Connected between Nodes  394                        and   419
                                  Element Connected between Nodes  419                        and   444
                                  Element Connected between Nodes  444                        and   469
                                  Element Connected between Nodes  469                        and   494
                                  Element Connected between Nodes  494                        and   519
                                  Element Connected between Nodes  519                        and   544
                                  Element Connected between Nodes  544                        and   569
                                  Element Connected between Nodes  569                        and   594
                                  Element Connected between Nodes  594                        and   619
                                  Element Connected between Nodes  619                        and   644
                                  Element Connected between Nodes  644                        and   669
                                  Element Connected between Nodes  669                        and   694
                                  Element Connected between Nodes  694                        and   719
                                  Element Connected between Nodes  719                        and   744
                                  Element Connected between Nodes  744                        and   769
  Beam Element Mesh generation for Reinforcement - Completed
 ---------------------------------------------

 Number of Stirrup Regions =          2

 Stirrup No =          1
 From height   100.000000000000      to height   1000.00000000000

 Stirrup No =          1 covers          9 layers

 Stirrup No =          2
 From height   2000.00000000000      to height   2900.00000000000

 Stirrup No =          2 covers          9 layers

 Element Connected between Nodes          32 and          33
 Element Connected between Nodes          33 and          34
 Element Connected between Nodes          34 and          39
 Element Connected between Nodes          39 and          44
 Element Connected between Nodes          44 and          43
 Element Connected between Nodes          43 and          42
 Element Connected between Nodes          42 and          37
 Element Connected between Nodes          37 and          32
 Element Connected between Nodes          57 and          58
 Element Connected between Nodes          58 and          59
 Element Connected between Nodes          59 and          64
 Element Connected between Nodes          64 and          69
 Element Connected between Nodes          69 and          68
 Element Connected between Nodes          68 and          67
 Element Connected between Nodes          67 and          62
 Element Connected between Nodes          62 and          57
 Element Connected between Nodes          82 and          83
 Element Connected between Nodes          83 and          84
 Element Connected between Nodes          84 and          89
 Element Connected between Nodes          89 and          94
 Element Connected between Nodes          94 and          93
 Element Connected between Nodes          93 and          92
 Element Connected between Nodes          92 and          87
 Element Connected between Nodes          87 and          82
```

INPUT_CHECK - Notepad

File Edit Format View Help

```
Element Connected between Nodes          107 and           108
Element Connected between Nodes          108 and           109
Element Connected between Nodes          109 and           114
Element Connected between Nodes          114 and           119
Element Connected between Nodes          119 and           118
Element Connected between Nodes          118 and           117
Element Connected between Nodes          117 and           112
Element Connected between Nodes          112 and           107
Element Connected between Nodes          132 and           133
Element Connected between Nodes          133 and           134
Element Connected between Nodes          134 and           139
Element Connected between Nodes          139 and           144
Element Connected between Nodes          144 and           143
Element Connected between Nodes          143 and           142
Element Connected between Nodes          142 and           137
Element Connected between Nodes          137 and           132
Element Connected between Nodes          157 and           158
Element Connected between Nodes          158 and           159
Element Connected between Nodes          159 and           164
Element Connected between Nodes          164 and           169
Element Connected between Nodes          169 and           168
Element Connected between Nodes          168 and           167
Element Connected between Nodes          167 and           162
Element Connected between Nodes          162 and           157
Element Connected between Nodes          182 and           183
Element Connected between Nodes          183 and           184
Element Connected between Nodes          184 and           189
Element Connected between Nodes          189 and           194
Element Connected between Nodes          194 and           193
Element Connected between Nodes          193 and           192
Element Connected between Nodes          192 and           187
Element Connected between Nodes          187 and           182
Element Connected between Nodes          207 and           208
Element Connected between Nodes          208 and           209
Element Connected between Nodes          209 and           214
Element Connected between Nodes          214 and           219
Element Connected between Nodes          219 and           218
Element Connected between Nodes          218 and           217
Element Connected between Nodes          217 and           212
Element Connected between Nodes          212 and           207
Element Connected between Nodes          232 and           233
Element Connected between Nodes          233 and           234
Element Connected between Nodes          234 and           239
Element Connected between Nodes          239 and           244
Element Connected between Nodes          244 and           243
Element Connected between Nodes          243 and           242
Element Connected between Nodes          242 and           237
Element Connected between Nodes          237 and           232
Element Connected between Nodes          257 and           258
Element Connected between Nodes          258 and           259
Element Connected between Nodes          259 and           264
Element Connected between Nodes          264 and           269
Element Connected between Nodes          269 and           268
Element Connected between Nodes          268 and           267
Element Connected between Nodes          267 and           262
```

INPUT_CHECK - Notepad

File Edit Format View Help

```
Element Connected between Nodes          507 and           508
Element Connected between Nodes          508 and           509
Element Connected between Nodes          509 and           514
Element Connected between Nodes          514 and           519
Element Connected between Nodes          519 and           518
Element Connected between Nodes          518 and           517
Element Connected between Nodes          517 and           512
Element Connected between Nodes          512 and           507
Element Connected between Nodes          532 and           533
Element Connected between Nodes          533 and           534
Element Connected between Nodes          534 and           539
Element Connected between Nodes          539 and           544
Element Connected between Nodes          544 and           543
Element Connected between Nodes          543 and           542
Element Connected between Nodes          542 and           537
Element Connected between Nodes          537 and           532
Element Connected between Nodes          557 and           558
Element Connected between Nodes          558 and           559
Element Connected between Nodes          559 and           564
Element Connected between Nodes          564 and           569
Element Connected between Nodes          569 and           568
Element Connected between Nodes          568 and           567
Element Connected between Nodes          567 and           562
Element Connected between Nodes          562 and           557
Element Connected between Nodes          582 and           583
Element Connected between Nodes          583 and           584
Element Connected between Nodes          584 and           589
Element Connected between Nodes          589 and           594
Element Connected between Nodes          594 and           593
Element Connected between Nodes          593 and           592
Element Connected between Nodes          592 and           587
Element Connected between Nodes          587 and           582
Element Connected between Nodes          607 and           608
Element Connected between Nodes          608 and           609
Element Connected between Nodes          609 and           614
Element Connected between Nodes          614 and           619
Element Connected between Nodes          619 and           618
Element Connected between Nodes          618 and           617
Element Connected between Nodes          617 and           612
Element Connected between Nodes          612 and           607
Element Connected between Nodes          632 and           633
Element Connected between Nodes          633 and           634
Element Connected between Nodes          634 and           639
Element Connected between Nodes          639 and           644
Element Connected between Nodes          644 and           643
Element Connected between Nodes          643 and           642
Element Connected between Nodes          642 and           637
Element Connected between Nodes          637 and           632
Element Connected between Nodes          657 and           658
Element Connected between Nodes          658 and           659
Element Connected between Nodes          659 and           664
Element Connected between Nodes          664 and           669
Element Connected between Nodes          669 and           668
Element Connected between Nodes          668 and           667
Element Connected between Nodes          667 and           662
```

INPUT_CHECK - Notepad

File Edit Format View Help

```
Element Connected between Nodes        662 and        657
Element Connected between Nodes        682 and        683
Element Connected between Nodes        683 and        684
Element Connected between Nodes        684 and        689
Element Connected between Nodes        689 and        694
Element Connected between Nodes        694 and        693
Element Connected between Nodes        693 and        692
Element Connected between Nodes        692 and        687
Element Connected between Nodes        687 and        682
Element Connected between Nodes        707 and        708
Element Connected between Nodes        708 and        709
Element Connected between Nodes        709 and        714
Element Connected between Nodes        714 and        719
Element Connected between Nodes        719 and        718
Element Connected between Nodes        718 and        717
Element Connected between Nodes        717 and        712
Element Connected between Nodes        712 and        707
Element Connected between Nodes        732 and        733
Element Connected between Nodes        733 and        734
Element Connected between Nodes        734 and        739
Element Connected between Nodes        739 and        744
Element Connected between Nodes        744 and        743
Element Connected between Nodes        743 and        742
Element Connected between Nodes        742 and        737
Element Connected between Nodes        737 and        732
Mesh-size limit =    7.74193548387097
  Loads are generated using Coordinates
      Load No    273          in direction    2         applied at    100.00    300.00   1000.00
      Load No    523          in direction    2         applied at    100.00    300.00   2000.00

