FLOOR STIFFENER CRACKING IN LARGE MINING TRUCK DUMP BODIES

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by

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Abstract

Due to the soft nature of the underfoot conditions in an oil sand mine, mobile equipment tends to develop greater amounts of maintenance problems than similar equipment in other types of mines. This is an investigation into cracking of haul truck dump bodies in oil sand mining service using the Finite Element Method (FEM). This work identifies the damage mechanism and source causing this persistent problem, which occurs at the intersection of the widthwise and lengthwise box-style floor stiffeners. In particular, compressive, membrane stresses are setup at these intersections resulting from overall bending of the floor plate from the weight of the ore. Superimposed onto these membrane stresses are localized bending stresses caused by very slight deflections, or twist, within the frame. Depending on the magnitude of twist, these localized bending stresses can overcome the compressive membrane stress producing sufficient tension to propagate a crack in this as-welded, non-heat-treated connection.

Acknowledgements

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Lastly, I would like to thank my family for raising me to believe that there are no limits to what can be accomplished, and for supporting me in my endeavors. In particular, I would like to thank my uncle, Ken Whalen. Ken, without your years of support, advice, and encouragement, I might not be where I am today. Thank you.

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Table of Contents

List of Figures

Chapter: 1 Introduction

Syncrude Canada Ltd. (SCL) is the world's largest producer of crude oil from oil sands, and the largest single-source producer in Canada. Its crude oil production facility operates on the immense reserves of the Athabasca oil sand deposit north of Fort McMurray, Alberta, converting bitumen, an asphalt like oil that is as thick as molasses in its natural state, into a marketable crude oil. Oil sand is mined in an open pit using large shovels and heavy hauler trucks. The extraction of bitumen from oil sand involves mixing the ore with hot water and caustic soda, conditioning it for separation as it travels through a hydro-transport pipeline. Once inside the separation vessel, bitumen floats to the surface while the sand settles away. In the upgrading plant, bitumen is converted into a light crude oil by fluid coking, hydroprocessing, hydrotreating and blending. The final product (Syncrude Sweet Blend) is transported by pipeline to Edmonton area refineries and to pipeline terminals, which in turn ship it to other refineries in Canada and the United States.

Syncrude uses some of the largest mining trucks available in the world, known as heavy haulers, for its mining operations in both the Mildred Lake and the Aurora mines. These include such trucks as the Komatsu 930E (Figure 1-1) with a payload rating of 320 tons, and the largest truck in the world, the Caterpillar 797 (380 tons). They move overburden material to storage areas, move ore to the crushers where the process starts, move tailings sand, and even move material back into the mine to reclaim depleted areas. To put it into perspective, it takes two tons of oil sand to produce one barrel of oil. As well, an equal amount of overburden must be removed to expose that ore. At present, Syncrude produces over 250,000 barrels of crude oil daily, which means that over 1 Million tons of material are moved each day.

Figure 1-1: Komatsu 930E Heavy Hauler Mining Truck

To move such vast amounts of material daily, SCL employs a fleet of almost 80 heavy haulers, all of which were acquired through two local dealerships. The business of developing and selling mining trucks, however, is fiercely competitive. Due to this competitiveness, information beyond standard specifications and promotional material is rarely shared by each of the vendors. When specific information is shared, it is usually used to troubleshoot maintenance activities and is safeguarded from being disclosed to other vendors. The result is an environment of limited communication in which information does not flow freely. Although it hinders research activities, it is an accepted and essential part of the haul truck business; one that researchers and engineers must learn to work with.

SCL is not in the business of designing better haul trucks; however, to improve the reliability, productivity and safety of the haul truck fleet, it is necessary to understand the mine-specific operating conditions. This thesis should help to develop a more detailed understanding of the nature and magnitude of the forces subjected to a typical haul truck body in Syncrude mining operations. This work should provide information useful with respect to maintenance issues with the existing fleet, and help reduce operational costs. The increased understanding may also guide decisions to purchase future equipment, and may generate better designs for oil sand applications.

The equipment modeled in this study is a Syncrude owned Komatsu 930E heavy hauler mining truck. It is currently the second largest type of mining truck used at the site, and has a payload rating of 320 tons (290 metric tonnes). The truck is equipped with what is referred to as a standard dump body. Strictly speaking, however, the body is not a standard 930E body. Significant modifications have been made to adapt the structure for oil sand mining operations, including the addition of abrasion resistant cladding on the floor and sidewalls, and measures for strengthening the floor structure. Considering the fact that this work is an evaluation of a floor-stiffener cracking problem, it should be recognized that the modifications to the floor structure were quite extensive. All of the stiffening structure from the hinge pivot to the rear was replaced with materials of twice the original thickness, and one-inch thick plates have been added to both sides of the two main rails. Although floor-stiffener cracking is most prevalent in this body, the problem is observed to lesser degrees in all haul truck bodies on the SCL mine sites. In other words, this thesis should not be considered as a design evaluation of standard 930E dump bodies. Rather, it is an investigation into a persistent problem observed in all types of dump bodies in oil sand service.

Chapter: 2 Basic Concepts

Before we get into the details, it would be helpful to introduce some of the basic concepts and techniques of the finite element method. The finite element method, also known as Finite Element Analysis (FEA), is a numerical method for solving problems in engineering and physics. For many real-world problems, it is impossible to obtain an analytical solution. Analytical solutions generally require the solution of differential equations and auxiliary conditions, which can become cumbersome or even impossible depending on the complexity of the geometry, material properties and boundary conditions for the problem at hand. As a result, engineers and scientists often resort to numerical methods such as the finite element method to obtain acceptable solutions. Some of the areas where FEA is frequently applied include structural analysis, heat transfer, mass transfer, and electromagnetism.

Finite element formulations recast the differential equations normally required to solve real world problems with a series of simultaneous algebraic equations. The underlying concept of FEA is to divide the complex geometry into a system of interconnected bodies, such that a solution for each is approximated. This process of dividing a problem into discrete finite elements is called discretization. Rather than attempting to solve the entire problem in one cumbersome operation, algebraic equations for each element are formulated and then combined to obtain the solution of the entire system[1].

2.1 Finite Element Theory

2.1.1 Basic Principle of Finite Element Analysis (FEA)

To illustrate the basic principle of FEA, we consider the spring displacement system of Figure 2-1. The system consists of three paddles connected together with an arrangement of springs. Each of the three paddles has a single degree of freedom (DOF), which is translation along the horizontal plane, and has an external force applied. The paddles represent nodes in a FEA, while the springs represent the elements interconnecting them. The symbols at the base of the paddles represent the boundary conditions applied to this system. The triangular shaped symbols represent a fixed displacement condition, while the circle shaped symbols represent rollers that imply these paddles are free to move in the horizontal direction only.

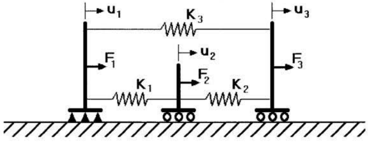


Figure 2-1: Spring Displacement System

The objective is to establish a relationship between displacements and forces.

$$\begin{Bmatrix} u_1 \\ u_2 \\ u_3 \end{Bmatrix} \& \begin{Bmatrix} F_1 \\ F_2 \\ F_3 \end{Bmatrix} \tag{2-1}$$

2.1.1.1 Element Stiffness Matrices

The first step in the finite element method is to discretize the problem and to formulate the element stiffness equations. Figure 2-2 represents the behavior of a generic spring element. The governing equation for a spring is $f = kd$. That is, the force in a spring is proportional to the difference in the end displacements, and the constant of proportionality is referred to as the spring stiffness, k.

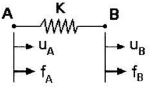


Figure 2-2: Generic Spring Behavior

For this particular element, the relationship between the nodal displacements (u_i) and the nodal forces (f_i) can be expressed as:

$$\begin{bmatrix} K & -K \\ -K & K \end{bmatrix} \begin{Bmatrix} u_A \\ u_B \end{Bmatrix} = \begin{Bmatrix} f_A \\ f_B \end{Bmatrix} \quad \textbf{(2-2)}$$

Similarly, each of the spring elements for the system in Figure 2-1 can be described in terms of the nodal displacements and the element forces, the internal forces within each spring element.

Element #1
$$K_1 \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \begin{Bmatrix} u_1 \\ u_2 \end{Bmatrix} = \begin{Bmatrix} f_1 \\ f_2 \end{Bmatrix} \quad \textbf{(2-3)}$$

Element #2
$$K_2 \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \begin{Bmatrix} u_2 \\ u_3 \end{Bmatrix} = \begin{Bmatrix} f_2 \\ f_3 \end{Bmatrix} \quad \textbf{(2-4)}$$

$$\text{Element \#3} \quad K_3\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}\begin{Bmatrix} u_1 \\ u_3 \end{Bmatrix} = \begin{Bmatrix} f_1 \\ f_3 \end{Bmatrix} \tag{2-5}$$

2.1.1.2 Assembly of Element Equations into Global Stiffness Matrix

The objective, however, is to represent the relationship between the nodal displacements and the nodal forces, or the forces applied externally to the nodes of the finite element model. To do this, the element stiffness matrices above must be assembled into one global stiffness matrix formulation. By representing the above element stiffness formulations with all the nodal degrees-of-freedom (DOF) present, it is possible to directly superimpose them forming the global stiffness matrix.

$$K_1\begin{bmatrix} 1 & -1 & 0 \\ -1 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}\begin{Bmatrix} u_1 \\ u_2 \\ u_3 \end{Bmatrix} + K_2\begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & -1 \\ 0 & -1 & 1 \end{bmatrix}\begin{Bmatrix} u_1 \\ u_2 \\ u_3 \end{Bmatrix} + K_3\begin{bmatrix} 1 & 0 & -1 \\ 0 & 0 & 0 \\ -1 & 0 & 1 \end{bmatrix}\begin{Bmatrix} u_1 \\ u_2 \\ u_3 \end{Bmatrix} = \begin{Bmatrix} F_1 \\ F_2 \\ F_3 \end{Bmatrix} \tag{2-6}$$

$$\begin{bmatrix} K_1 + K_3 & -K_1 & -K_3 \\ -K_1 & K_1 + K_2 & -K_2 \\ -K_3 & -K_2 & K_2 + K_3 \end{bmatrix}\begin{Bmatrix} u_1 \\ u_2 \\ u_3 \end{Bmatrix} = \begin{Bmatrix} F_1 \\ F_2 \\ F_3 \end{Bmatrix} \tag{2-7}$$

2.1.1.3 Boundary Conditions and Solution

The boundary conditions associated with displacement based finite element formulations consist of known displacements and forces (or pressures, etc.) at each node. In order to solve a FEA problem, an externally applied displacement or force must be known for each DOF of each node in the system. Either a displacement or force is specified, or the externally applied force is known to be zero. In the system described in Figure 2-1, the first paddle is fixed. As a result, this nodal displacement is known ($u_1=0$). Considering this, it is possible to reduce the system by eliminating the row and column of the stiffness matrix associated with this DOF as follows:

$$\begin{bmatrix} K_1 + K_3 & -K_1 & -K_3 \\ -K_1 & K_1 + K_2 & -K_2 \\ -K_3 & -K_2 & K_2 + K_3 \end{bmatrix} \begin{Bmatrix} u_1 \\ u_2 \\ u_3 \end{Bmatrix} = \begin{Bmatrix} F_1 \\ F_2 + K_1 * u_1 \\ F_3 + K_3 * u_1 \end{Bmatrix} \quad \textbf{(2-8)}$$

$$\begin{bmatrix} K_1 + K_2 & -K_2 \\ -K_2 & K_2 + K_3 \end{bmatrix} \begin{Bmatrix} u_2 \\ u_3 \end{Bmatrix} = \begin{Bmatrix} F_2 + K_1 * u_1 \\ F_3 + K_3 * u_1 \end{Bmatrix} \quad \textbf{(2-9)}$$

With the known displacements accounted for, we are left with the global stiffness matrix relating the nodal displacements to the forces applied at the nodes. Therefore, it is possible to determine the unknown displacements by re-arranging and solving the system of equations as follows:

$$\begin{Bmatrix} u_2 \\ u_3 \end{Bmatrix} = \begin{bmatrix} K_1 + K_2 & -K_2 \\ -K_2 & K_2 + K_3 \end{bmatrix}^{-1} \begin{Bmatrix} F_2 + K_1 * u_1 \\ F_3 + K_3 * u_1 \end{Bmatrix} \quad \textbf{(2-10)}$$

2.1.2 Formulation of a 2D Bar Element Stiffness Matrix

A spring element is perhaps the simplest form of a finite element, which was well suited for describing the overall solution methodology used in FEA. As stated earlier, however FEA is used to solve problems in many different technical disciplines. The first step in any such analysis is to develop the element matrix equations, called stiffness matrices in the structural analysis realm. The following procedure will illustrate the concepts used in structural FEA to develop element stiffness matrices using the case of a one-dimensional bar element, suitable for modeling pin connected truss networks[2].

2.1.2.1 Definition of the Element Type

Figure 2-3 is a schematic representation of a simple pin connected structural element subjected to the tensile force, **T**. The pin connections are represented in FEA by nodes, labeled **1** and **2**. Nodal displacements, u_1 and u_2, represent positive axial displacements at the pinholes, while f_1 and f_2 represent positive axial forces acting on the bar element at the pinholes.

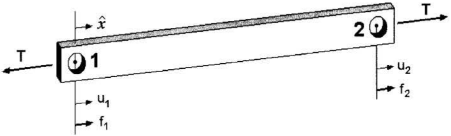


Figure 2-3: One-dimensional Bar Element

The following assumptions have been made in deriving the bar element stiffness matrix[3]:

1. The bar cannot sustain a shear force.
2. Any effect of transverse displacement is ignored.
3. Hooke's law applies; that is, axial stress σ_x is related to the axial strain ε_x by $\sigma_x = E\varepsilon_x$.

2.1.2.2 Selection of the Displacement Function

To begin, we must choose a displacement function with the total number of coefficients equal to the number of degrees of freedom associated with the element.

$$u = a_1 + a_2\hat{x} \tag{2-11}$$

Expressed in matrix form, this equation becomes:

$$u = \begin{bmatrix} 1 & \hat{x} \end{bmatrix} \begin{Bmatrix} a_1 \\ a_2 \end{Bmatrix} \tag{2-12}$$

To express this function in terms of nodal displacements, u_1 and u_2, we evaluate u at each node solving for a_1 and a_2 as follows:

$$u(0) = u_1 = a_1 \tag{2-13}$$

$$u(L) = u_2 = u_1 + a_2 L \tag{2-14}$$

$$a_2 = \frac{u_2 - u_1}{L} \tag{2-15}$$

which gives:

$$u = u_1 + \left(\frac{u_2 - u_1}{L}\right)\hat{x} \tag{2-16}$$

Expressed in matrix form, u becomes,

$$u = \begin{bmatrix} 1 - \dfrac{\hat{x}}{L} & \dfrac{\hat{x}}{L} \end{bmatrix} \begin{Bmatrix} u_1 \\ u_2 \end{Bmatrix} \quad \text{or} \quad u = \begin{bmatrix} N_1 & N_2 \end{bmatrix} \begin{Bmatrix} u_1 \\ u_2 \end{Bmatrix} \tag{2-17}$$

where N_1 and N_2 are called shape functions:

$$N_1 = 1 - \frac{\hat{x}}{L} \tag{2-18a}$$

$$N_2 = \frac{\hat{x}}{L} \tag{2-18b}$$

2.1.2.3 Strain - Displacement and Stress - Strain Relationships

The strain - displacement relationship for this one-dimensional problem is,

$$\varepsilon_x = \frac{du}{d\hat{x}} = \frac{u_2 - u_1}{L} \tag{2-19}$$

and the stress - strain relationship for this uniaxial state of stress is,

$$\sigma_x = E\varepsilon_x \tag{2-20}$$

where E is the modulus of elasticity for the bar material, and σ_x is the axial stress.

2.1.2.4 Element Stiffness Matrix

From mechanics, we know that the tension, T, in the bar is,

$$T = A\sigma_x \tag{2-21}$$

where A is the cross-sectional area of the bar. Using the strain-displacement and stress-strain relationships, the expression becomes

$$T = AE\left(\frac{u_2 - u_1}{L}\right) \tag{2-22}$$

Using the nodal sign convention,

$$f_1 = -T \qquad \text{or} \qquad f_1 = \frac{AE}{L}(u_1 - u_2) \tag{2-23}$$

Similarly,

$$f_2 = T \qquad \text{or} \qquad f_2 = \frac{AE}{L}(u_2 - u_1) \tag{2-24}$$

When expressed together, in matrix form, these equations become,

$$\begin{Bmatrix} f_1 \\ f_2 \end{Bmatrix} = \frac{AE}{L}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}\begin{Bmatrix} u_1 \\ u_2 \end{Bmatrix} \quad \textbf{(2-25)}$$

For a one-dimensional bar element, the stiffness matrix is:

$$\underline{k} = \frac{AE}{L}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \quad \textbf{(2-26)}$$

2.1.2.5 Transformation into Global Coordinate System

The one-dimensional bar element, as derived above, is not well suited for solving engineering problems in its present form. To solve pin-connected truss networks, it would be helpful to have nodal forces and displacements defined in a bi-axial (planar) coordinate system as opposed to a uniaxial coordinate system (Figure 2-4).

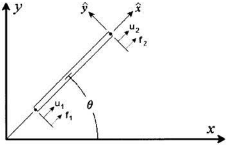


Figure 2-4: Transformation into Global Coordinate System

Transforming the nodal displacements, u_1 and u_2, into the global (***x***-***y***) coordinate system we get,

$$\hat{u}_1 = u_{1x}\cos\theta + u_{1y}\sin\theta \quad \textbf{(2-27)}$$

$$\hat{u}_2 = u_{2x}\cos\theta + u_{2y}\sin\theta \quad \textbf{(2-28)}$$

which can be written in matrix form as[4],

$$\begin{Bmatrix} \hat{u}_1 \\ \hat{u}_2 \end{Bmatrix} = \begin{bmatrix} C & S & 0 & 0 \\ 0 & 0 & C & S \end{bmatrix} \begin{Bmatrix} u_{1x} \\ u_{1y} \\ u_{2x} \\ u_{2y} \end{Bmatrix} \quad \text{or} \quad \underline{\hat{u}} = \underline{T}^* \underline{u} \tag{2-29}$$

where C = cos θ and S = sin θ. Similarly, the global force vector can be obtained

$$\underline{\hat{f}} = \underline{T}^* \underline{f} \tag{2-30}$$

Substituting the above relations into the equation,

$$\underline{\hat{f}} = \underline{\hat{k}\hat{u}} \tag{2-31}$$

yields:

$$\underline{T}^* \underline{f} = \underline{\hat{k}T}^* \underline{u} \tag{2-32}$$

In order to determine the expression relating the global forces to global displacements, we must invert $\underline{T}$* which is not immediately possible because it is not a square matrix. Instead, we must expand the element matrices to be consistent with the global coordinates, recognizing the fact that the nodal forces normal to the bar element axis will always be zero. The relationship between element and global displacements becomes,

$$\begin{Bmatrix} \hat{u}_{1x} \\ \hat{u}_{1y} \\ \hat{u}_{2x} \\ \hat{u}_{2y} \end{Bmatrix} = \begin{bmatrix} C & S & 0 & 0 \\ -S & C & 0 & 0 \\ 0 & 0 & C & S \\ 0 & 0 & -S & C \end{bmatrix} \begin{Bmatrix} u_{1x} \\ u_{1y} \\ u_{2x} \\ u_{2y} \end{Bmatrix} \quad \text{or} \quad \underline{\hat{u}} = \underline{Tu} \tag{2-33}$$

and similarly,

$$\underline{\hat{f}} = \underline{Tf} \tag{2-34}$$

The element stiffness matrix must also be expanded to the same order, as follows:

$$\begin{Bmatrix} \hat{f}_{1x} \\ \hat{f}_{1y} \\ \hat{f}_{2x} \\ \hat{f}_{2y} \end{Bmatrix} = \frac{AE}{L} \begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \begin{Bmatrix} \hat{u}_{1x} \\ \hat{u}_{1y} \\ \hat{u}_{2x} \\ \hat{u}_{2y} \end{Bmatrix} \quad \textbf{(2-35)}$$

Now as before, substituting the above relations into the equation,

$$\underline{\hat{f}} = \underline{\hat{k}\hat{u}} \quad \textbf{(2-36)}$$

yields:

$$\underline{T}\,\underline{f} = \underline{\hat{k}T u} \quad \textbf{(2-37)}$$

By multiplying both sides of this equation by $\underline{T}^{1}$, we obtain the relationship between the global forces and global displacements:

$$\underline{f} = \underline{T}^{-1}\underline{\hat{k}T u} \quad \textbf{(2-38)}$$

However, $\underline{T}$ is an orthogonal matrix, and as a result, the inverse of $\underline{T}$ is equal to its transpose.

$$\underline{T}^{-1} = \underline{T}^{T} \quad \textbf{(2-39)}$$

Therefore,

$$\underline{f} = \underline{T}^{T}\,\underline{\hat{k}T u} \quad \textbf{(2-40)}$$

From above, we can see that the stiffness matrix in global coordinates, $\underline{k}$, is

$$\underline{k} = \underline{T}^{T}\,\underline{\hat{k}T} \quad \textbf{(2-41)}$$

When expanded, $\underline{k}$ becomes

$$\underline{k} = \frac{AE}{L}\begin{bmatrix} C^2 & CS & -C^2 & -CS \\ CS & S^2 & -CS & -S^2 \\ -C^2 & -CS & C^2 & CS \\ CS & -S^2 & CS & S^2 \end{bmatrix} \quad \text{(2-42)}$$

2.2 FEA Techniques

2.2.1 Example of a Bar Element Truss Problem

With the global stiffness matrix for a one-dimensional bar element defined in Cartesian coordinates, it is now possible to use this element to solve a pin-connected truss problem. Figure 2-5 is an example of a pin-connected truss. Each of the truss members has a cross-sectional area, A, and a modulus of elasticity, E; and the truss is subjected to two loads, P and 2P. The purpose of this problem will be to illustrate the process involved in solving for member forces and displacements using the finite element method, and later, to demonstrate several techniques, used throughout the thesis, that could be utilized to reduce the computational effort required in obtaining this solution.

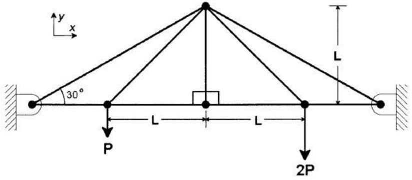


Figure 2-5: Pin-Connected Truss Problem

2.2.1.1 Discretize Geometry and Formulate Element Equations

The first step in the solution process is to break up the geometry into discrete or finite elements. As shown in Figure 2-6, the truss structure has been broken into nine elements (in red) and the pin connections have been designated as nodes (in blue)

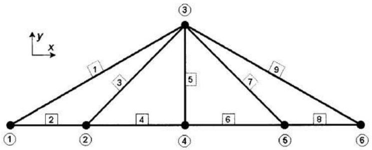


Figure 2-6: Discretized Truss Structure

The second step is to formulate the stiffness equations for each of the nine elements. Element number 1 has a length of *2L* and θ = 30°, therefore its stiffness matrix is evaluated as follows:

Element #1

$$\begin{Bmatrix} f_{1x} \\ f_{1y} \\ f_{3x} \\ f_{3y} \end{Bmatrix} = \frac{AE}{8L} \begin{bmatrix} 3 & \sqrt{3} & -3 & -\sqrt{3} \\ \sqrt{3} & 1 & -\sqrt{3} & -1 \\ -3 & -\sqrt{3} & 3 & \sqrt{3} \\ -\sqrt{3} & -1 & \sqrt{3} & 1 \end{bmatrix} \begin{Bmatrix} u_{1x} \\ u_{1y} \\ u_{3x} \\ u_{3y} \end{Bmatrix} \qquad \textbf{(2-43)}$$

Element 3 has a length of $\sqrt{2}\,L$ and θ = 45°, therefore its stiffness matrix is evaluated as follows:

$$\begin{Bmatrix} f_{2x} \\ f_{2y} \\ f_{3x} \\ f_{3y} \end{Bmatrix} = \frac{\sqrt{2}AE}{4L} \begin{bmatrix} 1 & 1 & -1 & -1 \\ 1 & 1 & -1 & -1 \\ -1 & -1 & 1 & 1 \\ -1 & -1 & 1 & 1 \end{bmatrix} \begin{Bmatrix} u_{2x} \\ u_{2y} \\ u_{3x} \\ u_{3y} \end{Bmatrix}$$

Element #3 **(2-44)**

Element 5 has a length of L and $\theta = 270^o$, therefore its stiffness matrix is evaluated as follows:

$$\begin{Bmatrix} f_{3x} \\ f_{3y} \\ f_{4x} \\ f_{4y} \end{Bmatrix} = \frac{AE}{L} \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 \end{bmatrix} \begin{Bmatrix} u_{3x} \\ u_{3y} \\ u_{4x} \\ u_{4y} \end{Bmatrix}$$

Element #5 **(2-45)**

Element 7 has a length of $\sqrt{2}\,L$ and $\theta = 315^o$, therefore its stiffness matrix is evaluated as follows:

$$\begin{Bmatrix} f_{3x} \\ f_{3y} \\ f_{5x} \\ f_{5y} \end{Bmatrix} = \frac{\sqrt{2}AE}{4L} \begin{bmatrix} 1 & -1 & -1 & 1 \\ -1 & 1 & 1 & -1 \\ -1 & 1 & 1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix} \begin{Bmatrix} u_{3x} \\ u_{3y} \\ u_{5x} \\ u_{5y} \end{Bmatrix}$$

Element #7 **(2-46)**

Element 9 has a length of $2L$ and $\theta = 330^o$, therefore its stiffness matrix is evaluated as follows:

$$\begin{Bmatrix} f_{3x} \\ f_{3y} \\ f_{6x} \\ f_{6y} \end{Bmatrix} = \frac{AE}{4L} \begin{bmatrix} 3 & -\sqrt{3} & -3 & \sqrt{3} \\ -\sqrt{3} & 1 & \sqrt{3} & -1 \\ -3 & \sqrt{3} & 3 & -\sqrt{3} \\ \sqrt{3} & -1 & -\sqrt{3} & 1 \end{bmatrix} \begin{Bmatrix} u_{3x} \\ u_{3y} \\ u_{6x} \\ u_{6y} \end{Bmatrix}$$

Element #9 **(2-47)**

Elements 4 and 6 have lengths of L and $\theta = 0^o$, therefore their stiffness matrices are evaluated as follows:

Element #4

$$\begin{Bmatrix} f_{2x} \\ f_{2y} \\ f_{4x} \\ f_{4y} \end{Bmatrix} = \frac{AE}{L} \begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \begin{Bmatrix} u_{2x} \\ u_{2y} \\ u_{4x} \\ u_{4y} \end{Bmatrix} \quad \textbf{(2-48)}$$

Element #6

$$\begin{Bmatrix} f_{4x} \\ f_{4y} \\ f_{5x} \\ f_{5y} \end{Bmatrix} = \frac{AE}{L} \begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \begin{Bmatrix} u_{4x} \\ u_{4y} \\ u_{5x} \\ u_{5y} \end{Bmatrix} \quad \textbf{(2-49)}$$

Elements 2 and 8 have lengths of $(\sqrt{3}-1)L$ and $\theta = 0^{\circ}$, therefore their stiffness matrices are evaluated as follows:

Element #2

$$\begin{Bmatrix} f_{1x} \\ f_{1y} \\ f_{2x} \\ f_{2y} \end{Bmatrix} = \frac{AE}{(\sqrt{3}-1)L} \begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \begin{Bmatrix} u_{1x} \\ u_{1y} \\ u_{2x} \\ u_{2y} \end{Bmatrix} \quad \textbf{(2-50)}$$

Element #8

$$\begin{Bmatrix} f_{5x} \\ f_{5y} \\ f_{6x} \\ f_{6y} \end{Bmatrix} = \frac{AE}{(\sqrt{3}-1)L} \begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \begin{Bmatrix} u_{5x} \\ u_{5y} \\ u_{6x} \\ u_{6y} \end{Bmatrix} \quad \textbf{(2-51)}$$

2.2.1.2 Assemble Global Stiffness Matrix

With each of the element equations formulated, it is now possible to assemble the global stiffness matrix. In this particular FEA model, nodal displacements at the two pin supports (nodes 1 and 6) are known to be zero. Since these nodes are inactive, there is no need to include the terms associated with these DOF into the stiffness matrix. For node 2, we wish to assemble the two equations that relate nodal displacement to the global forces applied to the model at that node. To do this, we must incorporate the stiffness terms related to the global forces, F_{2x} and F_{2y}, from each of the three elements connected to this node (elements 2, 3 and 4) as follows:

$$\frac{AE}{L}\begin{bmatrix} \frac{1}{\sqrt{3}-1}+\frac{\sqrt{2}}{4}+1 & \frac{\sqrt{2}}{4} & -\frac{\sqrt{2}}{4} & -\frac{\sqrt{2}}{4} & 1 & 0 & 0 & 0 \\ \frac{\sqrt{2}}{4} & \frac{\sqrt{2}}{4} & -\frac{\sqrt{2}}{4} & \frac{\sqrt{2}}{4} & 0 & 0 & 0 & 0 \end{bmatrix}\begin{Bmatrix} u_{2x} \\ u_{2y} \\ u_{3x} \\ u_{3y} \\ u_{4x} \\ u_{4y} \\ u_{5x} \\ u_{5y} \end{Bmatrix}=\begin{Bmatrix} F_{2x} \\ F_{2y} \end{Bmatrix} \qquad \textbf{(2-52)}$$

For node 3, we must incorporate the stiffness terms related to F_{3x} and F_{3y} from each of the five elements connected to this node (elements 1, 3, 5, 7 and 9) as follows:

$$\frac{AE}{L}\begin{bmatrix} -\frac{\sqrt{2}}{4} & -\frac{\sqrt{2}}{4} & \frac{3}{8}+\frac{\sqrt{2}}{4}+\frac{\sqrt{2}}{4}+\frac{3}{8} & \frac{\sqrt{3}}{8}+\frac{\sqrt{2}}{4}-\frac{\sqrt{2}}{4}-\frac{\sqrt{3}}{8} & 0 & 0 & -\frac{\sqrt{2}}{4} & \frac{\sqrt{2}}{4} \\ -\frac{\sqrt{2}}{4} & -\frac{\sqrt{2}}{4} & \frac{\sqrt{3}}{8}+\frac{\sqrt{2}}{4}-\frac{\sqrt{2}}{4}-\frac{\sqrt{3}}{8} & \frac{1}{8}+\frac{\sqrt{2}}{4}+1+\frac{\sqrt{2}}{4}+\frac{1}{8} & 0 & -1 & \frac{\sqrt{2}}{4} & -\frac{\sqrt{2}}{4} \end{bmatrix}\begin{Bmatrix} u_{2x} \\ u_{2y} \\ u_{3x} \\ u_{3y} \\ u_{4x} \\ u_{4y} \\ u_{5x} \\ u_{5y} \end{Bmatrix}=\begin{Bmatrix} F_{3x} \\ F_{3y} \end{Bmatrix} \qquad \textbf{(2-53)}$$

which simplifies to,

$$\frac{AE}{L}\begin{bmatrix} -\frac{\sqrt{2}}{4} & -\frac{\sqrt{2}}{4} & \frac{3+2\sqrt{2}}{4} & 0 & 0 & 0 & -\frac{\sqrt{2}}{4} & \frac{\sqrt{2}}{4} \\ -\frac{\sqrt{2}}{4} & -\frac{\sqrt{2}}{4} & 0 & \frac{5+2\sqrt{2}}{4} & 0 & -1 & \frac{\sqrt{2}}{4} & -\frac{\sqrt{2}}{4} \end{bmatrix}\begin{Bmatrix} u_{2x} \\ u_{2y} \\ u_{3x} \\ u_{3y} \\ u_{4x} \\ u_{4y} \\ u_{5x} \\ u_{5y} \end{Bmatrix}=\begin{Bmatrix} F_{3x} \\ F_{3y} \end{Bmatrix} \qquad \textbf{(2-54)}$$

For node 4, we must incorporate the stiffness terms related to F_{4x} and F_{4y} from each of the three elements connected to this node (elements 4, 5 and 6) as follows:

$$\frac{AE}{L}\begin{bmatrix} -1 & 0 & 0 & 0 & 2 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 & 0 & 1 & 0 & 0 \end{bmatrix}\begin{Bmatrix} u_{2x} \\ u_{2y} \\ u_{3x} \\ u_{3y} \\ u_{4x} \\ u_{4y} \\ u_{5x} \\ u_{5y} \end{Bmatrix} = \begin{Bmatrix} F_{4x} \\ F_{4y} \end{Bmatrix} \tag{2-55}$$

Lastly, for node 5, we must incorporate the stiffness terms related to F_{5x} and F_{5y} from each of the three elements connected to this node (elements 6, 7 and 8) as follows:

$$\frac{AE}{L}\begin{bmatrix} 0 & 0 & -\frac{\sqrt{2}}{4} & \frac{\sqrt{2}}{4} & -1 & 0 & \frac{1}{\left(\sqrt{3}-1\right)}+\frac{4+\sqrt{2}}{4} & -\frac{\sqrt{2}}{4} \\ 0 & 0 & \frac{\sqrt{2}}{4} & -\frac{\sqrt{2}}{4} & 0 & 0 & -\frac{\sqrt{2}}{4} & \frac{\sqrt{2}}{4} \end{bmatrix}\begin{Bmatrix} u_{2x} \\ u_{2y} \\ u_{3x} \\ u_{3y} \\ u_{4x} \\ u_{4y} \\ u_{5x} \\ u_{5y} \end{Bmatrix} = \begin{Bmatrix} F_{5x} \\ F_{5y} \end{Bmatrix} \tag{2-56}$$

Then, combining these expressions for nodal forces, we obtain the global stiffness matrix:

$$\frac{AE}{L}\begin{bmatrix} \frac{1}{\left(\sqrt{3}-1\right)}+\frac{4+\sqrt{2}}{4} & \frac{\sqrt{2}}{4} & -\frac{\sqrt{2}}{4} & -\frac{\sqrt{2}}{4} & -1 & 0 & 0 & 0 \\ \frac{\sqrt{2}}{4} & \frac{\sqrt{2}}{4} & -\frac{\sqrt{2}}{4} & -\frac{\sqrt{2}}{4} & 0 & 0 & 0 & 0 \\ -\frac{\sqrt{2}}{4} & -\frac{\sqrt{2}}{4} & \frac{3+2\sqrt{2}}{4} & 0 & 0 & 0 & -\frac{\sqrt{2}}{4} & \frac{\sqrt{2}}{4} \\ -\frac{\sqrt{2}}{4} & -\frac{\sqrt{2}}{4} & 0 & \frac{5+2\sqrt{2}}{4} & 0 & -1 & \frac{\sqrt{2}}{4} & -\frac{\sqrt{2}}{4} \\ -1 & 0 & 0 & 0 & 2 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 & 0 & 1 & 0 & 0 \\ 0 & 0 & -\frac{\sqrt{2}}{4} & \frac{\sqrt{2}}{4} & -1 & 0 & \frac{1}{\left(\sqrt{3}-1\right)}+\frac{4+\sqrt{2}}{4} & -\frac{\sqrt{2}}{4} \\ 0 & 0 & \frac{\sqrt{2}}{4} & -\frac{\sqrt{2}}{4} & 0 & 0 & -\frac{\sqrt{2}}{4} & \frac{\sqrt{2}}{4} \end{bmatrix} \begin{Bmatrix} u_{2x} \\ u_{2y} \\ u_{3x} \\ u_{3y} \\ u_{4x} \\ u_{4y} \\ u_{5x} \\ u_{5y} \end{Bmatrix} = \begin{Bmatrix} F_{2x} \\ F_{2y} \\ F_{3x} \\ F_{3y} \\ F_{4x} \\ F_{4y} \\ F_{5x} \\ F_{5y} \end{Bmatrix}$$

$$\text{or} \quad \underline{K}\underline{u} = \underline{F} \qquad \textbf{(2-57)}$$

2.2.1.3 Nodal Displacements

The next portion of the FEA solution process involves applying the specified boundary conditions and solving for nodal displacements. The supporting boundary conditions for this FEA model have already been accounted for. As was mentioned earlier, the DOF associated with nodes 1 and 6 are constrained to be zero by the pin boundary conditions. As a result, these DOF are inactive and have been omitted from the global stiffness matrix formulation. There are, however, two vertical loads applied to nodes on the bottom of the truss frame. Represented in vector form and adhering to the nodal sign convention, the force vector for this FEA problem is:

$$\underline{F} = \begin{Bmatrix} F_{2x} \\ F_{2y} \\ F_{3x} \\ F_{3y} \\ F_{4x} \\ F_{4y} \\ F_{5x} \\ F_{5y} \end{Bmatrix} = P \begin{Bmatrix} 0 \\ -1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ -2 \end{Bmatrix} \qquad \textbf{(2-58)}$$

To solve for nodal displacements, we must rearrange equation 2-57 by multiplying both sides with the inverse of the stiffness matrix

$$\underline{K}^{-1}\underline{K}\underline{u} = \underline{K}^{-1}\underline{F} \qquad \textbf{(2-59)}$$

which becomes

$$\underline{u} = \underline{K}^{-1}\underline{F} \qquad \textbf{(2-60)}$$

To compute the nodal displacement vector, we simply need to carry out the matrix multiplication resulting in

$$\underline{u} = \begin{Bmatrix} u_{2x} \\ u_{2y} \\ u_{3x} \\ u_{3y} \\ u_{4x} \\ u_{4y} \\ u_{5x} \\ u_{5y} \end{Bmatrix} = \frac{PL}{AE} \begin{Bmatrix} \frac{1}{6}\frac{\sqrt{3}\left(\sqrt{3}-1\right)\left(5\sqrt{3}-3\right)}{2\sqrt{3}-1} \\ \frac{1}{9}\frac{\sqrt{3}\left(-36\sqrt{2}-219+44\sqrt{3}+6\sqrt{2}\sqrt{3}\right)}{2\sqrt{3}-1} \\ \frac{4}{3} \\ -12 \\ \frac{1}{2}\frac{\sqrt{3}-1}{2\sqrt{3}-1} \\ -12 \\ -\frac{1}{6}\frac{\sqrt{3}\left(\sqrt{3}-1\right)\left(7\sqrt{3}-3\right)}{2\sqrt{3}-1} \\ \frac{1}{9}\frac{\sqrt{3}\left(-276+55\sqrt{3}-72\sqrt{2}+12\sqrt{2}\sqrt{3}\right)}{2\sqrt{3}-1} \end{Bmatrix} \approx \frac{PL}{AE} \begin{Bmatrix} 0.485 \\ -14.0 \\ 1.33 \\ -12.0 \\ 0.149 \\ -12.0 \\ -0.783 \\ -19.8 \end{Bmatrix} \qquad \textbf{(2-61)}$$

This portion of the results is referred to as the *nodal solution*.

2.2.1.4 Solve for Element Forces

Having determined the nodal displacements, we may now go back to the element level to determine the forces present within each element. Substituting the now known nodal displacements into the element stiffness equations and solving, we obtain what is referred to as the *element solution*. For example, the element stiffness equations for element number 1 were:

$$\begin{Bmatrix} f_{1x} \\ f_{1y} \\ f_{3x} \\ f_{3y} \end{Bmatrix} = \frac{AE}{8L}\begin{bmatrix} 3 & \sqrt{3} & -3 & -\sqrt{3} \\ \sqrt{3} & 1 & -\sqrt{3} & -1 \\ -3 & -\sqrt{3} & 3 & \sqrt{3} \\ -\sqrt{3} & -1 & \sqrt{3} & 1 \end{bmatrix}\begin{Bmatrix} u_{1x} \\ u_{1y} \\ u_{3x} \\ u_{3y} \end{Bmatrix} \tag{2-62}$$

Substituting in the nodal displacements,

$$\begin{Bmatrix} f_{1x} \\ f_{1y} \\ f_{3x} \\ f_{3y} \end{Bmatrix} = \frac{AE}{8L}\begin{bmatrix} 3 & \sqrt{3} & -3 & -\sqrt{3} \\ \sqrt{3} & 1 & -\sqrt{3} & -1 \\ -3 & -\sqrt{3} & 3 & \sqrt{3} \\ -\sqrt{3} & -1 & \sqrt{3} & 1 \end{bmatrix}\frac{PL}{AE}\begin{Bmatrix} 0 \\ 0 \\ \frac{4}{3} \\ -12 \end{Bmatrix} \tag{2-63}$$

and carrying out the multiplication yields:

$$\begin{Bmatrix} f_{1x} \\ f_{1y} \\ f_{2x} \\ f_{2y} \end{Bmatrix} = P\begin{Bmatrix} -\frac{1}{2}+\frac{3\sqrt{3}}{2} \\ \frac{3}{2}-\frac{\sqrt{3}}{6} \\ \frac{1}{2}-\frac{3\sqrt{3}}{2} \\ -\frac{3}{2}+\frac{\sqrt{3}}{6} \end{Bmatrix} \approx P\begin{Bmatrix} 2.10 \\ 1.21 \\ -2.10 \\ -1.21 \end{Bmatrix} \tag{2-64}$$

Since element 1 is situated on an angle, we must find the resultant of the nodal force components to determine the tensile or compressive inline force within the element. The resultant, R, of the force components f_{1x} and f_{1y} is

$$R = P\sqrt{\left(-\frac{1}{2}+\frac{3\sqrt{3}}{2}\right)_x^2+\left(\frac{3}{2}-\frac{\sqrt{3}}{6}\right)_y^2} = P\left(-\frac{1}{2}+\frac{3\sqrt{3}}{2}\right)\left(\frac{3}{2}-\frac{\sqrt{3}}{6}\right) \approx 2.54P \quad \textbf{(2-65)}$$

and from the direction of these force components we can ascertain that element #1 is in compression. This procedure is then repeated to determine the forces in each of the remaining elements, and with these forces it is possible to evaluate the stress and strain within each element.

2.2.2 Symmetry Considerations

The truss problem suggested in Section 2.2.1 was geometrically symmetrical about a line drawn down the center of the structure. If the loading applied to the truss had been symmetrical about this centerline as well (Figure 2-7), then the principle of symmetry could be used to reduce the computational effort required to solve the problem. When subjected to a symmetrical set of loads, the results will be a mirror image on both sides of line of symmetry. To take advantage of this property, the model may be cut along line of symmetry, and only half of the model needs to be processed to obtain a solution. By reducing the number of active DOF required to solve the problem, the size of the stiffness matrix that must be assembled has also been reduced. When used in FEA software to solve large problems, the advantages include faster solution times and a reduction in storage requirements, or the ability to produce finer mesh densities or larger models within computer hardware and software limitations.

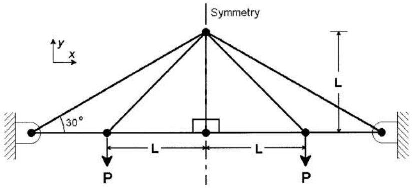


Figure 2-7: Symmetrical Truss Problem

In this half model analysis, symmetry boundary conditions are applied to nodes along the cut boundary, and the vertical element is reduced in cross-sectional area by one-half. In general, symmetry boundary conditions consist of constraining nodal displacements normal to the line (or plane) of symmetry, while permitting displacement along this line (or plane). If rotational degrees of freedom were used, then the rotational DOF out of the plane of symmetry would be constrained. For this particular model, the symmetry boundary conditions are simply the condition, $u_x = 0$, applied to the nodes along the line of symmetry (Figure 2-8).

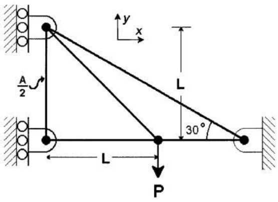


Figure 2-8: Truss Half Model with Symmetry Boundary Conditions

Figure 2-9 shows the discretization used to solve this half model analysis. The element and node numbering has been chosen to be consistent with the full model analysis in Section 2.1.1. As a result, the equations for element numbers 6 thru 9 will be the same.

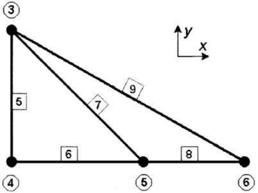


Figure 2-9: Truss Half Model Discretization

In this half model analysis, however, element 5 has half the cross-sectional area of the element 5 in the full model problem. Therefore, the equations for this element must be adjusted as follows:

$$\begin{Bmatrix} f_{3x} \\ f_{3y} \\ f_{4x} \\ f_{4y} \end{Bmatrix} = \frac{AE}{2L}\begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 \end{bmatrix}\begin{Bmatrix} u_{3x} \\ u_{3y} \\ u_{4x} \\ u_{4y} \end{Bmatrix} \quad \textbf{(2-66)}$$

As before, the global stiffness matrix mqst be assembled, but needs only the terms corresponding to the active DOF included. The global stiffness equations for this half model analysis with symmetry boundary conditions are:

$$\frac{AE}{L}\begin{bmatrix} \frac{1}{2}+\frac{\sqrt{2}}{4}+\frac{1}{8} & -\frac{1}{2} & \frac{\sqrt{2}}{4} & -\frac{\sqrt{2}}{4} \\ -\frac{1}{2} & \frac{1}{2} & 0 & 0 \\ \frac{\sqrt{2}}{4} & 0 & 1+\frac{\sqrt{2}}{4}+\frac{1}{\sqrt{3}-1} & -\frac{\sqrt{2}}{4} \\ -\frac{\sqrt{2}}{4} & 0 & -\frac{\sqrt{2}}{4} & \frac{\sqrt{2}}{4} \end{bmatrix}\begin{Bmatrix} u_{3y} \\ u_{4y} \\ u_{5x} \\ u_{5y} \end{Bmatrix} = \begin{Bmatrix} F_{3y} \\ F_{4y} \\ F_{5x} \\ F_{5y} \end{Bmatrix} \quad \textbf{(2-67)}$$

which can be simplified to

$$\frac{AE}{L}\begin{bmatrix} \frac{5+2\sqrt{2}}{8} & -\frac{1}{2} & \frac{\sqrt{2}}{4} & -\frac{\sqrt{2}}{4} \\ -\frac{1}{2} & \frac{1}{2} & 0 & 0 \\ \frac{\sqrt{2}}{4} & 0 & \frac{4+\sqrt{2}}{4}+\frac{1}{\sqrt{3}-1} & -\frac{\sqrt{2}}{4} \\ -\frac{\sqrt{2}}{4} & 0 & -\frac{\sqrt{2}}{4} & \frac{\sqrt{2}}{4} \end{bmatrix}\begin{Bmatrix} u_{3y} \\ u_{4y} \\ u_{5x} \\ u_{5y} \end{Bmatrix} = \begin{Bmatrix} F_{3y} \\ F_{4y} \\ F_{5x} \\ F_{5y} \end{Bmatrix} \quad \textbf{(2-68)}$$

The force vector for this half model symmetry analysis is

$$\underline{F} = \begin{Bmatrix} F_{3y} \\ F_{4y} \\ F_{5x} \\ F_{5y} \end{Bmatrix} = P \begin{Bmatrix} 0 \\ 0 \\ 0 \\ -1 \end{Bmatrix} \tag{2-69}$$

To solve for nodal displacements, we must carry out the matrix multiplication of equation 2-60 resulting in:

$$\underline{u} = \begin{Bmatrix} u_{3y} \\ u_{4y} \\ u_{5x} \\ u_{5y} \end{Bmatrix} = \frac{PL}{AE} \begin{Bmatrix} -8 \\ -8 \\ -\frac{1}{3}\sqrt{3}\left(\sqrt{3}-1\right) \\ -\frac{1}{6}\left(9\sqrt{2}\sqrt{3}-\sqrt{2}+4\sqrt{3}\right)\sqrt{2}\sqrt{3} \end{Bmatrix} \approx \frac{PL}{AE} \begin{Bmatrix} -8.00 \\ -8.00 \\ -0.423 \\ -11.3 \end{Bmatrix} \tag{2-70}$$

2.2.3 Anti-symmetry Considerations

Another useful technique in FEA uses the principle of anti-symmetry. In Section 2.2.2, it was shown that a symmetrical FEA model with a symmetrical load set could be solved by applying appropriate boundary conditions to a reduced FEA model. The same can be done if the loading applied to the symmetrical model was anti-symmetrical about the line of symmetry. An anti-symmetrical load set consists of forces (or pressures, displacements, etc.) applied to mirrored locations on either side of the line of symmetry that are equal and opposite in magnitude and direction. For example, an anti-symmetric load set applied to the same truss arrangement as earlier could look like Figure 2-10. Note that the applied loads are in opposite directions on either side.

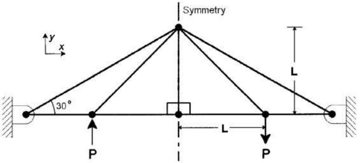


Figure 2-10: Truss Problem with Anti-Symmetric Load Set

Like the symmetrical analysis of Section 2.2.2, the solution for this scenario can be obtained by applying appropriate boundary conditions to a half model analysis. Again, this half model analysis will have a reduced number of active DOF, which reduces the computational effort required in obtaining a solution. In general, anti-symmetry boundary conditions consist of constraining nodal displacements in the line (or plane) of symmetry, while permitting displacement perpendicular to this line (or plane). If rotational degrees of freedom were used, then the rotational DOF within the plane of symmetry would be constrained. For this particular model, the anti-symmetry boundary conditions are simply the condition, $u_y = 0$, applied to the nodes along the line of symmetry (Figure 2-11).

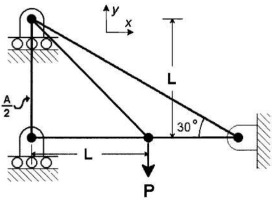


Figure 2-11: Truss Half Model with Anti-Symmetry Boundary Conditions

The same discretization used for the symmetry analysis in Section 2.2.2 (Figure 2-9) will be used for this half model analysis. As before, the global stiffness matrix must be assembled, but needs only the terms corresponding to the active DOF included. The global stiffness equations for this half model analysis with anti-symmetry boundary conditions are:

$$\frac{AE}{L}\begin{bmatrix} \frac{3+2\sqrt{2}}{8} & 0 & -\frac{\sqrt{2}}{4} & \frac{\sqrt{2}}{4} \\ 0 & 1 & -1 & 0 \\ -\frac{\sqrt{2}}{4} & -1 & \frac{4+\sqrt{2}}{4}+\frac{1}{\sqrt{3}-1} & -\frac{\sqrt{2}}{4} \\ \frac{\sqrt{2}}{4} & 0 & -\frac{\sqrt{2}}{4} & \frac{\sqrt{2}}{4} \end{bmatrix}\begin{Bmatrix} u_{3x} \\ u_{4x} \\ u_{5x} \\ u_{5y} \end{Bmatrix}=\begin{Bmatrix} F_{3x} \\ F_{4x} \\ F_{5x} \\ F_{5y} \end{Bmatrix} \tag{2-71}$$

And the force vector for this FEA problem is:

$$\underline{F} = \begin{Bmatrix} F_{3x} \\ F_{4x} \\ F_{5x} \\ F_{5y} \end{Bmatrix} = P \begin{Bmatrix} 0 \\ 0 \\ 0 \\ -1 \end{Bmatrix} \tag{2-72}$$

To solve for nodal displacements, we must carry out the matrix multiplication of equation 2-60 resulting in:

$$\underline{u} = \begin{Bmatrix} u_{3x} \\ u_{4x} \\ u_{5x} \\ u_{5y} \end{Bmatrix} = \frac{PL}{AE} \begin{Bmatrix} \frac{8}{3} \\ 1-\sqrt{3} \\ 1-\sqrt{3} \\ -\frac{1}{6}\left(3\sqrt{2}\sqrt{3}+5\sqrt{2}+12\right)\sqrt{2} \end{Bmatrix} \approx \frac{PL}{AE} \begin{Bmatrix} 2.67 \\ -0.732 \\ -0.732 \\ -6.23 \end{Bmatrix} \tag{2-73}$$

2.2.4 Superposition Considerations

The final FEA technique to be described, utilizes the principle of superposition. The properties of superposition are that FEA results are both additive and linear. In other words, the analysis results arising from separate load vectors applied to the same FEA model may be added together, or superimposed, and the combined results would be the same as if both load vectors had been superimposed and solved simultaneously. For instance, the truss frame example in Section 2.2.1 was subjected a load vector ($\underline{F}$) that can be expressed as a superposition of two separate load vectors ($\underline{F}_S$ and $\underline{F}_A$), as follows:

$$\underline{F} = \begin{Bmatrix} F_{2x} \\ F_{2y} \\ F_{3x} \\ F_{3y} \\ F_{4x} \\ F_{4y} \\ F_{5x} \\ F_{5y} \end{Bmatrix} = P \begin{Bmatrix} 0 \\ -1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ -2 \end{Bmatrix} = \underline{F}_S + \underline{F}_A = \frac{3P}{2} \begin{Bmatrix} 0 \\ -1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ -1 \end{Bmatrix}_S + \frac{P}{2} \begin{Bmatrix} 0 \\ 1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ -1 \end{Bmatrix}_A \quad \textbf{(2-74)}$$

where $\underline{F}_S$ and $\underline{F}_A$ are symmetric and anti-symmetric, respectively, about the centerline of the model. Using the principle of superposition, it is possible to solve these load vectors separately; and considering the fact that FEA results are linear, it is possible to scale the results of results of in Sections 2.2.2 and 2.2.3 to obtain equivalent results, as would be produced from the vectors above. Therefore, it is now possible to obtain the identical results of the full truss problem subjected to the unsymmetrical load vector, $\underline{F}$, without assembling the full FEA model, but by superimposing the results of two half model analyses instead.

The results of the symmetry analysis in Section 2.2.2 ($\underline{u}_s$) expanded to the same order of the full truss problem can be expressed as,

$$\underline{u}_s = \begin{Bmatrix} u_{2x} \\ u_{2y} \\ u_{3x} \\ u_{3y} \\ u_{4x} \\ u_{4y} \\ u_{5x} \\ u_{5y} \end{Bmatrix} = \frac{PL}{AE}\begin{Bmatrix} \frac{1}{3}\sqrt{3}\left(\sqrt{3}-1\right) \\ -\frac{1}{6}\left(9\sqrt{2}\sqrt{3}-\sqrt{2}+4\sqrt{3}\right)\sqrt{2}\sqrt{3} \\ 0 \\ -8 \\ 0 \\ -8 \\ -\frac{1}{3}\sqrt{3}\left(\sqrt{3}-1\right) \\ -\frac{1}{6}\left(9\sqrt{2}\sqrt{3}-\sqrt{2}+4\sqrt{3}\right)\sqrt{2}\sqrt{3} \end{Bmatrix} \approx \frac{PL}{AE}\begin{Bmatrix} 0.423 \\ -11.3 \\ 0 \\ -8.00 \\ 0 \\ -8.00 \\ -0.423 \\ -11.3 \end{Bmatrix} \tag{2-75}$$

taking into consideration the effect of the symmetry conditions on the results of the un-modeled portion of the truss. To obtain the results of the full truss problem subjected to the load vector $\underline{F}_S$, we simply need to multiply the results of Section 2.2.2 by the appropriate linearity constant:

$$\underline{U}_S = \frac{3}{2}\underline{u}_s = \frac{3}{2}\begin{Bmatrix} u_{2x} \\ u_{2y} \\ u_{3x} \\ u_{3y} \\ u_{4x} \\ u_{4y} \\ u_{5x} \\ u_{5y} \end{Bmatrix} = \frac{3}{2}\frac{PL}{AE}\begin{Bmatrix} \frac{1}{3}\sqrt{3}\left(\sqrt{3}-1\right) \\ -\frac{1}{6}\left(9\sqrt{2}\sqrt{3}-\sqrt{2}+4\sqrt{3}\right)\sqrt{2}\sqrt{3} \\ 0 \\ -8 \\ 0 \\ -8 \\ -\frac{1}{3}\sqrt{3}\left(\sqrt{3}-1\right) \\ -\frac{1}{6}\left(9\sqrt{2}\sqrt{3}-\sqrt{2}+4\sqrt{3}\right)\sqrt{2}\sqrt{3} \end{Bmatrix} \approx \frac{PL}{AE}\begin{Bmatrix} 0.634 \\ -16.9 \\ 0 \\ -12.0 \\ 0 \\ -12.0 \\ -0.634 \\ -16.9 \end{Bmatrix} \tag{2-76}$$

Similarly, the results of the anti-symmetry analysis in Section 2.2.3 ($\underline{u}_a$) expanded to the same order of the full truss problem can be expressed as

$$\underline{u}_a = \begin{Bmatrix} u_{2x} \\ u_{2y} \\ u_{3x} \\ u_{3y} \\ u_{4x} \\ u_{4y} \\ u_{5x} \\ u_{5y} \end{Bmatrix} = \frac{PL}{AE} \begin{Bmatrix} 1-\sqrt{3} \\ \frac{1}{6}\left(3\sqrt{2}\sqrt{3}+5\sqrt{2}+12\right)\sqrt{2} \\ \frac{8}{3} \\ 0 \\ 1-\sqrt{3} \\ 0 \\ 1-\sqrt{3} \\ -\frac{1}{6}\left(3\sqrt{2}\sqrt{3}+5\sqrt{2}+12\right)\sqrt{2} \end{Bmatrix} \approx \frac{PL}{AE} \begin{Bmatrix} -0.732 \\ 6.23 \\ 2.67 \\ 0 \\ -0.732 \\ 0 \\ -0.732 \\ -6.23 \end{Bmatrix} \qquad \text{(2-77)}$$

taking into consideration the effect of the anti-symmetry conditions on the results of the un-modeled portion of the truss. And, we may obtain the results of the full truss problem subjected to the load vector $\underline{F}_A$ by multiplying the results of Section 2.2.3 by the appropriate linearity constant:

$$\underline{U}_A = \frac{1}{2}\underline{u}_a = \frac{1}{2} \begin{Bmatrix} u_{2x} \\ u_{2y} \\ u_{3x} \\ u_{3y} \\ u_{4x} \\ u_{4y} \\ u_{5x} \\ u_{5y} \end{Bmatrix} = \frac{1}{2}\frac{PL}{AE} \begin{Bmatrix} 1-\sqrt{3} \\ \frac{1}{6}\left(3\sqrt{2}\sqrt{3}+5\sqrt{2}+12\right)\sqrt{2} \\ \frac{8}{3} \\ 0 \\ 1-\sqrt{3} \\ 0 \\ 1-\sqrt{3} \\ -\frac{1}{6}\left(3\sqrt{2}\sqrt{3}+5\sqrt{2}+12\right)\sqrt{2} \end{Bmatrix} \approx \frac{PL}{AE} \begin{Bmatrix} -0.366 \\ 3.11 \\ 1.34 \\ 0 \\ -0.366 \\ 0 \\ -0.366 \\ -3.11 \end{Bmatrix} \qquad \text{(2-78)}$$

To obtain the same results as the full model analysis in Section 2.2.1, we simply must superimpose the results of the above half model analyses to obtain:

$$\underline{U} = \underline{U}_S + \underline{U}_A = \begin{Bmatrix} u_{2x} \\ u_{2y} \\ u_{3x} \\ u_{3y} \\ u_{4x} \\ u_{4y} \\ u_{5x} \\ u_{5y} \end{Bmatrix} \approx \frac{PL}{AE} \left(\begin{Bmatrix} 0.634 \\ -16.9 \\ 0 \\ -12.0 \\ 0 \\ -12.0 \\ -0.634 \\ -16.9 \end{Bmatrix} + \begin{Bmatrix} -0.366 \\ 3.11 \\ 1.34 \\ 0 \\ -0.366 \\ 0 \\ -0.366 \\ -3.11 \end{Bmatrix} \right) \approx \frac{PL}{AE} \begin{Bmatrix} 0.268 \\ -13.8 \\ 1.34 \\ .-12.0 \\ -0.366 \\ -12.0 \\ -1.00 \\ -20.0 \end{Bmatrix} \tag{2-79}$$

Note that any discrepancy between the results above and those of Section 2.2.1 is due to rounding errors in expressing the exact solution in decimal form using floating-point-arithmetic. This discrepancy was also expected considering the fact that the decimal solution has been presented to only three significant figures. A check of this analysis indicated that there is no discrepancy between the exact solutions.

Chapter: 3 Design and Performance of Heavy Hauler Bodies

3.1 Construction and Fabrication

The standard dump body for most mining trucks is a welded, steel plate structure consisting of flat floor, sidewall and canopy components with an intricate pattern of box-style stiffeners on the outer sides of each. An array of floor stiffeners (called bolsters) run from side to side, while two main rails (called stringers) run lengthwise. Where the two intersect, the main rails are cut to fit over the bolsters and the intersection seam is continuously welded. The floor bolsters are not of a regular, constant cross-section. Instead, they vary in cross-section providing greater stiffness towards the centerline of the structure.

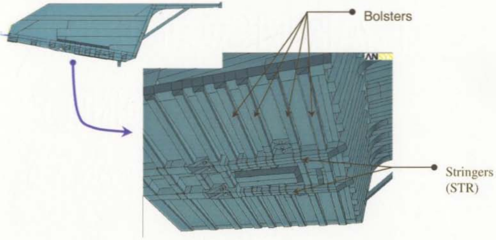


Figure 3-1: Floor Stiffening Arrangement

Size restrictions, imposed by transportation limitations, prevent the entire truck from being assembled at the manufacturing facility. The only way to access or transport goods to the mine sites north of Fort McMurray, Alberta is by a provincial highway. Considering the fact that a fully assembled haul truck is too large to be driven on conventional highways, it is impossible to deliver them in one piece. Instead, large portions are assembled at the factory and transported to the site by tractor-trailer. Final assembly occurs on-site where manufacturing and assembly tools are limited in comparison to the manufacturing facility. In the case of the dump body, the body arrives in several separate pieces and is arranged for welding upside down supported by jacks and blocks, often outdoors on the ground.

Weld repairs, as well, are quite often carried out with the dump body laid upside down outdoors. Cracks and cracked welds are ground away completely with hand-held grinders, and the original volume of material is replaced with multiple weld passes until the original weld fillet is built-up. In some circumstances, SCL replaces the original weld specifications with heavier, more robust weld sizes. Although it is possible to stress relieve such weld repairs with strap-on heat packs, no stress relieving of any sort is carried out on these repairs. The result is that the replacement welds themselves are no better suited to resist cracking, and the cracks quickly return.

3.2 Operational Performance

It is a full time effort for SCL's truck maintenance group to keep these heavy hauler mining trucks running continuously. Haul truck operators work on 12-hour shifts taking only 1-hour worth of breaks daily. At end of each shift, another operator takes over keeping the truck in constant service. These trucks, however, do come out of service on a regular basis for scheduled maintenance. Things like engine oil changes, gearbox oil changes, electrical system inspection and maintenance, and recharging of the suspension strut pressures are necessary to keep the truck operating properly. After a certain number of operating hours, even the engine module gets rebuilt. Because of the lead-time required to rebuild an engine module, a spare engine module is used to keep the fleet operating constantly.

All regularly scheduled maintenance repairs occur at a specified number of operating hours. Quite often, however, repairs are required for incidental occurrences. From time to time, certain items like handrails, stairs and brackets need repair. Other times, trucks are damaged by accidents such as contact with other mining equipment; for example, the shovel operator may contact the haul box while loading. While such repairs are a common part of heavy hauler operation, they are all caused by circumstances outside of what would be referred to as 'regular service'. All heavy haulers at Syncrude mine sites, however, develop some degree of cracking in the dump body during regular service, which requires weld repair on a regular basis. Although these repairs are required regularly, they should not be considered a part of regular truck maintenance. At present, these non-incidental repairs are a continuous cost of operation, and should be reduced if not eliminated in the future.

This perpetual cracking occurs in the welds forming the intersections between the widthwise and lengthwise floor stiffeners (bolsters and stringers respectively). These regions of interest will hereafter be referred to as bolster-stringer intersections. Cracking seems to develop first on the inside of the stringers, near the hinge pivots, even after very short periods of regular service (Figure 3-2). If left un-repaired, the cracks will propagate until all of the bolster-stringer intersection welds have eventually cracked.

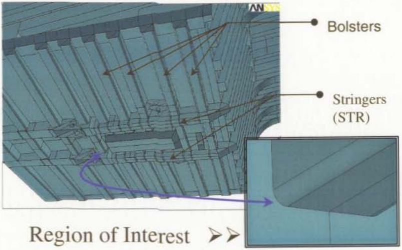


Figure 3-2: Location of Floor Stiffener Cracking

3.3 Weld Repair Costs

Heavy hauler floor stiffener cracking is such a problem in oil sand mining operations that trucks are inspected with Non-Destructive Testing (NDT) to track the extent of crack growth whenever the truck undergoes routine maintenance such as oil changes. In the case of the Komatsu 930E fleet in operation in the Mildred Lake mines, $248,753 was spent on welding crack repairs alone in these eight trucks over a period of 2 years and 9 months, according to the work orders entered into the Syncrude process information system (Appendix A). In terms of shop time, 3473 man-hours in total were put in to repairing the cracked welds in the Syncrude maintenance shops. Not included in these costs are the charges of getting work done at an outside contractor's site, where the bulk of large repair overhauls and modification work is done.

To minimize the downtime impact on production required to continually repair floor stiffener cracking, a spare body is used. For a fleet of eight trucks, the ninth (spare) body is continuously out-of-service getting weld repairs. Although fleet downtime is significantly reduced with this spare body, it does represent another $306,000 in a capital expense. In short, floor stiffener cracking is an ongoing and very expensive problem associated with running a fleet of heavy haulers. The company is currently investigating several options to reduce or minimize these costs, including purchasing new body designs. This work is providing insight as to the cause of these problems, which will assist in the decision making process.

Chapter: 4 Stress and Deformation Modeling

4.1 Modeling Methodology

4.1.1 Requirements and Limitations

The primary factors that govern the complexity of a FEA model are the structural geometry, loading conditions, and the information to be extracted from the model. The intricate pattern of reinforcement in this structure need only be included in sufficient detail to model the results of interest. Incorporating a level of detail beyond this would waste both model creation time and valuable computational resources. The information of primary interest from this FEA model is the state of stress at the many bolster-stringer intersections, where cracking is a continual problem. To investigate the stress at these locations, the overall deformation of the haul body floor must be accurately modeled in the analysis. To capture this deformation, the flat plate stiffening arrangement has been modeled in detail.

During regular mining operations, the entire truck structure experiences a combination of static, dynamic and impact loading. While dynamic and impact loading would produce stresses within the structure greater than that of static loading, a static analysis has been used for the purpose of this investigation. The reason for this is that although a dynamic analysis would better reflect the nature of the loading, it would also require an analytical effort well beyond what was achievable in the desired timeline. In addition, a prerequisite for any dynamic analysis is to understand the static response in detail. This work identifies, for the first time, the damage mechanism and source responsible for floor stiffener cracking.

Since FEA is a numerical analysis technique, the limitations of the computer software and hardware must also be considered. A significant effort has been put into making this FEA model as efficient as possible. This includes efficiency in data storage, computational effort, and overall serviceability and adaptability of the model. Perhaps the most valuable feature of the ANSYS 5.5.3 finite element software package used in this analysis is the ability to use input files. Input files are standard text files containing a sequence of commands to be executed by the software. Instead of saving the FEA model database files directly, a much smaller text file containing the commands used to assemble the model can be stored instead. At present, the ANSYS software does not have a simple 'undo' command for correcting simple mistakes made during model creation. Using input files, small mistakes may be corrected easily by editing the text file. In addition, using the ANSYS parametric design language (APDL) it is possible to include logic statements, program loops, as well as statements calling other input files to be read.

All of the geometry creation, material property selection, mesh sizing, and even analysis commands used in this analysis have been assembled into a hierarchy of thirty-six such text based input files. The first input file (called 1_MAIN_INPUT) is at the top of the hierarchy, and breaks the work into discrete sections such as geometry creation and meshing. Each section then contains call statements for input files that contain the appropriate commands for that portion. The 2_series of files setup the analysis options and build the model geometry. The 3_series of files assign the appropriate material thickness settings to the geometry areas. The 4_series of files apply the element mesh and boundary conditions for the analysis. While the 5_series of files contain commands for viewing and analyzing the results of the haul body analysis. The 6_series of files contain commands for a shell-to-solid sub-model analysis, which will be discussed later. The 7_series of files were used to model the frame of the haul truck supported on uneven strut forces, and as will be discussed later the 8_series of files combine both the frame and body FEA models. A printed copy of these thirty-six text based files is contained in Appendix B.

As mentioned previously, the software used for this analysis was ANSYS version 5.5.3. This software is licensed for use at SCL's Edmonton Research Center. Unlike university versions that are restricted to 32,000 nodes, this software does not restrict the size of the FEA models that can be analyzed. Instead, computer hardware offers the only modeling limitations. The platform on which the software runs is a DEC Personal Workstation 600au (EV 5/6chip 600 MHz) with a Digital Unix alpha 4.0D operating system. With 1.256Gb of physical memory, 1.270Gb of swap disk space, and 28Gb of storage capacity in a Raid disk, this platform was more than sufficient to solve the largest FEA models used in this analysis.

4.1.2 Element Selection

Two groups of elements are applicable for this type of analysis: shell and solid elements. Shell elements efficiently model the behavior of thin plates provided that the assumptions made in the element formulation are acceptable, and offer a significant reduction in computational effort when compared to a similar analysis using solid elements. The SHELL93 element has a quadratic displacement shape function that produces a linear strain distribution within the element. Bending stresses vary linearly though the thickness, while the transverse shear stresses are assumed constant though the element. This element is well suited to efficiently model the global behavior of the steel plate structure.

Shell elements are limited, however, in that they represent stresses through the material thickness as a linear variation from one surface to another. If greater detail is required, then shell elements will not suffice. In a three-dimensional model, such information can only be obtained through a discretization of volume elements. When compared to an equivalent shell element model, the number of elements and DOF associated with a volume element analysis is enormous. Conducting a volume element analysis of the entire body structure is beyond the solution capabilities of the computer hardware used in this project; hence, it simply was not feasible.

If required later, a Shell-to-Solid sub-model analysis using SOLID95 elements could be used. In a sub-model analysis, results of a larger and coarser global model are used to form the boundary conditions for a smaller and more refined sub-model. This technique makes it possible to analyze specific regions in detail without having to refine and re-solve the entire FEA model. By using solid elements in the sub-model, it is possible to see the results of interest in greater detail than is possible with a shell element analysis alone. The shell element or global model would adequately describe the structural response of the entire body to various loading scenarios, while the solid element sub-model would 'feed' off of these results to reveal the state of stress in localized regions in much greater detail. Presently, however, such detail has not been required and this analysis option has not been used.

4.1.3 Meshing

Meshing is the term used to describe the discretization of the model geometry into discrete or 'finite' elements. Two meshing options are available in the ANSYS software package: free and mapped meshing. Mapped meshing allows the user to directly control the element size and pattern during the discretization process. Through such control, clean, uniform and efficient meshes are possible resulting in lower solution times. Free meshing uses computer algorithms to automatically discretize the model geometry. These algorithms respond to the geometry, refining the mesh near regions of detail such as small curves and angles. The primary advantage of free meshing is the speed of mesh generation. By adjusting the algorithm parameters, meshes of varying density can be generated quickly, which is particularly useful in establishing convergence.

The meshing technique used in this model, however, was a combination of both. In the ANSYS software package, it is possible to exercise direct control of the mesh sizing at some locations of the model, while allowing the free meshing routines to generate the mesh and discretize the remaining geometry automatically. In this way, the advantages of both meshing options are exploited.

4.2 Boundary Conditions

The accuracy of FEA results are highly dependant on the accuracy of the boundary conditions (BCs) applied to the model. It is therefore, a major concern of this study to adequately represent the support and load conditions on a working haul truck box. Often, the results of interest are sensitive to some BCs and not sensitive to others. It is important to understand this sensitivity in order to effectively evaluate the effect assumptions have on the results of interest. For BCs that are not sensitive, general engineering judgment may be sufficient, whereas BCs that are sensitive to the results of interest may require a much more judicial effort.

4.2.1 Symmetry

If a model is symmetrical about one or more planes, in terms of both loading and geometry, then symmetry BCs can be used to dramatically reduce the computational effort required in obtaining a solution. A 930E haul body is geometrically symmetrical about a single plane down the middle of the structure. For analyses in which both the applied loading and support conditions are symmetrical about this plane as well, only half of the structure needs to be modeled (see Figure 4-1). Along the plane of symmetry, BCs are applied to represent the effects of the other half of the model. More specifically, the nodal displacements are not permitted to cross the place of symmetry, and nodal rotations out of the plane of symmetry are held at zero.

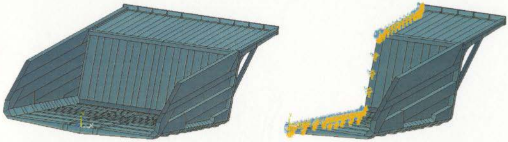


Figure 4-1: 930E Body Full Model Geometry and Symmetry Model with BCs

In situations where the applied loading or the support BCs are not symmetrical about this plane, the symmetry condition cannot be used. If the applied load or displacement is equal and opposite on the other symmetrical half of the model, on the other hand, anti-symmetry conditions may be used along the cut plane. Symmetrical and anti-symmetrical loads may be analyzed separately and superimposed to study the combined effect of each. This technique was used extensively in the trial analyses that identified the need to study support displacement in detail, which will be discussed in Chapter 5.

For asymmetrical loading situations, or verification of superimposed half-model results, a full finite element model has to be assembled. The input routines used for this FEA model have been created in such a way that this poses no significant challenge.

However, solution times of a full model FEA are as much as four times that of a half model analysis. Whenever possible, half model analyses were conducted to save time.

4.2.2 Initial Supporting Conditions

In order to obtain a solution, initial supporting conditions were applied to the model geometry. These conditions are meant to simulate the supporting effect the frame has on the haul body when the truck is stationary sitting on level ground, an ideal situation. It later became evident that frame displacement is a source of structural loading, and an entirely different means of supporting the body structure in a FEA will be discussed in detail later. The following initial supporting conditions were used to start the analysis process.

Haul truck dump bodies have three support locations: a hinged pin connection at the rear of the truck frame, a rubber pad distributed support condition along the main beams of the frame, and hinged pivot connections to the hoist cylinders. For this analysis, the lowered box position only will be considered, so the effect of the hoist cylinder supports in this position has been ignored. The distributed support condition of the rubber pads along the front stringers of the frame has been represented by constraining the displacement in the vertical direction $Uy=0$ on the areas representing the stringer bottom plate (see Figure 4-2). Such solid-model BCs are transferred to the nodes of the finite element mesh when a solution is initiated.

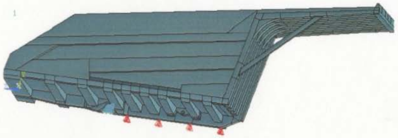


Figure 4-2: Stringer Distributed Support Boundary Condition

Representing hinge pivot conditions effectively is often a considerable challenge. For the present load case, the structure is not expected to rotate significantly about the center axis of the hinge pin. Rather, the bearing forces of the weight resting on the pin were deemed significant. The weight resting on the pin was represented by constraining $U_y=0$ on the lines that make up the top of the hinge pivot holes. To resist any forward motion, due to the 9° slope of the floor, the constraint $U_z=0$ was applied to the lines that make up the rear of the same pivot holes (see Figure 4-3).

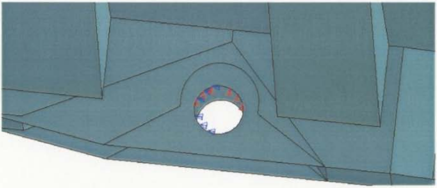


Figure 4-3: Hinged Pin Boundary Conditions

4.2.3 Ore Load Application

The most significant force that is applied to a truck body is pressure on the inside faces due to the weight of a full load of oil sand. This pressure distribution is a function of the oil sand soil mechanics and the pile shape. The version of FEA software used is limited in that pressure gradients may be specified on only one coordinate direction at a time. To apply the distributed load of a rounded pile of oil sand, some amount of discretization and approximation was necessary. One option was to break the inside face areas into a number of sections, applying appropriate face pressures as required. While this manual discretization would be effective, a more adaptive, adjustable concept proved to be much more useful.

An ANSYS algorithm that applies face pressures to elements based on their location within the structure was developed. The result is a much finer pressure discretization than would be attempted manually, and one that is directly proportional to the mesh density of the inside face areas. With this algorithm, rounded pressure distributions were now possible, circumventing the ANSYS single gradient limitation. Most importantly, the algorithm allows for adjustments in the pressure distribution with minimal effort. In this way, the effect of off-center loads and oversized loads can be investigated for a variety of soil types and conditions.

4.2.3.1 Approximate Profile Shape

The only established standards for haul box design are the Society of Automotive Engineers (SAE) Standard J1363[5] and the International Standards Organization (ISO)

Standard 6483[6], which is the same as the SAE standard adopted without modification. The interesting thing about these standards is that both are capacity ratings only. They make no reference to the types of material being hauled, no reference to the forces expected in service, and specify nothing with respect to structural strength. Instead, they specify a detailed way to measure the volumetric rating, or the volume of material that the body can carry, for any given body geometry. While the volumetric rating is useful in comparing the capacity ratings of different bodies, it has little relevant use in haul body design. The ore load shape specified suggests a 2:1 slope above the haul body sidewalls and a 1:1 slope near the rear (Figure 4-4). Such a shape is impossible because no known material would form two separate slopes when poured naturally.

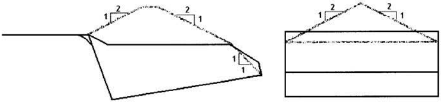


Figure 4-4: SAE J1363 Capacity Rating

In addition, using this shape as a load profile has been shown to be a poor estimator of the true center-of-gravity location. Philipi-Hagenbuch, a producer of patented lightweight haul body designs, suggests that the center-of-gravity location predicted by the established standards is not accurate when compared to on-site investigations[7]. The result of this is that the true center-of-gravity location is offset from the location for which the truck has been designed, and the weight distribution onto the frame is affected accordingly. To develop lightweight bodies that also correct the center-of-gravity location onto the truck frame, Philipi-Hagenbuch uses a patented profiled shape that more accurately represents the load shapes seen on individual customer sites.

For similar reasons, it was decided that a more realistic shape than the established standards should be used in this analysis. From a recent payload study[8], side profile and rear profile pictures were collected for a number of oil sand payloads along with their corresponding weigh scale weights. Some minor editing of the pictures was done to accentuate the features of interest, namely the floor and front wall lines, and the oil sand pile profile lines. The trend line fitting feature of Microsoft Excel was used to determine relative functions describing the geometry (Figures 4-5 and 4-6).

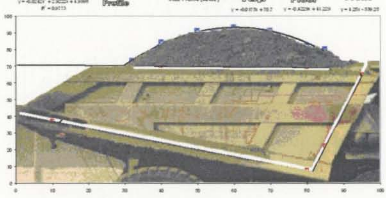


Figure 4-5: Side Profile Shape from Payload Study Picture

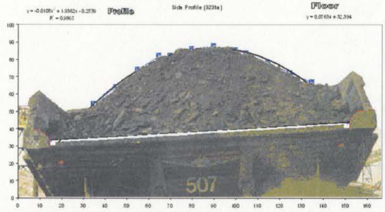


Figure 4-6: Rear Profile Shape from Payload Study Picture

Using symbolic math software, the picture rotation effect was subtracted from the shape functions, and known box dimensions were used to return to a true scale. Once scaled, it was then possible to create a three-dimensional function to approximate the payload observed. The average of nine different approximate payload functions was used to develop a simplified shape function (Figure 4-7) shown here along with the floor and front wall planes.

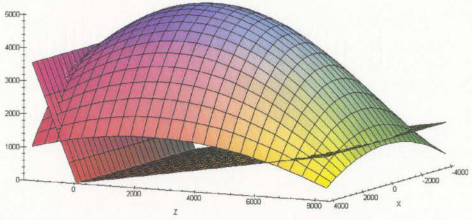


Figure 4-7: Approximate Profile Shape Function

Mathematically, the above function can be described in mm units as follows:

$$PROFILE = MaxHeight * \left[1 - \left(\frac{X - XPeak}{4850}\right)^2\right] * \left[1 - \left(\frac{Z - ZPeak}{6650}\right)^2\right] \quad \textbf{(4-1)}$$

where *XPeak* is the location of the pile peak offset from the centerline of the truck, *ZPeak* is the location of the pile peak measured from the floor - front wall edge, and *MaxHeight* is the height of the pile peak from that same floor - front wall edge. *MaxHeight* in mm can be expressed as a function of oil sand mass and density in the range of interest (250 ~ 400 short tons):

$$MaxHeight = \left(22.2 * \frac{Mass}{Density}\right) + 1020 \quad \textbf{(4-2)}$$

where *Mass* is expressed in metric tonnes (te) and *Density* is expressed in metric tonnes per cubic meter ($^{te}/_{m^3}$).

In a word of caution, it should be noted that this is not meant to be a statistical representation of the ore shapes expected in an oil sand mine. It does not include such factors as seasonal soil properties, large lumps, rocks, etc. This representation is not intended to be used for any other purposes such as the studies used to optimize shovel-loading practices. It does, however, provide an easily adjustable load shape that is more representative of reality than the established SAE standards.

4.2.3.2 Soil Mechanics

The next step in the ore load application scheme was to determine the pressures on the inside faces as a function of this approximate load shape. Using the same soil mechanics principles used in foundation design, the pressures on the walls of this dump box can be broken down into vertical and lateral components. The vertical pressure σ_v is simply:

$$\sigma_v = \rho g h \quad \text{or} \quad \sigma_v = \gamma h \qquad \textbf{(4-3)}$$

where ρ is the density of oil sand ($^{kg}/_{m^3}$), g is the acceleration due to gravity (9.81 $^{m}/_{sec^2}$), and h is the height of the column of soil directly above the area in question (Figure 4-8).

The horizontal or lateral load exerted on a frictionless, vertical wall varies linearly with a maximum pressure at the base (see Figure 4-8). According to Das in *Principles of Foundation Engineering*, the Rankine lateral earth pressure at the base is $\sigma_h = K_a\sigma_v$ where K_a is the Rankine active pressure coefficient[9]:

$$K_a = \tan^2(45 - \varphi/2) \quad \text{or} \quad K_a = (1 - \sin\varphi)/(1 + \sin\varphi) \qquad \textbf{(4-4)}$$

and σ_v is the vertical pressure evaluated at the base of the wall. The angle φ refers to the angle of repose, or the soil friction angle. The commonly accepted value for oil sand from the Athabasca oil sand deposit is 33°.

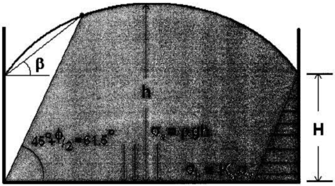


Figure 4-8: Soil Pressure Components

The presence of a sloped pile near the wall has the effect of applying a surcharge to the lateral earth pressure. According to Bowles in *Foundation Analysis and Design*, this effect is incorporated as an increase in the Rankine active pressure coefficient as follows[10]:

$$K_a = \cos\beta \frac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi}} \tag{4-5}$$

where β is the average slope angle for the active wedge as defined in Figure 4-8. Theoretically, it is impossible for the angle β to be greater than the angle of friction φ. Since β is usually a few degrees less than φ, the value $\beta \approx 30^o$ was chosen as a good estimate resulting in $K_a \approx 0.5$.

4.2.3.3 Load Application Algorithm

The final step in this load application scheme was to write an algorithm that would autonomously apply an appropriate pressure to the face of each element based on its location within the structure. An overview of the algorithm is as follows.

First, a number of parameters are set to allow for adjustment including total payload, density, K_a, as well as the location of the pile peak (for off center loads). The areas that form the inside face of the floor, side and front walls are selected and defined as components for ease of selection later. A specific component (e.g. the front wall) is selected for load application and all the elements making up that component are selected as well. The algorithm then enters a loop indexing through all of the selected elements, executing the commands below.

The algorithm addresses each element by indexing through the elements numbers of the currently selected element set. Entering the loop, the element index is set at the minimum selected element number. After processing that element, ANSYS APDL commands are issued which set the element index to the next selected element number, and the process commands are repeated. Once all the selected elements have been processed, the APDL commands will deliver a value of zero for the next available element number, which causes the loop to be exited.

The first step in processing each element is to determine the appropriate lateral and vertical pressure components for that element. APDL commands are issued which collect the three-dimensional coordinate location of the element centroid. The height of the column of soil directly above the element centroid is determined by evaluating the height of the load shape function by substituting in the element X and Z coordinates into the function stated earlier, and subtracting the Y co-ordinate of the element centroid. The vertical pressure on the element is then calculated by substituting this column height into the equation $\sigma_v = \rho g h$.

Calculating the lateral pressure on the element is a little more involved. As described earlier, the lateral pressure varies linearly from a maximum pressure at the base. For each element location, this base pressure must first be determined. The base pressure is defined as $\sigma_h = K_a \rho g H$ where H is the vertical height up the sloped wall where the oil sand surface and the wall intersect (see Figure 4-8). The appropriate lateral pressure for the element location is then determined using the ratio of element centroid Y co-ordinate to the active height H.

Lastly, the calculated pressures are applied directly to the element face as a constant pressure. This is done by superimposing the normal-to-face components. The normal-to-face component of the vertical pressure is $\sigma_v \cos \theta$ where θ is the angle between the wall and the horizontal plane (see Figure 4-9), and $\sigma_h \sin \theta$ is the normal-to-face component of the lateral pressure. The pressure components along the element face are neglected since the wall is assumed frictionless. This assumption is valid in the presence of vibration since any friction effects on the walls will dissipate as the oil sand settles.

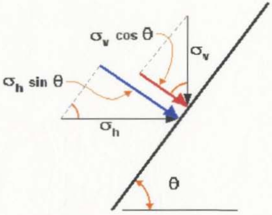


Figure 4-9: Superposition of Normal-To-Face Components

The above process is repeated for all selected elements until appropriate pressures have been applied to all of the elements within the component. Then, the next component is selected (e.g. the floor) and the process is continued with a similar methodology. The result is a well discretized pressure profile on the inside element faces (Figure 4-10).

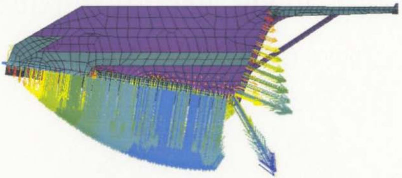


Figure 4-10: FEA Model After Pressure Application

4.3 Mesh Convergence

4.3.1 Preliminary Mesh

There is a need to demonstrate convergence of the results from a finite element mesh. The mesh must be such that further refinements are not justified since no significant improvement in the results can be expected. To demonstrate this, a suitable quantifier is needed. The initial concept was to refine the mesh until convergence of the stress pattern in an area of interest was achieved. A coarse mesh of the entire geometry was produced (Figure 4-11) with the applied loading and initial support conditions described above, and a solution was initiated.

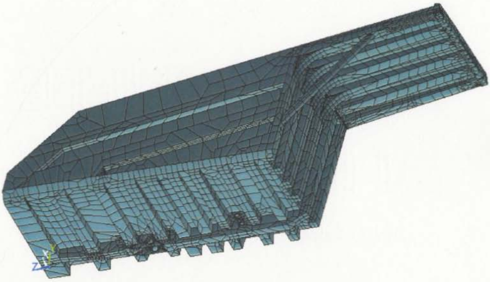


Figure 4-11: Coarse Mesh of 930E Box Structure

Bending stresses are setup in the floor due to the weight resting outside of the central supports resulting in a near uniaxial state of stress in the lower plate of the closed-form bolster stiffeners. Given the simplicity of the stress in this region and its proximity to the troublesome bolster-stinger intersections, this location was isolated as a suitable region to demonstrate convergence of the finite element mesh. The state of stress in one such bolster stiffener may be examined by mapping the mid-plane stress results to a path function or a line drawn down the centerline of the lower bolster plate (see Figure 4-12). Mapping the mid-plane stress results omits the effects of localized bending near the bolster-stringer intersections, which will be discussed in detail later. At this time, the overall bending, or global deformation, of the floor stiffener is the result of interest.

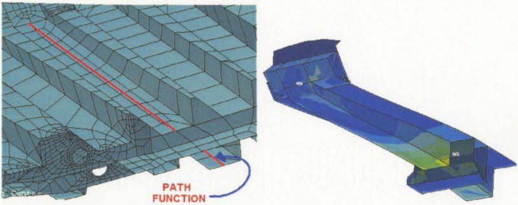


Figure 4-12: Path Function on Bolster, and Plot of Stress Results

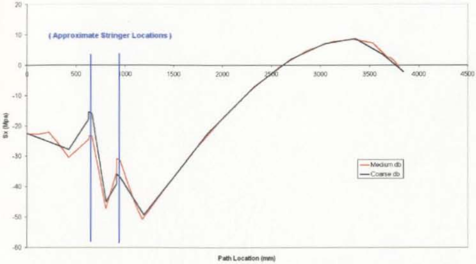


Figure 4-13: Bolster Path Mid-Plane Stress Results

Figure 4-13 is a plot of the mid-plane stress results with respect to the path length for the test case examined. As expected, the central portion of the stress pattern resembles that of a bending moment diagram for a beam subjected to a distributed load. Compressive stress in the lower plate increases in magnitude towards the direction of the stringer, or main rail. As the bolster passes through the stringer, some discontinuity is expected. The tension seen in the lower plate near the outside of the bolster path can be explained due to the deformed shape of the stiffener. The outer portion of the floor is attached to the sidewall of the body. As the floor plate deforms downward, one would expect the wall to rotate outward. However, the sidewall resists deflection since it is attached to the front wall, and as a result, there is a change in the curvature of the floor. This effect is less pronounced in bolster stiffeners further away from the front wall where the sidewall stiffness is considerably less.

With respect to mesh quality, the stress pattern along the span of the bolster is smooth and seems to change little with mesh refinement. Near the stringer intersection, on the other hand, the results are very erratic, discontinuous, and change significantly with mesh refinement. For these reasons, it is obvious that further mesh refinement in this area is required. In addition to this, this location is precisely the location of the persistent floor stiffener cracking problems. Therefore, demonstrating a reliable convergence in the results of this region is of particular importance. Uniformly refining the mesh over the entire structure produced cumbersome models, excessive solution times, and minimal improvements in the results of this region. In order to produce a suitably converged mesh, within the limitations of the computer hardware, an efficient refinement methodology was required.