**************************************************
 ConfinedLoadGenerateUsingCoordinatesYorN:
   Y: CoorConfinedLoad.TXT --> CONFINED_NODAL_LOADS.TXT
**************************************************

  Confined Loads are generated using Coordinates
 ---------------------------------------------

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

 Boundary Conditions are Directly imposed to Nodes
 ---------------------------------------------

 Multiple-Point Constraints are imposed directly to nodes
 ---------------------------------------------

ApplyPlaneRestraint_NormalAxis_1X_2Y_3Z           3
CoordinateOfRestraintPlaneOnSelectedAxis   0.000000000000000E+000
PlaneRestraintDirection            1
ApplyPlaneRestraint_NormalAxis_1X_2Y_3Z           3
CoordinateOfRestraintPlaneOnSelectedAxis   0.000000000000000E+000
PlaneRestraintDirection            2
ApplyPlaneRestraint_NormalAxis_1X_2Y_3Z           3
CoordinateOfRestraintPlaneOnSelectedAxis    3000.00000000000
PlaneRestraintDirection            1
```

INPUT_CHECK - Notepad

File Edit Format View Help

```
ApplyPlaneRestraint_NormalAxis_1X_2Y_3Z            3
CoordinateOfRestraintPlaneOnSelectedAxis    3000.00000000000
PlaneRestraintDirection            2

LineRestraint-X-Y-Z-CoordinatesAtBothEnds
 0.000000000000000E+000   150.000000000000       0.000000000000000E+000
  200.000000000000        150.000000000000       0.000000000000000E+000
LineRestraintDirection            3

ApplyPlaneConstraint_NormalAxis_1X_2Y_3Z            3
CoordinateOfConstraintPlaneOnSelectedAxis    1000.00000000000
PlaneConstraintDirection            2
PlaneConstraintMasterX-Y-Z-Coordinates
  100.000000000000        300.000000000000        1000.00000000000
ApplyPlaneConstraint_NormalAxis_1X_2Y_3Z            3
CoordinateOfConstraintPlaneOnSelectedAxis    2000.00000000000
PlaneConstraintDirection            2
PlaneConstraintMasterX-Y-Z-Coordinates
  100.000000000000        300.000000000000        2000.00000000000


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


Number of Nodes                  =         775
------------------------------------------------
Number of Solid elements         =         480

Number of Shell elements         =           0

Number of Bar elements          =         280
-------------------------------------------------
COORDINATES OF NODES
        NOD      X(mm)            Y(mm)            Z(mm)
         1       0.0000000        0.0000000        0.0000000
         2      25.0000000        0.0000000        0.0000000
         3     100.0000000        0.0000000        0.0000000
         4     175.0000000        0.0000000        0.0000000
         5     200.0000000        0.0000000        0.0000000
         6       0.0000000       25.0000000        0.0000000
         7      25.0000000       25.0000000        0.0000000
         8     100.0000000       25.0000000        0.0000000
         9     175.0000000       25.0000000        0.0000000
        10     200.0000000       25.0000000        0.0000000
        11       0.0000000      150.0000000        0.0000000
        12      25.0000000      150.0000000        0.0000000
        13     100.0000000      150.0000000        0.0000000
        14     175.0000000      150.0000000        0.0000000
        15     200.0000000      150.0000000        0.0000000
        16       0.0000000      275.0000000        0.0000000
        17      25.0000000      275.0000000        0.0000000
        18     100.0000000      275.0000000        0.0000000
        19     175.0000000      275.0000000        0.0000000
        20     200.0000000      275.0000000        0.0000000
        21       0.0000000      300.0000000        0.0000000
```

INPUT_CHECK - Notepad

File Edit Format View Help