4.3.2 Estimating Solution Error

The error approximation technique included in the ANSYS software is an elegant means of proving reliable convergence. It estimates the amount of solution error due specifically to mesh discretization. The structural energy error (SERR) is a measure of the discontinuity in the stress field from element to element, while the percentage error (SEPC) indicates the relative amount of error due to a particular discretization.

The continuity assumption used in many displacement-based finite element formulations results in a continuous displacement field from element to element, but a discontinuous stress field. To obtain more acceptable stresses, averaging of the element nodal stresses is done within the ANSYS software. *Element nodal* data consist of the element derived data, such as stresses and strains, calculated at the interior integration points and then extrapolated to the nodes[11]. The POST1 postprocessor averages component tensor or vector data at nodes used by more than one element to arrive at a smoothened *nodal solution.*

The error approximation technique incorporated into the ANSYS software package is similar to that given by Zienkiewicz and Zhu[12]. Using these averaged nodal stresses, the processor returns to the element level and evaluates the discrepancy between the averaged results and the results of each element. The stresses at each node of each element are processed to yield:

$$\{\Delta\sigma_n^i\} = \{\sigma_n^a\} - \{\sigma_n^i\} \tag{4-6}$$

where:

$\{\Delta\sigma_n^i\}$ = stress error vector at node *n* of element *i*

$\{\sigma_n^a\}$ = $\dfrac{\sum_{i=1}^{N_e^n}\{\sigma_n^i\}}{N_e^n}$ averaged stress vector at node *n*

N_e^n = number of elements connecting to node *n*

$\{\sigma_n^i\}$ = stress vector of node *n* of element *i*

Then for each element, the energy associated with this stress error (structural energy error, or SERR) is evaluated similar to the concept of strain energy:

$$e_i = \frac{1}{2}\int_{vol}\{\Delta\sigma\}^T[D]^{-1}\{\Delta\sigma\}d(vol) \tag{4-7}$$

where: e_i = energy error for element i

vol = volume of the element

$[D]$ = constitutive matrix

$[\Delta\sigma]$ = stress error vector at points as needed (evaluated from all $[\Delta\sigma_n]$ of this element).

The total energy associated with discontinuity in the stress field, or energy error, is:

$$e = \sum_{i=1}^{N_r} e_i \tag{4-8}$$

where: e = energy error over the entire (or part of the) model.

N_r = number of elements in the model or part of model.

Energy error can be normalized against the total strain energy to give some measure of the effect on the results of interest. This can be defined over the entire solution domain, or for element subdomains. When calculated over localized regions, it is more meaningful.

$$E = 100\left(\frac{e}{U+e}\right)^{\frac{1}{2}} \tag{4-9}$$

where: E = percentage error in energy norm (or SEPC)

U = $\sum_{i=1}^{N_r} E_{ei}^{po}$ strain energy over the entire (or part of the) model

E_{ei}^{po} = strain energy of element i

Although it is a good indicator of mesh quality, the percentage error in energy norm (or SEPC) gives little direct information about the stresses. An estimation of the upper and lower stress bounds considering the effect of discretization error is available. Again, these results are more meaningful when evaluated over a localized element subdomain rather than the entire solution domain.

$$\sigma_j^{mnb} = \min\left(\sigma_{j,n}^a - \Delta\sigma_n\right) \tag{4-10}$$

$$\sigma_j^{mxb} = \max\left(\sigma_{j,n}^a + \Delta\sigma_n\right) \tag{4-11}$$

where min and max are defined over the selected nodes, and:

σ_j^{mnb} = output quantity for nodal minimum of stress (SMNB)

σ_j^{mxb} = output quantity for nodal maximum of stress (SMXB)

j = subscript for particular stress component or combined stress component

$\sigma^a_{j,n}$ = averaged stress quantity j at node n

$\Delta\sigma_n$ = root mean square of all $\Delta\sigma_i$ from elements connecting to node n

$\Delta\sigma_i$ = maximum absolute value of any component $\Delta\sigma^i_n$ for all nodes of the element

4.3.3 Adaptive Refinement

The above ANSYS error estimation technique gives the user the tools necessary to evaluate the effectiveness of a FEA discretization, to decide where the mesh should be refined, and the effect discretization error has on the results of interest. When applied to the initial mesh of the 930E body bolster stiffener region, the drastic need for mesh refinement can clearly be seen. A plot of the structural energy error (SERR) reported for each element clearly shows which regions of the structure are highly stressed and have a large stress discontinuity, and thus require significant mesh refinement (see Figure 4-14).

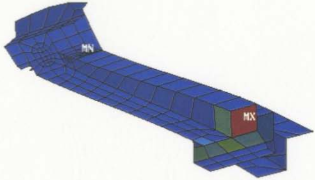


Figure 4-14: Coarse Mesh SERR in Bolster Stringer Region

With each refinement iteration, the SERR values reported for each element steered the refinement efforts into the region where the bolster stiffener and the stringer main rail intersect. After considerable refinement in this region, the mesh shown in Figure 4-15 was produced. Note the extensive refinement in the lower edge of the outer bolster-stringer intersection.

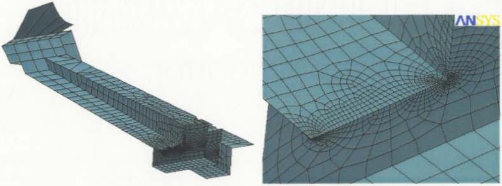


Figure 4-15: Refined Mesh in Bolster Stringer Region

Although mesh refinement reduced the structural energy error in the bolster-stringer region considerably, it was noticed that some error always remained in the sharp corner regardless of the level of refinement (Figure 4-16).

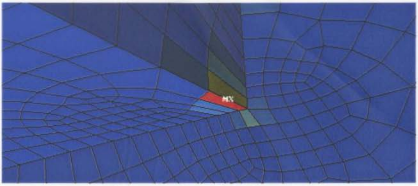


Figure 4-16: SERR in Sharp Corner

The explanation for this has to do with the way that ANSYS estimates solution error. As stated previously, the post-processor averages the element nodal stresses, and the discrepancy between the individual element results and the averaged results is used to evaluate discretization error. In a corner section, shell elements in two or more intersecting planes share common nodes. During the element nodal solution averaging process, component stresses in three separate planes are averaged. The problem arises from relative magnitudes. When subjected to displacements along a particular plane, the elements in that plane will develop large stresses in comparison to the elements experiencing out-of-plane displacement. The result is a discontinuity in the element nodal solution. Since this averaged solution is used to estimate discretization error, some error will always be predicted in shell element corner transitions.

The need to demonstrate a suitable convergence of the results in this region remains. As before, the mid-plane stress results of this refined mesh were mapped to a path function in the location shown in Figure 4-12. By comparing the results alongside those of an unrefined mesh, considerable refinement especially in the region of interest can be clearly seen (Figure 4-17). The two spikes in the solution data correspond to the location of the bolster-stringer intersections.

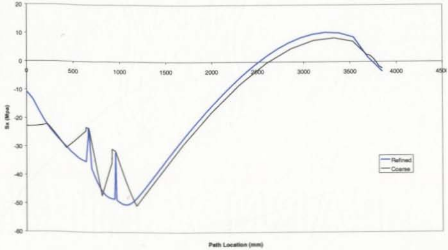


Figure 4-17: Bolster Path Mid-plane Stress Results

To understand the structural behavior in this region, in light of this numerical discontinuity, let us zoom in on this region of interest to have a closer look (path length: 625mm–975mm). The *Element Nodal Solution* line represents data mapped from the averaged element nodal results, while the *Element Solution* line represents data mapped from the element solution directly with no averaging of results (Figure 4-18). In order to explain the spike in the element solution results, an explanation of how ANSYS maps results to path function is necessary. For each path point, elements are searched to find elements containing that geometric location[13] and the results from the first element found are mapped to the path. Therefore, within an element thickness of the intersection, element solution data may be obtained from stinger elements rather than the bolster elements. A sharp transition from a compressed state to a near zero stress state can be seen at both intersection locations, because un-averaged stress results are mapped from the out-of-plane stringer elements instead. The averaged results at these intersections appear as less sharp spikes in the otherwise continuous plot.

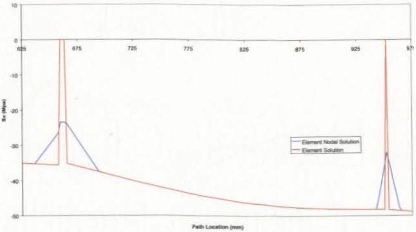


Figure 4-18: Path Mid-plane Stress Results (Bolster - Stringer Intersection)

To confirm this explanation, a similar path results plot was produced with only the bolster stiffener elements selected (Figure 4-19). The result: the intersection effect in the averaging of element nodal data has been eliminated because the out-of-plane stringer elements are no longer selected. Since the structural energy error in this region is less than other, less important regions and the numerical discontinuity effects have been accounted for, the mesh was considered sufficiently converged.

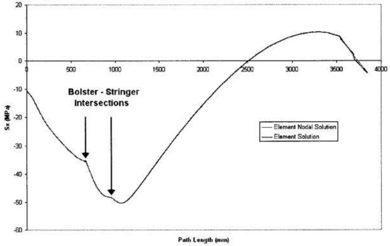


Figure 4-19: Path Results with Only Bolster Elements Selected

Chapter: 5 Analysis, Results and Implications

5.1 Bolster-Stringer Stress

Away from the bolster-stringer intersection, the compressive stresses in the bolster are relatively uniform across the bolster width. At the bolster-stringer intersection, however, the compressive stresses are greatest in the two corners near the bolster sidewalls (Figure 5-1). In order to interpret useful information from this region, a better understanding of the state of stress needed to be developed. Searching for an explanation of this stress, trials were conducted on a simplified geometry with similar support conditions. This smaller, more efficient model enabled faster manipulation of geometry, boundary conditions, and FEA modeling techniques.

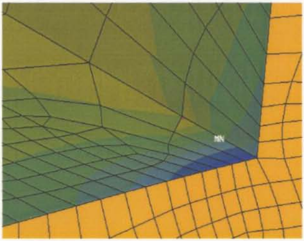


Figure 5-1: Compressive Stresses at a Bolster-Stringer Intersection

5.1.1 Rounded Corner Trial Analysis

The first trial was a shell element representation very similar to the bolster stiffener of the full FEA model. Some subtle differences include the fact that the tapered bolster is replaced with a stiffener of uniform cross section, and the stringer wall is modeled as a single plate in this investigation. When subjected to load conditions similar to the full FEA model, (pressure on the top surface and Uy=0 on the base of the stringer plate) this trial structure develops a similar state of stress at the bolster-stringer intersection (Figure 5-2).

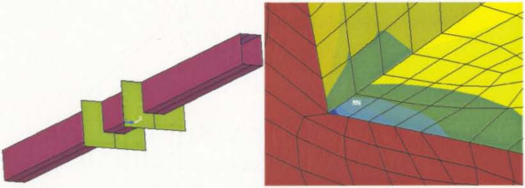
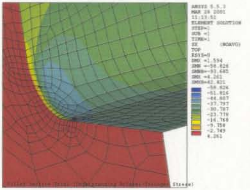


Figure 5-2: Square Section (Bolster-Stringer Stress Trial)

In reality, however, this sharp corner does not exist. On the dump body studied here, bolsters are formed from a single piece of steel with a 38mm rounded corner in this region. The box-like representation above was a geometric modeling simplification. As it will be demonstrated shortly, this representation of the corner does adversely affect the results, and as a result, this oversimplification had to be revisited. The second trial solution involved a more accurate representation of this rounded corner region (Figure 5-3).



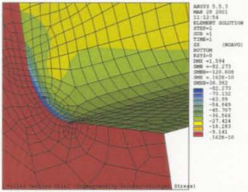


Figure 5-3: Rounded Corner Section (Bolster-Stringer Stress Trial)

Interestingly, the results of this analysis indicate a significant difference between the in-plane stress results reported from the top and bottom of the shell elements along the rounded corner edge. As stated previously, the formulation of the SHELL93 elements used here includes an assumption that the stress varies linearly through the shell element thickness. This linear variation is reported in the element output as top and bottom results, which correspond here to the inside and outside surfaces of the bolster stiffener respectively. The top solution indicates 4 MPa of tension in the corner (Figure 5-3, Left), while the bottom solution indicates 82 MPa of compression (Figure 5-3, Right). This variation though the thickness implies the presence of localized bending.

5.1.2 Solid Element Trial Analysis

In the analyses thus far, the geometry has been modeled using shell type elements that cannot geometrically represent the fillet weld in this region. To validate whether shell elements effectively model the stress in this region, another trial was conducted using solid-volume brick elements (SOLID95) and the same loading conditions as the two previous trials (Figure 5-4). This time, however, the 12 mm full penetration fillet weld that exists in this region was included.

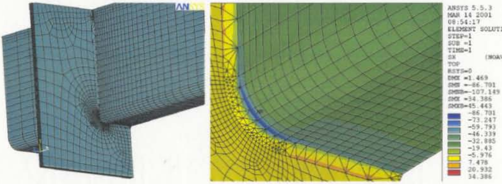


Figure 5-4: Solid Section (Bolster-Stringer Stress Trial)

To explain the stresses near this welded joint, it is helpful to consider the rounded corner section separately. Vertical stresses exist in this region that are set up to equilibrate the vertical load applied to the truck box floor. These vertical forces cause an upward deflection in the plate, which results in a highly localized bending stress (Figure 5-5).

Figure 5-5: Localized Bending (Bolster-Stringer Stress Trial)

Figure 5-6 is a plot of the stress results in the direction of the bolster centerline (σ_x). Bending stresses appear as a variation of σ_x though the thickness of the material. When superimposed over the ≈45MPa of compressive membrane stress set up due to the global bending of the bolster stiffener, this secondary bending stress reduces the magnitude of σ_x on the inside surface of the bolster plate to ≈7MPa, and increases the magnitude of σ_x on the outside surface to ≈87MPa of compression.

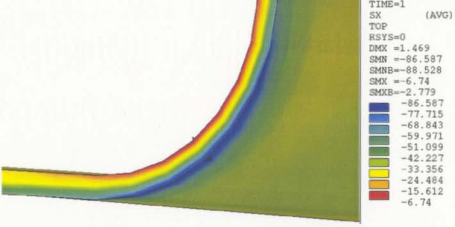


Figure 5-6: Stress Variation through Material Thickness

The purpose of these trial analyses was to shed some light on the state of stress in the bolster-stringer intersection region, and to evaluate whether a shell element finite element model is suitable to study the same. The rounded corner trial indicated the need to correct the oversimplification in the bolster-stringer intersection corner in order to obtain meaningful FEA results. The solid element trial solution linked the high stresses in the corner to the presence of localized bending in the region. And, a comparison of the results of the shell element and solid element trial solutions indicate a difference in the outer compression magnitudes of only 5%. With this it was concluded, that the shell element model does reasonably predict the presence and magnitude of both the global and localized stresses in the corner region. By retrofitting the haul body FEA model with proper rounded bolsters, meaningful results at the many troublesome bolster-stringer intersections can be obtained.

5.2 Frame Twist as a Source of Structural Loading

With the shell element model corrected, it was possible to model the stresses present within the structure set up to equilibrate the applied loading and the resulting deformations. Figure 5-7 is a rear-view, schematic diagram of a typical section of a dump body floor. Under the weight of the ore load, the stiffened floor arrangement deflects slightly as illustrated by the exaggerated deformation shown in red. Resulting from this 'global deformation', a slight tensile stress exists in the floor plate, stresses vary linearly down the stiffener sidewalls, and a uniform, compressive membrane stress is setup through the thickness of the stiffener lower plate.

In addition to this, there is some 'local deformation' in the immediate vicinity of the bolster-stringer intersection. The curvature of the plate results in a bending stress component superimposed onto the compressive membrane stress in the area (Figure 5-7). For both the ore load and the self-weight of the structure, the membrane and local bending stresses in this region combine to form compression throughout the plate thickness. Compression, however, does not explain the source of the extensive cracking problems in this area.

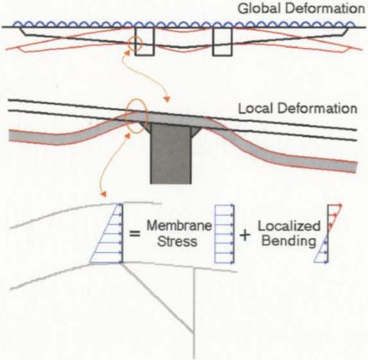


Figure 5-7: Localized Bending at Bolster-Stringer Intersection

Crack growth is usually caused by some form of alternating tension. In order to explain the extensive crack growth observed in the floor stiffener intersections, a state of stress producing tension at the outer edge of the material thickness must be demonstrated. At this stage, the hypothesis was that localized bending could be present in the region that is in reverse to the bending demonstrated thus far. If present in sufficient magnitudes, this localized bending could overcome the compressive membrane stress in the area resulting in a variation through the thickness with tension present at the outside edge (Figure 5-8).

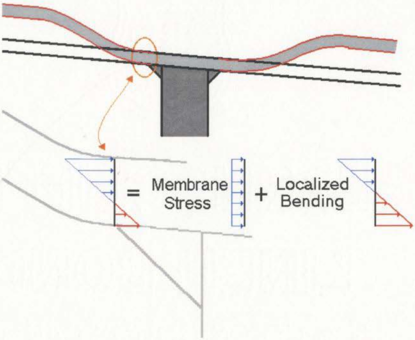


Figure 5-8: Reversed Localized Bending

5.2.1 Frame Displacement Trial Analyses

The frame or chassis of any heavy hauler mining truck is essentially the backbone of the entire truck structure. When a fully loaded haul truck with a gross vehicle weight of over one million pounds drives over uneven ground, the frame is subjected to some very intense forces. As the wheels drive over bumps and sink into holes, a certain amount of deflection within the frame can be expected. Deflection within the frame directly translates into displacement of the dump body supports, which is a form of structural loading.

At this stage, the magnitude and mode shape of the frame deflections that could be expected during regular service were not known. Instead, trial mode shapes were applied to see what effect they would have on structural loading. Two modes of frame displacement were investigated using a half model with anti-symmetry conditions along the center plane. With this scenario, any force, pressure or displacement applied to the half model has the effect of being accompanied by an equal and opposite load applied to the other half. In other words, the frame displacements studied are assumed anti-symmetrical about the truck centerline.

Mode #1 (Figure 5-9) is a representation of frame twist, defined as a displacement arrangement in which the vertical deflection varies linearly from a 2mm difference at the stringer nose to an equal and opposite 2mm difference at the hinge pin. Mode #2 (Figure 5-10) is a uniform frame displacement of 2mm from the stringer nose to the hinge pin. These two trial displacement modes may be scaled and or superimposed to represent other feasible displacement patterns, and superimposed with the ore load and self-weight to investigate the combined effect on the structural deformation. Studying their effects separately, however, offers more insight into the damage mechanisms seen in service.

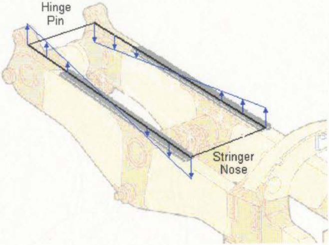


Figure 5-9: Trial Frame Displacement Mode - Twist

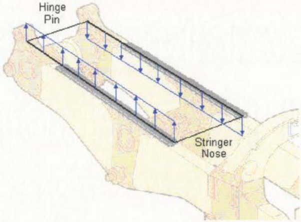


Figure 5-10: Trial Frame Displacement Mode – Uniform

The uniform displacement mode resulted in negligible stresses. The reason for this is that a shear displacement pattern in the frame will not be transmitted to the body through the rubber support pads. As each side deflects upward or downward, the stringers are free to rotate which causes a slight roll producing no significant stresses within the structure.

Initially, the frame twist results produced a similar state of stress to that of the ore load, but larger in magnitude. That is, global bending of the floor plate resulting in a compressive membrane stress in the lower plate of the bolster, and localized bending at the stringer intersection resulting in a variation of the in-plane stresses through the material thickness. The combined the state of stress at the intersection weld is, again, predominately in compression.

According to the anti-symmetry assumption, however, the frame twist applied to the other side is in the opposite direction. To investigate the response of the other side, the frame twist displacement mode can be inverted by multiplication with a scale factor of -1. This inverted frame twist produced equal-and-opposite results, this time, with the state of stress predominately in tension. The implication is that frame twist does produce reversed localized bending in the bolster-stringer intersections that may explain the cracking in this region.

In reality, this frame twist structural loading would coexist with the ore load. When superimposed, this 2mm trial mode of frame displacement was more than sufficient to overcome the compression results of the ore-load, producing tension at the outside edge of the material thickness at the fillet weld toe (Figure 5-11). It is important to note, however, that these findings were the result of an assumed shape and magnitude of frame displacement. The frame deflections present in reality may produce different results. Nonetheless, this analysis does demonstrate the fact that frame twist can explain the cracking problems present, and a more detailed analysis to determine the true extent of frame deflections was warranted.

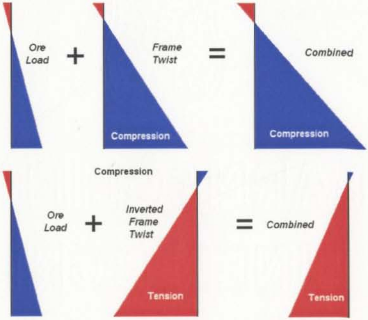


Figure 5-11: Superimposed Ore Load and Trial Frame Twist Results

5.2.2 Frame Displacement Verification

Initially, the extent of frame deflection was to be determined through a direct measurement. The data collected would have served as an excellent input, validating the support boundary conditions of the analyses. Although multiple means of measuring frame deflections were proposed, no feasible alternatives were found. The most promising concept involved a beam welded to both sides of the frame main rails and instrumented with strain gauges to monitor deflection within the beam. The concept was ruled out, however, due to the inability to differentiate between relative vertical deflection and rotation of the ends of the beam. The need to gather physical inputs to validate the results remained, despite the fact that there was no feasible means of directly measuring frame deflection. The alternative was to model the frame of the haul truck using FEA and using strut pressure data as the physically collected input.

The frame of a typical haul truck consists of box section main rails, tubular cross members, and castings at critical stress transition zones. Near the front, a rigid horse collar structure accommodates the strut mounts while providing clearance for the engine and associated propulsion equipment. For the purpose of this analysis, frame stresses at critical locations are not of interest; rather, capturing the true deflection shape is the intent. Hence, the model created represents the overall dimensions and metal thickness properly. However, details and features that would have little effect on the overall deformation of the frame have been omitted (see Figure 5-12). The de-featured FEA model is sufficient to capture the true deflection shape, but frame stresses at transition regions should be ignored.

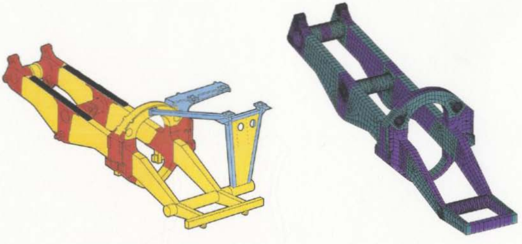


Figure 5-12: Haul Truck Frame[14] and De-featured FEA Model

5.2.2.1 Strut Force Boundary Conditions

Modern haul trucks are equipped with telemetry capable of monitoring most of the onboard vital systems. The truck investigated here was equipped with pressure transducers in each of the four hydro-pneumatic suspension struts for use in a payload metering system. By attaching a laptop to the onboard payload meter, it was possible to acquire real-time pressure data at a rate of 50 Hz. It was then possible to determine the corresponding forces and moments applied to the frame using the strut active areas collected from the manufacturer, and relevant dimensions (moment arms) that were measured directly.

In the FEA, the four struts are modeled as spring elements. At the rear, the struts are attached to the frame with a clevis pin mounted in a spherical bushing. This ensures a straight line-force with no significant moment applied to the frame. In the FEA, the line-forces from the spring elements are distributed evenly over the nodes representing the clevis pinhole. At the front, the upper strut housing is rigidly bolted to the horse collar at four locations. Here, both a vertical force component and an associated moment are transferred to the frame structure (Figure 5-13). In the FEA, a rigid region is defined between the nodes of the strut mount and a node located the appropriate distance away to capture the moment arm effect. This way, the vertical strut force present in the spring element is transferred to the horse collar as both a vertical force and moment.

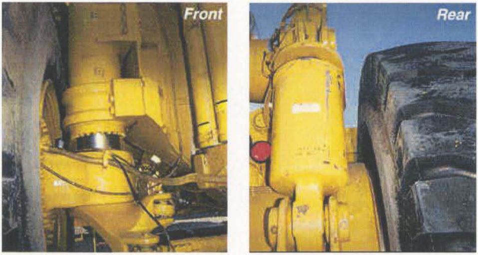


Figure 5-13: Front and Rear Suspension Struts[15]

Much of the strut pressure data collected for this investigation was collected with the truck moving. For the most part, this was done to interfere with normal production as little as possible. By multiplying the force difference between the right and left struts by the appropriate moment arm, moments about the truck centerline exerted onto the frame by the front and rear strut-pairs can be plotted (Figure 5-14). As can be seen, these forces are dynamic in nature. This analysis, however, is purely static. Each haul run begins with the truck parked next to the shovel getting loaded with ore (see Figure 6-1). The underfoot conditions at this location are characterized by soft uneven ground. The data used for this FEA was the static strut pressures after the last shovel bucket of ore is placed into the dump body, and the truck is stationary momentarily before being cleared to proceed along the haul route (shown in red, Figure 5-14).

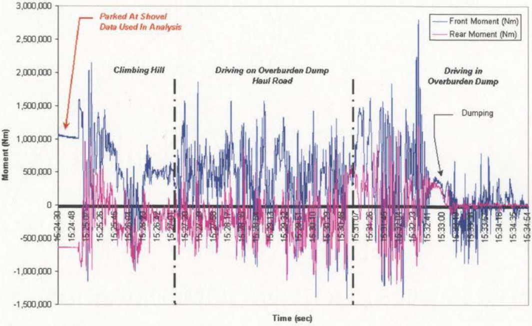


Figure 5-14: Front and Rear Moment Data Calculated from Strut Pressure Data

A large component of the raw strut pressure data, however, is the weight of haul truck including the engine, propulsion systems, etc. To remove this component, averages of dynamic data were collected with the truck 'running empty' along a relatively smooth portion of the haul road. These running empty average pressures were then subtracted from the raw data leaving only the ore load component of the strut forces. In the FEA, the self-weight of the body and frame were neglected, leaving only the ore load to be in equilibrium with these strut forces. The end result was that the frame twist demonstrated in this analysis is due solely to the way the ore load is distributed onto the four struts while the truck is parked on uneven ground.

5.2.2.2 Haul Body - Frame Interaction

Modeling the interaction between the frame and the haul body using conventional boundary conditions (forces, pressures, displacements, etc.) would have been difficult. The weight of the body and ore load is distributed onto the hinge pins and rubber pads, and this distribution changes significantly as the frame twists. Since a FEA model of the dump body was already in existence, the simplest solution was to import the model combining both body and frame into a single FEA, leaving it to the software to work out the appropriate force transfer between them.

The rubber pad support was modeled by meshing the region between the dump body stringers and the main rails of the frame with solid elements. Modeling the hinge pin connection, however, was a little more difficult. It was necessary to form a connection between the two models that accurately represented the force transfer and allowed free rotation about the pin axis. Defining a rigid region comprised of the nodes representing the pinholes, would accomplish the force transfer. Without allowing the rotation DOF about the hinge, however, there was a risk of over-constraining the FEA model. Instead, the following hinge-pin representation scheme was devised.

The pinholes for the body and frame are nearly concentric in the FEA model because in the real structure there is a slight clearance to allow for rotation about the hinge. For each hole, a node was placed in the center of the circle and a series of very stiff springs connect this center node to the outer nodes of the circle forming a 'wagon wheel' pattern. For each near pair of holes, all of the center node degrees of freedom were coupled using constraint equations with the exception of rotation about the pin axis. Thus, the nodes in this region are forced to behave much like a real pin connection (Figure 5-15).

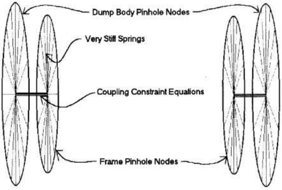


Figure 5-15: 'Wagon Wheel' Representation of Hinge Pin Connections

Ideally, these very stiff springs would have been defined as rigid regions. Problems were encountered, however, in that the master node of a rigid region cannot be used in other constraint equations. The reason for this has to do with how constraint equations are handled by the solution process. Constraint equations define a relationship between the nodal DOF of a group of nodes called slave nodes and one master node. When processed by the software, the nodal DOF for each of the slave nodes are condensed out of the element stiffness matrix, keeping only those of the master node. If a master node for one constraint equation is used as a slave node in another, errors occur. What happened here was that the constraint equations coupling the DOF at the center would be processed, condensing one of the center nodes out of the stiffness matrix. When the constraint equations defining the rigid region were processed, a master node was named that no longer existed in the stiffness matrix, and the solution would terminate. This scenario would work as long as the constraint equations were processed in the right order. The ANSYS software, however, offered no means of controlling the order of constraint equation processing. The problem was circumvented by replacing the rigid region links between the pinhole and center nodes with a series of very stiff springs instead.

There was also a concern that adding large stiffness constants may adversely affect the condition of the element stiffness matrix, which would in turn adversely affect the reliability of the results. This was addressed by choosing a spring constant that was stiff enough to be considered rigid with respect to this region of the FEA model, but was no larger than the highest pivot term reported by the solver in previous solutions. In other words, the large terms added to the matrix for these stiff springs were no larger than the largest already there, and the condition of the matrix was not adversely affected.

5.2.2.3 Combined Frame - Body FEA Results

Figure 5-16 is a picture of the frame and body FEA model used for the frame twist analysis. The many colored arrows indicate the pressure applied to the inside faces of the body by the weight of the ore load. The spring elements representing the four struts can be seen in light blue. At the top of each spring element, rigid region constraint equations distribute the line-forces onto the appropriate nodes of the frame. At the lower ends of each strut spring, displacement boundary conditions constrain all nodal displacements.

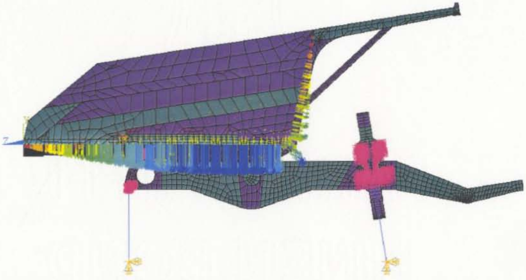


Figure 5-16: Frame and Dump Body FEA Model

The most pronounced shape of displacement observed with this frame analysis was torsion about the truck centerline. That is, the frame twists like a corkscrew in response to the opposing moments applied by a difference in the two front strut forces and the two rear strut forces. In the FEA, front and rear strut force differences were applied as vertical displacement differences in the lower nodes of the front and rear strut springs.

According to the collected strut pressure data, the moments about the truck centerline for the front and rear struts do not balance. This means, there is a significant moment component coming from the fact that the ore load is placed slightly off-center in the body. Even though the moment arm of ore load resulting force is a little as 145mm (the dump body is 8m wide), this moment must be taken into consideration in order to capture the true frame torsion present. It was possible to capture this effect by offsetting the load shape slightly in the load application algorithm. This would require, however, integrating the load shape function to determine the appropriate amount to offset the load. Instead, time was saved by applying a force couple that balanced the front and rear moments. This couple was applied as line forces acting along both outer edges of the body floor, far away from any regions of particular interest.

Ideally, we would like to re-run this analysis with an offset load shape rather than a force couple correction. Unfortunately, the resources required to re-solve the FEA model are no longer available. The version of ANSYS used by Memorial University of Newfoundland is the University high option, and is limited to 32,000 nodes. This finite element model was assembled and solved on an unlimited version of the ANSYS software licensed for use at SCL's Edmonton Research Center. The combined frame and dump body FEA model described here has over 930,000 nodes. Re-meshing the model to fit under the 32,000 node restriction would have detrimental effects on the convergence of the results.

The effect that frame torsion had on the dump body was as expected. Frame torsion causes localized bending in some bolster-stringer intersections, which result in tensile stresses. Furthermore, this occurs most extensively near the hinge pivots. This result is supported, at least in Syncrude's experience, by the fact that the bolster-stringer intersections in this region develop cracks first, regardless of the make or model of the haul truck. Under static conditions, parked fully loaded on uneven ground, the intersection between the sixth bolster from the front and the left-hand-side stringer had the greatest amount of tension present. To be more specific, the tension was present on the inside edge and the rearward-most rounded corner of the innermost bolster-stringer intersection (see Figure 3-2).

The bolster stiffeners in this hinge pin region are slightly different from those described earlier in that they are slightly smaller and are not tapered. Instead, they have a constant cross-section from the outer edge of the one stringer to the outer edge of the other. Outward from the stringers, these bolster stiffeners have a tapered cross-section like the rest. As described by Figure 5-17, the exaggerated results of the shell element model indicate the presence of localized bending stresses in this bolster-stringer intersection. The hypothesis presented earlier was that this bending would be reversed completely from that described in Figure 5-7, and would look similar to Figure 5-8. When subjected to a realistic frame deflection, however, the results were in fact a combination of both. Nonetheless, at the outer edge of this intersection, the bolster bottom plate is deformed upward, which is the appropriate direction to produce tension in the material near the weld toe.

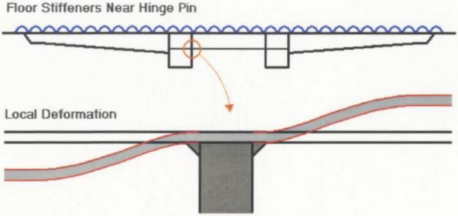


Figure 5-17: Floor Stiffener Deformation near Hinge Pins

The top and bottom results of the shell elements on either side of the stringer intersection indicate the state of stress through the bolster, with the assumption of a linear variation through the material thickness. From the trial analyses of Section 5.1, it was noted that the stress results at the corner intersection of a shell element analysis were not significantly different than the variation of stress through the thickness near the weld toe in a solid element model of the same region. It was therefore concluded that the shell element model does adequately represent this region, and the results obtained can be interpreted as follows:

The top and bottom results on the inward side of the intersection are –70 MPa and –170 MPa respectively (see Figure 5-18). The interpretation of this is that superimposed onto 120 MPa of uniform, compressive membrane stress in this area is 50 MPa of a pure bending stress. The combined state of stress, however, in entirely compression. On the outer edge, where cracking commonly occurs, the situation is different. This time, the top and bottom results indicate –168 MPa and +100 MPa respectively. Again, a secondary bending stress is superimposed onto a compressive membrane stress, however, this time the bending stress of 134 MPa is great enough to overcome the 34 MPa of compression, producing tension near the weld toe. This tension is causing the crack propagation problems of the area.

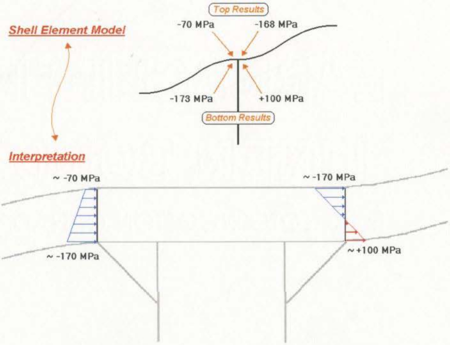


Figure 5-18: Interpretation of Shell Element Model Results

Again, it should be noted that this was an analysis of a static situation only. To reiterate slightly, the above analysis indicated that the frame of a mining truck does deflect under normal operating conditions, resulting in a displacement of the dump body supports, which is a form of structural loading. In response to this support displacement, localized bending stresses in some bolster-stringer intersections near the hinge pivots reverse with sufficient magnitude to produce tensile stresses. As a fully loaded haul truck drives over uneven ground, the frame can be expected to deflect similar to this, but back and forth, causing the stress at the weld toe to alternate between tension and compression. In addition to this, under dynamic conditions, one would expect the peak tension to be greater than that seen here under static conditions. It is the presence of alternating tensile stresses greater than 100 MPa, at the toe of a weld with poor fatigue resistance, that is causing the extensive cracking problems observed in this area.

Chapter: 6 Conclusions and Future Directions

The static analysis presented in this work, models the frame deflection of a fully loaded haul truck, parked at the shovel on uneven ground, prior to commencing a haul run (similar to Figure 6-1). In addition, this analysis models the effect this deflection has on the dump body, and the results indicate the presence of tensile stresses in the floor stiffener intersections. Since this deflection is actually a twist along the truck frame, we can expect that it will twist back and forth, as the truck drives over uneven ground, resulting in an alternating state of compression and tension. The magnitudes observed would easily explain fatigue cracking if present in a dynamic environment; and it is expected that a dynamic analysis of this truck would produce stresses greater than observed here. In conclusion, frame deflections caused by normal service conditions are the primary cause of fatigue cracking in the bolster-stringer intersections of mining truck dump bodies in oil sand operations.

Figure 6-1: Haul Truck Parked at Shovel, Receiving Last Load Pass

The frame, being the backbone of the entire truck structure, is the most crucial, most studied, and most analyzed part of the trucks design. Changing frame designs to better suit the dump body is not something that is likely to happen. The haul body, being significantly cheaper, is much more likely to be modified. It is the recommendation of this work to account for movement in the haul body supports when analyzing or designing future mining truck haul bodies.

New and improved haul truck designs, however, will do nothing to reduce the cost of maintaining existing fleets. Many companies, such as SCL, have large fleets of mining trucks currently in service. What can be done to mitigate the cost of weld repairs to these floor stiffener intersections? Several feasible alternatives exist including: replacing the current dump body design with one chosen specifically for its ability to accommodate frame deflections, and modifying existing body designs to improve the fatigue strength of the floor stiffener intersections.

6.1 Entire Body Replacement

Most standard haul truck bodies have a traditional box-style bolster-stringer floor stiffening arrangement, which has been demonstrated to not respond well to the normal frame deflections of the truck during service. Other stiffening arrangements, however, may accommodate frame torsions better. One such body design, by the Chilean manufacturer Dicsa-Tricon, is called the DT-HiLoad (shown in Figure 6-1). The DT-

HiLoad is a lightweight design with an unconventional floor stiffening arrangement currently being considered by SCL's truck maintenance group to replace the existing bodies for the entire 930E fleet.

The most notable difference in this design with respect to conventional designs is the reduction in the need for external wall stiffeners by utilizing the stiffness of curved plates. Although the floor does contain external stiffeners, they are of an I-Beam construction. Most significantly, the way these widthwise stiffeners intersect with the lengthwise stiffeners is different from traditional designs in that the intersection is not welded in place. Instead, reinforced contact pads are placed at the intersection (Figure 6-2). By allowing slight movements at this location, the cracking problems of traditional designs may be reduced.

Figure 6-2: DT-HiLoad Body Design - Close-up of Floor Stiffener Intersection

Syncrude Canada Limited has purchased one such body for trial purposes to see how this design will perform in oil sand mine operating conditions. In addition to this, there is a request from the truck maintenance group to investigate the relative performance of this new design when subjected to the same loading conditions. The recommendation for future work in this area is to conduct a FEA of this lightweight design, applying the same loading conditions studied earlier, and to compare the structural response of both designs. Together with the performance of the trial body soon to be in service, an educated decision should be possible as to which body design should be purchased as a replacement for the entire 930E fleet.

6.2 Modification of Existing Bodies

The other option to reduce the costs of weld repair would be to modify current designs. As stated before, localized bending in bolster-stringer intersections causes high stresses that the welds in the region are unable to withstand. Modifying the structural arrangement to reduce or eliminate this localized bending would be a cumbersome task, and one that is not feasible. Current cracking problems exist, however, not because high stresses exist in this region, but because a weld is located there as well. Intuitively, one could remedy the problem by removing the weld instead of the high stresses.

Although this is much easier said than done, the solution is quite ingenious. Simply cut out the troubled sections of the haul bodies and replace these sections with integral one-piece components of the same geometry. In the corners currently referred to as the bolster-stringer intersection, localized bending will continue to cause high stresses. These components, however, would be fabricated without welding and would replace the fillet welds of the intersection with rounded corners. This way, the fatigue life of the region would be substantially enhanced. Such components would have to be welded into place, but they can be welded with full-penetration butt-welds at locations away from the localized bending. Under much lower stress conditions, the fatigue life of these welds ought to be satisfactory.