```
22    25.0000000   300.0000000     0.0000000
23   100.0000000   300.0000000     0.0000000
24   175.0000000   300.0000000     0.0000000
25   200.0000000   300.0000000     0.0000000
26     0.0000000     0.0000000   100.0000000
27    25.0000000     0.0000000   100.0000000
28   100.0000000     0.0000000   100.0000000
29   175.0000000     0.0000000   100.0000000
30   200.0000000     0.0000000   100.0000000
31     0.0000000    25.0000000   100.0000000
32    25.0000000    25.0000000   100.0000000
33   100.0000000    25.0000000   100.0000000
34   175.0000000    25.0000000   100.0000000
35   200.0000000    25.0000000   100.0000000
36     0.0000000   150.0000000   100.0000000
37    25.0000000   150.0000000   100.0000000
38   100.0000000   150.0000000   100.0000000
39   175.0000000   150.0000000   100.0000000
40   200.0000000   150.0000000   100.0000000
41     0.0000000   275.0000000   100.0000000
42    25.0000000   275.0000000   100.0000000
43   100.0000000   275.0000000   100.0000000
44   175.0000000   275.0000000   100.0000000
45   200.0000000   275.0000000   100.0000000
46     0.0000000   300.0000000   100.0000000
47    25.0000000   300.0000000   100.0000000
48   100.0000000   300.0000000   100.0000000
49   175.0000000   300.0000000   100.0000000
50   200.0000000   300.0000000   100.0000000
51     0.0000000     0.0000000   200.0000000
52    25.0000000     0.0000000   200.0000000
53   100.0000000     0.0000000   200.0000000
54   175.0000000     0.0000000   200.0000000
55   200.0000000     0.0000000   200.0000000
56     0.0000000    25.0000000   200.0000000
57    25.0000000    25.0000000   200.0000000
58   100.0000000    25.0000000   200.0000000
59   175.0000000    25.0000000   200.0000000
60   200.0000000    25.0000000   200.0000000
61     0.0000000   150.0000000   200.0000000
62    25.0000000   150.0000000   200.0000000
63   100.0000000   150.0000000   200.0000000
64   175.0000000   150.0000000   200.0000000
65   200.0000000   150.0000000   200.0000000
66     0.0000000   275.0000000   200.0000000
67    25.0000000   275.0000000   200.0000000
68   100.0000000   275.0000000   200.0000000
69   175.0000000   275.0000000   200.0000000
70   200.0000000   275.0000000   200.0000000
71     0.0000000   300.0000000   200.0000000
72    25.0000000   300.0000000   200.0000000
73   100.0000000   300.0000000   200.0000000
74   175.0000000   300.0000000   200.0000000
75   200.0000000   300.0000000   200.0000000
76     0.0000000     0.0000000   300.0000000
```

INPUT_CHECK - Notepad

File Edit Format View Help

77	25.0000000	0.0000000	300.0000000
78	100.0000000	0.0000000	300.0000000
79	175.0000000	0.0000000	300.0000000
80	200.0000000	0.0000000	300.0000000
81	0.0000000	25.0000000	300.0000000
82	25.0000000	25.0000000	300.0000000
83	100.0000000	25.0000000	300.0000000
84	175.0000000	25.0000000	300.0000000
85	200.0000000	25.0000000	300.0000000
86	0.0000000	150.0000000	300.0000000
87	25.0000000	150.0000000	300.0000000
88	100.0000000	150.0000000	300.0000000
89	175.0000000	150.0000000	300.0000000
90	200.0000000	150.0000000	300.0000000
91	0.0000000	275.0000000	300.0000000
92	25.0000000	275.0000000	300.0000000
93	100.0000000	275.0000000	300.0000000
94	175.0000000	275.0000000	300.0000000
95	200.0000000	275.0000000	300.0000000
96	0.0000000	300.0000000	300.0000000
97	25.0000000	300.0000000	300.0000000
98	100.0000000	300.0000000	300.0000000
99	175.0000000	300.0000000	300.0000000
100	200.0000000	300.0000000	300.0000000
101	0.0000000	0.0000000	400.0000000
102	25.0000000	0.0000000	400.0000000
103	100.0000000	0.0000000	400.0000000
104	175.0000000	0.0000000	400.0000000
105	200.0000000	0.0000000	400.0000000
106	0.0000000	25.0000000	400.0000000
107	25.0000000	25.0000000	400.0000000
108	100.0000000	25.0000000	400.0000000
109	175.0000000	25.0000000	400.0000000
110	200.0000000	25.0000000	400.0000000
111	0.0000000	150.0000000	400.0000000
112	25.0000000	150.0000000	400.0000000
113	100.0000000	150.0000000	400.0000000
114	175.0000000	150.0000000	400.0000000
115	200.0000000	150.0000000	400.0000000
116	0.0000000	275.0000000	400.0000000
117	25.0000000	275.0000000	400.0000000
118	100.0000000	275.0000000	400.0000000
119	175.0000000	275.0000000	400.0000000
120	200.0000000	275.0000000	400.0000000
121	0.0000000	300.0000000	400.0000000
122	25.0000000	300.0000000	400.0000000
123	100.0000000	300.0000000	400.0000000
124	175.0000000	300.0000000	400.0000000
125	200.0000000	300.0000000	400.0000000
126	0.0000000	0.0000000	500.0000000
127	25.0000000	0.0000000	500.0000000
128	100.0000000	0.0000000	500.0000000
129	175.0000000	0.0000000	500.0000000
130	200.0000000	0.0000000	500.0000000
131	0.0000000	25.0000000	500.0000000

INPUT_CHECK - Notepad

File Edit Format View Help

132	25.0000000	25.0000000	500.0000000
133	100.0000000	25.0000000	500.0000000
134	175.0000000	25.0000000	500.0000000
135	200.0000000	25.0000000	500.0000000
136	0.0000000	150.0000000	500.0000000
137	25.0000000	150.0000000	500.0000000
138	100.0000000	150.0000000	500.0000000
139	175.0000000	150.0000000	500.0000000
140	200.0000000	150.0000000	500.0000000
141	0.0000000	275.0000000	500.0000000
142	25.0000000	275.0000000	500.0000000
143	100.0000000	275.0000000	500.0000000
144	175.0000000	275.0000000	500.0000000
145	200.0000000	275.0000000	500.0000000
146	0.0000000	300.0000000	500.0000000
147	25.0000000	300.0000000	500.0000000
148	100.0000000	300.0000000	500.0000000
149	175.0000000	300.0000000	500.0000000
150	200.0000000	300.0000000	500.0000000
151	0.0000000	0.0000000	600.0000000
152	25.0000000	0.0000000	600.0000000
153	100.0000000	0.0000000	600.0000000
154	175.0000000	0.0000000	600.0000000
155	200.0000000	0.0000000	600.0000000
156	0.0000000	25.0000000	600.0000000
157	25.0000000	25.0000000	600.0000000
158	100.0000000	25.0000000	600.0000000
159	175.0000000	25.0000000	600.0000000
160	200.0000000	25.0000000	600.0000000
161	0.0000000	150.0000000	600.0000000
162	25.0000000	150.0000000	600.0000000
163	100.0000000	150.0000000	600.0000000
164	175.0000000	150.0000000	600.0000000
165	200.0000000	150.0000000	600.0000000
166	0.0000000	275.0000000	600.0000000
167	25.0000000	275.0000000	600.0000000
168	100.0000000	275.0000000	600.0000000
169	175.0000000	275.0000000	600.0000000
170	200.0000000	275.0000000	600.0000000
171	0.0000000	300.0000000	600.0000000
172	25.0000000	300.0000000	600.0000000
173	100.0000000	300.0000000	600.0000000
174	175.0000000	300.0000000	600.0000000
175	200.0000000	300.0000000	600.0000000
176	0.0000000	0.0000000	700.0000000
177	25.0000000	0.0000000	700.0000000
178	100.0000000	0.0000000	700.0000000
179	175.0000000	0.0000000	700.0000000
180	200.0000000	0.0000000	700.0000000
181	0.0000000	25.0000000	700.0000000
182	25.0000000	25.0000000	700.0000000
183	100.0000000	25.0000000	700.0000000
184	175.0000000	25.0000000	700.0000000
185	200.0000000	25.0000000	700.0000000
186	0.0000000	150.0000000	700.0000000

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File Edit Format View Help

187	25.0000000	150.0000000	700.0000000
188	100.0000000	150.0000000	700.0000000
189	175.0000000	150.0000000	700.0000000
190	200.0000000	150.0000000	700.0000000
191	0.0000000	275.0000000	700.0000000
192	25.0000000	275.0000000	700.0000000
193	100.0000000	275.0000000	700.0000000
194	175.0000000	275.0000000	700.0000000
195	200.0000000	275.0000000	700.0000000
196	0.0000000	300.0000000	700.0000000
197	25.0000000	300.0000000	700.0000000
198	100.0000000	300.0000000	700.0000000
199	175.0000000	300.0000000	700.0000000
200	200.0000000	300.0000000	700.0000000
201	0.0000000	0.0000000	800.0000000
202	25.0000000	0.0000000	800.0000000
203	100.0000000	0.0000000	800.0000000
204	175.0000000	0.0000000	800.0000000
205	200.0000000	0.0000000	800.0000000
206	0.0000000	25.0000000	800.0000000
207	25.0000000	25.0000000	800.0000000
208	100.0000000	25.0000000	800.0000000
209	175.0000000	25.0000000	800.0000000
210	200.0000000	25.0000000	800.0000000
211	0.0000000	150.0000000	800.0000000
212	25.0000000	150.0000000	800.0000000
213	100.0000000	150.0000000	800.0000000
214	175.0000000	150.0000000	800.0000000
215	200.0000000	150.0000000	800.0000000
216	0.0000000	275.0000000	800.0000000
217	25.0000000	275.0000000	800.0000000
218	100.0000000	275.0000000	800.0000000
219	175.0000000	275.0000000	800.0000000
220	200.0000000	275.0000000	800.0000000
221	0.0000000	300.0000000	800.0000000
222	25.0000000	300.0000000	800.0000000
223	100.0000000	300.0000000	800.0000000
224	175.0000000	300.0000000	800.0000000
225	200.0000000	300.0000000	800.0000000
226	0.0000000	0.0000000	900.0000000
227	25.0000000	0.0000000	900.0000000
228	100.0000000	0.0000000	900.0000000
229	175.0000000	0.0000000	900.0000000
230	200.0000000	0.0000000	900.0000000
231	0.0000000	25.0000000	900.0000000
232	25.0000000	25.0000000	900.0000000
233	100.0000000	25.0000000	900.0000000
234	175.0000000	25.0000000	900.0000000
235	200.0000000	25.0000000	900.0000000
236	0.0000000	150.0000000	900.0000000
237	25.0000000	150.0000000	900.0000000
238	100.0000000	150.0000000	900.0000000
239	175.0000000	150.0000000	900.0000000
240	200.0000000	150.0000000	900.0000000
241	0.0000000	275.0000000	900.0000000

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File Edit Format View Help

242	25.0000000	275.0000000	900.0000000
243	100.0000000	275.0000000	900.0000000
244	175.0000000	275.0000000	900.0000000
245	200.0000000	275.0000000	900.0000000
246	0.0000000	300.0000000	900.0000000
247	25.0000000	300.0000000	900.0000000
248	100.0000000	300.0000000	900.0000000
249	175.0000000	300.0000000	900.0000000
250	200.0000000	300.0000000	900.0000000
251	0.0000000	0.0000000	1000.0000000
252	25.0000000	0.0000000	1000.0000000
253	100.0000000	0.0000000	1000.0000000
254	175.0000000	0.0000000	1000.0000000
255	200.0000000	0.0000000	1000.0000000
256	0.0000000	25.0000000	1000.0000000
257	25.0000000	25.0000000	1000.0000000
258	100.0000000	25.0000000	1000.0000000
259	175.0000000	25.0000000	1000.0000000
260	200.0000000	25.0000000	1000.0000000
261	0.0000000	150.0000000	1000.0000000
262	25.0000000	150.0000000	1000.0000000
263	100.0000000	150.0000000	1000.0000000
264	175.0000000	150.0000000	1000.0000000
265	200.0000000	150.0000000	1000.0000000
266	0.0000000	275.0000000	1000.0000000
267	25.0000000	275.0000000	1000.0000000
268	100.0000000	275.0000000	1000.0000000
269	175.0000000	275.0000000	1000.0000000
270	200.0000000	275.0000000	1000.0000000
271	0.0000000	300.0000000	1000.0000000
272	25.0000000	300.0000000	1000.0000000
273	100.0000000	300.0000000	1000.0000000
274	175.0000000	300.0000000	1000.0000000
275	200.0000000	300.0000000	1000.0000000
276	0.0000000	0.0000000	1100.0000000
277	25.0000000	0.0000000	1100.0000000
278	100.0000000	0.0000000	1100.0000000
279	175.0000000	0.0000000	1100.0000000
280	200.0000000	0.0000000	1100.0000000
281	0.0000000	25.0000000	1100.0000000
282	25.0000000	25.0000000	1100.0000000
283	100.0000000	25.0000000	1100.0000000
284	175.0000000	25.0000000	1100.0000000
285	200.0000000	25.0000000	1100.0000000
286	0.0000000	150.0000000	1100.0000000
287	25.0000000	150.0000000	1100.0000000
288	100.0000000	150.0000000	1100.0000000
289	175.0000000	150.0000000	1100.0000000
290	200.0000000	150.0000000	1100.0000000
291	0.0000000	275.0000000	1100.0000000
292	25.0000000	275.0000000	1100.0000000
293	100.0000000	275.0000000	1100.0000000
294	175.0000000	275.0000000	1100.0000000
295	200.0000000	275.0000000	1100.0000000
296	0.0000000	300.0000000	1100.0000000

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File Edit Format View Help

297	25.0000000	300.0000000	1100.0000000
298	100.0000000	300.0000000	1100.0000000
299	175.0000000	300.0000000	1100.0000000
300	200.0000000	300.0000000	1100.0000000
301	0.0000000	0.0000000	1200.0000000
302	25.0000000	0.0000000	1200.0000000
303	100.0000000	0.0000000	1200.0000000
304	175.0000000	0.0000000	1200.0000000
305	200.0000000	0.0000000	1200.0000000
306	0.0000000	25.0000000	1200.0000000
307	25.0000000	25.0000000	1200.0000000
308	100.0000000	25.0000000	1200.0000000
309	175.0000000	25.0000000	1200.0000000
310	200.0000000	25.0000000	1200.0000000
311	0.0000000	150.0000000	1200.0000000
312	25.0000000	150.0000000	1200.0000000
313	100.0000000	150.0000000	1200.0000000
314	175.0000000	150.0000000	1200.0000000
315	200.0000000	150.0000000	1200.0000000
316	0.0000000	275.0000000	1200.0000000
317	25.0000000	275.0000000	1200.0000000
318	100.0000000	275.0000000	1200.0000000
319	175.0000000	275.0000000	1200.0000000
320	200.0000000	275.0000000	1200.0000000
321	0.0000000	300.0000000	1200.0000000
322	25.0000000	300.0000000	1200.0000000
323	100.0000000	300.0000000	1200.0000000
324	175.0000000	300.0000000	1200.0000000
325	200.0000000	300.0000000	1200.0000000
326	0.0000000	0.0000000	1300.0000000
327	25.0000000	0.0000000	1300.0000000
328	100.0000000	0.0000000	1300.0000000
329	175.0000000	0.0000000	1300.0000000
330	200.0000000	0.0000000	1300.0000000
331	0.0000000	25.0000000	1300.0000000
332	25.0000000	25.0000000	1300.0000000
333	100.0000000	25.0000000	1300.0000000
334	175.0000000	25.0000000	1300.0000000
335	200.0000000	25.0000000	1300.0000000
336	0.0000000	150.0000000	1300.0000000
337	25.0000000	150.0000000	1300.0000000
338	100.0000000	150.0000000	1300.0000000
339	175.0000000	150.0000000	1300.0000000
340	200.0000000	150.0000000	1300.0000000
341	0.0000000	275.0000000	1300.0000000
342	25.0000000	275.0000000	1300.0000000
343	100.0000000	275.0000000	1300.0000000
344	175.0000000	275.0000000	1300.0000000
345	200.0000000	275.0000000	1300.0000000
346	0.0000000	300.0000000	1300.0000000
347	25.0000000	300.0000000	1300.0000000
348	100.0000000	300.0000000	1300.0000000
349	175.0000000	300.0000000	1300.0000000
350	200.0000000	300.0000000	1300.0000000
351	0.0000000	0.0000000	1400.0000000

INPUT_CHECK - Notepad

File Edit Format View Help

352	25.0000000	0.0000000	1400.0000000
353	100.0000000	0.0000000	1400.0000000
354	175.0000000	0.0000000	1400.0000000
355	200.0000000	0.0000000	1400.0000000
356	0.0000000	25.0000000	1400.0000000
357	25.0000000	25.0000000	1400.0000000
358	100.0000000	25.0000000	1400.0000000
359	175.0000000	25.0000000	1400.0000000
360	200.0000000	25.0000000	1400.0000000
361	0.0000000	150.0000000	1400.0000000
362	25.0000000	150.0000000	1400.0000000
363	100.0000000	150.0000000	1400.0000000
364	175.0000000	150.0000000	1400.0000000
365	200.0000000	150.0000000	1400.0000000
366	0.0000000	275.0000000	1400.0000000
367	25.0000000	275.0000000	1400.0000000
368	100.0000000	275.0000000	1400.0000000
369	175.0000000	275.0000000	1400.0000000
370	200.0000000	275.0000000	1400.0000000
371	0.0000000	300.0000000	1400.0000000
372	25.0000000	300.0000000	1400.0000000
373	100.0000000	300.0000000	1400.0000000
374	175.0000000	300.0000000	1400.0000000
375	200.0000000	300.0000000	1400.0000000
376	0.0000000	0.0000000	1500.0000000
377	25.0000000	0.0000000	1500.0000000
378	100.0000000	0.0000000	1500.0000000
379	175.0000000	0.0000000	1500.0000000
380	200.0000000	0.0000000	1500.0000000
381	0.0000000	25.0000000	1500.0000000
382	25.0000000	25.0000000	1500.0000000
383	100.0000000	25.0000000	1500.0000000
384	175.0000000	25.0000000	1500.0000000
385	200.0000000	25.0000000	1500.0000000
386	0.0000000	150.0000000	1500.0000000
387	25.0000000	150.0000000	1500.0000000
388	100.0000000	150.0000000	1500.0000000
389	175.0000000	150.0000000	1500.0000000
390	200.0000000	150.0000000	1500.0000000
391	0.0000000	275.0000000	1500.0000000
392	25.0000000	275.0000000	1500.0000000
393	100.0000000	275.0000000	1500.0000000
394	175.0000000	275.0000000	1500.0000000
395	200.0000000	275.0000000	1500.0000000
396	0.0000000	300.0000000	1500.0000000
397	25.0000000	300.0000000	1500.0000000
398	100.0000000	300.0000000	1500.0000000
399	175.0000000	300.0000000	1500.0000000
400	200.0000000	300.0000000	1500.0000000
401	0.0000000	0.0000000	1600.0000000
402	25.0000000	0.0000000	1600.0000000
403	100.0000000	0.0000000	1600.0000000
404	175.0000000	0.0000000	1600.0000000
405	200.0000000	0.0000000	1600.0000000
406	0.0000000	25.0000000	1600.0000000

INPUT_CHECK - Notepad

File Edit Format View Help

407	25.0000000	25.0000000	1600.0000000
408	100.0000000	25.0000000	1600.0000000
409	175.0000000	25.0000000	1600.0000000
410	200.0000000	25.0000000	1600.0000000
411	0.0000000	150.0000000	1600.0000000
412	25.0000000	150.0000000	1600.0000000
413	100.0000000	150.0000000	1600.0000000
414	175.0000000	150.0000000	1600.0000000
415	200.0000000	150.0000000	1600.0000000
416	0.0000000	275.0000000	1600.0000000
417	25.0000000	275.0000000	1600.0000000
418	100.0000000	275.0000000	1600.0000000
419	175.0000000	275.0000000	1600.0000000
420	200.0000000	275.0000000	1600.0000000
421	0.0000000	300.0000000	1600.0000000
422	25.0000000	300.0000000	1600.0000000
423	100.0000000	300.0000000	1600.0000000
424	175.0000000	300.0000000	1600.0000000
425	200.0000000	300.0000000	1600.0000000
426	0.0000000	0.0000000	1700.0000000
427	25.0000000	0.0000000	1700.0000000
428	100.0000000	0.0000000	1700.0000000
429	175.0000000	0.0000000	1700.0000000
430	200.0000000	0.0000000	1700.0000000
431	0.0000000	25.0000000	1700.0000000
432	25.0000000	25.0000000	1700.0000000
433	100.0000000	25.0000000	1700.0000000
434	175.0000000	25.0000000	1700.0000000
435	200.0000000	25.0000000	1700.0000000
436	0.0000000	150.0000000	1700.0000000
437	25.0000000	150.0000000	1700.0000000
438	100.0000000	150.0000000	1700.0000000
439	175.0000000	150.0000000	1700.0000000
440	200.0000000	150.0000000	1700.0000000
441	0.0000000	275.0000000	1700.0000000
442	25.0000000	275.0000000	1700.0000000
443	100.0000000	275.0000000	1700.0000000
444	175.0000000	275.0000000	1700.0000000
445	200.0000000	275.0000000	1700.0000000
446	0.0000000	300.0000000	1700.0000000
447	25.0000000	300.0000000	1700.0000000
448	100.0000000	300.0000000	1700.0000000
449	175.0000000	300.0000000	1700.0000000
450	200.0000000	300.0000000	1700.0000000
451	0.0000000	0.0000000	1800.0000000
452	25.0000000	0.0000000	1800.0000000
453	100.0000000	0.0000000	1800.0000000
454	175.0000000	0.0000000	1800.0000000
455	200.0000000	0.0000000	1800.0000000
456	0.0000000	25.0000000	1800.0000000
457	25.0000000	25.0000000	1800.0000000
458	100.0000000	25.0000000	1800.0000000
459	175.0000000	25.0000000	1800.0000000
460	200.0000000	25.0000000	1800.0000000
461	0.0000000	150.0000000	1800.0000000

INPUT_CHECK - Notepad

File Edit Format View Help

721	0.0000000	300.0000000	2800.0000000
722	25.0000000	300.0000000	2800.0000000
723	100.0000000	300.0000000	2800.0000000
724	175.0000000	300.0000000	2800.0000000
725	200.0000000	300.0000000	2800.0000000
726	0.0000000	0.0000000	2900.0000000
727	25.0000000	0.0000000	2900.0000000
728	100.0000000	0.0000000	2900.0000000
729	175.0000000	0.0000000	2900.0000000
730	200.0000000	0.0000000	2900.0000000
731	0.0000000	25.0000000	2900.0000000
732	25.0000000	25.0000000	2900.0000000
733	100.0000000	25.0000000	2900.0000000
734	175.0000000	25.0000000	2900.0000000
735	200.0000000	25.0000000	2900.0000000
736	0.0000000	150.0000000	2900.0000000
737	25.0000000	150.0000000	2900.0000000
738	100.0000000	150.0000000	2900.0000000
739	175.0000000	150.0000000	2900.0000000
740	200.0000000	150.0000000	2900.0000000
741	0.0000000	275.0000000	2900.0000000
742	25.0000000	275.0000000	2900.0000000
743	100.0000000	275.0000000	2900.0000000
744	175.0000000	275.0000000	2900.0000000
745	200.0000000	275.0000000	2900.0000000
746	0.0000000	300.0000000	2900.0000000
747	25.0000000	300.0000000	2900.0000000
748	100.0000000	300.0000000	2900.0000000
749	175.0000000	300.0000000	2900.0000000
750	200.0000000	300.0000000	2900.0000000
751	0.0000000	0.0000000	3000.0000000
752	25.0000000	0.0000000	3000.0000000
753	100.0000000	0.0000000	3000.0000000
754	175.0000000	0.0000000	3000.0000000
755	200.0000000	0.0000000	3000.0000000
756	0.0000000	25.0000000	3000.0000000
757	25.0000000	25.0000000	3000.0000000
758	100.0000000	25.0000000	3000.0000000
759	175.0000000	25.0000000	3000.0000000
760	200.0000000	25.0000000	3000.0000000
761	0.0000000	150.0000000	3000.0000000
762	25.0000000	150.0000000	3000.0000000
763	100.0000000	150.0000000	3000.0000000
764	175.0000000	150.0000000	3000.0000000
765	200.0000000	150.0000000	3000.0000000
766	0.0000000	275.0000000	3000.0000000
767	25.0000000	275.0000000	3000.0000000
768	100.0000000	275.0000000	3000.0000000
769	175.0000000	275.0000000	3000.0000000
770	200.0000000	275.0000000	3000.0000000
771	0.0000000	300.0000000	3000.0000000
772	25.0000000	300.0000000	3000.0000000
773	100.0000000	300.0000000	3000.0000000
774	175.0000000	300.0000000	3000.0000000
775	200.0000000	300.0000000	3000.0000000

INPUT_CHECK - Notepad

File Edit Format View Help

SOLID TYPE ELEMENT

ELEMENT	I_END	J_END	K_END	L_END	M_END	N_END	O_END	P_END
1	1	2	7	6	26	27	32	31
2	2	3	8	7	27	28	33	32
3	3	4	9	8	28	29	34	33
4	4	5	10	9	29	30	35	34
5	6	7	12	11	31	32	37	36
6	7	8	13	12	32	33	38	37
7	8	9	14	13	33	34	39	38
8	9	10	15	14	34	35	40	39
9	11	12	17	16	36	37	42	41
10	12	13	18	17	37	38	43	42
11	13	14	19	18	38	39	44	43
12	14	15	20	19	39	40	45	44
13	16	17	22	21	41	42	47	46
14	17	18	23	22	42	43	48	47
15	18	19	24	23	43	44	49	48
16	19	20	25	24	44	45	50	49
17	26	27	32	31	51	52	57	56
18	27	28	33	32	52	53	58	57
19	28	29	34	33	53	54	59	58
20	29	30	35	34	54	55	60	59
21	31	32	37	36	56	57	62	61
22	32	33	38	37	57	58	63	62
23	33	34	39	38	58	59	64	63
24	34	35	40	39	59	60	65	64
25	36	37	42	41	61	62	67	66
26	37	38	43	42	62	63	68	67
27	38	39	44	43	63	64	69	68
28	39	40	45	44	64	65	70	69
29	41	42	47	46	66	67	72	71
30	42	43	48	47	67	68	73	72
31	43	44	49	48	68	69	74	73
32	44	45	50	49	69	70	75	74
33	51	52	57	56	76	77	82	81
34	52	53	58	57	77	78	83	82
35	53	54	59	58	78	79	84	83