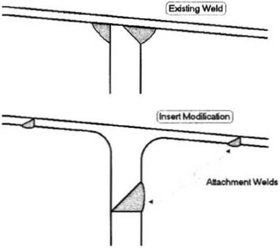


Figure 6-3: Modification Details

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Appendix A

Weld Repair Costs

EQUIPMENT	REG_HOURS	OT_HOURS	ACTUAL_COST	EST_HOURS	DESCRIPTION	DATE_BEGIN	DATE_END
45-17-81	10	0	$ 439.41	5	WELDING REPAIRS.		1998/03/06 0:00
45-17-81	6	0	$ 292.39	4	WELDING	1998/05/29 0:00	1998/05/29 0:00
45-17-81	12	0	$ 611.62	6	FIX BOX CRACKS	1998/12/01 0:00	1998/12/01 0:00
45-17-81	4	24	$ 1,797.58	24	REPAIR CRACKS IN BOX AS PER INSPECTION REPORT.	1999/01/05 0:00	1999/01/05 0:00
45-17-81	44	0	$ 2,088.13	24	REPAIR CRACKS IN BOX AS PER INSPECTION REPORT	1999/02/09 0:00	1999/02/09 0:00
45-17-81	14	60	$ 4,838.46	24	REPAIR CRACKS, FAB. AND INSTALL PLATES ON BACK END OF BOX.	1999/04/20 0:00	1999/04/20 0:00
45-17-81	0	0	$ -	12	REPAIR FRAME AND BOX CRACKS AS PER INSPECTION REPORT.	1999/05/25 0:00	1999/05/25 0:00
45-17-81	1	0	$ 48.48	12	REPAIR CRACKS AS PER INSPECTION REPORT.	1999/09/07 0:00	1999/09/07 0:00
45-17-81	0	0	$ -	16	REPAIR CRACKS. CHANGE BUSHINGS.	1999/10/12 0:00	1999/10/12 0:00
45-17-81	62	18	$ 4,210.77	24	COMPLETE WELDING REPAIRS AS PER INSPECTION REPORT	1999/11/16 0:00	1999/11/16 0:00
45-17-81	30	0	$ 1,308.60	24	COMPLETE WELDING REPAIRS AS PER INSPECTION REPORT	1999/12/21 0:00	1999/12/21 0:00
45-17-81	273	12	$ 21,983.13	24	WELDING MODS TO DUMP BODY	2000/03/03 0:00	2000/03/03 0:00
45-17-81	105	12	$ 6,809.59	72	COMPLETE WELD REPAIRS ON BOX AS PER INSPECTION REPORT	2000/04/06 0:00	2000/04/07 0:00
45-17-81	18	0	$ 862.05	5	REPAIR BOX CRACKS AS PER REPORT	2000/04/17 0:00	2000/04/17 0:00
45-17-81	0	0	$ -	5	REPAIR BOX MAIN FRAME CRACKS	2000/06/13 0:00	2000/06/13 0:00
45-17-81	202	0	$ 23,656.91	24	*REPLACE DUMP BODY DUE TO FATIGUE AND DAMAGE*	2000/07/17 0:00	2000/07/17 0:00
45-17-81	12	6	$ 1,149.20	12	COMPLETE WELDING REPAIRS AS PER INSPECTION REPORT	2000/09/26 0:00	2000/09/26 0:00
Totals:	*793*	*132*	*$ 70,096.32*	*317*	*02 Years 07 Months 23 Days*		
45-17-82	20	0	$ 997.43	12	REPAIR CRACKS AS PER INSPECTION REPORT.	1998/12/08 0:00	1998/12/08 0:00
45-17-82	0	0	$ -	12	REPAIR CRACKS IN BOX AS PER INSPECTION REPORT	1999/01/12 0:00	1999/01/12 0:00
45-17-82	20	0	$ 1,027.39	8	REPAIR CRACKS IN MAIN FRAME OF BOX AS PER INSPECTION REPORT	1999/02/16 0:00	1999/02/16 0:00
45-17-82	0	0	$ -	8	REPAIR CRACKS ON REAR OF BOX	1999/03/23 0:00	1999/03/23 0:00
45-17-82	0	0	$ -	8	FIX BOX MAIN BEAM CRACKS AS PER REPORT	1999/07/06 0:00	1999/07/06 0:00
45-17-82	48	0	$ 2,376.22	3	COMPLETE WELDING REPAIRS AS PER INSPECTION REPORT	1999/09/18 0:00	1999/09/18 0:00
45-17-82	24	0	$ 1,086.48	6	WELDING P.M. REPAIRS AS PER INSPECTION REPORT.	2000/02/01 0:00	2000/02/01 0:00
45-17-82	3	0	$ 144.12	3	REPAIR CRACKS AS PER REPORT	2000/05/16 0:00	2000/05/16 0:00
45-17-82	24	0	$ 1,398.77	36	REPAIR CRACKS AS PER INSPECTION REPORT.	2000/06/20 0:00	2000/06/20 0:00
45-17-82	12	0	$ 675.54	12	COMPLETE WELDING REPAIRS ON BOX AS PER INSPECTION REPORT	2000/10/02 0:00	2000/10/02 0:00
45-17-82	11	0	$ 611.55	24	REPAIR CRACKS AS PER INSPECTION REPORT	2000/11/11 0:00	2000/11/11 0:00
45-17-82	0	0	$ -	3	REPAIR CRACK AS PER REPORT	2000/11/11 0:00	2000/11/11 0:00
Totals:	*162*	*0*	*$ 8,317.50*	*135*	*01 Years 12 Months 04 Days*		
45-17-83	0	0	$ -	36	REPAIR CRACKS IN BOX AS PER INSPECTION REPORT.	1999/03/30 0:00	1999/03/30 0:00
45-17-83	25	2	$ 1,412.22	12	COMPLETE WELDING REPAIRS AS PER INSPECTION REPORT	1999/09/21 0:00	1999/09/21 0:00
45-17-83	149	2	$ 7,245.82	24	REPLACE CANOPY STIFFENER PLATES AND REPAIR CRACKS AS PER INS	1999/10/26 0:00	1999/10/26 0:00
45-17-83	20	0	$ 1,003.44	18	REPAIR CRACKS AS PER INSPECTION REPORT.	1999/11/30 0:00	1999/11/30 0:00
45-17-83	8	0	$ 362.16	8	COMPLETE WELDING REPAIRS AS PRE INSPECTION REPORT	2000/03/15 0:00	2000/03/15 0:00
45-17-83	4	0	$ 181.08	6	REPAIR CRACKS AS PER INSPECTION REPORT.	2000/04/18 0:00	2000/04/18 0:00
45-17-83	36	0	$ 2,283.48	24	BOX WELDING AS PER INSPECTION	2000/09/05 0:00	2000/09/05 0:00
45-17-83	36	12	$ 4,797.49	24	REPAIR CRACKS AS PER INSPECTION REPORT.	2000/10/10 0:00	2000/10/10 0:00
45-17-83	0	0	$ -	12	REPAIR CRACKS AS PER INSPECTION REPORT.	2000/11/14 0:00	2000/11/14 0:00
Totals:	*278*	*16*	*$ 17,285.69*	*164*	*01 Years 08 Months 17 Days*		
45-17-84	0	0	$ -	5	FIX BOX CRACKS AND LADDER	1998/12/22 0:00	1998/12/22 0:00
45-17-84	0	0	$ -	6	WELDING REPAIRS TO BOX	1999/01/26 0:00	1999/01/26 0:00
45-17-84	0	0	$ -	12	REPAIR CRACKING AND FISH PLATE REAR OF BOX	1999/04/06 0:00	1999/04/06 0:00

45-17-84	0	0	$	-	18	REPAIR BOX CRACKING AND EVALUATE WHEEL MOTOR CRACK.	1999/04/06 0:00	1999/04/06 0:00
45-17-84	0	0	$	-	12	WELD BOX CRACKS AS PER INSPECTION	1999/05/11 0:00	1999/05/11 0:00
45-17-84	0	0	$	-	8	FIX BOX CRACKS	1999/06/15 0:00	1999/06/15 0:00
45-17-84	0	0	$	-	7	REPAIR CRACKS AS PER REPORT	1999/07/22 0:00	1999/07/22 0:00
45-17-84	0	0	$	-	8	REPAIR CRACKS AS PER REPORT	1999/08/24 0:00	1999/08/24 0:00
45-17-84	36	34	$	10,185.92	16	COMPLETE WELDING REPAIRS AS PER INSPECTION REPORT	1999/11/08 0:00	1999/11/08 0:00
45-17-84	24	15	$	2,592.40	24	REPAIR CRACKS AS PER INSPECTION REPORT.	1999/12/07 0:00	1999/12/07 0:00
45-17-84	20	18	$	2,669.90	24	REPAIR CRACKS TO CANOPY AND MAIN BOX BEAMS.	2000/01/11 0:00	2000/01/11 0:00
45-17-84	14	33.5	$	3,496.01	24	COMPLETE WELD REPAIRS ON BOX AS PER INSPECTION REPORT	2000/01/28 0:00	2000/01/28 0:00
45-17-84	143	1	$	17,056.29	36	REMOVE AND FLIP BOX TO REPAIR CRACKING	2000/09/12 0:00	2000/09/12 0:00
45-17-84	98	6	$	9,810.86	12	REPAIR BOX CRACKINGAS PER REPORT	2000/09/12 0:00	2000/09/12 0:00
45-17-84	8	0	$	632.56	12	REPAIR BOX PIN CASTING CRACK	2000/09/12 0:00	2000/09/12 0:00
45-17-84	41	0	$	2,600.64	12	REPAIR BOX CRACKS AS PER INSPECTION REPORT.	2000/10/17 0:00	2000/10/17 0:00
45-17-84	0	0	$	-	24	REPLACE BOX WITH SPARE BOX DUE TO CRACKING	2000/11/23 0:00	2000/11/23 0:00
Totals:	*384*	*107.5*	*$*	*49,044.58*	*260*	*01 Years 12 Months 02 Days*		
45-17-85	14	0	$	677.87	8	FIX CRACKS IN BOX.	1998/11/24 0:00	1998/11/24 0:00
45-17-85	12	0	$	514.20	16	REPAIR CRACKS IN BOX AND INSTALL FISH PLATE AS PER INSPECTIO	1999/05/25 0:00	1999/05/25 0:00
45-17-85	0	0	$	-	18	REPAIR BOX CRACKS AS PER ATTACHED REPORT.	1999/06/22 0:00	1999/06/22 0:00
45-17-85	0	0	$	-	18	REPAIR BOX CRACKING BEFORE UNIT GOES BACK TO SERVICE.	1999/07/27 0:00	1999/07/27 0:00
45-17-85	28	2	$	3,314.40	8	REPAIR BOX CRACKS AS PER REPORT	1999/08/31 0:00	1999/08/31 0:00
45-17-85	11	0	$	526.32	12	REPAIR CRACKS AS PER INSPECTION REPORT.	1999/11/09 0:00	1999/11/09 0:00
45-17-85	48	6.5	$	3,186.59	4	REPAIR CRACK TO LEFT SIDE BOX PIN CASTING	2000/03/28 0:00	2000/03/28 0:00
45-17-85	116	8	$	6,600.52	18	REPAIR TWO CRACKS IN BOX MAIN RAIL.	2000/03/28 0:00	2000/03/28 0:00
45-17-85	36	0	$	1,828.50	12	COMPLETE WELDING REPAIRS AS PER INSPECTION REPORT	2000/05/02 0:00	2000/05/02 0:00
45-17-85	24	0	$	1,229.16	24	REPAIR CRACKS AS PER REPORT	2000/07/11 0:00	2000/07/11 0:00
45-17-85	34	0	$	2,156.62	24	REPAIR CRACKS AS PER INSPECTION	2000/08/15 0:00	2000/08/15 0:00
45-17-85	66	102.5	$	12,312.29	48	REPAIR BOX CRACKS AS PER INSPECTION REPORT.	2000/09/19 0:00	2000/09/19 0:00
45-17-85	0	0	$	-	12	REPAIR BOX CRACKS AS PER REPORT	2000/10/23 0:00	2000/10/23 0:00
45-17-85	30	0	$	1,524.12	5	REPAIR BOX CRACKS AS PER REPORT	2000/10/23 0:00	2000/10/23 0:00
45-17-85	0	0	$	-	16	COMPLETE WELD REPAIRS ON BOX AS PER INSPECTION REPORT	2000/10/30 0:00	2000/10/30 0:00
Totals:	*419*	*119*	*$*	*33,870.59*	*243*	*01 Years 12 Months 06 Days*		
45-17-86	0	0	$	-	36	REPAIR CRACKS, FABRICATE AND INSTALL FISH PLATE	1999/06/28 0:00	1999/06/28 0:00
45-17-86	0	0	$	-	36	COMPLETE WELDING REPAIRS AS PER INSPECTION REPORT	1999/08/04 0:00	1999/08/04 0:00
45-17-86	0	0	$	-	24	REPAIR CRACKS AT REAR OF BOX	1999/08/09 0:00	1999/08/09 0:00
45-17-86	0	24	$	1,751.52	12	BOX WELDING	2000/01/01 0:00	2000/01/01 0:00
45-17-86	30	12	$	2,261.48	16	COMPLETE WELDING REPAIRS TO BOX AS PER INSPECTION REPORT	2000/01/31 0:00	2000/01/31 0:00
45-17-86	78	48	$	8,638.36	36	REPAIR BOX CRACKS.	2000/02/10 0:00	2000/02/10 0:00
45-17-86	219	2	$	12,246.70	12	REPAIR BOX CRACKS AS PER INSPECTION REPORT.	2000/03/01 0:00	2000/03/01 0:00
45-17-86	0	0	$	-	5	REPAIR CRACK IN OUTBOARD SIDE OF LEFT BOX PIN CASTING.	2000/03/25 0:00	2000/03/25 0:00
45-17-86	6	0	$	288.24	8	REPAIR CRACKS AND BROKEN GENERATOR BRACKETS	2000/05/10 0:00	2000/05/10 0:00
45-17-86	0	0	$	-	5	REPAIR CRACKS AS PER REPORT	2000/06/14 0:00	2000/06/14 0:00
45-17-86	134.5	21	$	11,604.66	24	REPAIR BOX CRACKS AS PER INSPECTION REPORT.	2000/08/24 0:00	2000/08/24 0:00
45-17-86	3	0	$	117.00	8	REPAIR CRACKS AS PER REPORT	2000/11/01 0:00	2000/11/01 0:00
Totals:	*470.5*	*107*	*$*	*36,907.96*	*222*	*01 Years 05 Months 06 Days*		
45-17-87	0	0	$	-	8	REPAIR CRACKS IN UNIT AS PER INSPECTION REPORT	1999/03/25 0:00	1999/03/25 0:00

45-17-87	0	22	$	1,592.80	12 REPAIR CRACKS AS PER INSPECTION REPORT.	1999/06/02 0:00	1999/06/02 0:00
45-17-87	24	0	$	1,198.17	12 REPAIR CANOPY CRACK AND BOX CRACKS AS PER REPORT	1999/08/28 0:00	1999/08/28 0:00
45-17-87	14	0	$	840.00	12 REPAIR 2 LARGE BOX MAIN BEAM CRACKS AND OTHERS IF TIME PERMI	1999/10/09 0:00	1999/10/09 0:00
45-17-87	44.5	0	$	1,906.83	24 REPAIR CRACKS AT BACK OF BOX AS MARKED.	1999/10/20 0:00	1999/10/20 0:00
45-17-87	40	0	$	2,137.92	48 COMPLETE WELDING REPAIRS AS PER INSPECTION REPORT	1999/11/24 0:00	1999/11/24 0:00
45-17-87	14	0	$	840.00	24 REPAIR CRACKS IN UNIT AS PER INSPECTION REPORT	1999/11/29 0:00	1999/11/29 0:00
45-17-87	28	41	$	4,582.71	24 REPAIR CRACKS AS PER ATTACHED REPORT	1999/12/05 0:00	1999/12/05 0:00
45-17-87	0	0	$	-	12 REPAIR BOX CRACK AS PER INSPECTION REPORT.	2000/01/05 0:00	2000/01/05 0:00
45-17-87	2	0	$	96.08	8 MODIFICATION AND REPAIR CRACKS AS PER REPORT	2000/05/17 0:00	2000/05/17 0:00
45-17-87	26	6.5	$	2,155.21	9 REPAIR CRACKS AS PER REPORT	2000/07/26 0:00	2000/07/26 0:00
45-17-87	23	0	$	1,458.89	18 REPAIR CRACKS AS PER REPORT	2000/10/04 0:00	2000/10/04 0:00
45-17-87	2	0	$	114.85	12 REPAIR CRACKS AS PER REPORT	2000/11/10 0:00	2000/11/10 0:00
45-17-87	0	0	$	-	12 COMPLETE WELDING REPAIRS AS PER INSPECTION REPORT	2000/11/11 0:00	2000/11/11 0:00
Totals:	*217.5*	*69.5*	*$*	*16,923.46*	*235* *01 Years 08 Months 19 Days*		

45-17-88	0	0	$	-	8 PM REPAIRS (WELDING ON BOX) TRANSWEST	1999/02/25 0:00	1999/02/25 0:00
45-17-88	0	0	$	-	24 REPAIR CRACKS IN BOX AS PER INSPECTION REPORT.	1999/03/31 0:00	1999/03/31 0:00
45-17-88	0	0	$	-	36 BOX WELDING - MODIFY RAILS	1999/04/21 0:00	1999/04/21 0:00
45-17-88	0	0	$	-	24 WELDING ON BOX BY TRANSWEST (CRACKING AT REAR)	1999/05/07 0:00	1999/05/07 0:00
45-17-88	38	4	$	2,569.60	24 COMPLETE WELDING REPAIRS ON BOX AS PER INSPECTION REPORT	1999/06/09 0:00	1999/06/09 0:00
45-17-88	0	0	$	-	24 REPAIR DAMAGE & CRACKING TO BOX	1999/09/22 0:00	1999/09/22 0:00
45-17-88	6	0	$	404.46	12 SANDBLAST BOX AROUND CRACK	1999/10/14 0:00	1999/10/14 0:00
45-17-88	24	0	$	1,236.12	48 REPAIR CRACKING IN BOX AND FRAME	1999/10/27 0:00	1999/10/27 0:00
45-17-89	18	35	$	3,499.34	24 COMPLETE WELDING REPAIRS AS PER INSPECTION REPORT	1999/11/03 0:00	1999/11/03 0:00
45-17-88	6	0	$	5,276.39	4 COMPLETE WELDING REPAIRS AS PER INSPECTION REPORT	1999/11/25 0:00	1999/11/25 0:00
45-17-88	8	0	$	362.16	12 COMPLETE WELDING REPAIRS AS PER INSPECTION REPORT	2000/03/16 0:00	2000/03/16 0:00
45-17-89	0	0	$	-	36 REPAIR CRACKS IN BOX	2000/03/19 0:00	2000/03/19 0:00
45-17-89	0	0	$	-	36 REPAIR BOX CRACKS AT REAR OF BOX	2000/03/26 0:00	2000/03/26 0:00
45-17-88	45	0	$	2,127.61	12 REPAIR BOX CRACKS AS PER INSPECTION REPORT.	2000/05/24 0:00	2000/05/24 0:00
45-17-88	0	0	$	-	12 REPAIR WELDING AS PER INSPECTION REPORT	2000/06/28 0:00	2000/06/28 0:00
45-17-88	12	2	$	831.24	12 REPAIR CRACKS AND INSTALL STIFFENER PLATES AS PER INSPECTION	2000/07/25 0:00	2000/07/25 0:00
45-17-88	0	0	$	-	12 COMPLETE WELDING REPAIRS AS PER INSPECTION REPORT	2000/10/12 0:00	2000/10/12 0:00
Totals:	*157*	*41*	*$*	*16,306.92*	*360* *01 Years 08 Months 17 Days*		

Summary:

Total Cost:	$	248,753	**IN**	02 Years	09 Months
Cost/Unit:	$	31,094			
Total Cost / Year	$	88,775			
Total Cost / Unit / Year	$	11,097			

Down Time:	3473 Hrs	**IN**	02 Years	09 Months
Down Time / Unit:	434 Hrs			
Down Time / Year	1239 Hrs			
Down Time / Unit / Year	155 Hrs			

Appendix B

ANSYS Input Files

Table of Contents

❖ *Filename: 1_Main_INPUT*

```
!@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@

!       FEA of 930E Truck Box Structure

!@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~ Geometry Creation ~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
:build
! Setting Analsys Options, Element types, and Material Properties
        FINISH
        /CLEAR
        /CLEAR
        /FILNAM,geom
        /INPUT,2_1_setup_INPUT,,,:setup,0
!       /NERR,0,,                    ! Error Message Suppression
! Creating Geometry and Saving Database
        /INPUT,2_2_build_floor_INPUT,,,,0      ! Floor
        /INPUT,2_3_build_wall_INPUT,,,,0       ! Wall
        /INPUT,2_4_build_front_INPUT,,,,0      ! Front
        /INPUT,2_5_build_canopy_INPUT,,,,0     ! Canopy
        /INPUT,2_6_round_corners_INPUT,,,,0 ! Rounding Bolster Corners
        /INPUT,2_7_SCL_mods_INPUT,,,,0      ! SCL Modifications
! Assigning Thickness and Material Properties to All Areas
        /INPUT,3_1_assignprop_floor_INPUT,,,,0              ! Floor
        /INPUT,3_2_assignprop_wall_INPUT,,,,0               ! Wall
        /INPUT,3_3_assignprop_front_INPUT,,,,0          ! Front
        /INPUT,3_4_assignprop_canopy_INPUT,,,,0         ! Canopy
        /INPUT,3_5_add_guidepin_INPUT,,,,0  ! Canopy
SAVE                                 ! Saving geom.db
/EOF

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~ Finite Element Model ~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
:mesh
FINISH
FINISH
/CLEAR
RESUME,geom.db
!/NERR,0,10000,                      ! Error Message Suppression

                ! FE Meshing
/INPUT,4_1_FEA_manual_mesh_INPUT,,,,0      ! Meshing Routine

/FILNAME,mesh
SAVE            ! Saving Mesh.db
/EOF

:bcs
FINISH
FINISH
/CLEAR
RESUME,mesh.db

                ! Boundary Conditions
*SET,hingetyp,2                      ! 1=Bearing Forces 2=Rigid about Center
*SET,STRtype,3                       ! 1=Distributed 2=Line 3=Rubber
*SET,UyPin,0.0                       ! Uy Applied at HingePin
*SET,UyNose,0.0                      ! Uy Applied at Nose
*SET,Shim,0                          ! 0=Off 1=On
*SET,Amt_Shim,1.0                    ! Amount Of Steel Shim Added or Subrtacted
*SET,Loadcell,0                      ! 0=Off 1=On

/INPUT,4_3_FEA_support_INPUT,,,,0  ! Support BC's
```

```
!/INPUT,4_4_FEA_load_algorithm_INPUT,,/home/dw11589/930E_Full,1,

                        ! Symmetry Conditions
!/INPUT,4_5_FEA_symm_INPUT,,,,0              ! Symmetry BC's
!/INPUT,4_6_FEA_antisymm_INPUT,,,,0          ! Anti-Symm. BC's


!/FILNAM,BATCH
!SAVE                               ! Saving FEA.db


!/SOLU
!PIVCHECK,1              ! Pivot Check (Off=0) (On=1)
!SOLVE                   ! Solve Current Load Step
!LSSOLVE,1,3,1,          ! Solve Load Steps 1 thru 3, incr 1
!FINISH

!/DELETE,BATCH,emat,
!/DELETE,BATCH,esav,
!/DELETE,BATCH,mntr,
!/DELETE,BATCH,stat,
!/DELETE,BATCH,tri,                 ! Cleanup

/EOF !*****************************************************

:post
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~ Post Processing ~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~


!/INPUT,5_1_post_StressPath_INPUT,,,,0       ! Bolster Path Routine
/INPUT,5_2_post_USUM_INPUT,,,,0              ! Plot USUM Routine

/EOF
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~


!*****************************************************
!*****************************************************
FINISH
FINISH
/FILNAM,test
SAVE                                ! Saving test.db
/EOF

:here
FINISH
FINISH
/CLEAR
RESUME,test.db
/PREP7
APLOT

!*****************************************************
!*****************************************************
```

❖ *Filename: 2_1_Setup_INPUT*

```
!@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
!                              Analysis Setup
!@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@

:setup
/TITLE,Analysis Setup

/NOPR
KEYW,PR_SET,1
KEYW,PR_STRUC,1
/COM,Preferences for GUI filtering have been set to display:
/COM,  Structural

/PREP7
ET,1,SHELL93                ! Defining Shell Element Type
KEYOPT,1,4,0
KEYOPT,1,5,0
KEYOPT,1,6,0

                    ! Defining Real Constants
R,3,3, , , , , ,             ! 1/8" Exhaust Plenum
R,5,5, , , , , ,             ! 5mm Thickness
R,8,8, , , , , ,             ! 8mm Thickness
R,9,9, , , , , ,             ! 9mm Thickness
R,12,12, , , , , ,           ! 12mm Thickness
R,14,14, , , , , ,           ! 14mm Thickness
R,16,16, , , , , ,           ! 16mm Thickness
R,18,17.7, , , , , ,         ! 5mm + 1/2" Thickness
R,19,19, , , , , ,           ! 3/4" Thickness
R,21,20.7, , , , , ,         ! 8mm + 1/2" Thickness
R,22,21.7, , , , , ,         ! 9mm + 1/2" Thickness
R,25,25, , , , , ,           ! 1" Thickness
R,29,28.575, , , , , ,       ! 5/8"+1/2" Thickness or 1 1/8" Plate
R,35,35, , , , , ,           ! 11/8" Thickness
R,38,38, , , , , ,           ! 38mm Thickness
R,44,44, , , , , ,           ! 3/4" + 1"
R,54,54, , , , , ,           ! 1 1/8" + 1" FishPlate
R,63,63.5, , , , , ,         ! 1.5" + 1" Thickness
R,90,90, , , , , ,           ! 90mm Thickness

                    ! Material Properties
        ! Material #1
        ! 690 MPa Tensile Strength
        ! 620 Mpa Yield Strength
        ! Elognation in 50mm - 18%
        ! Modulus is Unknown
UIMP,1,EX, , ,207000,               ! Modulus in N/mm^2
UIMP,1,DENS, , ,0.00000786,         ! Density in kg/mm^3
UIMP,1,PRXY, , ,.3,

        ! Material #2
        ! 1379 MPa Tensile Strength
        ! Yield Strength Unknown
        ! Elognation in 50mm - Unknown
        ! Modulus is Unknown
!UIMP,2,EX, , ,207000,              ! Modulus in N/mm^2
!UIMP,2,DENS, , ,0.00000786,        ! Density in kg/mm^3
!UIMP,2,PRXY, , ,0.3,

FINISH
/EOF
```

❖ *Filename: 2_2_build_floor_INPUT*

```
!@@@@@@@@@@@@@@@@@@@@@@@@@@@
@@@@@@@@@@@@@@@@@@@@@@@@@@
!       FEA of 930E Truck Box Structure
!       Floor Geometry Construction Routine

:build

FINISH
FINISH

!/CLEAR
!/NERR,0,,                        ! Warning
Supression
!RESUME,setup.db
!/FILNAM,build_floor
!RESUME,geom.db

/FILNAM,geom
/TITLE,Building Floor Geometry

/PREP7

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
! ~~~~~~~~~~~~ Floor Construction
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
                                  ! Defined Parameters
*SET,bxlength,8105
*SET,bxwidth,7915
*SET,tonnes,320

                                  ! Creating Keypoints
K,1,0,0,0,
K,2,bxwidth/2,0,0,
K,3,bxwidth/2,0,-bxlength,
K,4,0,0,-bxlength,

FLST,2,4,3                        ! Floor Plate Area
FITEM,2,1
FITEM,2,2
FITEM,2,3
FITEM,2,4
A,P51X
CM,_Y,AREA
ASEL, , , ,     1
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    15,  2,    0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~ Bolsters
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

                                  ! EG9394 Angle, Rear
RH Item #16
                                  ! Keypoints
K,5,0,-340,0,
K,6,(bxwidth/2)-120,-115,0,
FLST,2,4,3
FITEM,2,1
FITEM,2,5
FITEM,2,6
FITEM,2,2
A,P51X                            ! Rear Area
FLST,3,1,5,ORDE,1                 ! Copy of Area
FITEM,3,2
AGEN,2,P51X, , , , ,-635, ,0
FLST,2,4,3
FITEM,2,6
FITEM,2,9
FITEM,2,8
FITEM,2,5
A,P51X                            ! Bottom Area

APLOT
/VIEW, 1 ,1,1,1
/USER, 1
/VIEW, 1, -0.391990212388   , -0.705334606237   ,
0.590632514036
/ANG, 1,  174.710908189
/AUTO, 1
/REP

                                  ! EG9379 Bolster, Rear
RH Item #14
FLST,3,1,5,ORDE,1
FITEM,3,2
AGEN,2,P51X, , , , ,-1535, ,0! Copying Rear Area to
Location
FLST,3,1,5,ORDE,1
FITEM,3,5
FLST,3,1,5,ORDE,1
FITEM,3,5
AGEN,2,P51X, , , , ,-350, ,0   ! Copying Area to other
side
FLST,2,4,3
FITEM,2,13
FITEM,2,17
FITEM,2,16
FITEM,2,12
A,P51X                            ! Creating Bottom


FLST,3,3,5,ORDE,2                 ! Item #12
FITEM,3,5
FITEM,3,-7
AGEN,2,P51X, , , , ,-2740+1535, ,0

FLST,3,3,5,ORDE,2                 ! Item #11
FITEM,3,5
FITEM,3,-7
AGEN,2,P51X, , , , ,-3690+1535, ,0

FLST,3,3,5,ORDE,2                 ! Item #10
FITEM,3,5
FITEM,3,-7
AGEN,2,P51X, , , , ,-4360+1535, ,0

FLST,3,3,5,ORDE,2                 ! Item #9
FITEM,3,5
FITEM,3,-7
AGEN,2,P51X, , , , ,-5035+1535, ,0


FLST,3,3,5,ORDE,2                 ! Item #7
FITEM,3,5
FITEM,3,-7
AGEN,2,P51X, , , , ,-5705+1535, ,0
```

```
KL,73,.25, ,
FLST,3,1,3,ORDE,1
FITEM,3,59
KGEN,2,P51X, , ,bxwidth/2, , , ,0
FLST,2,4,3
FITEM,2,60
FITEM,2,58
FITEM,2,55
FITEM,2,59
A,P51X
ASBA,    22,    23
FLST,2,4,3
FITEM,2,61
FITEM,2,58
FITEM,2,55
FITEM,2,59
A,P51X
FLST,2,2,5,ORDE,2
FITEM,2,21
FITEM,2,25
ADELE,P51X, , ,1

FLST,3,3,5,ORDE,3                                  ! Item #5
FITEM,3,20
FITEM,3,22
FITEM,3,24
ARSYM,Z,P51X, , , ,0,0
FLST,3,3,5,ORDE,3
FITEM,3,21
FITEM,3,23
FITEM,3,25
AGEN, ,P51X, , , , ,-12620, , ,1

FLST,3,3,5,ORDE,3                                  ! Item #3
FITEM,3,21
FITEM,3,23
FITEM,3,25
AGEN,2,P51X, , , , ,-7730+6915, ,0

                                                   ! Dividing Top
Area
FLST,2,1,5,ORDE,1
FITEM,2,1
FLST,3,1,5,ORDE,1
FITEM,3,3
ASBA,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,30
FLST,3,1,5,ORDE,1
FITEM,3,5
ASBA,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,1
FLST,3,15,5,ORDE,13
FITEM,3,6
FITEM,3,8
FITEM,3,-9
FITEM,3,11
FITEM,3,-12
FITEM,3,14
FITEM,3,-15
FITEM,3,17
FITEM,3,-18
FITEM,3,20
FITEM,3,-23
FITEM,3,26
FITEM,3,-27
ASBA,P51X,P51X, , ,KEEP

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

!~~~~~~~~~~~~~~~~~~    Rear Stringer
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

                                                   ! Keypoints for
Stringer Tail
K, ,(33*20.5+233),0,-635,
K, ,(33*20.5+233),-370,-635,
K, ,(33*20.5+233),-370,-1535,
K, ,(33*20.5+233),0,-1535,

                                                   ! Stringer Tail
Areas
LSTR,    75,    76
LSBL,     2,     9
LDELE,    130, , ,1
LSTR,    75,    78
LSTR,    78,    77
LSTR,    77,    79

FLST,3,1,4,ORDE,1
FITEM,3,4
LGEN,2,P51X, , , , ,635, ,0
LSTR,    76,    75
LSTR,    79,    80

FLST,2,4,4
FITEM,2,132
FITEM,2,133
FITEM,2,4
FITEM,2,134
AL,P51X
FLST,2,4,4
FITEM,2,4
FITEM,2,2
FITEM,2,130
FITEM,2,131
AL,P51X

K, ,(33*20.5+233),0,-1535-350,                     ! Stringer Tail
Keypoints
K, ,(33*20.5+233),-370,-1535-350,
K, ,(33*20.5+233),0,-2740+150,
K, ,(33*20.5+233),-370,-2740+150,

FLST,2,4,3
FITEM,2,81
FITEM,2,83
FITEM,2,84
FITEM,2,82
A,P51X                                             ! Stringer Tail
Area

FLST,2,1,4,ORDE,1
FITEM,2,130
FLST,3,1,4,ORDE,1
FITEM,3,15
LSBL,P51X,P51X, , ,KEEP
FLST,2,1,4,ORDE,1
FITEM,2,138
FLST,3,1,4,ORDE,1
FITEM,3,19
LSBL,P51X,P51X, , ,KEEP                            ! Dividing
Lines

FLST,2,4,3
FITEM,2,85
FITEM,2,86
FITEM,2,82
```

```
FITEM,2,77
A,P51X                                   ! Creating Little
Area

                              ! Keypoints for Stringer Tail
K, ,33*20.5,0,-635,
K, ,33*20.5,-370,-635,
K, ,33*20.5,-370,0,
K, ,33*20.5,0,0,

LSTR,    90,   89
LSBL,   143,    6
LDELE,    144, , ,1
FLST,3,1,4,ORDE,1
FITEM,3,145
LGEN,2,P51X, , , , ,-635, ,0
FLST,2,4,3
FITEM,2,92
FITEM,2,87
FITEM,2,90
FITEM,2,91
A,P51X                                   ! Area inside
Stringer tail
FLST,3,2,5,ORDE,2
FITEM,3,48
FITEM,3,-49
AGEN,2,P51X, , ,-233, , , ,0             ! Copying
Areas to form Stringer Sides

FLST,3,2,4,ORDE,2
FITEM,3,139
FITEM,3,-140
LGEN,2,P51X, , ,-233, , , ,0
FLST,2,4,3
FITEM,2,102
FITEM,2,99
FITEM,2,92
FITEM,2,87
A,P51X
FLST,2,4,3
FITEM,2,92
FITEM,2,79
FITEM,2,77
FITEM,2,99
A,P51X
FLST,2,4,3
FITEM,2,77
FITEM,2,82
FITEM,2,96
FITEM,2,99
A,P51X
FLST,2,4,3
FITEM,2,82
FITEM,2,84
FITEM,2,95
FITEM,2,96
A,P51X                                   ! Created
Bottom of Stringer Tail


FLST,2,1,5,ORDE,1
FITEM,2,3
FLST,3,2,4,ORDE,2
FITEM,3,4
FITEM,3,143
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,4
FLST,3,2,4,ORDE,2
FITEM,3,134
FITEM,3,147
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,29
FLST,3,2,4,ORDE,2
FITEM,3,133
FITEM,3,146
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,2
FLST,3,2,4,ORDE,2
FITEM,3,132
FITEM,3,145
ASBL,P51X,P51X, , ,KEEP                 ! Dividing
Areas in Rear Angle Bolster

FLST,2,1,5,ORDE,1
FITEM,2,6
FLST,2,1,5,ORDE,1
FITEM,2,52
FLST,2,1,5,ORDE,1
FITEM,2,52
FLST,3,1,5,ORDE,1
FITEM,3,7
ASBA,P51X,P51X, , ,KEEP
ADELE,      2, , ,1
FLST,2,1,5,ORDE,1
FITEM,2,5
FLST,3,2,5,ORDE,2
FITEM,3,47
FITEM,3,53
ASBA,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,7
FLST,3,2,5,ORDE,2
FITEM,3,49
FITEM,3,66
ASBA,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,6
FLST,3,2,5,ORDE,2
FITEM,3,48
FITEM,3,51
ASBA,P51X,P51X, , ,KEEP                 ! Dividing
Areas

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~  Forward Stringer
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

K, ,32*20.5,-440,-4235,
K, ,32*20.5,0,-4235,
K, ,32*20.5+14*20.5,-440,-4235,
K, ,32*20.5+14*20.5,0,-4235,

K, ,756,-440,-bxlength,
K, ,756,0,-bxlength,
K, ,756+14*20.5,-440,-bxlength,
K, ,756+14*20.5,0,-bxlength,

FLST,2,4,3
FITEM,2,107
FITEM,2,108
FITEM,2,112
FITEM,2,111
A,P51X
FLST,2,4,3
FITEM,2,105
FITEM,2,106
FITEM,2,110
```

```
FITEM,2,109
A,P51X                          ! Creating Forward
Stringer

FLST,2,15,5,ORDE,2
FITEM,2,14
FITEM,2,-28
FLST,2,15,5,ORDE,2
FITEM,2,14
FITEM,2,-28
FLST,3,2,5,ORDE,2
FITEM,3,6
FITEM,3,72
ASBA,P51X,P51X, , ,KEEP   ! Dividing Bolster Areas

FLST,2,4,3
FITEM,2,148
FITEM,2,147
FITEM,2,149
FITEM,2,150
A,P51X
FLST,2,4,3
FITEM,2,145
FITEM,2,146
FITEM,2,152
FITEM,2,151
A,P51X
FLST,2,4,3
FITEM,2,136
FITEM,2,135
FITEM,2,141
FITEM,2,142
A,P51X
FLST,2,4,3
FITEM,2,133
FITEM,2,134
FITEM,2,144
FITEM,2,143
A,P51X
FLST,2,4,3
FITEM,2,137
FITEM,2,138
FITEM,2,131
FITEM,2,132
A,P51X
FLST,2,4,3
FITEM,2,139
FITEM,2,140
FITEM,2,130
FITEM,2,129
A,P51X
FLST,2,4,3
FITEM,2,128
FITEM,2,127
FITEM,2,123
FITEM,2,124
A,P51X
FLST,2,4,3
FITEM,2,125
FITEM,2,126
FITEM,2,122
FITEM,2,121
A,P51X
FLST,2,4,3
FITEM,2,120
FITEM,2,119
FITEM,2,115
FITEM,2,116
A,P51X
FLST,2,4,3
FITEM,2,117
FITEM,2,118
FITEM,2,114
FITEM,2,113
A,P51X

FLST,3,5,5,ORDE,5
FITEM,3,15
FITEM,3,17
FITEM,3,19
FITEM,3,21
FITEM,3,23
ASBA,    72,P51X
FLST,3,5,5,ORDE,5
FITEM,3,14
FITEM,3,16
FITEM,3,18
FITEM,3,20
FITEM,3,22
ASBA,     6,P51X  ! Removing Bolster Holes in Front
Stringer

LANG,   191,    146,90,0,  0.9878158211681047E-01
LANG,   187,    147,90,0,  0.1071629505009111
KL,190,.5, ,
KL,186,.5, ,
FLST,2,3,3
FITEM,2,154
FITEM,2,156
FITEM,2,111
A,P51X
FLST,2,3,3
FITEM,2,153
FITEM,2,155
FITEM,2,109
A,P51X

ASBA,    15,     6
ASBA,    24,     14              ! Chopping Stringer Edge
Angle Area


FLST,2,4,3
FITEM,2,107
FITEM,2,105
FITEM,2,153
FITEM,2,154
A,P51X
FLST,2,4,3
FITEM,2,153
FITEM,2,155
FITEM,2,156
FITEM,2,154
A,P51X
FLST,2,4,3
FITEM,2,155
FITEM,2,110
FITEM,2,112
FITEM,2,156
A,P51X                  ! Closing Front Stringer (Added
Outer Plates)

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~  Pivot Structure
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

K, ,48*20.5,-370,-2740+50,
K, ,48*20.5,-440,-2740-370,
K, ,48*20.5,-440,-4090,
K, ,48*20.5,0,-4090,
```

```
K, ,48*20.5,0,-2740+50,
!K, ,970,-370,-2740+50,
!K, ,970,-440,-2740-370,
!K, ,970,-440,-4090,
!K, ,970,0,-4090,
!K, ,970,0,-2740+50,


FLST,2,5,3
FITEM,2,109
FITEM,2,111
FITEM,2,157
FITEM,2,158
FITEM,2,159
A,P51X                              ! Pivot
Structure Side Area

FLST,2,6,5,ORDE,2
FITEM,2,8
FITEM,2,-13
FLST,3,1,5,ORDE,1
FITEM,3,18
ASBA,P51X,P51X, ,DELETE,KEEP
FLST,2,6,5,ORDE,6
FITEM,2,19
FITEM,2,21
FITEM,2,24
FITEM,2,-25
FITEM,2,27
FITEM,2,118
ADELE,P51X, , ,1                    ! Deleting
Bolsters Inside Pivot

FLST,3,1,5,ORDE,1
FITEM,3,18
AGEN,2,P51X, , ,-383, , , ,0        ! Creating
Otherside


FLST,2,4,3
FITEM,2,160
FITEM,2,162
FITEM,2,163
FITEM,2,161
A,P51X
FLST,2,4,3
FITEM,2,165
FITEM,2,164
FITEM,2,166
FITEM,2,167
A,P51X
FLST,2,1,5,ORDE,1
FITEM,2,18
FLST,3,2,5,ORDE,2
FITEM,3,9
FITEM,3,-10
ASBA,P51X,P51X, , ,KEEP             ! Divided
Outside Area

FLST,3,2,4,ORDE,2
FITEM,3,295
FITEM,3,306
FLST,3,2,4,ORDE,2
FITEM,3,31
FITEM,3,33
LGEN,2,P51X, , , ,-234, , ,0
FLST,3,1,4,ORDE,1
FITEM,3,287
LGEN,2,P51X, , , , ,-275, ,0
FLST,3,1,4,ORDE,1
FITEM,3,303
LGEN,2,P51X, , , , ,275, ,0         ! Construction
Lines

FLST,2,1,4,ORDE,1
FITEM,2,287
FLST,3,1,4,ORDE,1
FITEM,3,38
LSBL,P51X,P51X, , ,KEEP
FLST,2,1,4,ORDE,1
FITEM,2,303
FLST,3,1,4,ORDE,1
FITEM,3,39
LSBL,P51X,P51X, , ,KEEP
LSBL,    38,    41
LSBL,    39,    43
LSTR,    177,    162
LSTR,    173,    164
FLST,2,2,4,ORDE,2
FITEM,2,38
FITEM,2,302
LDELE,P51X, , ,1                    ! Dividing
Lines

FLST,2,4,3
FITEM,2,160
FITEM,2,162
FITEM,2,177
FITEM,2,169
A,P51X
FLST,2,4,3
FITEM,2,164
FITEM,2,166
FITEM,2,172
FITEM,2,173
A,P51X
FLST,2,1,5,ORDE,1
FITEM,2,9
FLST,3,1,5,ORDE,1
FITEM,3,12
ASBA,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,10
FLST,3,1,5,ORDE,1
FITEM,3,13
ASBA,P51X,P51X, , ,KEEP             ! Dividing
Areas

FLST,3,2,5,ORDE,2
FITEM,3,12
FITEM,3,-13
AGEN,2,P51X, , ,-48*20.5, , , ,0

FLST,2,4,3
FITEM,2,19
FITEM,2,175
FITEM,2,169
FITEM,2,160
A,P51X
FLST,2,4,3
FITEM,2,175
FITEM,2,174
FITEM,2,177
FITEM,2,169
A,P51X
FLST,2,4,3
FITEM,2,177
FITEM,2,174
FITEM,2,23
FITEM,2,162
```

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A,P51X
FLST,2,4,3
FITEM,2,27
FITEM,2,180
FITEM,2,173
FITEM,2,164
A,P51X
FLST,2,4,3
FITEM,2,173
FITEM,2,180
FITEM,2,179
FITEM,2,172
A,P51X
FLST,2,4,3
FITEM,2,166
FITEM,2,172
FITEM,2,179
FITEM,2,31
A,P51X
FLST,2,2,5,ORDE,2
FITEM,2,10
FITEM,2,19
ADELE,P51X, , ,1                        ! Creating Tapered
Bolsters Inside Pivot


FLST,2,3,5,ORDE,3
FITEM,2,21
FITEM,2,24
FITEM,2,-25
FLST,3,1,5,ORDE,1
FITEM,3,8
ASBA,P51X,P51X, , ,KEEP
FLST,2,3,5,ORDE,3
FITEM,2,27
FITEM,2,118
FITEM,2,-119
FLST,3,1,5,ORDE,1
FITEM,3,8
ASBA,P51X,P51X, , ,KEEP                 ! Dividing
Tapered Bolsters

FLST,2,4,3
FITEM,2,176
FITEM,2,178
FITEM,2,171
FITEM,2,170
A,P51X
FLST,2,4,3
FITEM,2,183
FITEM,2,182
FITEM,2,181
FITEM,2,184
A,P51X
FLST,2,1,5,ORDE,1
FITEM,2,8
FLST,3,2,5,ORDE,2
FITEM,3,27
FITEM,3,118
ASBA,P51X,P51X, , ,KEEP                 ! Dividing
Inside Side Area


FLST,3,1,4,ORDE,1
FITEM,3,27
LGEN,2,P51X, , , ,600, ,0
FLST,3,1,4,ORDE,1
FITEM,3,25
LGEN,2,P51X, , ,160, , ,0
FLST,2,1,4,ORDE,1
FITEM,2,333
FLST,3,1,4,ORDE,1
FITEM,3,28
LSBL,P51X,P51X, , ,KEEP                 ! Const. Lines
KWPLAN,-1,    187,    189,    186
KWPLAN,-1,    189,    186,    187
PCIRC,83.5, ,0,360,                     ! Circle for
Pivot Hole

FLST,3,1,4,ORDE,1
FITEM,3,28
LGEN,2,P51X, , , , ,133, ,0
FLST,3,1,4,ORDE,1
FITEM,3,28
LGEN,2,P51X, , , , ,-133, ,0
FLST,2,2,4,ORDE,2
FITEM,2,334
FITEM,2,339
FLST,2,1,4,ORDE,1
FITEM,2,339
FLST,3,1,4,ORDE,1
FITEM,3,334
LSBL,P51X,P51X, , ,KEEP
FLST,2,1,4,ORDE,1
FITEM,2,340
FLST,3,1,4,ORDE,1
FITEM,3,335
LSBL,P51X,P51X, , ,KEEP                 ! Construction
Lines

LARC,198,199,186,133,
FLST,3,1,4,ORDE,1
FITEM,3,340
LGEN,2,P51X, , ,30, , ,0
FLST,3,1,4,ORDE,1
FITEM,3,27
LGEN,2,P51X, , , ,600-380, ,0
FLST,2,5,4,ORDE,5
FITEM,2,28
FITEM,2,334
FITEM,2,-335
FITEM,2,339
FITEM,2,341
LDELE,P51X, , ,1
LDELE,    340, , ,1
FLST,2,1,4,ORDE,1
FITEM,2,343
FLST,3,1,4,ORDE,1
FITEM,3,344
LSBL,P51X,P51X, , ,KEEP
FLST,2,1,4,ORDE,1
FITEM,2,342
FLST,3,1,4,ORDE,1
FITEM,3,344
LSBL,P51X,P51X, , ,KEEP
FLST,2,2,4,ORDE,2
FITEM,2,28
FITEM,2,335
LDELE,P51X, , ,1
LSTR,    202,    199
LSTR,    198,    24
LDELE,    345, , ,1
FLST,2,1,4,ORDE,1
FITEM,2,25
FLST,3,1,4,ORDE,1
FITEM,3,28
LSBL,P51X,P51X, , ,KEEP          ! Creating Lines 4 Pivot
Reinforced Area

FLST,3,5,4,ORDE,5
```

```
FITEM,3,28
FITEM,3,334
FITEM,3,-335
FITEM,3,339
FITEM,3,344
LGEN,2,P51X, , ,383, , , ,0
!LGEN,2,P51X, , ,380, , , ,0
FLST,3,1,5,ORDE,1
FITEM,3,8
AGEN,2,P51X, , ,383, , , ,0
!AGEN,2,P51X, , ,380, , , ,0
FLST,2,1,4,ORDE,1
FITEM,2,191
FLST,3,1,4,ORDE,1
FITEM,3,25
LSBL,P51X,P51X, , ,KEEP     ! Copied Lines and Hole
to Otherside

FLST,2,6,4
FITEM,2,28
FITEM,2,334
FITEM,2,344
FITEM,2,339
FITEM,2,335
FITEM,2,340
AL,P51X
NUMMRG,KP, , ,
FLST,2,6,4
FITEM,2,351
FITEM,2,25
FITEM,2,342
FITEM,2,346
FITEM,2,345
FITEM,2,343
AL,P51X
FLST,2,1,5,ORDE,1
FITEM,2,11
FLST,3,1,5,ORDE,1
FITEM,3,129
ASBA,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,129
FLST,3,1,5,ORDE,1
FITEM,3,127
ASBA,P51X,P51X, , ,DELETE
FLST,2,1,5,ORDE,1
FITEM,2,119
FLST,3,1,5,ORDE,1
FITEM,3,128
ASBA,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,128
FLST,3,1,5,ORDE,1
FITEM,3,8
ASBA,P51X,P51X, , ,DELETE          ! Finish
Dividing Areas Reinforced Area