36	54	55	60	59	79	80	85	84
37	56	57	62	61	81	82	87	86
38	57	58	63	62	82	83	88	87
39	58	59	64	63	83	84	89	88
40	59	60	65	64	84	85	90	89
41	61	62	67	66	86	87	92	91
42	62	63	68	67	87	88	93	92
43	63	64	69	68	88	89	94	93
44	64	65	70	69	89	90	95	94
45	66	67	72	71	91	92	97	96
46	67	68	73	72	92	93	98	97
47	68	69	74	73	93	94	99	98
48	69	70	75	74	94	95	100	99
49	76	77	82	81	101	102	107	106
50	77	78	83	82	102	103	108	107
51	78	79	84	83	103	104	109	108
52	79	80	85	84	104	105	110	109

INPUT_CHECK - Notepad

File Edit Format View Help

53	81	82	87	86	106	107	112	111
54	82	83	88	87	107	108	113	112
55	83	84	89	88	108	109	114	113
56	84	85	90	89	109	110	115	114
57	86	87	92	91	111	112	117	116
58	87	88	93	92	112	113	118	117
59	88	89	94	93	113	114	119	118
60	89	90	95	94	114	115	120	119
61	91	92	97	96	116	117	122	121
62	92	93	98	97	117	118	123	122
63	93	94	99	98	118	119	124	123
64	94	95	100	99	119	120	125	124
65	101	102	107	106	126	127	132	131
66	102	103	108	107	127	128	133	132
67	103	104	109	108	128	129	134	133
68	104	105	110	109	129	130	135	134
69	106	107	112	111	131	132	137	136
70	107	108	113	112	132	133	138	137
71	108	109	114	113	133	134	139	138
72	109	110	115	114	134	135	140	139
73	111	112	117	116	136	137	142	141
74	112	113	118	117	137	138	143	142
75	113	114	119	118	138	139	144	143
76	114	115	120	119	139	140	145	144
77	116	117	122	121	141	142	147	146
78	117	118	123	122	142	143	148	147
79	118	119	124	123	143	144	149	148
80	119	120	125	124	144	145	150	149
81	126	127	132	131	151	152	157	156
82	127	128	133	132	152	153	158	157
83	128	129	134	133	153	154	159	158
84	129	130	135	134	154	155	160	159
85	131	132	137	136	156	157	162	161
86	132	133	138	137	157	158	163	162
87	133	134	139	138	158	159	164	163
88	134	135	140	139	159	160	165	164
89	136	137	142	141	161	162	167	166
90	137	138	143	142	162	163	168	167
91	138	139	144	143	163	164	169	168
92	139	140	145	144	164	165	170	169
93	141	142	147	146	166	167	172	171
94	142	143	148	147	167	168	173	172
95	143	144	149	148	168	169	174	173
96	144	145	150	149	169	170	175	174
97	151	152	157	156	176	177	182	181
98	152	153	158	157	177	178	183	182
99	153	154	159	158	178	179	184	183
100	154	155	160	159	179	180	185	184
101	156	157	162	161	181	182	187	186
102	157	158	163	162	182	183	188	187
103	158	159	164	163	183	184	189	188
104	159	160	165	164	184	185	190	189
105	161	162	167	166	186	187	192	191
106	162	163	168	167	187	188	193	192
107	163	164	169	168	188	189	194	193

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File Edit Format View Help

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File Edit Format View Help

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File Edit Format View Help

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File Edit Format View Help

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INPUT_CHECK - Notepad

File Edit Format View Help

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INPUT_CHECK - Notepad

File Edit Format View Help

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463	718	719	724	723	743	744	749	748
464	719	720	725	724	744	745	750	749
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468	729	730	735	734	754	755	760	759
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471	733	734	739	738	758	759	764	763
472	734	735	740	739	759	760	765	764
473	736	737	742	741	761	762	767	766
474	737	738	743	742	762	763	768	767
475	738	739	744	743	763	764	769	768
476	739	740	745	744	764	765	770	769
477	741	742	747	746	766	767	772	771
478	742	743	748	747	767	768	773	772
479	743	744	749	748	768	769	774	773
480	744	745	750	749	769	770	775	774

SHELL TYPE ELEMENT

ELEMENT	I END	J END	K END	L END

BEAM TYPE ELEMENT

ELEMENT	I END	J END	LENGTH (mm)
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2	32	57	100.00000000
3	57	82	100.00000000

INPUT_CHECK - Notepad

File Edit Format View Help

3	57	82	100.00000000
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5	107	132	100.00000000
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7	157	182	100.00000000
8	182	207	100.00000000
9	207	232	100.00000000
10	232	257	100.00000000
11	257	282	100.00000000
12	282	307	100.00000000
13	307	332	100.00000000
14	332	357	100.00000000
15	357	382	100.00000000
16	382	407	100.00000000
17	407	432	100.00000000
18	432	457	100.00000000
19	457	482	100.00000000
20	482	507	100.00000000
21	507	532	100.00000000
22	532	557	100.00000000
23	557	582	100.00000000
24	582	607	100.00000000
25	607	632	100.00000000
26	632	657	100.00000000
27	657	682	100.00000000
28	682	707	100.00000000
29	707	732	100.00000000
30	732	757	100.00000000
31	9	34	100.00000000
32	34	59	100.00000000
33	59	84	100.00000000
34	84	109	100.00000000
35	109	134	100.00000000
36	134	159	100.00000000
37	159	184	100.00000000
38	184	209	100.00000000
39	209	234	100.00000000
40	234	259	100.00000000
41	259	284	100.00000000
42	284	309	100.00000000
43	309	334	100.00000000
44	334	359	100.00000000
45	359	384	100.00000000
46	384	409	100.00000000
47	409	434	100.00000000
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54	584	609	100.00000000
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56	634	659	100.00000000
57	659	684	100.00000000

INPUT_CHECK - Notepad

File Edit Format View Help

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62	42	67	100.00000000
63	67	92	100.00000000
64	92	117	100.00000000
65	117	142	100.00000000
66	142	167	100.00000000
67	167	192	100.00000000
68	192	217	100.00000000
69	217	242	100.00000000
70	242	267	100.00000000
71	267	292	100.00000000
72	292	317	100.00000000
73	317	342	100.00000000
74	342	367	100.00000000
75	367	392	100.00000000
76	392	417	100.00000000
77	417	442	100.00000000
78	442	467	100.00000000
79	467	492	100.00000000
80	492	517	100.00000000
81	517	542	100.00000000
82	542	567	100.00000000
83	567	592	100.00000000
84	592	617	100.00000000
85	617	642	100.00000000
86	642	667	100.00000000
87	667	692	100.00000000
88	692	717	100.00000000
89	717	742	100.00000000
90	742	767	100.00000000
91	19	44	100.00000000
92	44	69	100.00000000
93	69	94	100.00000000
94	94	119	100.00000000
95	119	144	100.00000000
96	144	169	100.00000000
97	169	194	100.00000000
98	194	219	100.00000000
99	219	244	100.00000000
100	244	269	100.00000000
101	269	294	100.00000000
102	294	319	100.00000000
103	319	344	100.00000000
104	344	369	100.00000000
105	369	394	100.00000000
106	394	419	100.00000000
107	419	444	100.00000000
108	444	469	100.00000000
109	469	494	100.00000000
110	494	519	100.00000000
111	519	544	100.00000000
112	544	569	100.00000000

INPUT_CHECK - Notepad

File Edit Format View Help

113	569	594	100.00000000
114	594	619	100.00000000
115	619	644	100.00000000
116	644	669	100.00000000
117	669	694	100.00000000
118	694	719	100.00000000
119	719	744	100.00000000
120	744	769	100.00000000
121	32	33	75.00000000
122	33	34	75.00000000
123	34	39	125.00000000
124	39	44	125.00000000
125	44	43	75.00000000
126	43	42	75.00000000
127	42	37	125.00000000
128	37	32	125.00000000
129	57	58	75.00000000
130	58	59	75.00000000
131	59	64	125.00000000
132	64	69	125.00000000
133	69	68	75.00000000
134	68	67	75.00000000
135	67	62	125.00000000
136	62	57	125.00000000
137	82	83	75.00000000
138	83	84	75.00000000
139	84	89	125.00000000
140	89	94	125.00000000
141	94	93	75.00000000
142	93	92	75.00000000
143	92	87	125.00000000
144	87	82	125.00000000
145	107	108	75.00000000
146	108	109	75.00000000
147	109	114	125.00000000
148	114	119	125.00000000
149	119	118	75.00000000
150	118	117	75.00000000
151	117	112	125.00000000
152	112	107	125.00000000
153	132	133	75.00000000
154	133	134	75.00000000
155	134	139	125.00000000
156	139	144	125.00000000
157	144	143	75.00000000
158	143	142	75.00000000
159	142	137	125.00000000
160	137	132	125.00000000
161	157	158	75.00000000
162	158	159	75.00000000
163	159	164	125.00000000
164	164	169	125.00000000
165	169	168	75.00000000
166	168	167	75.00000000
167	167	162	125.00000000

INPUT_CHECK - Notepad

File Edit Format View Help

168	162	157	125.00000000
169	182	183	75.00000000
170	183	184	75.00000000
171	184	189	125.00000000
172	189	194	125.00000000
173	194	193	75.00000000
174	193	192	75.00000000
175	192	187	125.00000000
176	187	182	125.00000000
177	207	208	75.00000000
178	208	209	75.00000000
179	209	214	125.00000000
180	214	219	125.00000000
181	219	218	75.00000000
182	218	217	75.00000000
183	217	212	125.00000000
184	212	207	125.00000000
185	232	233	75.00000000
186	233	234	75.00000000
187	234	239	125.00000000
188	239	244	125.00000000
189	244	243	75.00000000
190	243	242	75.00000000
191	242	237	125.00000000
192	237	232	125.00000000
193	257	258	75.00000000
194	258	259	75.00000000
195	259	264	125.00000000
196	264	269	125.00000000
197	269	268	75.00000000
198	268	267	75.00000000
199	267	262	125.00000000
200	262	257	125.00000000
201	507	508	75.00000000
202	508	509	75.00000000
203	509	514	125.00000000
204	514	519	125.00000000
205	519	518	75.00000000
206	518	517	75.00000000
207	517	512	125.00000000
208	512	507	125.00000000
209	532	533	75.00000000
210	533	534	75.00000000
211	534	539	125.00000000
212	539	544	125.00000000
213	544	543	75.00000000
214	543	542	75.00000000
215	542	537	125.00000000
216	537	532	125.00000000
217	557	558	75.00000000
218	558	559	75.00000000
219	559	564	125.00000000
220	564	569	125.00000000
221	569	568	75.00000000
222	568	567	75.00000000

INPUT_CHECK - Notepad

File Edit Format View Help

223	567	562	125.00000000
224	562	557	125.00000000
225	582	583	75.00000000
226	583	584	75.00000000
227	584	589	125.00000000
228	589	594	125.00000000
229	594	593	75.00000000
230	593	592	75.00000000
231	592	587	125.00000000
232	587	582	125.00000000
233	607	608	75.00000000
234	608	609	75.00000000
235	609	614	125.00000000
236	614	619	125.00000000
237	619	618	75.00000000
238	618	617	75.00000000
239	617	612	125.00000000
240	612	607	125.00000000
241	632	633	75.00000000
242	633	634	75.00000000
243	634	639	125.00000000
244	639	644	125.00000000
245	644	643	75.00000000
246	643	642	75.00000000
247	642	637	125.00000000
248	637	632	125.00000000
249	657	658	75.00000000
250	658	659	75.00000000
251	659	664	125.00000000
252	664	669	125.00000000
253	669	668	75.00000000
254	668	667	75.00000000
255	667	662	125.00000000
256	662	657	125.00000000
257	682	683	75.00000000
258	683	684	75.00000000
259	684	689	125.00000000
260	689	694	125.00000000
261	694	693	75.00000000
262	693	692	75.00000000
263	692	687	125.00000000
264	687	682	125.00000000
265	707	708	75.00000000
266	708	709	75.00000000
267	709	714	125.00000000
268	714	719	125.00000000
269	719	718	75.00000000
270	718	717	75.00000000
271	717	712	125.00000000
272	712	707	125.00000000
273	732	733	75.00000000
274	733	734	75.00000000
275	734	739	125.00000000
276	739	744	125.00000000
277	744	743	75.00000000

INPUT_CHECK - Notepad

File Edit Format View Help