FLST,3,1,4,ORDE,1
FITEM,3,351
LGEN,2,P51X, , , ,400, , ,0
FLST,3,1,4,ORDE,1
FITEM,3,282
LGEN,2,P51X, , , , ,580, ,0
LSBL,    171,    144
FLST,3,1,4,ORDE,1
FITEM,3,284
LGEN,2,P51X, , , , ,-133, ,0
LSTR,    109,    100
LSTR,    100,    204
LSTR,    204,    185
FLST,2,3,4,ORDE,3
FITEM,2,144
FITEM,2,181
FITEM,2,191
LDELE,P51X, , ,1              ! Creating Lines for Pivot
Indent


FLST,2,1,4,ORDE,1
FITEM,2,353
FLST,3,2,4,ORDE,2
FITEM,3,292
FITEM,3,295
LSBL,P51X,P51X, , ,KEEP
FLST,2,1,4,ORDE,1
FITEM,2,354
FLST,3,2,4,ORDE,2
FITEM,3,298
FITEM,3,306
LSBL,P51X,P51X, , ,KEEP
ASBL,     18,    191
FLST,3,2,4,ORDE,2
FITEM,3,144
FITEM,3,171
ASBL,     130,P51X
FLST,3,2,4,ORDE,2
FITEM,3,181
FITEM,3,355
ASBL,     129,P51X
ASBL,      9,    356
ASBL,     131,    353
                  ! Dividing Lines and Areas on Side
for Mesh reasons

FLST,2,7,4,ORDE,7             ! Sweeping Pivot Indent
Accros
FITEM,2,144
FITEM,2,171
FITEM,2,181
FITEM,2,191
FITEM,2,353
FITEM,2,355
FITEM,2,-356
ADRAG,P51X, , , , , ,     309

        ! Dividing Lines and Areas on Other Side for
Mesh reasons
FLST,2,1,5,ORDE,1
FITEM,2,127
FLST,3,7,4,ORDE,7
FITEM,3,306
FITEM,3,363
FITEM,3,365
FITEM,3,367
FITEM,3,369
FITEM,3,371
FITEM,3,373
ASBL,P51X,P51X, , ,KEEP

NUMMRG,KP, , ,    ! Merging Co-incident Keypoints

FLST,2,4,3
FITEM,2,20
FITEM,2,109
FITEM,2,84
FITEM,2,95
A,P51X
FLST,2,4,3
FITEM,2,109
FITEM,2,84
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```
FITEM,2,83
FITEM,2,159
A,P51X
FLST,2,4,3
FITEM,2,20
FITEM,2,95
FITEM,2,94
FITEM,2,168
A,P51X                  ! Attaching Pivot Structure to Rear
Stringer

FLST,2,4,3
FITEM,2,158
FITEM,2,108
FITEM,2,107
FITEM,2,157
A,P51X
FLST,2,4,3
FITEM,2,32
FITEM,2,106
FITEM,2,105
FITEM,2,28
A,P51X
FLST,2,4,3
FITEM,2,185
FITEM,2,202
FITEM,2,28
FITEM,2,157
A,P51X
FLST,2,4,3
FITEM,2,157
FITEM,2,28
FITEM,2,105
FITEM,2,107
A,P51X                  ! Attaching Pivot Structure to Front
Stringer

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~  Dividing Floor Plate Areas  - Near Stringer
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,2,1,5,ORDE,1
FITEM,2,31
FLST,3,2,4,ORDE,2
FITEM,3,2
FITEM,3,160
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,33
FLST,3,6,4,ORDE,6
FITEM,3,35
FITEM,3,135
FITEM,3,148
FITEM,3,318
FITEM,3,377
FITEM,3,-378
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,35
FLST,3,2,4,ORDE,2
FITEM,3,37
FITEM,3,332
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,36
FLST,3,2,4,ORDE,2
FITEM,3,33
FITEM,3,301
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,34
FLST,3,2,4,ORDE,2
FITEM,3,31
FITEM,3,296
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,37
FLST,3,6,4,ORDE,6
FITEM,3,34
FITEM,3,47
FITEM,3,69
FITEM,3,317
FITEM,3,379
FITEM,3,381
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,39
FLST,3,2,4,ORDE,2
FITEM,3,57
FITEM,3,74
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,41
FLST,3,2,4,ORDE,2
FITEM,3,61
FITEM,3,76
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,43
FLST,3,2,4,ORDE,2
FITEM,3,81
FITEM,3,85
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,45
FLST,3,2,4,ORDE,2
FITEM,3,67
FITEM,3,79
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,30
FLST,3,2,4,ORDE,2
FITEM,3,51
FITEM,3,71
ASBL,P51X,P51X, , ,KEEP

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~        Corner Stringer
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,3,18,4,ORDE,18
FITEM,3,95
FITEM,3,-96
FITEM,3,99
FITEM,3,101
FITEM,3,103
FITEM,3,105
FITEM,3,107
FITEM,3,109
FITEM,3,111
FITEM,3,113
FITEM,3,115
FITEM,3,117
FITEM,3,119
FITEM,3,121
FITEM,3,123
FITEM,3,125
FITEM,3,127
FITEM,3,129
LGEN,2,P51X, , ,-32*10, , , ,0
```

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FLST,3,18,4,ORDE,18
FITEM,3,95
FITEM,3,-96
FITEM,3,99
FITEM,3,101
FITEM,3,103
FITEM,3,105
FITEM,3,107
FITEM,3,109
FITEM,3,111
FITEM,3,113
FITEM,3,115
FITEM,3,117
FITEM,3,119
FITEM,3,121
FITEM,3,123
FITEM,3,125
FITEM,3,127
FITEM,3,129
LGEN,2,P51X, , ,-6*10,32*10, , ,0
FLST,3,18,4,ORDE,2
FITEM,3,403
FITEM,3,-420
LGEN,2,P51X, , ,23*10,-15*10, , ,0
FLST,3,18,4,ORDE,2
FITEM,3,421
FITEM,3,-438
LGEN,2,P51X, , ,-16*10,-2.5*10, , ,0
Copying Lines

FLST,2,5,3
FITEM,2,215
FITEM,2,272
FITEM,2,234
FITEM,2,253
FITEM,2,70
A,P51X
FLST,2,5,3
FITEM,2,230
FITEM,2,287
FITEM,2,249
FITEM,2,268
FITEM,2,72
A,P51X
FLST,2,5,3
FITEM,2,229
FITEM,2,286
FITEM,2,248
FITEM,2,267
FITEM,2,62
A,P51X
FLST,2,5,3
FITEM,2,228
FITEM,2,285
FITEM,2,247
FITEM,2,266
FITEM,2,64
A,P51X
FLST,2,5,3
FITEM,2,227
FITEM,2,284
FITEM,2,246
FITEM,2,265
FITEM,2,58
A,P51X
FLST,2,5,3
FITEM,2,226
FITEM,2,283
FITEM,2,245
FITEM,2,264
FITEM,2,54
A,P51X
FLST,2,5,3
FITEM,2,225
FITEM,2,282
FITEM,2,244
FITEM,2,263
FITEM,2,50
A,P51X
FLST,2,5,3
FITEM,2,224
FITEM,2,281
FITEM,2,243
FITEM,2,262
FITEM,2,46
A,P51X
FLST,2,5,3
FITEM,2,223
FITEM,2,280
FITEM,2,242
FITEM,2,261
FITEM,2,42
A,P51X
FLST,2,5,3
FITEM,2,222
FITEM,2,279
FITEM,2,241
FITEM,2,260
FITEM,2,38
A,P51X
FLST,2,5,3
FITEM,2,221
FITEM,2,278
FITEM,2,240
FITEM,2,259
FITEM,2,34
A,P51X
FLST,2,5,3
FITEM,2,220
FITEM,2,277
FITEM,2,239
FITEM,2,258
FITEM,2,30
A,P51X
FLST,2,5,3
FITEM,2,219
FITEM,2,276
FITEM,2,238
FITEM,2,257
FITEM,2,26
A,P51X
FLST,2,5,3
FITEM,2,218
FITEM,2,275
FITEM,2,237
FITEM,2,256
FITEM,2,22
A,P51X
FLST,2,5,3
FITEM,2,217
FITEM,2,274
FITEM,2,236
FITEM,2,255
FITEM,2,18
A,P51X
FLST,2,5,3
FITEM,2,216
FITEM,2,273
FITEM,2,235
FITEM,2,254
```

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FITEM,2,14
A,P51X
FLST,2,5,3
FITEM,2,213
FITEM,2,270
FITEM,2,232
FITEM,2,251
FITEM,2,10
A,P51X
FLST,2,4,3
FITEM,2,206
FITEM,2,231
FITEM,2,250
FITEM,2,2
A,P51X                 ! Creating Internal Stiffeners

                       ! Dividing Floor Plate Areas Near
Corner Stringer
FLST,2,1,5,ORDE,1
FITEM,2,169
FLST,3,1,4,ORDE,1
FITEM,3,386
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,46
FLST,3,1,4,ORDE,1
FITEM,3,402
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,167
FLST,3,1,4,ORDE,1
FITEM,3,401
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,44
FLST,3,1,4,ORDE,1
FITEM,3,400
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,166
FLST,3,1,4,ORDE,1
FITEM,3,399
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,42
FLST,3,1,4,ORDE,1
FITEM,3,398
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,163
FLST,3,1,4,ORDE,1
FITEM,3,397
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,40
FLST,3,1,4,ORDE,1
FITEM,3,396
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,161
FLST,3,1,4,ORDE,1
FITEM,3,395
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,38
FLST,3,1,4,ORDE,1
FITEM,3,394
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,34
FLST,3,1,4,ORDE,1
FITEM,3,393
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,35
FLST,3,1,4,ORDE,1
FITEM,3,392
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,153
FLST,3,1,4,ORDE,1
FITEM,3,391
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,157
FLST,3,1,4,ORDE,1
FITEM,3,390
ASBL,P51X,P51X, , ,KEEP
FLST,2,4,5,ORDE,4
FITEM,2,31
FITEM,2,-32
FITEM,2,62
FITEM,2,148
FLST,3,4,4,ORDE,3
FITEM,3,3
FITEM,3,387
FITEM,3,-389
ASBL,P51X,P51X, , ,KEEP

FLST,2,4,3
FITEM,2,206
FITEM,2,231
FITEM,2,232
FITEM,2,213
A,P51X
FLST,2,4,3
FITEM,2,216
FITEM,2,213
FITEM,2,232
FITEM,2,235
A,P51X
FLST,2,4,3
FITEM,2,217
FITEM,2,216
FITEM,2,235
FITEM,2,236
A,P51X
FLST,2,4,3
FITEM,2,217
FITEM,2,236
FITEM,2,237
FITEM,2,218
A,P51X
FLST,2,4,3
FITEM,2,219
FITEM,2,218
FITEM,2,237
FITEM,2,238
A,P51X
FLST,2,4,3
FITEM,2,220
FITEM,2,219
FITEM,2,238
FITEM,2,239
A,P51X
FLST,2,4,3
FITEM,2,220
FITEM,2,239
FITEM,2,240
FITEM,2,221
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A,P51X
FLST,2,4,3
FITEM,2,222
FITEM,2,221
FITEM,2,240
FITEM,2,241
A,P51X
FLST,2,4,3
FITEM,2,223
FITEM,2,222
FITEM,2,241
FITEM,2,242
A,P51X
FLST,2,4,3
FITEM,2,224
FITEM,2,223
FITEM,2,242
FITEM,2,243
A,P51X
FLST,2,4,3
FITEM,2,225
FITEM,2,224
FITEM,2,243
FITEM,2,244
A,P51X
FLST,2,4,3
FITEM,2,226
FITEM,2,225
FITEM,2,244
FITEM,2,245
A,P51X
FLST,2,4,3
FITEM,2,227
FITEM,2,226
FITEM,2,245
FITEM,2,246
A,P51X
FLST,2,4,3
FITEM,2,228
FITEM,2,227
FITEM,2,246
FITEM,2,247
A,P51X
FLST,2,4,3
FITEM,2,229
FITEM,2,228
FITEM,2,247
FITEM,2,248
A,P51X
FLST,2,4,3
FITEM,2,230
FITEM,2,229
FITEM,2,248
FITEM,2,249
A,P51X
FLST,2,4,3
FITEM,2,215
FITEM,2,230
FITEM,2,249
FITEM,2,234
A,P51X
FLST,2,4,3
FITEM,2,214
FITEM,2,215
FITEM,2,234
FITEM,2,233
A,P51X
Areas

! Adding Inside Plate

! Creatng Exhaust Holes

KWPLAN,-1,     3,   214,     70
PCIRC,120, ,0,360,
KDISTANCE,     3,   214
KDISTANCE,     3,    70
KDISTANCE,    70,   230
FLST,3,1,5,ORDE,1
FITEM,3,224
AGEN, ,P51X, , ,-160, ,375+175, , ,1
KDISTANCE,    70,    62
FLST,3,1,5,ORDE,1
FITEM,3,224
AGEN,2,P51X, , , , ,815, ,0
KDISTANCE,    64,    54
FLST,3,1,5,ORDE,1
FITEM,3,225
AGEN,2,P51X, , , , ,860, ,0
KDISTANCE,    58,    50
KDISTANCE,    58,   263
KDISTANCE,    58,    50
FLST,3,1,5,ORDE,1
FITEM,3,226
AGEN,2,P51X, , , , ,670, ,0
KDISTANCE,    50,    42
FLST,3,1,5,ORDE,1
FITEM,3,227
AGEN,2,P51X, , , , ,675, ,0
KDISTANCE,    42,    26
FLST,3,1,5,ORDE,1
FITEM,3,228
AGEN,2,P51X, , , , ,1620, ,0
KDISTANCE,    26,    18
FLST,3,1,5,ORDE,1
FITEM,3,229
AGEN,2,P51X, , , , ,1205, ,0
ASBA,   169,   224
ASBA,   167,   225
ASBA,   166,   226
ASBA,   163,   227
ASBA,   161,   228
ASBA,   202,   229
ASBA,   206,   230

FLST,2,4,3
FITEM,2,2
FITEM,2,10
FITEM,2,251
FITEM,2,250
A,P51X
FLST,2,4,3
FITEM,2,10
FITEM,2,14
FITEM,2,254
FITEM,2,251
A,P51X
FLST,2,4,3
FITEM,2,14
FITEM,2,18
FITEM,2,255
FITEM,2,254
A,P51X
FLST,2,4,3
FITEM,2,18
FITEM,2,22
FITEM,2,256
FITEM,2,255
A,P51X
FLST,2,4,3
FITEM,2,22
FITEM,2,26
FITEM,2,257
```

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FITEM,2,256
A,P51X
FLST,2,4,3
FITEM,2,26
FITEM,2,30
FITEM,2,258
FITEM,2,257
A,P51X
FLST,2,4,3
FITEM,2,30
FITEM,2,34
FITEM,2,259
FITEM,2,258
A,P51X
FLST,2,4,3
FITEM,2,34
FITEM,2,38
FITEM,2,260
FITEM,2,259
A,P51X
FLST,2,4,3
FITEM,2,38
FITEM,2,42
FITEM,2,261
FITEM,2,260
A,P51X
FLST,2,4,3
FITEM,2,42
FITEM,2,46
FITEM,2,262
FITEM,2,261
A,P51X
FLST,2,4,3
FITEM,2,46
FITEM,2,50
FITEM,2,263
FITEM,2,262
A,P51X
FLST,2,4,3
FITEM,2,50
FITEM,2,54
FITEM,2,264
FITEM,2,263
A,P51X
FLST,2,4,3
FITEM,2,54
FITEM,2,58
FITEM,2,265
FITEM,2,264
A,P51X
FLST,2,4,3
FITEM,2,58
FITEM,2,64
FITEM,2,266
FITEM,2,265
A,P51X
FLST,2,4,3
FITEM,2,64
FITEM,2,62
FITEM,2,267
FITEM,2,266
A,P51X
FLST,2,4,3
FITEM,2,62
FITEM,2,72
FITEM,2,268
FITEM,2,267
A,P51X
FLST,2,4,3
FITEM,2,72
FITEM,2,70
FITEM,2,253
FITEM,2,268
A,P51X
FLST,2,4,3
FITEM,2,70
FITEM,2,3
FITEM,2,252
FITEM,2,253
A,P51X                         ! Adding Lower Outside
Plate Areas

FLST,2,4,3
FITEM,2,250
FITEM,2,251
FITEM,2,232
FITEM,2,231
A,P51X
FLST,2,4,3
FITEM,2,251
FITEM,2,254
FITEM,2,235
FITEM,2,232
A,P51X
FLST,2,4,3
FITEM,2,254
FITEM,2,255
FITEM,2,236
FITEM,2,235
A,P51X
FLST,2,4,3
FITEM,2,255
FITEM,2,256
FITEM,2,237
FITEM,2,236
A,P51X
FLST,2,4,3
FITEM,2,256
FITEM,2,257
FITEM,2,238
FITEM,2,237
A,P51X
FLST,2,4,3
FITEM,2,257
FITEM,2,258
FITEM,2,239
FITEM,2,238
A,P51X
FLST,2,4,3
FITEM,2,258
FITEM,2,259
FITEM,2,240
FITEM,2,239
A,P51X
FLST,2,4,3
FITEM,2,259
FITEM,2,260
FITEM,2,241
FITEM,2,240
A,P51X
FLST,2,4,3
FITEM,2,260
FITEM,2,261
FITEM,2,242
FITEM,2,241
A,P51X
FLST,2,4,3
FITEM,2,261
FITEM,2,262
FITEM,2,243
```

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FITEM,2,242
A,P51X
FLST,2,4,3
FITEM,2,262
FITEM,2,263
FITEM,2,244
FITEM,2,243
A,P51X
FLST,2,4,3
FITEM,2,263
FITEM,2,264
FITEM,2,245
FITEM,2,244
A,P51X
FLST,2,4,3
FITEM,2,264
FITEM,2,265
FITEM,2,246
FITEM,2,245
A,P51X
FLST,2,4,3
FITEM,2,265
FITEM,2,266
FITEM,2,247
FITEM,2,246
A,P51X
FLST,2,4,3
FITEM,2,266
FITEM,2,267
FITEM,2,248
FITEM,2,247
A,P51X
FLST,2,4,3
FITEM,2,267
FITEM,2,268
FITEM,2,249
FITEM,2,248
A,P51X
FLST,2,4,3
FITEM,2,268
FITEM,2,253
FITEM,2,234
FITEM,2,249
A,P51X
FLST,2,4,3
FITEM,2,253
FITEM,2,252
FITEM,2,233
FITEM,2,234
A,P51X                          ! Adding Upper Outside
Plate Areas

FLST,2,4,3
FITEM,2,6
FITEM,2,9
FITEM,2,10
FITEM,2,2
A,P51X
FLST,2,4,3
FITEM,2,13
FITEM,2,17
FITEM,2,18
FITEM,2,14
A,P51X
FLST,2,4,3
FITEM,2,21
FITEM,2,25
FITEM,2,26
FITEM,2,22
A,P51X
FLST,2,4,3
FITEM,2,29
FITEM,2,33
FITEM,2,34
FITEM,2,30
A,P51X
FLST,2,4,3
FITEM,2,37
FITEM,2,41
FITEM,2,42
FITEM,2,38
A,P51X
FLST,2,4,3
FITEM,2,45
FITEM,2,49
FITEM,2,50
FITEM,2,46
A,P51X
FLST,2,4,3
FITEM,2,53
FITEM,2,61
FITEM,2,58
FITEM,2,54
A,P51X
FLST,2,4,3
FITEM,2,63
FITEM,2,60
FITEM,2,62
FITEM,2,64
A,P51X
FLST,2,4,3
FITEM,2,71
FITEM,2,69
FITEM,2,70
FITEM,2,72
A,P51X                          ! Closing
Bolster Ends

!-----------------------------------------
!--------------     Hoist  Pivot
!-----------------------------------------

FLST,3,3,4,ORDE,3
FITEM,3,121
FITEM,3,123
FITEM,3,125
LGEN,2,P51X, , ,-bxwidth/2+1177.6, , , ,0
FLST,3,2,4,ORDE,2
FITEM,3,599
FITEM,3,601
LGEN,2,P51X, , , ,-300, , ,0
FLST,2,4,3
FITEM,2,322
FITEM,2,319
FITEM,2,316
FITEM,2,320
A,P51X
FLST,2,5,4,ORDE,2
FITEM,2,599
FITEM,2,-603
LDELE,P51X, , ,1                ! Construction
Lines

FLST,3,1,5,ORDE,1
FITEM,3,269
AGEN,2,P51X, , ,249, , , ,0
FLST,2,9,5,ORDE,9
FITEM,2,44
FITEM,2,86
FITEM,2,88
```

```
FITEM,2,-89
FITEM,2,91
FITEM,2,93
FITEM,2,95
FITEM,2,192
FITEM,2,194
FLST,3,2,5,ORDE,2
FITEM,3,269
FITEM,3,-270
ASBA,P51X,P51X                          ! Cutting
Bolster Areas

FLST,3,1,3,ORDE,1
FITEM,3,321
KGEN,2,P51X, , , ,-164,-72, ,0
FLST,3,1,3,ORDE,1
FITEM,3,317
KGEN,2,P51X, , , ,0,-60, ,0
FLST,2,6,3
FITEM,2,321
FITEM,2,317
FITEM,2,320
FITEM,2,334
FITEM,2,325
FITEM,2,324
A,P51X
FLST,3,1,3,ORDE,1
FITEM,3,318
KGEN,2,P51X, , , ,-164,72, ,0
FLST,3,1,3,ORDE,1
FITEM,3,322
KGEN,2,P51X, , , ,0,60, ,0
FLST,2,6,3
FITEM,2,318
FITEM,2,322
FITEM,2,323
FITEM,2,335
FITEM,2,327
FITEM,2,326
A,P51X
FLST,3,6,4,ORDE,6
FITEM,3,223
FITEM,3,229
FITEM,3,232
FITEM,3,-233
FITEM,3,238
FITEM,3,-239
LGEN,2,P51X, , ,-249, , , ,0
!FLST,2,6,4
!FITEM,2,255
!FITEM,2,551
!FITEM,2,599
!FITEM,2,623
!FITEM,2,626
!FITEM,2,618
!AL,P51X
NUMMRG,KP, , ,
FLST,2,6,4
FITEM,2,623
FITEM,2,626
FITEM,2,618
FITEM,2,255
FITEM,2,551
FITEM,2,599
AL,P51X
FLST,2,6,4
FITEM,2,600
FITEM,2,601
FITEM,2,602
FITEM,2,625
FITEM,2,627
FITEM,2,621
AL,P51X                                 ! Stiffeners
Inside Bolsters

KL,623,0.4, ,
KL,625,0.6, ,
FLST,3,1,3,ORDE,1
FITEM,3,328
KGEN,2,P51X, , , ,-240,-255, ,0
KL,646,0.6, ,
KL,648,0.4, ,
FLST,3,1,3,ORDE,1
FITEM,3,334
KGEN,2,P51X, , , ,-240,-255, ,0
LSTR,    343,    345
LSTR,    345,    344
LSTR,    336,    340
LSTR,    340,    339
FLST,2,4,4,ORDE,4
FITEM,2,623
FITEM,2,625
FITEM,2,646
FITEM,2,648
FLST,3,4,4,ORDE,4
FITEM,3,466
FITEM,3,476
FITEM,3,549
FITEM,3,-550
LSBL,P51X,P51X, , ,KEEP
FLST,2,5,4
FITEM,2,651
FITEM,2,466
FITEM,2,476
FITEM,2,652
FITEM,2,632
AL,P51X
FLST,2,5,4
FITEM,2,606
FITEM,2,549
FITEM,2,550
FITEM,2,607
FITEM,2,615
AL,P51X                                 ! Pivot Areas

                    ! Punching Holes Through Hoist
Pivot and Front Stringer
FLST,3,1,3,ORDE,1
FITEM,3,334
KGEN,2,P51X, , , ,-140,-260, ,0
KWPLAN,-1,    346,    334,    335
PCIRC,60, ,0,360,
FLST,2,1,5,ORDE,1
FITEM,2,95
VEXT,P51X, , ,-2000,0,0,,,,
FLST,2,4,5,ORDE,4
FITEM,2,6
FITEM,2,16
FITEM,2,91
FITEM,2,93
ASBV,P51X,     1

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~ Correcting Angles at Ends of Corner Stringer
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

KWPLAN,-1,     2,    206,    250
wpro,,5.000000,
wpro,,5.000000,
wpro,,1.000000,
```

```
FLST,2,3,5,ORDE,3
FITEM,2,31
FITEM,2,206
FITEM,2,242
ASBW,P51X
FLST,2,4,5,ORDE,4
FITEM,2,6
FITEM,2,16
FITEM,2,187
FITEM,2,192
ADELE,P51X, , ,1
FLST,2,4,4
FITEM,2,655
FITEM,2,659
FITEM,2,653
FITEM,2,545
AL,P51X                          ! Correcting Rear End of
Corner STR

KWPLAN,-1,    112,    110,    156
wpro,,12.500000,
FLST,2,3,5,ORDE,3
FITEM,2,15
FITEM,2,301
FITEM,2,-302
ASBW,P51X
FLST,2,4,5,ORDE,4
FITEM,2,16
FITEM,2,-17
FITEM,2,31
FITEM,2,192
ADELE,P51X, , ,1
FLST,2,4,4
FITEM,2,542
FITEM,2,656
FITEM,2,403
FITEM,2,189
AL,P51X                          ! Correcting Front of
Stringer

FLST,3,3,5,ORDE,3
FITEM,3,223
FITEM,3,241
FITEM,3,259
AGEN,2,P51X, , , ,-375, ,0
FLST,2,3,5,ORDE,3
FITEM,2,16
FITEM,2,-17
FITEM,2,31
ASBW,P51X
FLST,2,3,5,ORDE,3
FITEM,2,269
FITEM,2,-270
FITEM,2,298
ADELE,P51X, , ,1
FLST,2,6,5,ORDE,6
FITEM,2,192
FITEM,2,223
FITEM,2,241
FITEM,2,-242
FITEM,2,259
FITEM,2,301
ADELE,P51X
FLST,2,9,4,ORDE,9
FITEM,2,87
FITEM,2,404
FITEM,2,422
FITEM,2,568
FITEM,2,597
FITEM,2,-598
FITEM,2,660
FITEM,2,668
FITEM,2,670
LDELE,P51X, , ,1
LDELE,    672, , ,1
LDELE,    440, , ,1
LSTR,     253,    366
LSTR,     234,    365
NUMMRG,KP, , ,
FLST,2,4,4
FITEM,2,96
FITEM,2,671
FITEM,2,65
FITEM,2,460
AL,P51X
FLST,2,4,4
FITEM,2,386
FITEM,2,669
FITEM,2,87
FITEM,2,567
AL,P51X
FLST,2,4,4
FITEM,2,459
FITEM,2,65
FITEM,2,675
FITEM,2,87
AL,P51X
FLST,2,4,4
FITEM,2,671
FITEM,2,548
FITEM,2,669
FITEM,2,675
AL,P51X                          ! Correcting Front End of
Corner STR

WPCSYS,-1,0

NUMMRG,ALL, , ,                  ! Merging Coincident
Items
NUMCMP,AREA
NUMCMP,LINE
NUMCMP,KP                        ! Compressing Numbers

FINISH
!SAVE
/EOF
```

❖ *Filename: 2_3_build_wall_INPUT*

```
!@@@@@@@@@@@@@@@@@@@@@@@@@
!         FEA of 930E Truck Box Structure
!         Side Wall Construction Routine

:build

FINISH
FINISH
!/CLEAR
!/NERR,0,,
!RESUME,build_floor.db
!/FILNAM,build_wall
!RESUME,geom.db
!/FILNAM,geom

/TITLE,Building Wall Geometry

/PREP7

/VIEW, 1 ,1,1,1
/ANG, 1
/REP,FAST
/USER, 1
/VIEW, 1, 0.784420712192   , -0.258767530301   ,
0.563669683011
/ANG, 1, -1.85612833420
/AUTO, 1
APLOT

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~ Wall Construction
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

*AFUN,DEG
WPSTYLE,,,,,,,,0
FLST,3,1,3,ORDE,1
FITEM,3,346
KGEN,2,P51X, , , ,21*20.5*sin(90-13),-21*20.5*cos(90-
13), ,0
FLST,3,1,3,ORDE,1
FITEM,3,356
KGEN,2,P51X, , , ,79*20.5*sin(39.5),-
79*20.5*cos(39.5), ,0
FLST,3,1,3,ORDE,1
FITEM,3,354
KGEN,2,P51X, , , ,123*20.5*sin(89.25),-
123*20.5*cos(89.25), ,0
FLST,3,1,3,ORDE,1
FITEM,3,354
KGEN,2,P51X, , , ,160*20.5*sin(77.5),-
160*20.5*cos(77.5), ,0

LSTR,   346,   356
LSTR,   356,   357
LSTR,   357,   358
LSTR,   358,   359
LSTR,   354,   359

FLST,2,23,4
FITEM,2,646
FITEM,2,401
FITEM,2,402
FITEM,2,403
FITEM,2,404
FITEM,2,405
FITEM,2,406
FITEM,2,407
FITEM,2,408
FITEM,2,409
FITEM,2,410
FITEM,2,411
FITEM,2,412
FITEM,2,413
FITEM,2,414
FITEM,2,415
FITEM,2,416
FITEM,2,87
FITEM,2,662
FITEM,2,661
FITEM,2,660
FITEM,2,659
FITEM,2,658
AL,P51X                       ! Side Wall Plate

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~ Top Tapered Bolster
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,3,1,3,ORDE,1
FITEM,3,356
KGEN,2,P51X, , ,230, , , ,0
LSTR,   356,   360
LSTR,   360,   347
KL,659,29.5/79, ,
FLST,3,1,3,ORDE,1
FITEM,3,361
KGEN,2,P51X, , ,230, , , ,0
LSTR,   362,   361                  ! Lines Near
Tail End.

FLST,2,1,4,ORDE,1
FITEM,2,659
FLST,3,1,4,ORDE,1
FITEM,3,665
LSBL,P51X,P51X, , ,KEEP             ! Dividing Back
Line

LSTR,   360,   362

FLST,3,1,3,ORDE,1
FITEM,3,361
KGEN,2,P51X, , , ,1564.34,-10000, ,0
LSTR,   361,   363
FLST,2,1,4,ORDE,1
FITEM,2,668
FLST,3,1,4,ORDE,1
FITEM,3,662
LSBL,P51X,P51X, , ,KEEP
FLST,2,1,4,ORDE,1
FITEM,2,662
FLST,3,1,4,ORDE,1
FITEM,3,670
LSBL,P51X,P51X, , ,DELETE                     !
Horizontal Line

FLST,3,1,3,ORDE,1
FITEM,3,364
KGEN,2,P51X, , ,230, , , ,0
LSTR,   364,   363
LSTR,   363,   362
FLST,3,3,3,ORDE,2
FITEM,3,357
FITEM,3,-359
KGEN,2,P51X, , ,230, , , ,0
```

```
LSTR,   365,   357
LSTR,   366,   358
LSTR,   367,   359
LSTR,   362,   365
LSTR,   365,   366
LSTR,   366,   367
LSTR,   367,   363                    ! Box Section
Lines

KL,675,0.56, ,
LSTR,   368,   357
FLST,3,1,3,ORDE,1
FITEM,3,368
KGEN,2,P51X, , , ,1564.34,-10000, ,0
LSTR,   368,   369
FLST,2,1,4,ORDE,1
FITEM,2,675
FLST,3,1,4,ORDE,1
FITEM,3,680
LSBL,P51X,P51X, , ,KEEP
FLST,2,4,4,ORDE,4
FITEM,2,672
FITEM,2,-673
FITEM,2,676
FITEM,2,682
LDELE,P51X, , ,1
FLST,2,1,4,ORDE,1
FITEM,2,680
FLST,2,1,4,ORDE,1
FITEM,2,678
FLST,2,1,4,ORDE,1
FITEM,2,680
FLST,3,1,4,ORDE,1
FITEM,3,678
LSBL,P51X,P51X, , ,KEEP
FLST,2,1,4,ORDE,1
FITEM,2,678
FLST,3,1,4,ORDE,1
FITEM,3,673
LSBL,P51X,P51X, , ,DELETE
ADELE,   294
LDELE,   660, , ,1
FLST,2,2,4,ORDE,2
FITEM,2,661
FITEM,2,677
LDELE,P51X, , ,1
FLST,3,1,3,ORDE,1
FITEM,3,357
KGEN,2,P51X, , , ,1564.34,-10000, ,0
LSTR,   357,   358
FLST,2,1,4,ORDE,1
FITEM,2,671
FLST,2,1,4,ORDE,1
FITEM,2,660
FLST,3,1,4,ORDE,1
FITEM,3,671
LSBL,P51X,P51X, , ,KEEP
FLST,2,1,4,ORDE,1
FITEM,2,671
FLST,3,1,4,ORDE,1
FITEM,3,673
LSBL,P51X,P51X, , ,DELETE
LSTR,   365,   366

*AFUN,DEG
KWPLAN,-1,   359,   367,   366
wprot,0,-33.35,0
FLST,2,2,4,ORDE,2
FITEM,2,661
FITEM,2,672
LSBW,P51X
LSTR,   358,   359
LSTR,   367,   369
LSTR,   369,   358                    ! Making
Tapered Section
WPCSYS,-1,0

FLST,2,3,4
FITEM,2,661
FITEM,2,660
FITEM,2,680
AL,P51X
FLST,2,6,4
FITEM,2,662
FITEM,2,675
FITEM,2,676
FITEM,2,674
FITEM,2,677
FITEM,2,660
AL,P51X
FLST,2,4,4
FITEM,2,678
FITEM,2,671
FITEM,2,680
FITEM,2,683
AL,P51X
FLST,2,3,4
FITEM,2,678
FITEM,2,676
FITEM,2,672
AL,P51X
FLST,2,4,4
FITEM,2,683
FITEM,2,672
FITEM,2,674
FITEM,2,661
AL,P51X
FLST,2,5,4
FITEM,2,673
FITEM,2,680
FITEM,2,677
FITEM,2,669
FITEM,2,667
AL,P51X
FLST,2,4,4
FITEM,2,665
FITEM,2,667
FITEM,2,679
FITEM,2,681
AL,P51X
FLST,2,4,4
FITEM,2,673
FITEM,2,682
FITEM,2,679
FITEM,2,683
AL,P51X
FLST,2,4,4
FITEM,2,665
FITEM,2,669
FITEM,2,670
FITEM,2,662
AL,P51X
FLST,2,5,4
FITEM,2,670
FITEM,2,682
FITEM,2,681
FITEM,2,678
FITEM,2,675
AL,P51X          ! Creating Top Tapered Bolster
Areas
```

```
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~ Rear Bolster Section
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

KL,669,57.5/391.5, ,
KWPAVE,   370
*AFUN,DEG
wpro,,-50.500000,              ! Placing Workplane

FLST,2,4,4,ORDE,4
FITEM,2,646
FITEM,2,-647
FITEM,2,669
FITEM,2,-670
LSBW,P51X                      ! Using Workplane to
divide lines

WPSTYLE,,,,,,,0

NUMMRG,KP, , ,
LSTR,    371,    370
LSTR,    370,    374
LSTR,    374,    372
LSTR,    372,    371           ! Creating Lines

FLST,2,4,4
FITEM,2,658
FITEM,2,663
FITEM,2,664
FITEM,2,648
AL,P51X
FLST,2,4,4
FITEM,2,666
FITEM,2,663
FITEM,2,659
FITEM,2,665
AL,P51X
FLST,2,4,4
FITEM,2,669
FITEM,2,646
FITEM,2,647
FITEM,2,670
AL,P51X
FLST,2,5,4
FITEM,2,688
FITEM,2,646
FITEM,2,686
FITEM,2,658
FITEM,2,666
AL,P51X
FLST,2,5,4
FITEM,2,664
FITEM,2,659
FITEM,2,689
FITEM,2,669
FITEM,2,687
AL,P51X                                ! Creating
Areas

FLST,2,1,5,ORDE,1
FITEM,2,302
FLST,3,1,4,ORDE,1
FITEM,3,647
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,95
FLST,3,1,4,ORDE,1
FITEM,3,670
ASBL,P51X,P51X, , ,KEEP                ! Dividing
Existing Areas

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~ Middle Bolster Section - Rear Block
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

KL,646,23.5/77, ,
FLST,3,1,3,ORDE,1
FITEM,3,373
KGEN,2,P51X, , , ,1564.34,-10000, ,0
LSTR,    373,    375

FLST,2,1,4,ORDE,1
FITEM,2,692
FLST,3,1,4,ORDE,1
FITEM,3,668
LSBL,P51X,P51X, , ,KEEP
FLST,2,1,4,ORDE,1
FITEM,2,668
FLST,3,1,4,ORDE,1
FITEM,3,694
LSBL,P51X,P51X, , ,DELETE
FLST,2,1,4,ORDE,1
FITEM,2,646
FLST,3,1,4,ORDE,1
FITEM,3,693
LSBL,P51X,P51X, , ,KEEP                ! Horizontal
Line

FLST,3,1,4,ORDE,1
FITEM,3,693
LGEN,2,P51X, , ,230, , , ,0
LSTR,    375,    373
LSTR,    377,    376
FLST,2,1,4,ORDE,1
FITEM,2,669
FLST,3,1,4,ORDE,1
FITEM,3,696
LSBL,P51X,P51X, , ,KEEP                ! Top Area
Lines

KL,693,2019.25/7362.2, ,
KWPAVE,   378
WPCSYS,-1,0
WPSTYLE,,,,,,,0
KWPAVE,   378
wpro,,9.000000,                        ! Moving
Workplane

FLST,2,4,4,ORDE,4
FITEM,2,405
FITEM,2,421
FITEM,2,646
FITEM,2,693
LSBW,P51X                      ! Using WorkPlane to
Divide Lines

NUMMRG,KP, , ,

WPSTYLE,,,,,,,0
LSTR,    378,    379
LSTR,    379,    380
LSTR,    380,    382
LSTR,    382,    378                   ! Creating
Lines

FLST,2,2,5,ORDE,2
FITEM,2,244
FITEM,2,306
```

```
FLST,3,2,4,ORDE,2
FITEM,3,421
FITEM,3,696
ASBL,P51X,P51X, , ,KEEP                    ! Dividing
Existing Areas

FLST,2,9,4
FITEM,2,694
FITEM,2,684
FITEM,2,401
FITEM,2,402
FITEM,2,403
FITEM,2,404
FITEM,2,669
FITEM,2,405
FITEM,2,703
AL,P51X
FLST,2,9,4
FITEM,2,646
FITEM,2,701
FITEM,2,420
FITEM,2,419
FITEM,2,418
FITEM,2,417
FITEM,2,685
FITEM,2,698
FITEM,2,704
AL,P51X
FLST,2,4,4
FITEM,2,696
FITEM,2,704
FITEM,2,703
FITEM,2,693
AL,P51X
FLST,2,4,4
FITEM,2,646
FITEM,2,421
FITEM,2,405
FITEM,2,693
AL,P51X                                    ! Creating
Areas

!-------------------------------------------
!------- Middle Bolster Section - Block Along Side
!-------------------------------------------

KL,405,24*20.5/631.6, ,

FLST,3,1,3,ORDE,1
FITEM,3,381
KGEN,2,P51X, , , ,10000*tan(9),-10000, ,0

LSTR,   381,   383

FLST,2,1,4,ORDE,1
FITEM,2,707
FLST,3,1,4,ORDE,1
FITEM,3,692
LSBL,P51X,P51X, , ,KEEP
FLST,2,1,4,ORDE,1
FITEM,2,692
FLST,3,1,4,ORDE,1
FITEM,3,709
LSBL,P51X,P51X, , ,DELETE
FLST,2,1,4,ORDE,1
FITEM,2,405
FLST,3,1,4,ORDE,1
FITEM,3,708
LSBL,P51X,P51X, , ,KEEP
FLST,3,1,4,ORDE,1
FITEM,3,708
LGEN,2,P51X, , ,230, , , ,0
FLST,2,1,4,ORDE,1
FITEM,2,646
FLST,3,1,4,ORDE,1
FITEM,3,405
LSBL,P51X,P51X, , ,KEEP
LSTR,   383,   381
LSTR,   385,   384
LSTR,   385,   377

FLST,2,1,5,ORDE,1
FITEM,2,316
FLST,3,1,4,ORDE,1
FITEM,3,646
ASBL,P51X,P51X, , ,KEEP
FLST,2,4,4
FITEM,2,706
FITEM,2,705
FITEM,2,693
FITEM,2,697
AL,P51X
FLST,2,4,4
FITEM,2,708
FITEM,2,710
FITEM,2,705
FITEM,2,692
AL,P51X
FLST,2,4,4
FITEM,2,646
FITEM,2,405
FITEM,2,708
FITEM,2,713
AL,P51X
FLST,2,4,4
FITEM,2,405
FITEM,2,714
FITEM,2,706
FITEM,2,712
AL,P51X

FLST,2,5,4
FITEM,2,705
FITEM,2,703
FITEM,2,668
FITEM,2,691
FITEM,2,695
AL,P51X                         ! Upper Unstiffened Wall
Area

!-------------------------------------------
!---------------- Lower Corner Bolster
!-------------------------------------------

FLST,3,1,4,ORDE,1
FITEM,3,708
LGEN,2,P51X, , , ,-550*cos(9), , ,0        ! Copy Line
Down

FLST,2,1,4,ORDE,1
FITEM,2,715
FLST,3,1,4,ORDE,1
FITEM,3,707
LSBL,P51X,P51X, , ,KEEP
FLST,2,1,4,ORDE,1
FITEM,2,707
FLST,3,1,4,ORDE,1
FITEM,3,717
LSBL,P51X,P51X, , ,DELETE
FLST,2,1,4,ORDE,1
```

```
FITEM,2,716
FLST,3,1,4,ORDE,1
FITEM,3,411
LSBL,P51X,P51X, , ,KEEP
LDELE,   707, , ,1                ! Cleanup Constr. Line

KL,717,(2582-82.5*20.5)/2582, ,
FLST,3,1,3,ORDE,1
FITEM,3,386
KGEN,2,P51X, , ,230, , , ,0
LSTR,   389,   386
FLST,2,1,4,ORDE,1
FITEM,2,717
FLST,3,1,4,ORDE,1
FITEM,3,707
LSBL,P51X,P51X, , ,KEEP
LDELE,   716, , ,1                ! Trim Line to Right
Length

FLST,3,1,3,ORDE,1
FITEM,3,388
KGEN,2,P51X, , ,230, , , ,0
LSTR,   388,   387
LSTR,   387,   355
LSTR,   387,   389
LSTR,   386,   244
LSTR,   389,   262                   ! Creating
Lines

FLST,2,7,4
FITEM,2,715
FITEM,2,87
FITEM,2,416
FITEM,2,415
FITEM,2,414
FITEM,2,721
FITEM,2,719
AL,P51X
FLST,2,4,4
FITEM,2,719
FITEM,2,720
FITEM,2,716
FITEM,2,707
AL,P51X
FLST,2,4,4
FITEM,2,721
FITEM,2,467
FITEM,2,722
FITEM,2,707
AL,P51X
FLST,2,7,4
FITEM,2,430
FITEM,2,431
FITEM,2,432
FITEM,2,65
FITEM,2,717
FITEM,2,720
FITEM,2,722
AL,P51X                              ! Creating
Areas

FLST,2,14,4
FITEM,2,721
FITEM,2,413
FITEM,2,412
FITEM,2,411
FITEM,2,410
FITEM,2,409
FITEM,2,408
FITEM,2,407
FITEM,2,406
FITEM,2,700
FITEM,2,709
FITEM,2,708
FITEM,2,718
FITEM,2,719
AL,P51X                   ! Lower Unstiffened Wall
Area

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~           Side Boards
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

*AFUN,DEG                 ! Work in Degrees

FLST,3,1,3,ORDE,1
FITEM,3,359
KGEN,2,P51X, , , ,-327*20.5*sin(9),327*20.5*cos(9), ,0

LSTR,   357,   390
LSTR,   390,   359

FLST,3,1,3,ORDE,1
FITEM,3,390
KGEN,2,P51X, , ,230, , , ,0             ! Keypoints

LSTR,   368,   391
LSTR,   391,   367
LSTR,   391,   390                      ! Lines

FLST,2,4,4
FITEM,2,727
FITEM,2,724
FITEM,2,726
FITEM,2,674
AL,P51X
FLST,2,4,4
FITEM,2,661
FITEM,2,673
FITEM,2,723
FITEM,2,724
AL,P51X
FLST,2,4,4
FITEM,2,679
FITEM,2,723
FITEM,2,725
FITEM,2,727
AL,P51X
FLST,2,4,4
FITEM,2,726
FITEM,2,725
FITEM,2,682
FITEM,2,672
AL,P51X                   ! Areas

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~           Cleanup
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

ADELE,    295, , ,1  ! Deleting Unneeded Area

NUMMRG,ALL, , ,           ! Merging Coincident
Items
NUMCMP,AREA
NUMCMP,LINE
NUMCMP,KP                 ! Compressing Numbers

FINISH
!SAVE
/EOF
```

❖ *Filename: 2_4_build_front_INPUT*

```
!@@@@@@@@@@@@@@@@@@@@@@@@@@
!        FEA of 930E Truck Box Structure
!        Front Wall Construction Routine