```
    278          743          742     75.00000000
    279          742          737    125.00000000
    280          737          732    125.00000000

 ----------------------------------------------------------
  BOUNDARY CONDITIONS
     FIXED NODE     FIXED DIRECTION
          1               X DIRECTON
          2               X DIRECTON
          3               X DIRECTON
          4               X DIRECTON
          5               X DIRECTON
          6               X DIRECTON
          7               X DIRECTON
          8               X DIRECTON
          9               X DIRECTON
         10               X DIRECTON
         11               X DIRECTON
         12               X DIRECTON
         13               X DIRECTON
         14               X DIRECTON
         15               X DIRECTON
         16               X DIRECTON
         17               X DIRECTON
         18               X DIRECTON
         19               X DIRECTON
         20               X DIRECTON
         21               X DIRECTON
         22               X DIRECTON
         23               X DIRECTON
         24               X DIRECTON
         25               X DIRECTON
          1               Y DIRECTON
          2               Y DIRECTON
          3               Y DIRECTON
          4               Y DIRECTON
          5               Y DIRECTON
          6               Y DIRECTON
          7               Y DIRECTON
          8               Y DIRECTON
          9               Y DIRECTON
         10               Y DIRECTON
         11               Y DIRECTON
         12               Y DIRECTON
         13               Y DIRECTON
         14               Y DIRECTON
         15               Y DIRECTON
         16               Y DIRECTON
         17               Y DIRECTON
         18               Y DIRECTON
         19               Y DIRECTON
         20               Y DIRECTON
         21               Y DIRECTON
         22               Y DIRECTON
         23               Y DIRECTON
```

INPUT_CHECK - Notepad

File Edit Format View Help