:build

FINISH
FINISH

!/CLEAR
!/NERR,0,,
!RESUME,build_wall.db
!/FILNAM,build_front
!RESUME,geom.db
!/FILNAM,geom

/TITLE,Building Front Wall Geometry

/PREP7
*AFUN,DEG

/USER, 1
/VIEW, 1, 0.484264822294   , -0.192301274690   , -
0.853526684785
/ANG, 1, 20.5950751333
/REPLO
/FOC, 1, 811.708286462   , 2215.46451192   , -
5428.73841967
/VIEW, 1, 0.484264822294   , -0.192301274690   , -
0.853526684785
/REPLO
/VIEW, 1, 0.484264822294   , -0.192301274690   , -
0.853526684785
/DIST, 1, 2341.72159713
/ANG, 1, 13.6350751333
/REPLO
/FOC, 1, 654.212217908   , 2313.76522174   , -
5540.24419816
/VIEW, 1, 0.484264822294   , -0.192301274690   , -
0.853526684785
APLOT

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~ Top Bolster – Lines Only
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

KL,676,(872.3-6*20.5)/872.3, ,
KL,676,(872.3-15*20.5)/872.3, , ! Keypoints on Lines

FLST,3,1,3,ORDE,1
FITEM,3,393
KGEN,2,P51X, , , ,-12.5*20.5*sin(21.5-9),-
12.5*20.5*cos(21.5-9), ,0

LSTR,   394,   393
LSTR,   393,   392

FLST,3,1,3,ORDE,1
FITEM,3,392
KGEN,2,P51X, , , ,13.5*20.5*sin(9),-13.5*20.5*cos(9),
,0

LSTR,   392,   395
LSTR,   394,   395
LDELE,    729, , ,1

FLST,3,3,4,ORDE,3   ! Copying Lines into Middle
FITEM,3,728
FITEM,3,730
FITEM,3,-731
LGEN,2,P51X, , ,-0.4127500000E+04, , , ,0

LSTR,   392,   398
LSTR,   395,   399
LSTR,   393,   397
LSTR,   394,   396
LSTR,   398,   397          ! Creating Lines

FLST,2,1,4,ORDE,1
FITEM,2,676
FLST,3,2,4,ORDE,2
FITEM,3,728
FITEM,3,730
LSBL,P51X,P51X, , ,KEEP ! Dividing Line on Side Wall

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~ Outside Bolster Construction
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,3,1,3,ORDE,1
FITEM,3,393
KGEN,2,P51X, , ,-16.5*20.5, , , ,0 ! Width of Bolster

FLST,3,1,3,ORDE,1          ! Line Down Front Wall
FITEM,3,400
KGEN,2,P51X, , , ,-
0.3225329875E+04,0.7150384185E+03, ,0
LSTR,   401,   400

FLST,2,1,4,ORDE,1
FITEM,2,660
FLST,3,2,4,ORDE,2
FITEM,3,734
FITEM,3,736
LSBL,P51X,P51X, , ,KEEP
FLST,2,2,4,ORDE,2
FITEM,2,734
FITEM,2,736
FLST,3,1,4,ORDE,1
FITEM,3,744
LSBL,P51X,P51X, , ,KEEP    ! Dividing Lines Near Top
Edge

FLST,2,4,4
FITEM,2,660
FITEM,2,742
FITEM,2,674
FITEM,2,740
AL,P51X
FLST,2,4,4
FITEM,2,741
FITEM,2,744
FITEM,2,660
FITEM,2,745
AL,P51X
FLST,2,4,4
FITEM,2,739
FITEM,2,745
FITEM,2,743
FITEM,2,671
AL,P51X
FLST,2,4,4
FITEM,2,675
FITEM,2,671
```

```
FITEM,2,677
FITEM,2,662
AL,P51X
LSTR,   363,   377
LSTR,   385,   387
FLST,2,4,4
FITEM,2,734
FITEM,2,662
FITEM,2,695
FITEM,2,697
AL,P51X
FLST,2,4,4
FITEM,2,714
FITEM,2,710
FITEM,2,697
FITEM,2,713
AL,P51X
FLST,2,4,4
FITEM,2,736
FITEM,2,713
FITEM,2,718
FITEM,2,716
AL,P51X
FLST,2,4,4
FITEM,2,716
FITEM,2,715
FITEM,2,657
FITEM,2,717
AL,P51X
FLST,2,1,4,ORDE,1
FITEM,2,676
FLST,3,1,4,ORDE,1
FITEM,3,655
LSBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,192
FLST,3,1,4,ORDE,1
FITEM,3,749
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,4,ORDE,1
FITEM,2,746
FLST,3,1,4,ORDE,1
FITEM,3,748
LSBL,P51X,P51X, , ,KEEP
FLST,2,9,4
FITEM,2,655
FITEM,2,677
FITEM,2,743
FITEM,2,748
FITEM,2,695
FITEM,2,710
FITEM,2,718
FITEM,2,715
FITEM,2,752
AL,P51X  ! Areas & Lines for Wall Behind Bolster

FLST,3,1,4,ORDE,1
FITEM,3,730
LGEN,2,P51X, , ,-230, , , ,0
                        ! Line for Canopy Edge Stiffener

FLST,3,2,3,ORDE,2
FITEM,3,400
FITEM,3,-401
KGEN,2,P51X, , , , ,-10*20.5, ,0
LSTR,   407,   408
KWPLAN,-1,   394,   393,   400
LSBW,   753
LDELE,   754, , ,1
WPCSYS,-1,0
FLST,3,2,3,ORDE,2
FITEM,3,3
FITEM,3,355
KGEN,2,P51X, , , , ,-10*20.5, ,0
LSTR,   410,   407
LSTR,   407,   408
LSTR,   408,   401
LSTR,   407,     3
LSTR,   410,   355
FLST,3,1,3,ORDE,1
FITEM,3,409
KGEN,2,P51X, , ,16.5*20.5, , , ,0
LSTR,   411,   410
LSTR,   411,   409
LSTR,   409,   400
FLST,2,1,4,ORDE,1
FITEM,2,728
FLST,3,1,4,ORDE,1
FITEM,3,760
LSBL,P51X,P51X, , ,KEEP    ! Lines 4 Bolster

FLST,2,5,4
FITEM,2,760
FITEM,2,755
FITEM,2,759
FITEM,2,753
FITEM,2,754
AL,P51X
FLST,2,4,4
FITEM,2,756
FITEM,2,754
FITEM,2,757
FITEM,2,751
AL,P51X
FLST,2,4,4
FITEM,2,656
FITEM,2,753
FITEM,2,757
FITEM,2,758
AL,P51X
FLST,2,9,4
FITEM,2,758
FITEM,2,759
FITEM,2,717
FITEM,2,736
FITEM,2,714
FITEM,2,734
FITEM,2,675
FITEM,2,739
FITEM,2,762
AL,P51X
FLST,2,5,4
FITEM,2,762
FITEM,2,745
FITEM,2,655
FITEM,2,761
FITEM,2,760
AL,P51X
FLST,2,5,4
FITEM,2,761
FITEM,2,748
FITEM,2,755
FITEM,2,749
FITEM,2,756
AL,P51X                  ! Areas For Bolster
```

```
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~ First Inside Bolster Construction
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,3,3,4,ORDE,3
FITEM,3,755
FITEM,3,-756
FITEM,3,761
LGEN,2,P51X, , ,-776.6, , , ,0

FLST,3,3,4,ORDE,3
FITEM,3,728
FITEM,3,764
FITEM,3,-765
LGEN,2,P51X, , ,16.5*20.5, , , ,0

LSTR,   416,   412
LSTR,   417,   413
LSTR,   414,   415
LSTR,   419,   418          ! Constructing Lines

FLST,2,1,4,ORDE,1
FITEM,2,538
FLST,2,2,4,ORDE,2
FITEM,2,538
FITEM,2,540
FLST,3,4,4,ORDE,4
FITEM,3,764
FITEM,3,-765
FITEM,3,767
FITEM,3,-768
LSBL,P51X,P51X, , ,KEEP    ! Dividing Lines

FLST,2,5,4
FITEM,2,776
FITEM,2,748
FITEM,2,750
FITEM,2,774
FITEM,2,772
AL,P51X
FLST,2,4,4
FITEM,2,778
FITEM,2,772
FITEM,2,771
FITEM,2,777
AL,P51X
FLST,2,4,4
FITEM,2,768
FITEM,2,770
FITEM,2,765
FITEM,2,778
AL,P51X
FLST,2,4,4
FITEM,2,769
FITEM,2,767
FITEM,2,764
FITEM,2,777
AL,P51X
FLST,2,4,4
FITEM,2,772
FITEM,2,766
FITEM,2,768
FITEM,2,767
AL,P51X
FLST,2,4,4
FITEM,2,765
FITEM,2,764
FITEM,2,728
FITEM,2,771
AL,P51X
FLST,2,4,4
FITEM,2,770
FITEM,2,728
FITEM,2,766
FITEM,2,769
AL,P51X                    ! Areas

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~ 2nd & 3rd Inside Bolsters
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,3,10,4,ORDE,3         ! Copying Lines
FITEM,3,728
FITEM,3,764
FITEM,3,-772
LGEN,3,P51X, , ,-776.6, , , ,0

FLST,2,2,4,ORDE,2
FITEM,2,773
FITEM,2,775
FLST,3,8,4,ORDE,8
FITEM,3,540
FITEM,3,779
FITEM,3,781
FITEM,3,-782
FITEM,3,788
FITEM,3,-789
FITEM,3,791
FITEM,3,-792
LSBL,P51X,P51X, , ,KEEP
FLST,2,4,4
FITEM,2,771
FITEM,2,799
FITEM,2,786
FITEM,2,800
AL,P51X
FLST,2,4,4
FITEM,2,785
FITEM,2,786
FITEM,2,801
FITEM,2,803
AL,P51X
FLST,2,4,4
FITEM,2,803
FITEM,2,784
FITEM,2,779
FITEM,2,782
AL,P51X
FLST,2,4,4
FITEM,2,781
FITEM,2,783
FITEM,2,540
FITEM,2,801
AL,P51X
FLST,2,4,4
FITEM,2,780
FITEM,2,786
FITEM,2,782
FITEM,2,781
AL,P51X
FLST,2,4,4
FITEM,2,540
FITEM,2,785
FITEM,2,538
FITEM,2,779
AL,P51X
FLST,2,4,4
FITEM,2,784
FITEM,2,783
FITEM,2,780
```

```
FITEM,2,538
AL,P51X
FLST,2,4,4
FITEM,2,785
FITEM,2,796
FITEM,2,802
FITEM,2,804
AL,P51X
FLST,2,4,4
FITEM,2,796
FITEM,2,795
FITEM,2,805
FITEM,2,806
AL,P51X
FLST,2,4,4
FITEM,2,794
FITEM,2,789
FITEM,2,806
FITEM,2,792
AL,P51X
FLST,2,4,4
FITEM,2,805
FITEM,2,793
FITEM,2,788
FITEM,2,791
AL,P51X
FLST,2,4,4
FITEM,2,788
FITEM,2,795
FITEM,2,787
FITEM,2,789
AL,P51X
FLST,2,4,4
FITEM,2,796
FITEM,2,790
FITEM,2,792
FITEM,2,791
AL,P51X
FLST,2,4,4
FITEM,2,794
FITEM,2,790
FITEM,2,787
FITEM,2,793
AL,P51X                                  ! Areas

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~          Stringer Bolster
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,3,3,4,ORDE,3
FITEM,3,789
FITEM,3,792
FITEM,3,794
LGEN,2,P51X, , ,-752.625, , , ,0
FLST,2,1,4,ORDE,1
FITEM,2,798
FLST,3,2,4,ORDE,2
FITEM,3,773
FITEM,3,775
LSBL,P51X,P51X, , ,KEEP
FLST,3,2,3,ORDE,2
FITEM,3,110
FITEM,3,112
KGEN,2,P51X, , , ,-6*20.5,-10*20.5, ,0
LSTR,    247,   441
LSTR,    441,   438
LSTR,    439,   112
LSTR,    229,   440
LSTR,    440,   436
LSTR,    437,   110
LSTR,    441,   440                                   !
Lines
LSTR,    112,   441
LSTR,    110,   440

FLST,2,4,4
FITEM,2,809
FITEM,2,797
FITEM,2,812
FITEM,2,795
AL,P51X
FLST,2,4,4
FITEM,2,812
FITEM,2,815
FITEM,2,186
FITEM,2,810
AL,P51X
FLST,2,3,4
FITEM,2,817
FITEM,2,798
FITEM,2,535
AL,P51X
FLST,2,3,4
FITEM,2,818
FITEM,2,400
FITEM,2,813
AL,P51X
FLST,2,4,4
FITEM,2,645
FITEM,2,798
FITEM,2,813
FITEM,2,816
AL,P51X
FLST,2,4,4
FITEM,2,815
FITEM,2,814
FITEM,2,818
FITEM,2,773
AL,P51X
FLST,2,4,4
FITEM,2,812
FITEM,2,811
FITEM,2,817
FITEM,2,775
AL,P51X
FLST,2,4,4
FITEM,2,807
FITEM,2,810
FITEM,2,773
FITEM,2,775
AL,P51X
FLST,2,4,4
FITEM,2,811
FITEM,2,814
FITEM,2,816
FITEM,2,807
AL,P51X                                  ! Areas

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~          Center Bolster
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,3,1,4,ORDE,1
FITEM,3,787
LGEN,2,P51X, , ,-1483+23.55, , , ,0

FLST,2,1,4,ORDE,1
FITEM,2,729
FLST,3,1,4,ORDE,1
FITEM,3,819
```

```
LSBL,P51X,P51X, , ,KEEP
LSTR,    397,     4
LSTR,     4,    442
FLST,3,1,4,ORDE,1
FITEM,3,819
LGEN,2,P51X, , ,290, , , ,0
LSTR,    445,    443
LSTR,    444,    442
FLST,3,2,4,ORDE,2
FITEM,3,821
FITEM,3,-822
LGEN,2,P51X, , ,290, , , ,0
LSTR,    446,    448
NUMMRG,KP, , ,
FLST,2,2,4,ORDE,2
FITEM,2,382
FITEM,2,808
FLST,3,2,4,ORDE,2
FITEM,3,826
FITEM,3,-827
LSBL,P51X,P51X, , ,KEEP                              !
Lines

FLST,2,4,4
FITEM,2,832
FITEM,2,828
FITEM,2,830
FITEM,2,815
AL,P51X
FLST,2,4,4
FITEM,2,828
FITEM,2,729
FITEM,2,831
FITEM,2,829
AL,P51X
FLST,2,4,4
FITEM,2,827
FITEM,2,825
FITEM,2,822
FITEM,2,829
AL,P51X
FLST,2,4,4
FITEM,2,831
FITEM,2,824
FITEM,2,821
FITEM,2,826
AL,P51X
FLST,2,4,4
FITEM,2,823
FITEM,2,828
FITEM,2,826
FITEM,2,827
AL,P51X
FLST,2,4,4
FITEM,2,729
FITEM,2,819
FITEM,2,822
FITEM,2,821
AL,P51X
FLST,2,4,4
FITEM,2,823
FITEM,2,819
FITEM,2,824
FITEM,2,825
AL,P51X                                    ! Areas

!-------------------------------------------
!------------ Misc and Inside Front Angle Plate
!-------------------------------------------

FLST,2,24,4
FITEM,2,763
FITEM,2,760
FITEM,2,761
FITEM,2,776
FITEM,2,768
FITEM,2,770
FITEM,2,765
FITEM,2,800
FITEM,2,782
FITEM,2,784
FITEM,2,779
FITEM,2,804
FITEM,2,792
FITEM,2,794
FITEM,2,789
FITEM,2,809
FITEM,2,775
FITEM,2,807
FITEM,2,773
FITEM,2,832
FITEM,2,826
FITEM,2,824
FITEM,2,820
FITEM,2,737
AL,P51X               ! Bottom Area of Top Bolster

FLST,3,1,3,ORDE,1
FITEM,3,4
KGEN,2,P51X, , , , ,190, ,0
KL,729,(3303.6-190)/3303.6, ,
FLST,3,2,3,ORDE,2
FITEM,3,405
FITEM,3,447
KGEN,2,P51X, , ,10000, , , ,0
FLST,2,4,3
FITEM,2,447
FITEM,2,405
FITEM,2,449
FITEM,2,450
A,P51X                          ! Front Angle Plate

FLST,2,1,5,ORDE,1
FITEM,2,385
FLST,3,1,5,ORDE,1
FITEM,3,17
ASBA,P51X,P51X, , ,KEEP
ADELE,    387, , ,1
FLST,2,1,5,ORDE,1
FITEM,2,17
FLST,3,1,5,ORDE,1
FITEM,3,386
ASBA,P51X,P51X, , ,KEEP
FLST,2,10,5,ORDE,10
FITEM,2,347
FITEM,2,-348
FITEM,2,354
FITEM,2,-355
FITEM,2,361
FITEM,2,-362
FITEM,2,368
FITEM,2,-369
FITEM,2,377
FITEM,2,-378
FLST,3,1,5,ORDE,1
FITEM,3,386
```

```
ASBA,P51X,P51X, , ,KEEP
FLST,2,3,5,ORDE,3
FITEM,2,45
FITEM,2,170
FITEM,2,188
FLST,3,1,5,ORDE,1
FITEM,3,386
ASBA,P51X,P51X, , ,KEEP    ! Dividing Areas

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~             Cleanup
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

NUMMRG,ALL, , ,              ! Merging Coincident
Items
NUMCMP,AREA
NUMCMP,LINE
NUMCMP,KP                    ! Compressing Numbers

FINISH
!SAVE
/EOF
```

❖ *Filename: 2_5_build_canopy_INPUT*

```
!@@@@@@@@@@@@@@@@@@@@@@@@@
!        FEA of 930E Truck Box Structure
!        Canopy Construction Routine

:build

FINISH

/FILNAM,geom
/TITLE,Building Canopy Geometry

/PREP7
*AFUN,DEG

/VIEW, 1 ,1,1,1
/ANG, 1
/REP,FAST
/AUTO, 1
/REP
/USER, 1
/FOC, 1, 3101.70013053 , 4316.90917962 , -
10130.9161949
/VIEW, 1, 0.577350269190 , 0.577350269190 ,
0.577350269190
/REPLO
/DIST, 1, 2537.46312511
/ANG, 1, -3.48000000000
APLOT

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~ Outer Bolster
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

KL,728,(283.9-12.5*20.5)/283.9, ,
FLST,3,1,3,ORDE,1
FITEM,3,462
KGEN,2,P51X, , ,-16.5*20.5, , , ,0
LSTR, 462, 463
LSBL, 728, 863
FLST,3,1,4,ORDE,1
FITEM,3,865
LGEN,2,P51X, , ,-16.5*20.5, , , ,0
FLST,2,1,4,ORDE,1
FITEM,2,732
FLST,3,2,4,ORDE,2
FITEM,3,728
FITEM,3,743
LSBL,P51X,P51X, , ,KEEP
LSTR, 464, 462          ! Lines in Top Corner

FLST,3,2,4,ORDE,2
FITEM,3,863
FITEM,3,867
LGEN,2,P51X, , , ,4225*sin(9),-4225*cos(9), ,0
LSTR, 395, 465
LSTR, 406, 466
LSTR, 463, 467          ! Lines out canopy

FLST,3,2,3,ORDE,2
FITEM,3,465
FITEM,3,467
KGEN,2,P51X, , , ,-5*20.7*cos(9),-5*20.7*sin(9), ,0
LSTR, 462, 468
LSTR, 464, 469
LSTR, 469, 467
LSTR, 468, 465
LSTR, 468, 469          ! Lines 4 Lower Bolster

FLST,3,1,4,ORDE,1
FITEM,3,868
LGEN,2,P51X, , , ,5*20.7*cos(9),5*20.7*sin(9), ,0
LSTR, 466, 471
LSTR, 465, 470
LSTR, 471, 359
LSTR, 367, 470          ! Lines 4 Upper Bolster

FLST,2,5,4
FITEM,2,865
FITEM,2,732
FITEM,2,728
FITEM,2,867
FITEM,2,863
AL,P51X
FLST,2,4,4
FITEM,2,732
FITEM,2,874
FITEM,2,873
FITEM,2,877
AL,P51X
FLST,2,5,4
FITEM,2,875
FITEM,2,869
FITEM,2,868
FITEM,2,876
FITEM,2,877
AL,P51X
FLST,2,4,4
FITEM,2,728
FITEM,2,874
FITEM,2,872
FITEM,2,875
AL,P51X
FLST,2,4,4
FITEM,2,876
FITEM,2,873
FITEM,2,870
FITEM,2,865
AL,P51X
FLST,2,4,4
FITEM,2,869
FITEM,2,872
FITEM,2,871
FITEM,2,867
AL,P51X
FLST,2,4,4
FITEM,2,870
FITEM,2,871
FITEM,2,863
FITEM,2,868
AL,P51X
FLST,2,4,4
FITEM,2,879
FITEM,2,878
FITEM,2,880
FITEM,2,868
AL,P51X
FLST,2,5,4
FITEM,2,881
FITEM,2,871
FITEM,2,879
FITEM,2,743
FITEM,2,739
AL,P51X
```

```
FLST,2,5,4
FITEM,2,737
FITEM,2,870
FITEM,2,727
FITEM,2,882
FITEM,2,880
AL,P51X
FLST,2,4,4
FITEM,2,727
FITEM,2,657
FITEM,2,743
FITEM,2,863
AL,P51X
FLST,2,4,4
FITEM,2,671
FITEM,2,881
FITEM,2,882
FITEM,2,878
AL,P51X                     ! Creating Areas

!-------------------------------------------
!-----------------       Interior Bolsters
!-------------------------------------------

FLST,3,4,5,ORDE,2
FITEM,3,401
FITEM,3,-404
AGEN,5,P51X, , ,-776.6, , , ,0  ! Copying Areas

FLST,2,1,4,ORDE,1
FITEM,2,866
FLST,3,8,4,ORDE,8
FITEM,3,891
FITEM,3,894
FITEM,3,903
FITEM,3,906
FITEM,3,915
FITEM,3,918
FITEM,3,927
FITEM,3,930
LSBL,P51X,P51X, , ,KEEP ! Dividing Top Bolster Line

FLST,2,4,4
FITEM,2,891
FITEM,2,883
FITEM,2,894
FITEM,2,933
AL,P51X
FLST,2,5,4
FITEM,2,933
FITEM,2,893
FITEM,2,892
FITEM,2,889
FITEM,2,888
AL,P51X
FLST,2,4,4
FITEM,2,903
FITEM,2,935
FITEM,2,906
FITEM,2,895
AL,P51X
FLST,2,5,4
FITEM,2,904
FITEM,2,935
FITEM,2,905
FITEM,2,901
FITEM,2,900
AL,P51X
FLST,2,4,4
FITEM,2,907
FITEM,2,918
FITEM,2,915
FITEM,2,937
AL,P51X
FLST,2,5,4
FITEM,2,937
FITEM,2,917
FITEM,2,916
FITEM,2,913
FITEM,2,912
AL,P51X
FLST,2,4,4
FITEM,2,919
FITEM,2,930
FITEM,2,939
FITEM,2,927
AL,P51X
FLST,2,5,4
FITEM,2,939
FITEM,2,929
FITEM,2,928
FITEM,2,925
FITEM,2,924
AL,P51X             ! Completing Bolster Areas

!-------------------------------------------
!-----------------  Middle Bolsters
!-------------------------------------------

FLST,3,6,4,ORDE,6
FITEM,3,919
FITEM,3,-920
FITEM,3,923
FITEM,3,926
FITEM,3,929
FITEM,3,-930
LGEN,2,P51X, , ,-682.85, , , ,0
FLST,2,1,4,ORDE,1
FITEM,2,730
FLST,3,1,4,ORDE,1
FITEM,3,866
LSBL,P51X,P51X, , ,KEEP
LSTR,    512,   399
LSTR,    511,   508
LSTR,    512,   513
LSTR,    511,   510
FLST,2,1,4,ORDE,1
FITEM,2,931
FLST,3,1,4,ORDE,1
FITEM,3,944
LSBL,P51X,P51X, , ,KEEP              ! Lines

FLST,2,4,4
FITEM,2,866
FITEM,2,944
FITEM,2,950
FITEM,2,946
AL,P51X
FLST,2,4,4
FITEM,2,866
FITEM,2,947
FITEM,2,940
FITEM,2,949
AL,P51X
FLST,2,4,4
FITEM,2,943
FITEM,2,940
FITEM,2,944
FITEM,2,942
AL,P51X
```

```
FLST,2,4,4
FITEM,2,948
FITEM,2,949
FITEM,2,941
FITEM,2,942
AL,P51X
FLST,2,4,4
FITEM,2,730
FITEM,2,947
FITEM,2,941
FITEM,2,946
AL,P51X
FLST,2,4,4
FITEM,2,950
FITEM,2,730
FITEM,2,943
FITEM,2,948
AL,P51X                                 ! Areas

!------------------------------------------
!---------------- Closing Top Bolster
!------------------------------------------

FLST,2,24,4
FITEM,2,734
FITEM,2,945
FITEM,2,866
FITEM,2,944
FITEM,2,951
FITEM,2,927
FITEM,2,919
FITEM,2,930
FITEM,2,938
FITEM,2,915
FITEM,2,907
FITEM,2,918
FITEM,2,936
FITEM,2,903
FITEM,2,895
FITEM,2,906
FITEM,2,934
FITEM,2,891
FITEM,2,883
FITEM,2,894
FITEM,2,932
FITEM,2,728
FITEM,2,732
FITEM,2,864
AL,P51X                     ! Front Area

FLST,2,6,4
FITEM,2,738
FITEM,2,727
FITEM,2,865
FITEM,2,864
FITEM,2,760
FITEM,2,759
AL,P51X                     ! Side Area

FLST,2,14,4
FITEM,2,741
FITEM,2,652
FITEM,2,773
FITEM,2,775
FITEM,2,797
FITEM,2,800
FITEM,2,801
FITEM,2,803
FITEM,2,806
FITEM,2,807
```

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FITEM,2,828
FITEM,2,827
FITEM,2,735
FITEM,2,744
AL,P51X                     ! Area Inside Box

FLST,2,14,4
FITEM,2,743
FITEM,2,744
FITEM,2,729
FITEM,2,950
FITEM,2,951
FITEM,2,939
FITEM,2,938
FITEM,2,937
FITEM,2,936
FITEM,2,935
FITEM,2,934
FITEM,2,933
FITEM,2,932
FITEM,2,867
AL,P51X                     ! Top Area

!------------------------------------------
!---------------- Outer Lip
!------------------------------------------

FLST,3,1,3,ORDE,1
FITEM,3,512
KGEN,2,P51X, , ,230*cos(9),230*sin(9), ,0
LSTR,   512,   515
FLST,3,1,3,ORDE,1
FITEM,3,515
KGEN,2,P51X, , ,-75*sin(9),75*cos(9), ,0
LSTR,   516,   515
FLST,3,1,3,ORDE,1
FITEM,3,512
KGEN,2,P51X, , ,-140*cos(9),-140*sin(9), ,0
LSTR,   517,   511
KL,730,190/4225, ,
FLST,3,1,3,ORDE,1
FITEM,3,518
KGEN,2,P51X, , ,-140*cos(9),-140*sin(9), ,0
LSTR,   519,   518
LSTR,   519,   517                  ! Shape of Lip

FLST,3,3,4,ORDE,3
FITEM,3,952
FITEM,3,954
FITEM,3,-955
LGEN,2,P51X, , ,4127.5, , , ,0  ! Copy to Outside

LSTR,   516,   520
LSTR,   521,   515
LSTR,   517,   524
LSTR,   522,   519          ! Connecting Lines
LSTR,   523,   520
LSTR,   521,   470
LSTR,   468,   524

FLST,2,2,5,ORDE,2
FITEM,2,404
FITEM,2,409
FLST,2,3,4,ORDE,3
FITEM,2,870
FITEM,2,873
FITEM,2,882
FLST,3,2,4,ORDE,2
FITEM,3,957
FITEM,3,963
```

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LSBL,P51X,P51X, , ,KEEP
FLST,2,2,4,ORDE,2
FITEM,2,957
FITEM,2,963
FLST,3,2,4,ORDE,2
FITEM,3,970
FITEM,3,-971
LSBL,P51X,P51X, , ,KEEP
FLST,2,2,5,ORDE,2
FITEM,2,404
FITEM,2,409
FLST,3,2,4,ORDE,2
FITEM,3,882
FITEM,3,972
ASBL,P51X,P51X, , ,KEEP
FLST,2,4,4
FITEM,2,971
FITEM,2,964
FITEM,2,956
FITEM,2,870
AL,P51X
FLST,2,4,4
FITEM,2,970
FITEM,2,958
FITEM,2,873
FITEM,2,965
AL,P51X                     ! Areas On Outside Edge

LSTR,   518,   523
NUMMRG,KP, , ,
FLST,2,5,4
FITEM,2,954
FITEM,2,957
FITEM,2,962
FITEM,2,873
FITEM,2,972
AL,P51X                     ! Lip Inside Area

FLST,2,28,5,ORDE,25
FITEM,2,401
FITEM,2,403
FITEM,2,405
FITEM,2,-406
FITEM,2,408
FITEM,2,411
FITEM,2,-412
FITEM,2,414
FITEM,2,-416
FITEM,2,418
FITEM,2,-420
FITEM,2,422
FITEM,2,-424
FITEM,2,426
FITEM,2,-427
FITEM,2,429
FITEM,2,431
FITEM,2,433
FITEM,2,435
FITEM,2,437
FITEM,2,-438
FITEM,2,440
FITEM,2,-441
FITEM,2,446
FITEM,2,449
ASBA,P51X,    450 ! Cutting Ends of Bolsters

FLST,2,25,5,ORDE,19
FITEM,2,413
FITEM,2,417
FITEM,2,421
FITEM,2,425
FITEM,2,439
FITEM,2,461
FITEM,2,-463
FITEM,2,467
FITEM,2,-469
FITEM,2,473
FITEM,2,-475
FITEM,2,479
FITEM,2,-481
FITEM,2,488
FITEM,2,-489
FITEM,2,492
FITEM,2,-493
FITEM,2,495
FITEM,2,-498
ADELE,P51X, , ,1
FLST,2,3,5,ORDE,3
FITEM,2,402
FITEM,2,458
FITEM,2,-459
ADELE,P51X, , ,1   ! Deleting Ends of Bolsters

FLST,2,2,4,ORDE,2
FITEM,2,931
FITEM,2,953
LDELE,P51X, , ,1
LSTR,   515,   517
LSTR,   519,   530
LSTR,   519,   522
LSTR,   527,   535
LSTR,   534,   539
LSTR,   538,   543
LSTR,   542,   547
LSTR,   546,   548 ! Connecting Missing Lines

FLST,2,5,4
FITEM,2,972
FITEM,2,977
FITEM,2,981
FITEM,2,974
FITEM,2,975
AL,P51X
FLST,2,4,4
FITEM,2,987
FITEM,2,1029
FITEM,2,993
FITEM,2,991
AL,P51X
FLST,2,4,4
FITEM,2,998
FITEM,2,1030
FITEM,2,1004
FITEM,2,1002
AL,P51X
FLST,2,4,4
FITEM,2,1009
FITEM,2,1031
FITEM,2,1013
FITEM,2,1015
AL,P51X
FLST,2,4,4
FITEM,2,1020
FITEM,2,1032
FITEM,2,1026
FITEM,2,1024
AL,P51X
FLST,2,4,4
FITEM,2,980
FITEM,2,1041
```

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FITEM,2,1038
FITEM,2,1035
AL,P51X                 ! Areas on Ends of Bolsters

FLST,2,24,4
FITEM,2,872
FITEM,2,871
FITEM,2,980
FITEM,2,1038
FITEM,2,885
FITEM,2,1024
FITEM,2,1020
FITEM,2,884
FITEM,2,1026
FITEM,2,1013
FITEM,2,1009
FITEM,2,877
FITEM,2,1015
FITEM,2,1002
FITEM,2,998
FITEM,2,1004
FITEM,2,875
FITEM,2,991
FITEM,2,987
FITEM,2,993
FITEM,2,873
FITEM,2,975
FITEM,2,974
FITEM,2,874
AL,P51X                        ! Lip Inside Area

FLST,2,4,4
FITEM,2,958
FITEM,2,961
FITEM,2,955
FITEM,2,872
AL,P51X
FLST,2,7,4
FITEM,2,964
FITEM,2,880
FITEM,2,876
FITEM,2,965
FITEM,2,730
FITEM,2,961
FITEM,2,960
AL,P51X
FLST,2,4,4
FITEM,2,956
FITEM,2,952
FITEM,2,960
FITEM,2,959
AL,P51X                        ! Lip Outer Areas

KWPLAN,-1,   527,   467,   535
ASBW,   414
WPSTYLE,,,,,,,0     ! Cut Outer Area w/ WPlane

LSTR,   518,   469
FLST,2,1,4,ORDE,1
FITEM,2,886
FLST,3,1,4,ORDE,1
FITEM,3,983
LSBL,P51X,P51X, , ,KEEP
FLST,2,13,4
FITEM,2,730
FITEM,2,1041
FITEM,2,885
FITEM,2,1032
FITEM,2,884
FITEM,2,1031
FITEM,2,877
FITEM,2,1030
FITEM,2,875
FITEM,2,1029
FITEM,2,874
FITEM,2,983
FITEM,2,890
AL,P51X                        ! Lip Internal Area

FLST,2,1,5,ORDE,1
FITEM,2,417
FLST,3,1,5,ORDE,1
FITEM,3,407
ASBA,P51X,P51X, , ,KEEP
          ! Subtracted Upper Bolster End Area

KWPLAN,-1,   535,   533,   480
WPSTYLE,,,,,,,0
FLST,2,3,5,ORDE,3
FITEM,2,414
FITEM,2,-415
FITEM,2,418
ASBW,P51X
KWPAVE,   539
FLST,2,3,5,ORDE,3
FITEM,2,419
FITEM,2,-420
FITEM,2,423
ASBW,P51X
KWPAVE,   543
FLST,2,3,5,ORDE,3
FITEM,2,414
FITEM,2,424
FITEM,2,426
ASBW,P51X
KWPAVE,   547
FLST,2,3,5,ORDE,3
FITEM,2,419
FITEM,2,427
FITEM,2,431
ASBW,P51X
WPCSYS,-1,0          ! Using WPlane to Cut Lip Areas

LSTR,   547,   493
LSTR,   543,   486
LSTR,   539,   483
LSTR,   535,   476
FLST,2,4,4
FITEM,2,896
FITEM,2,926
FITEM,2,912
FITEM,2,929
AL,P51X
FLST,2,4,4
FITEM,2,898
FITEM,2,920
FITEM,2,900
FITEM,2,922
AL,P51X
FLST,2,4,4
FITEM,2,921
FITEM,2,911
FITEM,2,905
FITEM,2,913
AL,P51X
FLST,2,4,4
FITEM,2,931
FITEM,2,899
FITEM,2,897
FITEM,2,893
```

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AL,P51X                    ! Lip Gusset Areas

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~ Top Plate Areas
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,2,4,4
FITEM,2,951
FITEM,2,1039
FITEM,2,1027
FITEM,2,885
AL,P51X
FLST,2,4,4
FITEM,2,1028
FITEM,2,1016
FITEM,2,938
FITEM,2,884
AL,P51X
FLST,2,4,4
FITEM,2,936
FITEM,2,1017
FITEM,2,877
FITEM,2,1005
AL,P51X
FLST,2,4,4
FITEM,2,1006
FITEM,2,875
FITEM,2,994
FITEM,2,934
AL,P51X
FLST,2,4,4
FITEM,2,995
FITEM,2,874
FITEM,2,963
FITEM,2,932
AL,P51X

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~ Internal Bolster Gussets
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

*AFUN,DEG
KWPAVE,   398
wpro,,9.000000,
KWPAVE,   508
wpoff,0,0,-503             ! Placing WPlane

FLST,2,3,5,ORDE,3
FITEM,2,454
FITEM,2,490
FITEM,2,-491
ASBW,P51X
WPSTYLE,,,,,,,,0
KL,943,.5,,
KL,949,.5,,
LSTR,    502,    503
FLST,2,2,4,ORDE,2
FITEM,2,943
FITEM,2,949
FLST,3,1,4,ORDE,1
FITEM,3,960
LSBL,P51X,P51X,,,KEEP
FLST,2,4,4
FITEM,2,978
FITEM,2,962
FITEM,2,960
FITEM,2,942
AL,P51X                    ! 1st Center Gusset Area

WPSTYLE,,,,,,,,1
wpoff,0,0,-700.5+503
FLST,2,5,5,ORDE,4
FITEM,2,446
FITEM,2,451
FITEM,2,-453
FITEM,2,455
ASBW,P51X
FLST,2,5,4
FITEM,2,1001
FITEM,2,1000
FITEM,2,1003
FITEM,2,988
FITEM,2,990
AL,P51X                    ! Outside Bolster Gusset

WPSTYLE,,,,,,,,1
wpoff,0,0,-1575-503+700.5
FLST,2,3,5,ORDE,3
FITEM,2,463
FITEM,2,467
FITEM,2,-468
ASBW,P51X
KL,1033,.5,,
KL,1022,.5,,
LSTR,    552,    553
FLST,2,2,4,ORDE,2
FITEM,2,1022
FITEM,2,1033
FLST,3,1,4,ORDE,1
FITEM,3,953
LSBL,P51X,P51X,,,KEEP
FLST,2,4,4
FITEM,2,957
FITEM,2,954
FITEM,2,953
FITEM,2,968
AL,P51X               ! 2nd Center Gusset Area

wpoff,0,0,-75.5*20.7
FLST,2,3,5,ORDE,3
FITEM,2,452
FITEM,2,-453
FITEM,2,455
ASBW,P51X
KL,1044,.5,,
KL,1046,.5,,
LSTR,    559,    558
FLST,2,2,4,ORDE,2
FITEM,2,1044
FITEM,2,1046
FLST,3,1,4,ORDE,1
FITEM,3,973
LSBL,P51X,P51X,,,KEEP
FLST,2,4,4
FITEM,2,973
FITEM,2,976
FITEM,2,1039
FITEM,2,1023
AL,P51X                    ! 3rd Center Gusset Area

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~ Rounded Sections of Bolsters
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

WPCSYS,-1,0
KL,756,34*20.5/3085.14,,
KWPLAN,-1,    510,    511,    462
FLST,3,1,3,ORDE,1
FITEM,3,510
KGEN,2,P51X,,,-1000,,,0
```

```
LARC,510,560,561,60*20.5,                    ! Creating Arc

WPSTYLE,,,,,,,0
FLST,2,1,4,ORDE,1
FITEM,2,756
FLST,3,1,4,ORDE,1
FITEM,3,1044
LSBL,P51X,P51X, , ,KEEP
FLST,2,5,4
FITEM,2,989
FITEM,2,1044
FITEM,2,1050
FITEM,2,760
FITEM,2,864
AL,P51X                                      ! Creating Area

FLST,3,1,5,ORDE,1
FITEM,3,453
AGEN,2,P51X, , ,-16.5*20.5, , , ,0
FLST,2,2,5,ORDE,2
FITEM,2,377
FITEM,2,442
ASBA,P51X,   455
          ! Used Copied Area to Cut Top Bolster

FLST,3,1,4,ORDE,1
FITEM,3,1044
LGEN,2,P51X, , ,-16.5*20.5, , , ,0
LSTR,    563,    560
FLST,2,1,5,ORDE,1
FITEM,2,341
FLST,2,1,5,ORDE,1
FITEM,2,338
FLST,3,1,4,ORDE,1
FITEM,3,756
ASBL,P51X,P51X, , ,KEEP         ! Dividing Areas

NUMMRG,KP, , ,
FLST,2,5,4
FITEM,2,734
FITEM,2,1051
FITEM,2,1056
FITEM,2,1057
FITEM,2,949
AL,P51X
FLST,2,4,4
FITEM,2,734
FITEM,2,1044
FITEM,2,756
FITEM,2,990
AL,P51X               ! Closing Rounded Section

KWPLAN,-1,   480,    473,    419
FLST,2,2,5,ORDE,2
FITEM,2,501
FITEM,2,-502
ASBW,P51X
KWPLAN,-1,   479,    472,    415
FLST,2,2,5,ORDE,2
FITEM,2,505
FITEM,2,-506
ASBW,P51X
KWPLAN,-1,   489,    482,    427
FLST,2,2,5,ORDE,2
FITEM,2,507
FITEM,2,-508
ASBW,P51X
KWPLAN,-1,   488,    481,    423
FLST,2,2,5,ORDE,2
FITEM,2,509
FITEM,2,-510
ASBW,P51X
KWPLAN,-1,   498,    491,    435
FLST,2,2,5,ORDE,2
FITEM,2,511
FITEM,2,-512
ASBW,P51X
KWPLAN,-1,   497,    490,    431
FLST,2,2,5,ORDE,2
FITEM,2,513
FITEM,2,-514
ASBW,P51X          ! Cutting Top Bolster As Required

WPCSYS,-1,0
WPSTYLE,,,,,,,0
FLST,3,1,5,ORDE,1
FITEM,3,455
AGEN,4,P51X, , ,-776.6, , , ,0
                   ! Copying Rounded Section

FLST,2,6,5,ORDE,6
FITEM,2,350
FITEM,2,357
FITEM,2,364
FITEM,2,460
FITEM,2,466
FITEM,2,472
FLST,3,3,5,ORDE,3
FITEM,3,513
FITEM,3,-514
FITEM,3,517
ASBA,P51X,P51X, , ,KEEP    ! Dividing Areas

FLST,2,5,4
FITEM,2,1098
FITEM,2,752
FITEM,2,1075
FITEM,2,1053
FITEM,2,1088
AL,P51X
FLST,2,5,4
FITEM,2,1070
FITEM,2,1087
FITEM,2,1060
FITEM,2,1058
FITEM,2,1097
AL,P51X
FLST,2,5,4
FITEM,2,1079
FITEM,2,1092
FITEM,2,1063
FITEM,2,1054
FITEM,2,1100
AL,P51X
FLST,2,5,4
FITEM,2,1077
FITEM,2,1091
FITEM,2,1061
FITEM,2,1066
FITEM,2,1099
AL,P51X
FLST,2,5,4
FITEM,2,1083
FITEM,2,1096
FITEM,2,1064
FITEM,2,1069
FITEM,2,1102
AL,P51X
FLST,2,5,4
FITEM,2,1081
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FITEM,2,1101
FITEM,2,1067
FITEM,2,1072
FITEM,2,1095
AL,P51X                          ! Filling in Side Areas

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~    Canopy Brace
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,3,3,4,ORDE,2
FITEM,3,757
FITEM,3,-759
LGEN,2,P51X, , , ,-(2000-300)*cos(12.5),(2000-
300)*sin(12.5), ,0
FLST,3,3,4,ORDE,2
FITEM,3,757
FITEM,3,-759
LGEN,2,P51X, , , ,-
(2000+300)*cos(12.5),(2000+300)*sin(12.5), ,0
FLST,2,3,5,ORDE,3
FITEM,2,341
FITEM,2,343
FITEM,2,442
FLST,3,6,4,ORDE,6
FITEM,3,535
FITEM,3,725
FITEM,3,763
FITEM,3,777
FITEM,3,784
FITEM,3,787
ASBL,P51X,P51X, , ,KEEP    ! Lower Reinforced Area

KWPLAN,-1,   465,   474,   521
KWPAVE,   395
wpoff,0,0,2000-300
FLST,2,2,5,ORDE,2
FITEM,2,480
FITEM,2,488
ASBW,P51X
wpoff,0,0,600
FLST,2,2,5,ORDE,2
FITEM,2,341
FITEM,2,343
ASBW,P51X
WPCSYS,-1,0                      ! Upper Reinforced Area

KL,996,160/600, ,
KL,996,(600-160)/600, ,
FLST,3,2,3,ORDE,2
FITEM,3,596
FITEM,3,-597
KGEN,2,P51X, , ,-92.925, , , ,0
FLST,3,2,3,ORDE,2
FITEM,3,598
FITEM,3,-599
KGEN,2,P51X, , ,-6*25.4, , , ,0
FLST,2,4,3
FITEM,2,598
FITEM,2,600
FITEM,2,601
FITEM,2,599
A,P51X
FLST,2,1,5,ORDE,1
FITEM,2,531
FLST,3,1,5,ORDE,1
FITEM,3,341
ASBA,P51X,P51X, , ,KEEP    ! Lower End Area

KDISTANCE,   591,   594
KL,1011,160/600.29, ,
KL,1011,(600.29-160)/600.29, ,
FLST,3,2,3,ORDE,2
FITEM,3,602
FITEM,3,-603
KGEN,2,P51X, , ,-92.925, , , ,0
FLST,3,2,3,ORDE,2
FITEM,3,604
FITEM,3,-605
KGEN,2,P51X, , ,-6*25.4, , , ,0
FLST,2,4,3
FITEM,2,604
FITEM,2,606
FITEM,2,607
FITEM,2,605
A,P51X
FLST,2,1,5,ORDE,1
FITEM,2,541
FLST,3,1,5,ORDE,1
FITEM,3,531
ASBA,P51X,P51X, , ,KEEP    ! Upper End Area

LSTR,   598,   604
LSTR,   605,   599
LSTR,   600,   606
LSTR,   607,   601
FLST,2,4,4
FITEM,2,1124
FITEM,2,1128
FITEM,2,1130
FITEM,2,1129
AL,P51X
FLST,2,4,4
FITEM,2,1132
FITEM,2,1130
FITEM,2,1046
FITEM,2,1127
AL,P51X
FLST,2,4,4
FITEM,2,711
FITEM,2,1131
FITEM,2,1129
FITEM,2,1125
AL,P51X
FLST,2,4,4
FITEM,2,733
FITEM,2,1126
FITEM,2,1132
FITEM,2,1131
AL,P51X                          ! Canopy Brace Areas

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~ Correcting Mistake in Front Floor/Wall Angle Plate
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
! Correction Necessary for correct mesh generation.
! Old Area was not attached to Wall or Floor plates...