```
         24               Y DIRECTON
         25               Y DIRECTON
        751               X DIRECTON
        752               X DIRECTON
        753               X DIRECTON
        754               X DIRECTON
        755               X DIRECTON
        756               X DIRECTON
        757               X DIRECTON
        758               X DIRECTON
        759               X DIRECTON
        760               X DIRECTON
        761               X DIRECTON
        762               X DIRECTON
        763               X DIRECTON
        764               X DIRECTON
        765               X DIRECTON
        766               X DIRECTON
        767               X DIRECTON
        768               X DIRECTON
        769               X DIRECTON
        770               X DIRECTON
        771               X DIRECTON
        772               X DIRECTON
        773               X DIRECTON
        774               X DIRECTON
        775               X DIRECTON
        751               Y DIRECTON
        752               Y DIRECTON
        753               Y DIRECTON
        754               Y DIRECTON
        755               Y DIRECTON
        756               Y DIRECTON
        757               Y DIRECTON
        758               Y DIRECTON
        759               Y DIRECTON
        760               Y DIRECTON
        761               Y DIRECTON
        762               Y DIRECTON
        763               Y DIRECTON
        764               Y DIRECTON
        765               Y DIRECTON
        766               Y DIRECTON
        767               Y DIRECTON
        768               Y DIRECTON
        769               Y DIRECTON
        770               Y DIRECTON
        771               Y DIRECTON
        772               Y DIRECTON
        773               Y DIRECTON
        774               Y DIRECTON
        775               Y DIRECTON
         11               Z DIRECTON
         12               Z DIRECTON
         13               Z DIRECTON
```

INPUT_CHECK - Notepad

File Edit Format View Help

```
         14              Z DIRECTON
         15              Z DIRECTON


 NODAL LOADS
NODE   LOADING TYPE          DIRECTION           P     M
                                                 N     Nmm
273    CONCENTRATED P           GLOBAL Y -.4000E+06
523    CONCENTRATED P           GLOBAL Y -.4000E+06


CurrentCompressionPlasticityParameter   0.000000000000000E+000
CurrentTensionPlasticityParameter   0.000000000000000E+000
CurrentCompressionDamageParameter   0.000000000000000E+000
CurrentTensionDamageParameter   0.000000000000000E+000

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

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

Number of Integration Points for Solid           3

Number of Integration Points for Reinforcement           2

Number of Integration Points for FRP Wrap           2

Analysis Control type: Enter 1 for Load Control or Enter 2 for Displacement Con
trol           2

The control node number          273

Direction: 1 for X | 2 for Y | 3 for Z | 4 for XRot  | 5 for YRot | 6 for XRot
Control direction =           2 selected

Enter the step increment size -0.400000000000000

How many steps do you want to continue          140

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

Plastic return type: 1 for Cutting plane | 2 for Closest Point Projection
          1

Tangent Modulus: Enter 0 for Elastic    Enter 1 for Elasto-plastic
          1

Iteration limit for plasticity algorithm incase it does not converge
       1000

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

 0 For rate-independent | 1 For visco-plastic | 2 For viscous regularization
          0

-----------------------------------------------------------------------
```

INPUT_CHECK - Notepad

File Edit Format View Help

```
Enter number of steps for every graphical output         10

Enter amplification factor for graphical output   100.000000000000


  The results are produced only for           2 files


  The results are produced for Lamda.DAC

  The results are produced for U_Y.DAC
Enter GlobalAlgorithm_ErrorMargin  9.9999999747524270E-007

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


Enter PlasticityAlgorithm_ErrorMargin  9.9999997473787520E-005


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

Number of cycles           1
C_type=           1
Number of steps in each cycles        1000
-----------------------------------------------------------------------
ASR Volumetric strain =  0.000000000000000E+000
Contribution of ASR strain on the effective stress =  0.000000000000000E+000
Correlation of tension damage to compression damage  0.000000000000000E+000
-----------------------------------------------------------------------

New Run is performed
-----------------------------------------------------------------------



MPC CONSTRAINTS
   MASTER NOD    CONNECTED DOF    SLAVE NOD
        273            2            251
        273            2            252
        273            2            253
        273            2            254
        273            2            255
        273            2            256
        273            2            257
        273            2            258
        273            2            259
        273            2            260
        273            2            261
        273            2            262
        273            2            263
        273            2            264
        273            2            265
        273            2            266
        273            2            267
        273            2            268
        273            2            269
        273            2            270
        273            2            271
```

INPUT_CHECK - Notepad

File Edit Format View Help

```
        273            2            255
        273            2            256
        273            2            257
        273            2            258
        273            2            259
        273            2            260
        273            2            261
        273            2            262
        273            2            263
        273            2            264
        273            2            265
        273            2            266
        273            2            267
        273            2            268
        273            2            269
        273            2            270
        273            2            271
        273            2            272
        273            2            274
        273            2            275
        523            2            501
        523            2            502
        523            2            503
        523            2            504
        523            2            505
        523            2            506
        523            2            507
        523            2            508
        523            2            509
        523            2            510
        523            2            511
        523            2            512
        523            2            513
        523            2            514
        523            2            515
        523            2            516
        523            2            517
        523            2            518
        523            2            519
        523            2            520
        523            2            521
        523            2            522
        523            2            524
        523            2            525
-----------------------------------------


-----------------------------------------
No further ASR loading
A_WEIGHT  0.000000000000000E+000
-----------------------------------------




No Smoothing
```

A1.3.3. Output files

U_Y

U_Y - Notepad

File Edit Format View Help

```
-0.400000000000000
-0.800000000000000
-1.20000000000000
-1.60000000000000
-2.00000000000000
-2.40000000000000
-2.80000000000000
-3.20000000000000
-3.60000000000000
-4.00000000000000
-4.40000000000000
-4.80000000000000
-5.20000000000000
-5.60000000000000
-6.00000000000000
-6.40000000000000
-6.80000000000000
-7.20000000000000
-7.60000000000000
-8.00000000000000
-8.40000000000000
-8.80000000000000
-9.20000000000000
-9.60000000000000
-10.0000000000000
-10.4000000000000
-10.8000000000000
-11.2000000000000
-11.6000000000000
-12.0000000000000
-12.4000000000000
-12.8000000000000
-13.2000000000000
-13.6000000000000
-14.0000000000000
-14.4000000000000
-14.8000000000000
-15.2000000000000
-15.6000000000000
-16.0000000000000
-16.4000000000000
-16.8000000000000
-17.2000000000000
```

U_Y - Notepad

File Edit Format View Help

```
-17.6000000000000
-18.0000000000000
-18.4000000000000
-18.8000000000000
-19.2000000000000
-19.6000000000000
-20.0000000000000
-20.4000000000000
-20.8000000000000
-21.2000000000000
-21.6000000000000
-22.0000000000000
-22.4000000000000
-22.8000000000000
-23.2000000000000
-23.6000000000000
-24.0000000000000
-24.4000000000000
-24.8000000000000
-25.2000000000000
-25.6000000000000
-26.0000000000000
-26.4000000000000
-26.8000000000000
-27.2000000000000
-27.6000000000000
-28.0000000000000
-28.4000000000000
-28.8000000000000
-29.2000000000000
-29.6000000000000
-30.0000000000000
-30.4000000000000
-30.8000000000000
-31.2000000000000
-31.6000000000000
-32.0000000000000
-32.3999999999999
-32.7999999999999
-33.1999999999999
-33.5999999999999
-33.9999999999999
-34.3999999999999
```

Lamda

Lamda - Notepad

File Edit Format View Help

```
1.744498814446482E-002
2.692103819204879E-002
3.251127129821774E-002
3.659991751691873E-002
3.950245430382231E-002
4.196302121652758E-002
4.433960616369986E-002
4.666172938179439E-002
4.893456010316080E-002
5.115284760170831E-002
5.334357580522630E-002
5.548551010975797E-002
5.726102655929892E-002
5.891716701402835E-002
6.055237486985624E-002
6.217201423718734E-002
6.377711843443569E-002
6.537481370358063E-002
6.695730825954122E-002
6.853918463781056E-002
7.008478993078962E-002
7.162136866864716E-002
7.314732167664331E-002
7.469164161523466E-002
7.621336008615585E-002
7.773022635938807E-002
7.921336616666119E-002
8.072925706049619E-002
8.220229779419128E-002
8.367970072731845E-002
8.517723067393550E-002
8.666481728827077E-002
8.814326938487130E-002
8.959728574623819E-002
9.107252333594330E-002
9.253324126940481E-002
9.399957493542889E-002
9.544462944729035E-002
9.689540265581779E-002
9.836983339253071E-002
9.980217088730557E-002
0.101264935333923
0.102698065397792
```

Lamda - Notepad

File Edit Format View Help

```
0.107044739355935
0.108447783048950
0.109913876022766
0.111313974100190
0.112770912396734
0.114181409830162
0.115619724618058
0.117008591146658
0.118473873722783
0.119852281889457
0.121311786768985
0.122675840256735
0.124131501102614
0.125510120270440
0.126940069855015
0.128310276779950
0.129746720553124
0.131122575112253
0.132545054689177
0.133920781027581
0.135342853124630
0.136707802752236
0.138128366989171
0.139476257784828
0.140908866010611
0.142240402226569
0.143675605376452
0.144991010141916
0.146421127279070
0.147746781479762
0.149165845275052
0.150487090465904
0.151904232681837
0.153213821924986
0.154631657821385
0.155960006286652
0.157353600332789
0.158683241380335
0.160068397509881
0.161388730216399
0.162778731722319
0.164107144155913
0.165478552913535
```