ADELE,   379, , ,1 ! Deleted Area with unbroken sides

LSTR,   447,   405               ! Replaced Missing Edge

FLST,2,15,4
FITEM,2,379
FITEM,2,792
FITEM,2,769
FITEM,2,809
FITEM,2,833
FITEM,2,837
FITEM,2,839
FITEM,2,845
```

```
FITEM,2,848
FITEM,2,850
FITEM,2,853
FITEM,2,843
FITEM,2,835
FITEM,2,860
FITEM,2,858
AL,P51X  ! Replaced Area using proper line segments

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~ Adding Missing Gusset in Pivot Structure
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

KWPLAN,-1,    180,    183,    178
KWPAVE,    209
FLST,2,3,5,ORDE,3
FITEM,2,33
FITEM,2,129
FITEM,2,140
ASBW,P51X          ! Using Workplane to Cut Areas

WPSTYLE,,,,,,,0
FLST,2,4,4
FITEM,2,1137
FITEM,2,1133
FITEM,2,1134
FITEM,2,362
AL,P51X
          ! Creating Gusset Area from Created lines

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~Correcting Mistake in 2nd Bolster/Rear Stringer
Connection ~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
! Correction Necessary for correct mesh generation.
! Old Area was not made up of proper lines to be
! attached to surrounding areas.  Caused discontinuous
! mesh.

ADELE,    52
FLST,2,5,4
FITEM,2,151
FITEM,2,173
FITEM,2,155
FITEM,2,139
FITEM,2,156
AL,P51X

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~              Cleanup
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

NUMMRG,ALL, , ,              ! Merging Coincident
Items
NUMCMP,AREA
NUMCMP,LINE
NUMCMP,KP                    ! Compressing Numbers

FINISH
/EOF
```

❖ *Filename: 2_6_round_corners_INPUT*

```
!@@@@@@@@@@@@@@@@@@@@@@@@@@
!          FEA of 930E Truck Box Structure
!Routine to Add Rounded Bolster Fillets to Geometry
!@@@@@@@@@@@@@@@@@@@@@@@@@@

FINISH

/TITLE,Adding Bolster Fillets

/PREP7
*AFUN,DEG
APLOT
/AUTO, 1
/REP
/USER, 1
/VIEW, 1, 0.909916171862   , -0.375169699704   ,
0.176918785347
/ANG, 1,  179.498910154
/LIG, 1,1,1.000, 0.501901609919   , 0.563136024018
, 0.656485028324   , 0.000000000000E+00
/ZOOM,1,RECT,0.068021,0.615836,0.967367,0.09853
4

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~ Forward Bolsters
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,2,2,5,ORDE,2
FITEM,2,189
FITEM,2,201
ADELE,P51X, , ,1   ! Deleting STR Side Areas

AFILLT,97,100,38,             ! First Bolster from Front
AFILLT,114,116,38,
AFILLT,96,101,38,
AFILLT,552,99,38,
AFILLT,551,115,38,
AFILLT,550,98,38,             ! 38mm Bolster Fillets
ADELE,   259, , ,1            ! Deleting End Cap Area
LSTR,    70,   611            ! Creating Line in Middle
FLST,2,4,4
FITEM,2,83
FITEM,2,1136
FITEM,2,253
FITEM,2,1144
AL,P51X
FLST,2,4,4
FITEM,2,124
FITEM,2,83
FITEM,2,85
FITEM,2,1161
AL,P51X              ! Creating New End Cap Areas

AFILLT,282,261,38,
AFILLT,274,280,38,
AFILLT,264,268,38,
AFILLT,109,113,38,
AFILLT,86,95,38,
AFILLT,561,93,38,
AFILLT,560,111,38,
AFILLT,559,266,38,
AFILLT,558,278,38,
AFILLT,557,284,38,
FLST,2,3,4
FITEM,2,79
FITEM,2,625
FITEM,2,647
AL,P51X
FLST,2,3,4
FITEM,2,243
FITEM,2,605
FITEM,2,1165
AL,P51X
FLST,2,3,4
FITEM,2,269
FITEM,2,1167
FITEM,2,220
AL,P51X
FLST,2,3,4
FITEM,2,1181
FITEM,2,221
FITEM,2,634
AL,P51X
FLST,3,2,5,ORDE,2
FITEM,3,284
FITEM,3,568
ASBA,    85,P51X
FLST,3,2,5,ORDE,2
FITEM,3,557
FITEM,3,567
ASBA,    88,P51X
ADELE,   258, , ,1
LSTR,    62,   640
FLST,2,4,4
FITEM,2,1147
FITEM,2,242
FITEM,2,1187
FITEM,2,68
AL,P51X
FLST,2,4,4
FITEM,2,120
FITEM,2,68
FITEM,2,72
FITEM,2,1190
AL,P51X                       ! Second Bolster

AFILLT,283,260,38,
AFILLT,277,279,38,
AFILLT,265,267,38,
AFILLT,110,112,38,
AFILLT,89,91,38,
AFILLT,572,84,38,
AFILLT,571,108,38,
AFILLT,570,263,38,
AFILLT,568,272,38,
AFILLT,567,281,38,
FLST,2,3,4
FITEM,2,1189
FITEM,2,595
FITEM,2,237
AL,P51X
FLST,2,3,4
FITEM,2,592
FITEM,2,1207
FITEM,2,214
AL,P51X
FLST,2,3,4
FITEM,2,1162
FITEM,2,589
FITEM,2,75
AL,P51X
FLST,2,3,4
FITEM,2,602
FITEM,2,1209
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FITEM,2,215
AL,P51X
FLST,3,2,5,ORDE,2
FITEM,3,578
FITEM,3,-579
ASBA,    44,P51X
FLST,3,2,5,ORDE,2
FITEM,3,281
FITEM,3,567
ASBA,    87,P51X
ADELE,    257, , ,1
LSTR,    58,    131
FLST,2,4,4
FITEM,2,69
FITEM,2,1210
FITEM,2,233
FITEM,2,625
AL,P51X
FLST,2,4,4
FITEM,2,116
FITEM,2,1213
FITEM,2,64
FITEM,2,69
AL,P51X                         ! Third Bolster

AFILLT,81,82,38,
AFILLT,106,107,38,
AFILLT,80,83,38,
AFILLT,581,78,38,
AFILLT,579,105,38,
AFILLT,578,79,38,
ADELE,    256, , ,1
LSTR,    50,    66
FLST,2,4,4
FITEM,2,58
FITEM,2,1162
FITEM,2,211
FITEM,2,602
AL,P51X
FLST,2,4,4
FITEM,2,58
FITEM,2,112
FITEM,2,1222
FITEM,2,54
AL,P51X                    ! Fourth Bolster

AFILLT,75,76,38,
AFILLT,103,104,38,
AFILLT,74,77,38,
AFILLT,588,72,38,
AFILLT,587,102,38,
AFILLT,586,73,38,
ADELE,    255, , ,1
LSTR,    42,    59
FLST,2,4,4
FITEM,2,49
FITEM,2,1224
FITEM,2,197
FITEM,2,647
AL,P51X
FLST,2,4,4
FITEM,2,108
FITEM,2,1237
FITEM,2,45
FITEM,2,49
AL,P51X                    ! Fifth Bolster

LSTR,    616,    229
LSTR,    617,    247
LSTR,    619,    154
LSTR,    621,    153
FLST,2,5,4
FITEM,2,530
FITEM,2,766
FITEM,2,791
FITEM,2,1145
FITEM,2,187
AL,P51X
FLST,2,5,4
FITEM,2,395
FITEM,2,724
FITEM,2,781
FITEM,2,1139
FITEM,2,186
AL,P51X
FLST,2,4,4
FITEM,2,244
FITEM,2,190
FITEM,2,531
FITEM,2,186
AL,P51X
FLST,2,4,4
FITEM,2,187
FITEM,2,638
FITEM,2,188
FITEM,2,88
AL,P51X                    ! STR Nose Areas

KWPLAN,-1,    148,    70,    617
KWPAVE,    612
ASBW,    14
KWPAVE,    627
ASBW,    595
KWPAVE,    630
ASBW,    14
KWPAVE,    633
ASBW,    595
KWPAVE,    149
ASBW,    14
KWPAVE,    639
ASBW,    595
KWPAVE,    642
ASBW,    14
KWPAVE,    643
ASBW,    595
KWPAVE,    71
ASBW,    14
KWPAVE,    651
ASBW,    595
KWPAVE,    320
ASBW,    14
KWPAVE,    327
ASBW,    595
KWPAVE,    63
ASBW,    14
KWPAVE,    659
ASBW,    595
KWPAVE,    126
ASBW,    14
KWPAVE,    661
ASBW,    595
KWPAVE,    57
ASBW,    14
KWPAVE,    667
ASBW,    595
        ! Using Cplane to Divide STR Bottom Area

FLST,2,4,3
FITEM,2,153
FITEM,2,621
```

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FITEM,2,624
FITEM,2,36
A,P51X
FLST,2,4,3
FITEM,2,154
FITEM,2,619
FITEM,2,612
FITEM,2,37
A,P51X
LSTR,   626,   40
LSTR,   627,   41
FLST,2,4,4
FITEM,2,89
FITEM,2,192
FITEM,2,229
FITEM,2,1283
AL,P51X
FLST,2,4,4
FITEM,2,200
FITEM,2,249
FITEM,2,1284
FITEM,2,86
AL,P51X
LSTR,   627,   630
LSTR,   632,   626
FLST,2,4,4
FITEM,2,1159
FITEM,2,65
FITEM,2,626
FITEM,2,1285
AL,P51X
FLST,2,4,4
FITEM,2,1153
FITEM,2,1286
FITEM,2,611
FITEM,2,76
AL,P51X
LSTR,   632,   44
LSTR,   635,   48
LSTR,   630,   45
LSTR,   633,   49
LSTR,   634,   52
LSTR,   149,   53
LSTR,   115,   638
LSTR,   118,   639
FLST,2,4,4
FITEM,2,1286
FITEM,2,1283
FITEM,2,1234
FITEM,2,1287
AL,P51X
FLST,2,4,4
FITEM,2,240
FITEM,2,1288
FITEM,2,1239
FITEM,2,1287
AL,P51X
FLST,2,4,4
FITEM,2,1173
FITEM,2,1291
FITEM,2,1242
FITEM,2,1288
AL,P51X
FLST,2,4,4
FITEM,2,80
FITEM,2,1293
FITEM,2,1245
FITEM,2,1291
AL,P51X
FLST,2,4,4
FITEM,2,77
FITEM,2,1292
FITEM,2,1294
FITEM,2,1246
AL,P51X
FLST,2,4,4
FITEM,2,1243
FITEM,2,1178
FITEM,2,1292
FITEM,2,1290
AL,P51X
FLST,2,4,4
FITEM,2,239
FITEM,2,1289
FITEM,2,1240
FITEM,2,1290
AL,P51X
FLST,2,4,4
FITEM,2,1285
FITEM,2,1289
FITEM,2,1235
FITEM,2,1284
AL,P51X
LSTR,   639,   642
LSTR,   644,   638
LSTR,   642,   669
LSTR,   644,   668
LSTR,   643,   671
LSTR,   647,   670
LSTR,    71,   673
LSTR,   646,   672
FLST,2,4,4
FITEM,2,1176
FITEM,2,78
FITEM,2,610
FITEM,2,1296
AL,P51X
FLST,2,4,4
FITEM,2,1296
FITEM,2,1293
FITEM,2,1248
FITEM,2,1298
AL,P51X
FLST,2,4,4
FITEM,2,234
FITEM,2,1300
FITEM,2,1251
FITEM,2,1298
AL,P51X
FLST,2,4,4
FITEM,2,82
FITEM,2,1191
FITEM,2,1295
FITEM,2,1182
AL,P51X
FLST,2,4,4
FITEM,2,1295
FITEM,2,1297
FITEM,2,1249
FITEM,2,1294
AL,P51X
FLST,2,4,4
FITEM,2,235
FITEM,2,1299
FITEM,2,1252
FITEM,2,1297
AL,P51X
LSTR,   650,   674
LSTR,   651,   675
LSTR,   650,   69
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LSTR,    651,    320
LSTR,    320,    677
LSTR,     69,    676
LSTR,    327,    679
LSTR,    678,    655
FLST,2,4,4
FITEM,2,1198
FITEM,2,1300
FITEM,2,1254
FITEM,2,1302
AL,P51X
FLST,2,4,4
FITEM,2,1199
FITEM,2,1299
FITEM,2,1255
FITEM,2,1301
AL,P51X
FLST,2,4,4
FITEM,2,1303
FITEM,2,74
FITEM,2,1302
FITEM,2,1257
AL,P51X
FLST,2,4,4
FITEM,2,62
FITEM,2,1304
FITEM,2,1258
FITEM,2,1301
AL,P51X
FLST,2,4,4
FITEM,2,73
FITEM,2,273
FITEM,2,1305
FITEM,2,1201
AL,P51X
FLST,2,4,4
FITEM,2,1305
FITEM,2,1308
FITEM,2,1260
FITEM,2,1303
AL,P51X
FLST,2,4,4
FITEM,2,208
FITEM,2,1308
FITEM,2,1263
FITEM,2,1310
AL,P51X
FLST,2,4,4
FITEM,2,59
FITEM,2,227
FITEM,2,1306
FITEM,2,620
AL,P51X
FLST,2,4,4
FITEM,2,1304
FITEM,2,1306
FITEM,2,1307
FITEM,2,1261
AL,P51X
FLST,2,4,4
FITEM,2,60
FITEM,2,1309
FITEM,2,1264
FITEM,2,1307
AL,P51X
LSTR,     63,    681
LSTR,    654,    680
LSTR,    659,    683
LSTR,    658,    682
LSTR,    659,    126
LSTR,    658,     61
LSTR,    126,    685
LSTR,    684,     61
LSTR,    687,    661
LSTR,    686,    663
LSTR,     57,    689
LSTR,    662,    688
LSTR,    690,    666
LSTR,    691,    667
FLST,2,4,4
FITEM,2,1310
FITEM,2,1266
FITEM,2,1312
FITEM,2,1211
AL,P51X
FLST,2,4,4
FITEM,2,61
FITEM,2,1314
FITEM,2,1269
FITEM,2,1312
AL,P51X
FLST,2,4,4
FITEM,2,1216
FITEM,2,71
FITEM,2,247
FITEM,2,1316
AL,P51X
FLST,2,4,4
FITEM,2,1316
FITEM,2,1318
FITEM,2,1314
FITEM,2,1272
AL,P51X
FLST,2,4,4
FITEM,2,194
FITEM,2,1320
FITEM,2,1275
FITEM,2,1318
AL,P51X
FLST,2,4,4
FITEM,2,1228
FITEM,2,1322
FITEM,2,1278
FITEM,2,1320
AL,P51X
FLST,2,4,4
FITEM,2,51
FITEM,2,1323
FITEM,2,1281
FITEM,2,1322
AL,P51X
FLST,2,4,4
FITEM,2,1309
FITEM,2,1267
FITEM,2,1311
FITEM,2,1214
AL,P51X
FLST,2,4,4
FITEM,2,52
FITEM,2,1313
FITEM,2,1270
FITEM,2,1311
AL,P51X
FLST,2,4,4
FITEM,2,55
FITEM,2,1219
FITEM,2,1315
FITEM,2,210
AL,P51X
FLST,2,4,4
```

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FITEM,2,1315
FITEM,2,1317
FITEM,2,1273
FITEM,2,1313
AL,P51X
FLST,2,4,4
FITEM,2,1276
FITEM,2,1319
FITEM,2,50
FITEM,2,1317
AL,P51X
FLST,2,4,4
FITEM,2,1229
FITEM,2,1321
FITEM,2,1279
FITEM,2,1319
AL,P51X
FLST,2,4,4
FITEM,2,43
FITEM,2,1324
FITEM,2,1282
FITEM,2,1321
AL,P51X
FLST,2,5,4
FITEM,2,44
FITEM,2,181
FITEM,2,67
FITEM,2,1231
FITEM,2,1323
AL,P51X
FLST,2,5,4
FITEM,2,53
FITEM,2,21
FITEM,2,46
FITEM,2,196
FITEM,2,1324
AL,P51X                ! Create new STR Side Areas

FLST,2,2,4
FITEM,2,645
FITEM,2,644
AL,P51X
FLST,2,1,5,ORDE,1
FITEM,2,659
VEXT,P51X, , ,-500,0,0,,,,
FLST,2,2,5,ORDE,2
FITEM,2,627
FITEM,2,630
ASBV,P51X,1! Punching hoist pivot holes through STR

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~ View Commands
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

APLOT
/FOC, 1,  728.863089244  , 454.608961372  , -
2964.04580614
/LIG, 1,1,1.000, 0.501901609919  , 0.563136024018
, 0.656485028324  , 0.000000000000E+00
/REPLO
/FOC, 1,  546.253384735  , 414.680522353  , -
2109.53178436
/LIG, 1,1,1.000, 0.501901609919  , 0.563136024018
, 0.656485028324  , 0.000000000000E+00
/REPLO
/VIEW, 1, 0.979085862791  , -0.172403948742  ,
0.108017367776
/ANG, 1,  177.967602415
/LIG, 1,1,1.000, 0.418274067285  , 0.665517664516
, 0.618169105386  , 0.000000000000E+00
/REPLO
/ZOOM,1,RECT,-0.054853,0.502041,1.365910,-
0.134694

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~ Rear Bolsters
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,2,8,5,ORDE,5
FITEM,2,1
FITEM,2,46
FITEM,2,-50
FITEM,2,52
FITEM,2,65
ADELE,P51X, , ,1

AFILLT,7,5,38,
AFILLT,70,68,38,
AFILLT,69,67,38,
AFILLT,2,52,38,
AFILLT,66,48,38,
AFILLT,51,47,38,
AFILLT,56,3,38,
AFILLT,57,60,38,
AFILLT,58,59,38,

KWPAVE,   709
ASBW,   54
KWPAVE,   714
ASBW,   58
WPSTYLE,,,,,,,,0

LDELE,151, , ,1
LDELE,152, , ,1
LDELE,153, , ,1

LSTR,    82,   707
LSTR,     8,   709
LSTR,    96,   705
LSTR,    12,   706
LSTR,    16,   714
LSTR,   700,    77
LSTR,    85,   713
LSTR,    99,   711
LSTR,   711,   698
LSTR,   700,   716
LSTR,   716,    79
LSTR,    79,   718
LSTR,   698,    92
LSTR,    92,   720

FLST,2,5,4
FITEM,2,143
FITEM,2,144
FITEM,2,145
FITEM,2,1328
FITEM,2,151
AL,P51X
FLST,2,5,4
FITEM,2,1338
FITEM,2,8
FITEM,2,132
FITEM,2,131
FITEM,2,130
AL,P51X
FLST,2,4,4
FITEM,2,142
FITEM,2,152
FITEM,2,15
FITEM,2,151
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```
AL,P51X
FLST,2,4,4
FITEM,2,22
FITEM,2,13
FITEM,2,136
FITEM,2,8
AL,P51X
FLST,2,4,4
FITEM,2,1349
FITEM,2,164
FITEM,2,147
FITEM,2,152
AL,P51X
FLST,2,4,4
FITEM,2,1
FITEM,2,169
FITEM,2,150
FITEM,2,164
AL,P51X
FLST,2,4,4
FITEM,2,1351
FITEM,2,153
FITEM,2,137
FITEM,2,13
AL,P51X
FLST,2,4,4
FITEM,2,14
FITEM,2,160
FITEM,2,149
FITEM,2,153
AL,P51X
FLST,2,6,4
FITEM,2,169
FITEM,2,177
FITEM,2,154
FITEM,2,1367
FITEM,2,1360
FITEM,2,155
AL,P51X
FLST,2,6,4
FITEM,2,126
FITEM,2,1363
FITEM,2,1355
FITEM,2,2
FITEM,2,170
FITEM,2,160
AL,P51X
FLST,2,3,4
FITEM,2,129
FITEM,2,1368
FITEM,2,1367
AL,P51X
FLST,2,3,4
FITEM,2,12
FITEM,2,1366
FITEM,2,1363
AL,P51X
FLST,2,4,4
FITEM,2,1366
FITEM,2,1368
FITEM,2,156
FITEM,2,1361
AL,P51X
FLST,2,5,4
FITEM,2,129
FITEM,2,138
FITEM,2,140
FITEM,2,141
FITEM,2,1360
AL,P51X
FLST,2,5,4
FITEM,2,12
FITEM,2,10
FITEM,2,127
FITEM,2,128
FITEM,2,1355
AL,P51X

FLST,2,2,5,ORDE,2
FITEM,2,251
FITEM,2,-252
ADELE,P51X, , ,1
LSTR,     18,     701
FLST,2,4,4
FITEM,2,16
FITEM,2,1353
FITEM,2,133
FITEM,2,1337
AL,P51X
FLST,2,4,4
FITEM,2,16
FITEM,2,18
FITEM,2,1342
FITEM,2,96
AL,P51X
LSTR,     10,      6
FLST,2,4,4
FITEM,2,1354
FITEM,2,23
FITEM,2,4
FITEM,2,20
AL,P51X
FLST,2,3,4
FITEM,2,91
FITEM,2,7
FITEM,2,20
AL,P51X

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~ View Commands
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

/FOC, 1,  616.287701829   ,  133.456951868   , -
3193.18773912
/LIG, 1,1,1.000, 0.418274067285   , 0.665517664516
, 0.618169105386   , 0.000000000000E+00
/REPLO
/FOC, 1,  640.064788830   ,  123.004270488   , -
3425.39015066
/LIG, 1,1,1.000, 0.418274067285   , 0.665517664516
, 0.618169105386   , 0.000000000000E+00
/REPLO

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~ Bolsters Near Pivot Structure
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,2,3,5,ORDE,3
FITEM,2,138
FITEM,2,548
FITEM,2,-549
ADELE,P51X, , ,1
FLST,2,10,5,ORDE,10
FITEM,2,8
FITEM,2,-9
FITEM,2,12
FITEM,2,-13
FITEM,2,18
FITEM,2,127
FITEM,2,-128
```

```
FITEM,2,130
FITEM,2,545
FITEM,2,-546
ADELE,P51X, , ,1
FLST,2,2,5,ORDE,2
FITEM,2,27
FITEM,2,117
ADELE,P51X, , ,1
ADELE,    131, , ,1
FLST,2,6,5,ORDE,2
FITEM,2,132
FITEM,2,-137
ADELE,P51X, , ,1
FLST,2,2,5,ORDE,2
FITEM,2,253
FITEM,2,-254
ADELE,P51X, , ,1                ! Deleting Pivot Areas

AFILLT,23,20,38,
AFILLT,119,19,38,
AFILLT,120,121,38,
AFILLT,122,19,38,
AFILLT,10,13,38,
AFILLT,22,8,38,
AFILLT,71,26,38,
AFILLT,24,21,38,
AFILLT,124,123,38,
AFILLT,125,131,38,
AFILLT,25,130,38,
AFILLT,28,8,38,                 ! Creating 38mm Fillets

LSTR,     34,    101
LSTR,     26,    207
FLST,2,4,4
FITEM,2,39
FITEM,2,1395
FITEM,2,283
FITEM,2,321
AL,P51X
FLST,2,4,4
FITEM,2,104
FITEM,2,1381
FITEM,2,30
FITEM,2,39
AL,P51X
FLST,2,4,4
FITEM,2,284
FITEM,2,24
FITEM,2,364
FITEM,2,100
AL,P51X
FLST,2,4,4
FITEM,2,1379
FITEM,2,284
FITEM,2,348
FITEM,2,276
AL,P51X             ! Replacing Bolster End Caps

LSTR,    100,     89
LSTR,     89,    104
LSTR,    203,    104
LSTR,    203,    204
LSTR,    204,    162
LSTR,    162,    184
FLST,2,9,4
FITEM,2,139
FITEM,2,365
FITEM,2,1333
FITEM,2,313
FITEM,2,35
FITEM,2,277
FITEM,2,166
FITEM,2,286
FITEM,2,359
AL,P51X
FLST,2,6,4
FITEM,2,313
FITEM,2,32
FITEM,2,1375
FITEM,2,184
FITEM,2,308
FITEM,2,31
AL,P51X
FLST,2,4,4
FITEM,2,288
FITEM,2,1378
FITEM,2,38
FITEM,2,1372
AL,P51X
FLST,2,10,4
FITEM,2,1333
FITEM,2,365
FITEM,2,139
FITEM,2,32
FITEM,2,1375
FITEM,2,184
FITEM,2,308
FITEM,2,351
FITEM,2,288
FITEM,2,359
AL,P51X

FLST,2,6,4
FITEM,2,1373
FITEM,2,280
FITEM,2,1390
FITEM,2,41
FITEM,2,315
FITEM,2,33
AL,P51X
FLST,2,3,4
FITEM,2,292
FITEM,2,279
FITEM,2,1382
AL,P51X
ADELE,    134, , ,1
LSTR,    739,    162
FLST,2,4,4
FITEM,2,1395
FITEM,2,346
FITEM,2,297
FITEM,2,1394
AL,P51X
FLST,2,10,4
FITEM,2,1390
FITEM,2,280
FITEM,2,312
FITEM,2,1391
FITEM,2,278
FITEM,2,297
FITEM,2,292
FITEM,2,285
FITEM,2,315
FITEM,2,41
AL,P51X
FLST,2,9,4
FITEM,2,1373
FITEM,2,312
FITEM,2,1391
FITEM,2,278
```

```
FITEM,2,297
FITEM,2,296
FITEM,2,344
FITEM,2,275
FITEM,2,34
AL,P51X
FLST,2,4,4
FITEM,2,285
FITEM,2,291
FITEM,2,1132
FITEM,2,1133
AL,P51X
FLST,2,4,4
FITEM,2,290
FITEM,2,351
FITEM,2,829
FITEM,2,1132
AL,P51X
FLST,2,9,4
FITEM,2,359
FITEM,2,286
FITEM,2,166
FITEM,2,139
FITEM,2,1333
FITEM,2,365
FITEM,2,313
FITEM,2,35
FITEM,2,277
AL,P51X
LSTR,   111,    100
LSTR,   206,    24
FLST,2,15,4
FITEM,2,296
FITEM,2,291
FITEM,2,1382
FITEM,2,279
FITEM,2,290
FITEM,2,1372
FITEM,2,38
FITEM,2,1378
FITEM,2,286
FITEM,2,302
FITEM,2,335
FITEM,2,337
FITEM,2,338
FITEM,2,334
FITEM,2,25
AL,P51X

FLST,3,1,4,ORDE,1
FITEM,3,292
LGEN,2,P51X, , ,-383, , , ,1
LSTR,   209,    9
LSTR,    13,  201
LSTR,     9,  204
LSTR,    13,  162
FLST,2,4,4
FITEM,2,360
FITEM,2,352
FITEM,2,1386
FITEM,2,291
AL,P51X
FLST,2,4,4
FITEM,2,349
FITEM,2,1392
FITEM,2,292
FITEM,2,1386
AL,P51X
FLST,2,4,4
FITEM,2,358
FITEM,2,1392
FITEM,2,296
FITEM,2,366
AL,P51X
LSTR,   209,    206
FLST,2,6,4
FITEM,2,1393
FITEM,2,354
FITEM,2,286
FITEM,2,288
FITEM,2,290
FITEM,2,360
AL,P51X
FLST,2,6,4
FITEM,2,289
FITEM,2,1335
FITEM,2,176
FITEM,2,1357
FITEM,2,26
FITEM,2,361
AL,P51X
FLST,2,6,4
FITEM,2,294
FITEM,2,1384
FITEM,2,42
FITEM,2,1388
FITEM,2,36
FITEM,2,347
AL,P51X
FLST,2,11,4
FITEM,2,311
FITEM,2,361
FITEM,2,26
FITEM,2,1357
FITEM,2,176
FITEM,2,1335
FITEM,2,830
FITEM,2,1135
FITEM,2,1393
FITEM,2,299
FITEM,2,29
AL,P51X
FLST,2,13,4
FITEM,2,1134
FITEM,2,352
FITEM,2,36
FITEM,2,1388
FITEM,2,42
FITEM,2,1384
FITEM,2,310
FITEM,2,27
FITEM,2,333
FITEM,2,349
FITEM,2,358
FITEM,2,347
FITEM,2,1135
AL,P51X
FLST,2,10,4
FITEM,2,303
FITEM,2,327
FITEM,2,331
FITEM,2,336
FITEM,2,326
FITEM,2,28
FITEM,2,349
FITEM,2,358
FITEM,2,352
FITEM,2,1393
AL,P51X
```

```
LSTR,   111,   109
LSTR,    24,    20
FLST,2,3,4
FITEM,2,1396
FITEM,2,166
FITEM,2,302
AL,P51X
FLST,2,3,4
FITEM,2,303
FITEM,2,1397
FITEM,2,299
AL,P51X
FLST,2,2,5,ORDE,2
FITEM,2,681
FITEM,2,691
AADD,P51X
FLST,2,2,5,ORDE,2
FITEM,2,690
FITEM,2,692
AADD,P51X

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

!FINISH
!SAVE
/EOF
```

❖ *Filename: 2_7_SCL_mods_INPUT*

```
!@@@@@@@@@@@@@@@@@@@@@@@@@@@
!         FEA of 930E Truck Box Structure
!         Routine to Incorporate Syncrude
!         Modifications to Geometry
!@@@@@@@@@@@@@@@@@@@@@@@@@@@
FINISH
/TITLE,Incorporating Syncrude's Modifications
/PREP7
*AFUN,DEG

!-----------------------------------------------------
!-------------- Wear Package on Side Wall
!-----------------------------------------------------

KWPLAN,-1,   218,   30,   236

FLST,2,4,5,ORDE,4
FITEM,2,293
FITEM,2,313
FITEM,2,316
FITEM,2,321
ASBW,P51X  ! Used WPlane to divide Side Areas
! Wear Package only cover back 1/3rd of Sidewall

!-----------------------------------------------------
!-------------------- View Commands
!-----------------------------------------------------
APLOT
/AUTO, 1
/REP
/USER, 1
/VIEW, 1, 0.153749767104   , -0.580357600040   ,
0.799716240420
/ANG, 1, -172.364133592
/LIG, 1,1,1.000, -0.282687364737   , 0.461125582318
, 0.841101094489   , 0.000000000000E+00
/REPLO
/ZOOM,1,RECT,0.394496,0.585044,0.838009,0.06774
2

!-----------------------------------------------------
!    Flat Plate Between Forward Two Bolsters
!              between STR's
!-----------------------------------------------------

LSTR,   351,   625
FLST,2,4,4
FITEM,2,668
FITEM,2,603
FITEM,2,1286
FITEM,2,1156
AL,P51X

!-----------------------------------------------------
!---------------- Exhaust Plenum
!-----------------------------------------------------

KWPLAN,-1,   43,   47,   657
wpoff,0,0,-430
WPSTYLE,,,,,,,,0
FLST,2,17,5,ORDE,17
FITEM,2,74
FITEM,2,80
FITEM,2,83
FITEM,2,89
FITEM,2,91
FITEM,2,103
FITEM,2,-104
FITEM,2,106
FITEM,2,-107
FITEM,2,110
FITEM,2,112
FITEM,2,159
FITEM,2,161
FITEM,2,-162
FITEM,2,562
FITEM,2,573
FITEM,2,582
ASBW,P51X                          ! Dividing Bolster Areas
ASBW,95

FLST,3,2,3,ORDE,2
FITEM,3,752
FITEM,3,-753
KGEN,2,P51X, , , ,-25, , ,0
LSTR,   755,   754
LSTR,   752,   754
LSTR,   753,   755

FLST,2,21,4
FITEM,2,199
FITEM,2,236
FITEM,2,1451
FITEM,2,1423
FITEM,2,1449
FITEM,2,1444
FITEM,2,1453
FITEM,2,1412
FITEM,2,1441
FITEM,2,1418
FITEM,2,1448
FITEM,2,1438
FITEM,2,1454
FITEM,2,703
FITEM,2,1435
FITEM,2,1415
FITEM,2,1447
FITEM,2,1432
FITEM,2,1456
FITEM,2,228
FITEM,2,213
AL,P51X                            ! Plenum Side Area

LGEN,2,213, , ,-150,-150, , ,0
LGEN,2,260, , ,-280, , , ,0
LSTR,   754,   757
LSTR,   757,   759
LSTR,   759,   123
LSTR,   758,   756
LSTR,   756,   755
LSTR,   758,   353
FLST,2,4,4
FITEM,2,213
FITEM,2,260
FITEM,2,1195
FITEM,2,629
AL,P51X                            ! Slanted Side Area
FLST,2,5,4
FITEM,2,228
FITEM,2,629
FITEM,2,1169
FITEM,2,1179
FITEM,2,1455
AL,P51X                            ! End Area
```

```
FLST,2,4,4
FITEM,2,260
FITEM,2,1169
FITEM,2,1189
FITEM,2,592
AL,P51X                    ! Top Area

KWPLAN,-1,   753,   353,   756
wprot,0,45,0
FLST,2,2,5,ORDE,2
FITEM,2,89
FITEM,2,95
ASBW,P51X
FLST,2,2,5,ORDE,2
FITEM,2,106
FITEM,2,-107
ADELE,P51X, , ,1
ASBW,    83
ADELE,    89, , ,1
LSTR,   353,   762
WPSTYLE,,,,,,,,0
FLST,2,5,4
FITEM,2,213
FITEM,2,1217
FITEM,2,1230
FITEM,2,236
FITEM,2,191
AL,P51X
LDELE,   1200, , ,1          ! Created Front Slope


!--------------------------------------------------
!--------------- Guide Pin Stiffened Region
!--------------------------------------------------

KWPLAN,-1,    56,    73,   351
wpoff,0,0,-170
FLST,2,2,5,ORDE,2
FITEM,2,165
FITEM,2,293
ASBW,P51X
FLST,2,2,5,ORDE,2
FITEM,2,109
FITEM,2,553
ASBW,P51X
FLST,2,4,4
FITEM,2,1189
FITEM,2,250
FITEM,2,1460
FITEM,2,219
AL,P51X

!--------------------------------------------------
!--------------- Exhaust Holes Under Plenum
!--------------------------------------------------

WPSTYLE,,,,,,,,0
KWPLAN,-1,    51,   742,   649
wpoff,150,150,0
PCIRC,100, ,0,360,
ADELE,    165
FLST,3,2,4,ORDE,2
FITEM,3,603
FITEM,3,1464
LGEN,2,P51X, , ,75, , , ,0
FLST,2,2,4,ORDE,2
FITEM,2,603
FITEM,2,1464
LDELE,P51X, , ,1
LSTR,   769,   765
LSTR,   770,   767
FLST,2,6,4
FITEM,2,1466
FITEM,2,1464
FITEM,2,1463
FITEM,2,1156
FITEM,2,603
FITEM,2,1465
AL,P51X
FLST,2,1,5,ORDE,1
FITEM,2,165
VEXT,P51X, , ,0,0,-1000,,,,
                        ! Volume used to punch holes

FLST,2,2,5,ORDE,2
FITEM,2,718
FITEM,2,720
ASBV,P51X,    1              ! Punching Holes

KWPLAN,-1,    56,   133,   351
wpoff,150,150,0
wpoff,300
PCIRC,100, ,0,360,
ADELE,    165
FLST,3,2,4,ORDE,2
FITEM,3,1156
FITEM,3,1463
LGEN,2,P51X, , ,-75, , , ,0
FLST,2,2,4,ORDE,2
FITEM,2,1156
FITEM,2,1463
LDELE,P51X, , ,1
LSTR,   767,   770
LSTR,   768,   765
FLST,2,6,4
FITEM,2,1156
FITEM,2,1466
FITEM,2,1465
FITEM,2,1463
FITEM,2,603
FITEM,2,1464
AL,P51X
ASBA,   112,   165           ! Hole under Flat Plate

!--------------------------------------------------
!--------------------- View Commands
!--------------------------------------------------

APLOT
/AUTO, 1
/REP
/USER, 1
/VIEW, 1, -0.183489902166   , -0.610128668722   ,
0.770762261276
/ANG, 1,  165.565256178
/LIG, 1,1,1.000, -0.845654851235   , 0.254431698830
, 0.469182675739   , 0.000000000000E+00
/REPLO
/ZOOM,1,RECT,0.147238,-0.404082,0.416693,-
0.061224

!--------------------------------------------------
!------------- Completely Replaced Rear STR
!------------- 1 1/8 inch plate straight back
!--------------------------------------------------

FLST,2,21,5,ORDE,13
FITEM,2,53
FITEM,2,-55
FITEM,2,58
```

```
FITEM,2,-59
FITEM,2,126
FITEM,2,139
FITEM,2,-140
FITEM,2,660
FITEM,2,-662
FITEM,2,665
FITEM,2,-671
FITEM,2,674
FITEM,2,-676
ADELE,P51X, , ,1
FLST,2,2,5,ORDE,2
FITEM,2,672
FITEM,2,-673
ADELE,P51X, , ,1                    ! Deleting Old STR Areas

LSTR,   158,   167
ASBL,149,8, , ,KEEP
FLST,2,3,5,ORDE,3
FITEM,2,54
FITEM,2,148
FITEM,2,203
AADD,P51X
FLST,2,3,5,ORDE,3
FITEM,2,1
FITEM,2,5
FITEM,2,49
AADD,P51X
FLST,2,3,5,ORDE,2
FITEM,2,68
FITEM,2,-70
AADD,P51X
FLST,2,3,5,ORDE,3
FITEM,2,2
FITEM,2,48
FITEM,2,65
AADD,P51X
FLST,2,3,5,ORDE,3
FITEM,2,146
FITEM,2,-147
FITEM,2,154
AADD,P51X
FLST,2,3,5,ORDE,3
FITEM,2,3
FITEM,2,47
FITEM,2,57
AADD,P51X
FLST,2,3,5,ORDE,3
FITEM,2,627
FITEM,2,630
FITEM,2,659
AADD,P51X
FLST,2,3,5,ORDE,3
FITEM,2,29
FITEM,2,63
FITEM,2,-64
AADD,P51X
FLST,2,3,5,ORDE,3
FITEM,2,4
FITEM,2,62
FITEM,2,199
AADD,P51X                           ! Adding Areas (Cleanup)

KWPLAN,-1,   167,   175,   723
FLST,2,11,5,ORDE,10
FITEM,2,1
FITEM,2,-3
FITEM,2,5
FITEM,2,29
FITEM,2,47
FITEM,2,50
FITEM,2,54
FITEM,2,-55
FITEM,2,60
FITEM,2,67
ASBW,P51X
ASBW,   48
KWPAVE,   158
FLST,2,12,5,ORDE,10
FITEM,2,2
FITEM,2,46
FITEM,2,51
FITEM,2,66
FITEM,2,139
FITEM,2,-140
FITEM,2,146
FITEM,2,-149
FITEM,2,154
FITEM,2,165
ASBW,P51X              ! Cutting Areas for New Width

FLST,2,3,5,ORDE,3
FITEM,2,7
FITEM,2,54
FITEM,2,57
ADELE,P51X, , ,1
FLST,2,3,4,ORDE,3
FITEM,2,131
FITEM,2,1344
FITEM,2,1346
LCOMB,P51X, ,0
FLST,2,3,4,ORDE,3
FITEM,2,130
FITEM,2,1334
FITEM,2,1338
LCOMB,P51X, ,0
FLST,2,4,4
FITEM,2,131
FITEM,2,1347
FITEM,2,130
FITEM,2,132
AL,P51X
FLST,2,3,5,ORDE,3
FITEM,2,4
FITEM,2,29
FITEM,2,52
ADELE,P51X, , ,1
FLST,2,3,5,ORDE,3
FITEM,2,55
FITEM,2,-56
FITEM,2,64
ADELE,P51X, , ,1
FLST,2,2,4,ORDE,2
FITEM,2,1359
FITEM,2,1362
LDELE,P51X, , ,1
FLST,2,3,4,ORDE,3
FITEM,2,10
FITEM,2,178
FITEM,2,1348
LCOMB,P51X, ,0
FLST,2,3,4,ORDE,3
FITEM,2,2
FITEM,2,171
FITEM,2,177
LCOMB,P51X, ,0
FLST,2,3,4,ORDE,3
FITEM,2,144
FITEM,2,1340
FITEM,2,1349
```

```
LCOMB,P51X, ,0
FLST,2,3,4,ORDE,3
FITEM,2,145
FITEM,2,1351
FITEM,2,1361
LCOMB,P51X, ,0
FLST,2,4,4
FITEM,2,13
FITEM,2,10
FITEM,2,367
FITEM,2,2
AL,P51X
FLST,2,4,4
FITEM,2,144
FITEM,2,145
FITEM,2,147
FITEM,2,1325
AL,P51X                          ! Repairing Corner Areas

LSTR,    20,    92
LSTR,   766,   109
FLST,2,11,4
FITEM,2,9
FITEM,2,277
FITEM,2,1467
FITEM,2,1365
FITEM,2,1347
FITEM,2,1328
FITEM,2,367
FITEM,2,1367
FITEM,2,1358
FITEM,2,1366
FITEM,2,1325
AL,P51X
FLST,2,11,4
FITEM,2,1
FITEM,2,147
FITEM,2,6
FITEM,2,141
FITEM,2,150
FITEM,2,13
FITEM,2,153
FITEM,2,132
FITEM,2,152
FITEM,2,155
FITEM,2,29
AL,P51X
FLST,2,4,4
FITEM,2,353
FITEM,2,1
FITEM,2,145
FITEM,2,9
AL,P51X               ! Creating New STR Areas
FLST,2,5,4

FITEM,2,163
FITEM,2,1366
FITEM,2,1325
FITEM,2,170
FITEM,2,1368
AL,P51X
FLST,2,5,4
FITEM,2,6
FITEM,2,147
FITEM,2,154
FITEM,2,128
FITEM,2,138
AL,P51X ! Stiffeners inside Rear Angle Bolster

FLST,2,3,4,ORDE,3
FITEM,2,157
FITEM,2,162
FITEM,2,1470
LCOMB,P51X, ,0
FLST,2,3,4,ORDE,3
FITEM,2,158
FITEM,2,165
FITEM,2,1472
LCOMB,P51X, ,0
FLST,2,3,4,ORDE,3
FITEM,2,156
FITEM,2,168
FITEM,2,1471
LCOMB,P51X, ,0              ! Cleanup

KWPLAN,-1,    84,     11,     8
FLST,2,3,5,ORDE,3
FITEM,2,29
FITEM,2,46
FITEM,2,51
ASBW,P51X
KWPAVE,    12
FLST,2,3,5,ORDE,3
FITEM,2,56
FITEM,2,66
FITEM,2,139
ASBW,P51X
KWPAVE,    82
FLST,2,3,5,ORDE,3
FITEM,2,140
FITEM,2,146
FITEM,2,-147
ASBW,P51X
KWPAVE,    79
FLST,2,3,5,ORDE,3
FITEM,2,148
FITEM,2,-149
FITEM,2,154
ASBW,P51X  ! Using CPlane to Divide STR Areas

FLST,2,3,4,ORDE,3
FITEM,2,159
FITEM,2,179
FITEM,2,1468
LCOMB,P51X, ,0

!------------------------------------------
!----------- Areas for 1" Fishplating
!------------------------------------------

KL,155,0.3, ,
KWPAVE,    81
FLST,2,2,5,ORDE,2
FITEM,2,667
FITEM,2,-668
ASBW,P51X          ! Divided Rear STR Areas

KL,71,.5, ,
KWPAVE,   709
FLST,2,4,5,ORDE,4
FITEM,2,645
FITEM,2,-646
FITEM,2,652
FITEM,2,-653
ASBW,P51X
WPSTYLE,,,,,,,,0
         ! Divided Areas between 5th and 6th Bolsters

FINISH
/EOF   ! ------------------------------
```

❖ *Filename: 3_1_assignprop_floor_INPUT*

```
!@@@@@@@@@@@@@@@@@@@@@@@@@
!         FEA of 930E Truck Box Structure
!         Thickness and Mat Prop Assignment Routine
!         Floor Structure
!@@@@@@@@@@@@@@@@@@@@@@@@@
FINISH
FINISH
/TITLE,Assigning Floor Thicknesses and Material
Properties

/PREP7
*AFUN,DEG

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~ Pivot Structure
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

CM,_Y,AREA
ASEL, , , ,    33
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,     5,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1         ! Gusset Above Cutout - 5mm

FLST,5,2,5,ORDE,2
FITEM,5,11
FITEM,5,118
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    90,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1         ! Reinforced Section - 90mm total

FLST,5,8,5,ORDE,7
FITEM,5,137
FITEM,5,549
FITEM,5,679
FITEM,5,-681
FITEM,5,688
FITEM,5,-689
FITEM,5,693
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    63,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1         ! Sides - 1.5" thick+ 1" FishPlating

FLST,5,8,5,ORDE,8
FITEM,5,138
FITEM,5,253
FITEM,5,-254
FITEM,5,545
FITEM,5,-546
FITEM,5,548
FITEM,5,686
FITEM,5,-687
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    38,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1         ! Inner Pieces of Side Walls - 1.5"

FLST,5,2,5,ORDE,2
FITEM,5,141
FITEM,5,-142
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    19,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1         ! Front Narrowing Section - 3/4"

FLST,5,7,5,ORDE,5
FITEM,5,129
FITEM,5,143
FITEM,5,-144
FITEM,5,682
FITEM,5,-685
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    16,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                   ! Bottom Plates - 5/8"

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~ Rear Stringer Structure
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,15,5,ORDE,14
FITEM,5,29
FITEM,5,46
FITEM,5,51
FITEM,5,55
FITEM,5,-57
FITEM,5,64
FITEM,5,66
FITEM,5,139
FITEM,5,-140
FITEM,5,146
FITEM,5,-147
FITEM,5,154
FITEM,5,165
FITEM,5,669
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    29,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                   ! Side Areas 1 1/8"
```

```
FLST,5,2,5,ORDE,2
FITEM,5,148
FITEM,5,-149
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    54,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1  ! Side Areas - 1 1/8" w/ 1" FishPlate

FLST,5,2,5,ORDE,2
FITEM,5,52
FITEM,5,54
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    5,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1 ! Gusset Plates inside Rear Angle - 5mm

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~ Front Stringer Structure
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,19,5,ORDE,3
FITEM,5,14
FITEM,5,596
FITEM,5,-613
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    25,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                     ! Bottom Plate - 1"

FLST,5,12,5,ORDE,8
FITEM,5,647
FITEM,5,-649
FITEM,5,654
FITEM,5,-658
FITEM,5,668
FITEM,5,671
FITEM,5,674
FITEM,5,-675
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    44,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1          ! 3/4" SidePlate w/ 1" FishPlate

FLST,5,46,5,ORDE,20
FITEM,5,183
FITEM,5,363
FITEM,5,-365
FITEM,5,586
FITEM,5,592
FITEM,5,-595
FITEM,5,614
FITEM,5,-626
FITEM,5,628
FITEM,5,-629
FITEM,5,631
FITEM,5,-644
FITEM,5,650
FITEM,5,-651
FITEM,5,663
FITEM,5,-664
FITEM,5,667
FITEM,5,670
FITEM,5,672
FITEM,5,-673
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    19,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                     ! 3/4" SidePlate

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~ Bolsters and Back Angle Bolster
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,14,5,ORDE,14
FITEM,5,1
FITEM,5,5
FITEM,5,7
FITEM,5,48
FITEM,5,-49
FITEM,5,65
FITEM,5,112
FITEM,5,203
FITEM,5,562
FITEM,5,630
FITEM,5,660
FITEM,5,666
FITEM,5,677
FITEM,5,-678
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    16,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1          ! Rear Bolster (Angle) - 5/8"

FLST,5,17,5,ORDE,16
FITEM,5,2
FITEM,5,4
FITEM,5,47
FITEM,5,50
FITEM,5,58
FITEM,5,60
FITEM,5,63
FITEM,5,68
FITEM,5,-70
FITEM,5,199
FITEM,5,251
FITEM,5,-252
FITEM,5,553
FITEM,5,627
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FITEM,5,659
FITEM,5,661
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    9,  1,    0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1        ! 2nd Bolster from Back - 9mm

FLST,5,17,5,ORDE,14
FITEM,5,9
FITEM,5,-10
FITEM,5,12
FITEM,5,-13
FITEM,5,18
FITEM,5,-20
FITEM,5,23
FITEM,5,27
FITEM,5,117
FITEM,5,119
FITEM,5,-122
FITEM,5,127
FITEM,5,135
FITEM,5,-136
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    9,  1,    0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1        ! 3rd Bolster (Near Pivot) - 9mm

FLST,5,17,5,ORDE,12
FITEM,5,8
FITEM,5,21
FITEM,5,-22
FITEM,5,24
FITEM,5,-26
FITEM,5,28
FITEM,5,71
FITEM,5,123
FITEM,5,-125
FITEM,5,128
FITEM,5,130
FITEM,5,-134
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    9,  1,    0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1 ! 4th Bolster (1 Ahead of Pivot) - 9mm

FLST,5,20,5,ORDE,16
FITEM,5,72
FITEM,5,-73
FITEM,5,75
FITEM,5,-77
FITEM,5,102
FITEM,5,255
FITEM,5,578
FITEM,5,585
FITEM,5,587
```

```
FITEM,5,-591
FITEM,5,706
FITEM,5,-707
FITEM,5,714
FITEM,5,-715
FITEM,5,728
FITEM,5,-729
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    9,  1,    0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1        ! 5th Bolster (2 Ahead Pivot) - 9mm

FLST,5,22,5,ORDE,20
FITEM,5,78
FITEM,5,-79
FITEM,5,81
FITEM,5,-82
FITEM,5,105
FITEM,5,256
FITEM,5,281
FITEM,5,313
FITEM,5,316
FITEM,5,567
FITEM,5,579
FITEM,5,581
FITEM,5,583
FITEM,5,-584
FITEM,5,708
FITEM,5,-710
FITEM,5,716
FITEM,5,-717
FITEM,5,725
FITEM,5,-727
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    9,  1,    0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                  ! 6th Bolster - 9mm

FLST,5,32,5,ORDE,27
FITEM,5,84
FITEM,5,87
FITEM,5,108
FITEM,5,257
FITEM,5,260
FITEM,5,263
FITEM,5,265
FITEM,5,267
FITEM,5,272
FITEM,5,277
FITEM,5,279
FITEM,5,283
FITEM,5,-284
FITEM,5,321
FITEM,5,557
FITEM,5,568
FITEM,5,570
FITEM,5,-572
FITEM,5,574
FITEM,5,-577
FITEM,5,701
```

```
FITEM,5,711
FITEM,5,-713
FITEM,5,719
FITEM,5,722
FITEM,5,-724
FITEM,5,732
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    9,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1          ! 7th Bolster (Near Hoist) - 9mm

FLST,5,30,5,ORDE,26
FITEM,5,74
FITEM,5,80
FITEM,5,86
FITEM,5,88
FITEM,5,93
FITEM,5,111
FITEM,5,113
FITEM,5,161
FITEM,5,258
FITEM,5,261
FITEM,5,264
FITEM,5,266
FITEM,5,268
FITEM,5,274
FITEM,5,278
FITEM,5,280
FITEM,5,282
FITEM,5,293
FITEM,5,550
FITEM,5,556
FITEM,5,558
FITEM,5,-561
FITEM,5,563
FITEM,5,-566
FITEM,5,721
FITEM,5,733
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    9,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1          ! 8th Bolster (Near Hoist) - 9mm

FLST,5,18,5,ORDE,13
FITEM,5,96
FITEM,5,-101
FITEM,5,114
FITEM,5,-116
FITEM,5,159
FITEM,5,162
FITEM,5,189
FITEM,5,201
FITEM,5,259
FITEM,5,551
FITEM,5,-552
FITEM,5,554
FITEM,5,-555
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    9,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1          ! Last Bolster (Front) - 9mm

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~    Floor Plate
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,54,5,ORDE,43
FITEM,5,3
FITEM,5,34
FITEM,5,-37
FITEM,5,39
FITEM,5,-43
FITEM,5,45
FITEM,5,53
FITEM,5,59
FITEM,5,62
FITEM,5,67
FITEM,5,89
FITEM,5,106
FITEM,5,126
FITEM,5,150
FITEM,5,-153
FITEM,5,155
FITEM,5,-157
FITEM,5,185
FITEM,5,191
FITEM,5,193
FITEM,5,-194
FITEM,5,204
FITEM,5,262
FITEM,5,269
FITEM,5,-271
FITEM,5,273
FITEM,5,275
FITEM,5,-276
FITEM,5,285
FITEM,5,-286
FITEM,5,343
FITEM,5,349
FITEM,5,-350
FITEM,5,544
FITEM,5,547
FITEM,5,573
FITEM,5,582
FITEM,5,662
FITEM,5,665
FITEM,5,699
FITEM,5,-700
FITEM,5,702
FITEM,5,-705
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,   29,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
! Floor Plate - 5/8"+1/2" Wear Pkg. =28.575mm

FLST,5,4,5,ORDE,4
FITEM,5,342
FITEM,5,356
FITEM,5,-357
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```
FITEM,5,377
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    16,  1,      0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
   ! Front Angle Plate and Floor Plate Under - 5/8"

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~   Hoist Pivot
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,4,5,ORDE,4
FITEM,5,44
FITEM,5,85
FITEM,5,569
FITEM,5,580
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,     9,  1,      0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1         ! Gussets inside Bolsters - 9mm

FLST,5,2,5,ORDE,2
FITEM,5,287
FITEM,5,-288
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    38,  1,      0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                        ! Pivot Side Plates - 1.5"

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~ Wall Corner Section
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,17,5,ORDE,3
FITEM,5,30
FITEM,5,167
FITEM,5,-182
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,     5,  1,      0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1  ! Gussets inside Corner Stringer - 5mm

FLST,5,57,5,ORDE,27
FITEM,5,6
FITEM,5,16
FITEM,5,31
FITEM,5,38
FITEM,5,92
FITEM,5,94
FITEM,5,158
FITEM,5,160
FITEM,5,163
FITEM,5,-164
FITEM,5,166
FITEM,5,184
FITEM,5,186
FITEM,5,188
FITEM,5,190
FITEM,5,192
FITEM,5,195
FITEM,5,-198
FITEM,5,200
FITEM,5,202
FITEM,5,218
FITEM,5,-238
FITEM,5,240
FITEM,5,-250
FITEM,5,296
FITEM,5,305
FITEM,5,-306
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,     5,  1,      0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1  ! Corner Stringer Outside Plate - 5mm

FLST,5,13,5,ORDE,4
FITEM,5,207
FITEM,5,-217
FITEM,5,376
FITEM,5,378
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    12,  1,      0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
     ! Corner Plate (Not same as Side Wall) - 12mm

FLST,5,6,5,ORDE,6
FITEM,5,32
FITEM,5,61
FITEM,5,90
FITEM,5,145
FITEM,5,205
FITEM,5,-206
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    25,  1,      0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
       ! Corner Plate - 12mm + 1/2" Wear Package

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~ Exhaust Plenum
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,5,5,ORDE,5
FITEM,5,83
```

```
FITEM,5,91
FITEM,5,95
FITEM,5,103
FITEM,5,-104
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,     1,     3,  1,      0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1

!-------------------------------------------------
!------------------ Guide Pin Stiffened Region
!-------------------------------------------------

FLST,5,2,5,ORDE,2
FITEM,5,107
FITEM,5,109
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,     1,    16,  1,      0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                      ! 5/8" Plate

CM,_Y,AREA
ASEL, , , ,    110
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,     1,     9,  1,      0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                      ! 9mm Plate Between
Bolsters

FINISH
/EOF

!-------------------------------------------------
!-------------------------------------------------
```

❖ *Filename: 3_2_assignprop_wall_INPUT*

```
!@@@@@@@@@@@@@@@@@@@@@@@@@@@
!        FEA of 930E Truck Box Structure
!        Thickness and Mat Prop Assignment Routine
!        Side Structure
!@@@@@@@@@@@@@@@@@@@@@@@@@@@

FINISH
FINISH

/TITLE,Assigning Wall Thicknesses and Material
Properties

/PREP7
*AFUN,DEG

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~ Wall Structure
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,6,5,ORDE,6
FITEM,5,289
FITEM,5,317
FITEM,5,691
FITEM,5,694
FITEM,5,697
FITEM,5,-698
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    8,  1,    0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                    ! Side Sheet - 8mm

FLST,5,6,5,ORDE,6
FITEM,5,239
FITEM,5,301
FITEM,5,690
FITEM,5,692
FITEM,5,695
FITEM,5,-696
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,   21,  1,    0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
         ! Side Sheet - 8mm +1/2" Wear Pkg.

FLST,5,23,5,ORDE,14
FITEM,5,290
FITEM,5,-292
FITEM,5,294
FITEM,5,-295
FITEM,5,297
FITEM,5,-300
FITEM,5,302
FITEM,5,-304
FITEM,5,307
FITEM,5,-312
FITEM,5,314
FITEM,5,-315
FITEM,5,318
FITEM,5,-320
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    9,  1,    0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                    ! All Wall Bolsters - 9mm

FLST,5,4,5,ORDE,2
FITEM,5,322
FITEM,5,-325
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    9,  1,    0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1          ! SideBoards - 3/8" ~ 9mm

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FINISH
/EOF
```

❖ *Filename: 3_3_assignprop_front_INPUT*

```
!@@@@@@@@@@@@@@@@@@@@@@@@@
!        FEA of 930E Truck Box Structure
!        Thickness and Mat Prop Assignment Routine
!        Front Structure
!@@@@@@@@@@@@@@@@@@@@@@@@@
FINISH

/TITLE,Assigning Front Thicknesses and Material
Properties

/PREP7
*AFUN,DEG

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~ Top Beam
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,31,5,ORDE,20
FITEM,5,340
FITEM,5,344
FITEM,5,351
FITEM,5,358
FITEM,5,368
FITEM,5,371
FITEM,5,398
FITEM,5,408
FITEM,5,426
FITEM,5,428
FITEM,5,430
FITEM,5,432
FITEM,5,434
FITEM,5,441
FITEM,5,443
FITEM,5,496
FITEM,5,498
FITEM,5,-510
FITEM,5,513
FITEM,5,-514
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    9,  1,    0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                 ! Top Beam - 9mm

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~ Bolsters
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,34,5,ORDE,20
FITEM,5,337
FITEM,5,-338
FITEM,5,345
FITEM,5,-347
FITEM,5,352
FITEM,5,-354
FITEM,5,359
FITEM,5,-361
FITEM,5,363
FITEM,5,-367
FITEM,5,369
FITEM,5,-370
FITEM,5,372
FITEM,5,-375
FITEM,5,516
FITEM,5,-521
FITEM,5,528
FITEM,5,531
FITEM,5,-534
FITEM,5,536
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    9,  1,    0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1          ! All Front Bolsters - 9mm

CM,_Y,AREA
ASEL, , , ,     15
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    9,  1,    0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~ Front Sheet
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,32,5,ORDE,7
FITEM,5,17
FITEM,5,187
FITEM,5,326
FITEM,5,-335
FITEM,5,379
FITEM,5,-397
FITEM,5,442
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    9,  1,    0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1          ! Front Sheet - 9mm No Wear Pkg.

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FINISH
/EOF
```

❖ *Filename: 3_4_assignprop_canopy_INPUT*

```
!@@@@@@@@@@@@@@@@@@@@@@@@@
!        FEA of 930E Truck Box Structure
!        Thickness and Mat Prop Assignment Routine
!        Canopy Structure
!@@@@@@@@@@@@@@@@@@@@@@@@@
FINISH

/TITLE, Assigning Canopy Thickness and Material
Properties

/PREP7
*AFUN,DEG

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~  Bolsters
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,42,5,ORDE,27
FITEM,5,409
FITEM,5,440
FITEM,5,444
FITEM,5,447
FITEM,5,449
FITEM,5,-450
FITEM,5,452
FITEM,5,457
FITEM,5,459
FITEM,5,-463
FITEM,5,465
FITEM,5,-469
FITEM,5,471
FITEM,5,473
FITEM,5,-476
FITEM,5,479
FITEM,5,-481
FITEM,5,486
FITEM,5,489
FITEM,5,-491
FITEM,5,493
FITEM,5,-495
FITEM,5,497
FITEM,5,522
FITEM,5,-527
FITEM,5,537
FITEM,5,-538
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    5,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1          ! Top and Botton Bolsters - 5mm
                    ! Incl. Internal Stiffeners

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~  Canopy Sheet
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,21,5,ORDE,17
FITEM,5,415
FITEM,5,423
FITEM,5,427
FITEM,5,433
FITEM,5,435
FITEM,5,437
FITEM,5,-439
FITEM,5,448
FITEM,5,454
FITEM,5,-456
FITEM,5,472
FITEM,5,477
FITEM,5,482
FITEM,5,-485
FITEM,5,487
FITEM,5,-488
FITEM,5,492
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    5,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1        ! Canopy Sheet - 5mm Mat #1

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~  Rounded Fillet Sections
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,12,5,ORDE,12
FITEM,5,336
FITEM,5,348
FITEM,5,355
FITEM,5,362
FITEM,5,451
FITEM,5,453
FITEM,5,458
FITEM,5,464
FITEM,5,470
FITEM,5,511
FITEM,5,-512
FITEM,5,515
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    5,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1  ! Rounded Fillets and Side Plates - 5mm

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~  Eye Brow
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,28,5,ORDE,13
FITEM,5,399
FITEM,5,-407
FITEM,5,410
FITEM,5,-414
FITEM,5,416
FITEM,5,-422
FITEM,5,424
FITEM,5,-425
FITEM,5,429
FITEM,5,431
FITEM,5,436
FITEM,5,445
FITEM,5,-446
CM,_Y,AREA
```

```
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,     1,     5,  1,      0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                       ! All Plates - 5mm
                                 ! Incl. Gussets

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~ Canopy Braces
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,4,5,ORDE,3
FITEM,5,539
FITEM,5,541
FITEM,5,-543
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,     1,     8,  1,      0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                       ! Square Tubing - 8mm

FLST,5,3,5,ORDE,3
FITEM,5,478
FITEM,5,529
FITEM,5,540
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,     1,    18,  1,      0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
! Upper Reinforced Section - 5mm + 1/2" (17.7mm)


FLST,5,4,5,ORDE,4
FITEM,5,339
FITEM,5,341
FITEM,5,530
FITEM,5,535
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,     1,    22,  1,      0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
! Lower Reinforced Section - 9mm + 1/2" (21.7mm)

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FINISH
/EOF
```

❖ *Filename: 3_5_add_guidepin_INPUT*

```
!@@@@@@@@@@@@@@@@@@@@@@@@
!         FEA of 930E Truck Box Structure
!         Routine to Incorporate Syncrude
!         Modifications to Geometry
!@@@@@@@@@@@@@@@@@@@@@@@@

FINISH

/TITLE,Incorporating Syncrude's Modifications

/PREP7
*AFUN,DEG

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~ View Commands
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
APLOT
/AUTO, 1
/REP
/USER, 1
/VIEW, 1, 0.153749767104   , -0.580357600040   ,
0.799716240420
/ANG, 1, -172.364133592
/LIG, 1,1,1.000, -0.282687364737   , 0.461125582318
, 0.841101094489   , 0.000000000000E+00
/REPLO
/ZOOM,1,RECT,0.394496,0.585044,0.838009,0.06774
2

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~ Dividing Exhaust Plenum Side Area
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

KWPAVE,   744
LSBW,  1202
KWPAVE,   750
LSBW,    55
KWPAVE,    97
LSBW,  1202
KWPAVE,   748
LSBW,   55
KWPAVE,    33
LSBW,  1202
KWPAVE,   746
LSBW,  55
ADELE,    95, , ,1
WPSTYLE,,,,,,,,0

LSTR,   744,    782
FLST,2,5,4
FITEM,2,55
FITEM,2,71
FITEM,2,213
FITEM,2,199
FITEM,2,1451
AL,P51X
LSTR,   750,    783
FLST,2,6,4
FITEM,2,1423
FITEM,2,55
FITEM,2,1272
FITEM,2,1483
FITEM,2,1444
FITEM,2,1449
AL,P51X
LSTR,    97,    784
FLST,2,4,4
FITEM,2,1453
FITEM,2,1273
FITEM,2,1483
FITEM,2,1484
AL,P51X
LSTR,   748,    785
FLST,2,8,4
FITEM,2,1441
FITEM,2,1412
FITEM,2,1484
FITEM,2,1315
FITEM,2,1485
FITEM,2,1438
FITEM,2,1448
FITEM,2,1418
AL,P51X
LSTR,    33,    786
FLST,2,4,4
FITEM,2,1486
FITEM,2,1485
FITEM,2,1316
FITEM,2,1454
AL,P51X
LSTR,   746,    787
FLST,2,8,4
FITEM,2,1487
FITEM,2,1478
FITEM,2,1486
FITEM,2,703
FITEM,2,1435
FITEM,2,1415
FITEM,2,1447
FITEM,2,1432
AL,P51X
FLST,2,4,4
FITEM,2,1487
FITEM,2,1202
FITEM,2,1456
FITEM,2,228
AL,P51X

FLST,5,7,5,ORDE,7
FITEM,5,95
FITEM,5,645
FITEM,5,-646
FITEM,5,652
FITEM,5,-653
FITEM,5,676
FITEM,5,718
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,     1,       3,   1,       0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~ Creating Guide Pin Geometry
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

NUMSTR,AREA,750,! Start New Area Numbers at 750

KWPLAN,-1,   755,     56,    351
KWPAVE,   756
```

```
ASBW,   107
ASBW,   109
wpoff,0,0,250-80
FLST,2,2,5,ORDE,2
FITEM,2,750
FITEM,2,753
ASBW,P51X                    ! Cutting Existing Areas

LSTR,    788,   756
LSTR,    792,   790
FLST,2,3,4
FITEM,2,1189
FITEM,2,1490
FITEM,2,668
AL,P51X
FLST,2,3,4
FITEM,2,1488
FITEM,2,1498
FITEM,2,1494
AL,P51X                      ! Gussets Under pin

LSTR,    788,   756
LSTR,    792,   790
FLST,2,3,4
FITEM,2,1189
FITEM,2,1490
FITEM,2,668
AL,P51X
FLST,2,3,4
FITEM,2,1488
FITEM,2,1498
FITEM,2,1494
AL,P51X
FLST,3,1,3,ORDE,1
FITEM,3,791
KGEN,2,P51X, , ,-90,-250,-250*sin(9), ,0
FLST,3,1,3,ORDE,1
FITEM,3,793
KGEN,2,P51X, , ,0,-150,-150*sin(9), ,0
FLST,3,1,3,ORDE,1
FITEM,3,794
KGEN,2,P51X, , ,-80,-130,-130*sin(9), ,0
FLST,3,3,3,ORDE,2
FITEM,3,793
FITEM,3,-795
KGEN,2,P51X, , ,0,170*sin(9),-170, ,0
LSTR,    795,   798
LSTR,    794,   797
LSTR,    793,   796
FLST,3,1,4,ORDE,1
FITEM,3,1501
LGEN,2,P51X, , ,-80, , , ,0     ! guide pin lines

LSTR,    794,   795
LSTR,    797,   798
LSTR,    796,   800
LSTR,    793,   799
LSTR,    791,   793
LSTR,    789,   796
LSTR,    792,   799
LSTR,    800,   788
LSTR,    800,   798
LSTR,    799,   795
LSTR,    793,   794
LSTR,    796,   797
FLST,2,4,4
FITEM,2,1490
FITEM,2,1508
FITEM,2,1510
FITEM,2,1505
AL,P51X
FLST,2,4,4
FITEM,2,1505
FITEM,2,1514
FITEM,2,1504
FITEM,2,1511
AL,P51X
FLST,2,4,4
FITEM,2,1498
FITEM,2,1507
FITEM,2,1509
FITEM,2,1506
AL,P51X
FLST,2,4,4
FITEM,2,1506
FITEM,2,1512
FITEM,2,1503
FITEM,2,1513
AL,P51X
FLST,2,4,4
FITEM,2,1496
FITEM,2,1501
FITEM,2,1508
FITEM,2,1507
AL,P51X
FLST,2,4,4
FITEM,2,1501
FITEM,2,1514
FITEM,2,1513
FITEM,2,1500
AL,P51X
FLST,2,4,4
FITEM,2,1500
FITEM,2,1503
FITEM,2,1504
FITEM,2,1489
AL,P51X

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~ Updating Material Thickness Specs
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,6,5,ORDE,4
FITEM,5,751
FITEM,5,-752
FITEM,5,754
FITEM,5,-757
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    16,  1,    0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                          ! 5/8" Plate

FLST,5,2,5,ORDE,2
FITEM,5,750
FITEM,5,753
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    9,  1,    0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                          ! 9mm
GussetsPlate
```

```
FLST,5,7,5,ORDE,2
FITEM,5,758
FITEM,5,-764
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    16,  1.     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1          ! 5/8" Plate - Guide Material

!-----------------------------------------
!---------- Dividing Forward STR for New BC
!-----------------------------------------

NUMSTR,KP,1000,
NUMSTR,LINE,2000,
NUMSTR,AREA,1000,
                    ! Start New Area Numbers at 1000

KWPLAN,-1,    63,    327,    681

KL,1274,.5, ,

KWPAVE,   1000

FLST,2,16,5,ORDE,2
FITEM,2,596
FITEM,2,-611
ASBW,P51X

FLST,5,32,5,ORDE,2
FITEM,5,1000
FITEM,5,-1031
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    25,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                    ! Restoring 1" Plate
Thickness

!-----------------------------------------
!-----------------------------------------
!-----------------------------------------


FINISH
/EOF
```

❖ *Filename: 4_1_FEA_manual_mesh_INPUT*

```
!@@@@@@@@@@@@@@@@@@@@@@@@@
!          FEA of 930E Truck Box Structure
!          Manual Meshing Routine
!@@@@@@@@@@@@@@@@@@@@@@@@@

/TITLE,Meshing Model Geometry

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~ View Settings
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

ERASE
LPLOT
WPSTYLE,,,,,,,,0
/VIEW, 1 ,1,1,1
/ANG, 1
/REP,FAST
/AUTO, 1
/REP
/USER, 1
/VIEW, 1, 0.857837457633 , -0.313003209901 , -
0.407607515722
/ANG, 1, -12.1890301189
/LIG, 1,1,1.000, 0.935109786654 , -0.251682781996
, -0.249450324014 , 0.000000000000E+00
/REPLO

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~ Manual Mesh Sizing
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

/PREP7

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~ Bolster Stringer Joint Lines
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,4,4,ORDE,4
FITEM,5,150
FITEM,5,152
FITEM,5,1365
FITEM,5,1367
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,8,10,
CMDEL,_Y
CMDEL,_Y1          ! Div's Down Bolster Side Edges
                   ! 2nd Bolster

FLST,5,10,4,ORDE,10
FITEM,5,285
FITEM,5,308
FITEM,5,313
FITEM,5,315
FITEM,5,347
FITEM,5,351
FITEM,5,361
FITEM,5,1335
FITEM,5,1373
FITEM,5,1384
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
!LESIZE,_Y1, , ,15,1/10,
LESIZE,_Y1, , ,8,1/10,
CMDEL,_Y           ! Div's Down Bolster Side Edges
CMDEL,_Y1                    ! Pivot Region
FLST,5,2,4,ORDE,2
FITEM,5,351
FITEM,5,1384
CM,_Y1,LINE
LSEL, , , ,P51X
*GET,_z1,LINE,,COUNT
*SET,_z2,0
*DO,_z5,1,_z1
*SET,_z2,LSNEXT(_z2)
*GET,_z3,LINE,_z2,ATTR,NDIV
*GET,_z4,LINE,_z2,ATTR,SPAC
*IF,_z3,GT,0,THEN
*IF,_z4,NE,0,THEN
LESIZE,_z2,,,_z3,1/_z4
*ENDIF
*ENDIF
*ENDDO
CMSEL,S,_Y1
CMDELE,_Y1         ! Flip Bias on Some Lines

FLST,5,20,4,ORDE,20
FITEM,5,196
FITEM,5,210
FITEM,5,227
FITEM,5,247
FITEM,5,273
FITEM,5,610
FITEM,5,-611
FITEM,5,620
FITEM,5,626
FITEM,5,1139
FITEM,5,1145
FITEM,5,1153
FITEM,5,1159
FITEM,5,1176
FITEM,5,1182
FITEM,5,1191
FITEM,5,1201
FITEM,5,1216
FITEM,5,1219
FITEM,5,1231
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,8,1/10,
!LESIZE,_Y1, , ,15,1/10,
CMDEL,_Y
CMDELE,_Y1
        ! Div's Down Forward Bolster Side Edges

FLST,5,2,4,ORDE,2
FITEM,5,247
FITEM,5,273
CM,_Y1,LINE
LSEL, , , ,P51X
*GET,_z1,LINE,,COUNT
*SET,_z2,0
*DO,_z5,1,_z1
*SET,_z2,LSNEXT(_z2)
*GET,_z3,LINE,_z2,ATTR,NDIV
*GET,_z4,LINE,_z2,ATTR,SPAC
*IF,_z3,GT,0,THEN
*IF,_z4,NE,0,THEN
```

```
LESIZE,_z2,,,_z3,1/_z4
*ENDIF
*ENDIF
*ENDDO
CMSEL,S,_Y1
CMDELE,_Y1          ! Flip Bias on Some Lines

FLST,5,2,4,ORDE,2
FITEM,5,153
FITEM,5,1328
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,7,-5,
!LESIZE,_Y1, , ,10,-5,
                    ! Div's Small Near Bolster Corners
CMDEL,_Y            ! Larger in Center (2nd Bolster)
CMDEL,_Y1

FLST,5,9,4,ORDE,9
FITEM,5,297
FITEM,5,359
FITEM,5,1155
FITEM,5,1178
FITEM,5,1199
FITEM,5,1214
FITEM,5,1229
FITEM,5,1375
FITEM,5,1390
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,15,-7,
!LESIZE,_Y1, , ,17,-7,
                    ! Div's Small Near Bolster Corners
CMDEL,_Y ! Larger in Center (Bolster Bottom Outside)
CMDEL,_Y1

FLST,5,7,4,ORDE,7
FITEM,5,1149
FITEM,5,1173
FITEM,5,1198
FITEM,5,1211
FITEM,5,1228
FITEM,5,1357
FITEM,5,1388
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,15,-7,
!LESIZE,_Y1, , ,20,-7,
                    ! Div's Small Near Bolster Corners
CMDEL,_Y   ! Larger in Center (Bolster Bottom Inside)
CMDEL,_Y1

FLST,5,2,4,ORDE,2
FITEM,5,147
FITEM,5,1325
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,2,1,
CMDEL,_Y
CMDEL,_Y1
! Div's on Rounded Corners (1st Rear Bolster)

FLST,5,4,4,ORDE,4
FITEM,5,13
FITEM,5,132
FITEM,5,367
FITEM,5,1347
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,5,1,
CMDEL,_Y
CMDEL,_Y1 ! Div's on Rounded Corners (2nd Bolster)

FLST,5,18,4,ORDE,17
FITEM,5,32
FITEM,5,38
FITEM,5,41
FITEM,5,43
FITEM,5,50
FITEM,5,52
FITEM,5,60
FITEM,5,62
FITEM,5,77
FITEM,5,86
FITEM,5,88
FITEM,5,139
FITEM,5,184
FITEM,5,235
FITEM,5,239
FITEM,5,278
FITEM,5,-280
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,10,1,
!LESIZE,_Y1, , ,10,1,
CMDEL,_Y
CMDEL,_Y1  ! Div's on Rounded Corners (Outside)

FLST,5,14,4,ORDE,14
FITEM,5,26
FITEM,5,36
FITEM,5,42
FITEM,5,51
FITEM,5,61
FITEM,5,74
FITEM,5,80
FITEM,5,89
FITEM,5,176
FITEM,5,194
FITEM,5,208
FITEM,5,234
FITEM,5,240
FITEM,5,244
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,10,1,
!LESIZE,_Y1, , ,10,1,
CMDEL,_Y
CMDEL,_Y1       ! Div's on Rounded Corners (Inside)

FLST,2,2,4,ORDE,2
FITEM,2,365
FITEM,2,1333
LCOMB,P51X, ,0
FLST,5,2,4,ORDE,2
FITEM,5,365
```

```
FITEM,5,1378
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,10,1,
CMDEL,_Y
CMDEL,_Y1
FLST,5,1,4,ORDE,1
FITEM,5,1382
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,1,1,
CMDEL,_Y
CMDEL,_Y1
FLST,2,2,4,ORDE,2
FITEM,2,312
FITEM,2,1391
LCOMB,P51X, ,0
FLST,5,1,4,ORDE,1
FITEM,5,312
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,7,1,
CMDEL,_Y
CMDEL,_Y1          ! Sizing a Few Misc. Lines

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~ Bolster Lines Inside Stringer Box
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,2,3,4,ORDE,3
FITEM,2,160
FITEM,2,174
FITEM,2,1469
LCOMB,P51X, ,0
FLST,5,2,4,ORDE,2
FITEM,5,159
FITEM,5,-160
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,4,1,
CMDEL,_Y
CMDEL,_Y1          ! Inside Bolster (Top) (2nd Bolster)

FLST,5,14,4,ORDE,14
FITEM,5,37
FITEM,5,255
FITEM,5,257
FITEM,5,259
FITEM,5,261
FITEM,5,263
FITEM,5,265
FITEM,5,267
FITEM,5,270
FITEM,5,-271
FITEM,5,274
FITEM,5,301
FITEM,5,307
FITEM,5,319
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,4,1,
CMDEL,_Y
CMDEL,_Y1  ! Inside Bolster (Top) (Rest of Bolsters)

FLST,5,4,4,ORDE,4
FITEM,5,2
FITEM,5,10
FITEM,5,130
FITEM,5,-131
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,7,-5,
!LESIZE,_Y1, , ,10,-10,
                  ! Div's Small Near Bolster Corners
CMDEL,_Y   ! Larger in Center (Inside Bolster Bottom)
CMDEL,_Y1  ! (2nd Bolster)

FLST,5,28,4,ORDE,28
FITEM,5,218
FITEM,5,251
FITEM,5,-252
FITEM,5,254
FITEM,5,269
FITEM,5,305
FITEM,5,314
FITEM,5,320
FITEM,5,350
FITEM,5,362
FITEM,5,589
FITEM,5,648
FITEM,5,1141
FITEM,5,1151
FITEM,5,1157
FITEM,5,1168
FITEM,5,1174
FITEM,5,1180
FITEM,5,1192
FITEM,5,1197
FITEM,5,1203
FITEM,5,1209
FITEM,5,1218
FITEM,5,1227
FITEM,5,1233
FITEM,5,1374
FITEM,5,1376
FITEM,5,1383
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,7,-5,
!LESIZE,_Y1, , ,10,-10,
                  ! Div's Small Near Bolster Corners
CMDEL,_Y   ! Larger in Center (Inside Bolster Bottom)
CMDEL,_Y1  ! (Rest of Bolsters)

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~ Bolster Lines Between Two Stringers
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,2,4,ORDE,2
FITEM,5,126
FITEM,5,137
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,7,1/3,
```

```
!LESIZE,_Y1, , ,10,1/3,
                    ! Bolster Div's Inside Stringer (Top)
CMDEL,_Y            ! (1st Bolster)
CMDEL,_Y1

FLST,5,2,4,ORDE,2
FITEM,5,140
FITEM,5,151
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,7,1/3,
!LESIZE,_Y1, , ,10,1/3,
                    ! Bolster Div's Inside Stringer (Top)
CMDEL,_Y            ! (2nd Bolster)
CMDEL,_Y1

FLST,5,4,4,ORDE,4
FITEM,5,316
FITEM,5,-317
FITEM,5,323
FITEM,5,-324
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,10,1/3,
!LESIZE,_Y1, , ,10,1/3,
                    ! Bolster Div's Inside Stringer (Top)
CMDEL,_Y            ! 3rd and 4th Bolsters
CMDEL,_Y1

FLST,5,1,4,ORDE,1
FITEM,5,185
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,10,1/3,
!LESIZE,_Y1, , ,10,1/3,
CMDEL,_Y
CMDEL,_Y1
FLST,5,6,4,ORDE,2
FITEM,5,1424
FITEM,5,-1429
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,5,1/3,
!LESIZE,_Y1, , ,5,1/3,
CMDEL,_Y
CMDEL,_Y1
FLST,5,6,4,ORDE,6
FITEM,5,1413
FITEM,5,-1414
FITEM,5,1416
FITEM,5,-1417
FITEM,5,1421
FITEM,5,-1422
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,5,1,
!LESIZE,_Y1, , ,5,1,
                    ! Bolster Div's Inside Stringer (Top)
CMDEL,_Y            ! Forward Bolster Lines
CMDEL,_Y1
FLST,5,1,4,ORDE,1
FITEM,5,241
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,10,1/3,
!LESIZE,_Y1, , ,10,1/3,
CMDEL,_Y
CMDEL,_Y1
FLST,5,2,4,ORDE,2
FITEM,5,260
FITEM,5,592
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,8,3/1,
!LESIZE,_Y1, , ,8,3/1,
CMDEL,_Y
CMDEL,_Y1
FLST,5,2,4,ORDE,2
FITEM,5,1195
FITEM,5,1200
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,2,1,
CMDEL,_Y
CMDEL,_Y1

FLST,5,3,4,ORDE,3
FITEM,5,127
FITEM,5,148
FITEM,5,-149
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,7,3/1,
!LESIZE,_Y1, , ,10,3/1,
                    ! Bolster Div's Inside Stringer (Bottom)
CMDEL,_Y            ! (1st Bolster)
CMDEL,_Y1
FLST,5,1,4,ORDE,1
FITEM,5,127
CM,_Y1,LINE
LSEL, , , ,P51X
*GET,_z1,LINE,,COUNT
*SET,_z2,0
*DO,_z5,1,_z1
*SET,_z2,LSNEXT(_z2)
*GET,_z3,LINE,_z2,ATTR,NDIV
*GET,_z4,LINE,_z2,ATTR,SPAC
*IF,_z3,GT,0,THEN
*IF,_z4,NE,0,THEN
LESIZE,_z2,,,_z3,1/_z4
*ENDIF
*ENDIF
*ENDDO
CMSEL,S,_Y1
CMDELE,_Y1

FLST,5,4,4,ORDE,4
FITEM,5,135
FITEM,5,-136
FITEM,5,142
FITEM,5,-143
CM,_Y,LINE
```

```
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,7,3/1,
!LESIZE,_Y1, , ,10,3/1,
                ! Bolster Div's Inside Stringer (Bottom)
CMDEL,_Y        ! (2nd Bolster)
CMDEL,_Y1

FLST,5,8,4,ORDE,8
FITEM,5,295
FITEM,5,304
FITEM,5,309
FITEM,5,355
FITEM,5,1369
FITEM,5,1371
FITEM,5,1385
FITEM,5,1387
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,10,1/3,
!LESIZE,_Y1, , ,15,1/3,
                ! Bolster Div's Inside Stringer (Bottom)
CMDEL,_Y           ! (3rd and 4th Bolsters)
CMDEL,_Y1
FLST,5,3,4,ORDE,3
FITEM,5,355
FITEM,5,1369
FITEM,5,1385
CM,_Y1,LINE
LSEL, , , ,P51X
*GET,_z1,LINE,,COUNT
*SET,_z2,0
*DO,_z5,1,_z1
*SET,_z2,LSNEXT(_z2)
*GET,_z3,LINE,_z2,ATTR,NDIV
*GET,_z4,LINE,_z2,ATTR,SPAC
*IF,_z3,GT,0,THEN
*IF,_z4,NE,0,THEN
LESIZE,_z2,,,_z3,1/_z4
*ENDIF
*ENDIF
*ENDDO
CMSEL,S,_Y1
CMDELE,_Y1

FLST,5,1,4,ORDE,1
FITEM,5,1232
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,10,1/3,
!LESIZE,_Y1, , ,15,1/3,
CMDEL,_Y
CMDEL,_Y1
FLST,5,13,4,ORDE,13
FITEM,5,205
FITEM,5,1408
FITEM,5,-1409
FITEM,5,1419
FITEM,5,-1420
FITEM,5,1430
FITEM,5,-1431
FITEM,5,1436
FITEM,5,-1437
FITEM,5,1442
FITEM,5,-1443
FITEM,5,1452
FITEM,5,1457
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,4,2,
!LESIZE,_Y1, , ,7,2,
CMDEL,_Y
CMDEL,_Y1
FLST,5,2,4,ORDE,2
FITEM,5,1419
FITEM,5,-1420
CM,_Y1,LINE
LSEL, , , ,P51X
*GET,_z1,LINE,,COUNT
*SET,_z2,0
*DO,_z5,1,_z1
*SET,_z2,LSNEXT(_z2)
*GET,_z3,LINE,_z2,ATTR,NDIV
*GET,_z4,LINE,_z2,ATTR,SPAC
*IF,_z3,GT,0,THEN
*IF,_z4,NE,0,THEN
LESIZE,_z2,,,_z3,1/_z4
*ENDIF
*ENDIF
*ENDDO
CMSEL,S,_Y1
CMDELE,_Y1
FLST,5,2,4,ORDE,2
FITEM,5,1408
FITEM,5,-1409
CM,_Y1,LINE
LSEL, , , ,P51X
*GET,_z1,LINE,,COUNT
*SET,_z2,0
*DO,_z5,1,_z1
*SET,_z2,LSNEXT(_z2)
*GET,_z3,LINE,_z2,ATTR,NDIV
*GET,_z4,LINE,_z2,ATTR,SPAC
*IF,_z3,GT,0,THEN
*IF,_z4,NE,0,THEN
LESIZE,_z2,,,_z3,1/_z4
*ENDIF
*ENDIF
*ENDDO
CMSEL,S,_Y1
CMDELE,_Y1
FLST,5,13,4,ORDE,13
FITEM,5,191
FITEM,5,686
FITEM,5,700
FITEM,5,1410
FITEM,5,-1411
FITEM,5,1433
FITEM,5,-1434
FITEM,5,1439
FITEM,5,-1440
FITEM,5,1445
FITEM,5,-1446
FITEM,5,1450
FITEM,5,1455
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,6,2,
!LESIZE,_Y1, , ,8,2,
CMDEL,_Y
CMDEL,_Y1
```

```
FLST,5,9,4,ORDE,9
FITEM,5,191
FITEM,5,1433
FITEM,5,-1434
FITEM,5,1439
FITEM,5,-1440
FITEM,5,1445
FITEM,5,-1446
FITEM,5,1450
FITEM,5,1455
CM,_Y1,LINE
LSEL, , , ,P51X
*GET,_z1,LINE,,COUNT
*SET,_z2,0
*DO,_z5,1,_z1
*SET,_z2,LSNEXT(_z2)
*GET,_z3,LINE,_z2,ATTR,NDIV
*GET,_z4,LINE,_z2,ATTR,SPAC
*IF,_z3,GT,0,THEN
*IF,_z4,NE,0,THEN
LESIZE,_z2,,,_z3,1/_z4
*ENDIF
*ENDIF
*ENDDO
CMSEL,S,_Y1
CMDELE,_Y1
FLST,5,13,4,ORDE,13
FITEM,5,191
FITEM,5,686
FITEM,5,700
FITEM,5,1410
FITEM,5,-1411
FITEM,5,1433
FITEM,5,-1434
FITEM,5,1439
FITEM,5,-1440
FITEM,5,1445
FITEM,5,-1446
FITEM,5,1450
FITEM,5,1455
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,6,2,
!LESIZE,_Y1, , ,8,2,
CMDEL,_Y
CMDEL,_Y1
FLST,5,9,4,ORDE,9
FITEM,5,191
FITEM,5,1433
FITEM,5,-1434
FITEM,5,1439
FITEM,5,-1440
FITEM,5,1445
FITEM,5,-1446
FITEM,5,1450
FITEM,5,1455
CM,_Y1,LINE
LSEL, , , ,P51X
*GET,_z1,LINE,,COUNT
*SET,_z2,0
*DO,_z5,1,_z1
*SET,_z2,LSNEXT(_z2)
*GET,_z3,LINE,_z2,ATTR,NDIV
*GET,_z4,LINE,_z2,ATTR,SPAC
*IF,_z3,GT,0,THEN
*IF,_z4,NE,0,THEN
LESIZE,_z2,,,_z3,1/_z4
*ENDIF
*ENDIF
*ENDDO
CMSEL,S,_Y1
CMDELE,_Y1
FLST,5,4,4,ORDE,4
FITEM,5,1138
FITEM,5,1142
FITEM,5,1154
FITEM,5,1177
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,10,1/3,
!LESIZE,_Y1, , ,15,1/3,
CMDEL,_Y
CMDEL,_Y1
FLST,5,2,4,ORDE,2
FITEM,5,1154
FITEM,5,1177
CM,_Y1,LINE
LSEL, , , ,P51X
*GET,_z1,LINE,,COUNT
*SET,_z2,0
*DO,_z5,1,_z1
*SET,_z2,LSNEXT(_z2)
*GET,_z3,LINE,_z2,ATTR,NDIV
*GET,_z4,LINE,_z2,ATTR,SPAC
*IF,_z3,GT,0,THEN
*IF,_z4,NE,0,THEN
LESIZE,_z2,,,_z3,1/_z4
*ENDIF
*ENDIF
*ENDDO
CMSEL,S,_Y1
CMDELE,_Y1
FLST,5,2,4,ORDE,2
FITEM,5,1458
FITEM,5,-1459
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,1,1,
CMDEL,_Y
CMDEL,_Y1
FLST,5,2,4,ORDE,2
FITEM,5,1461
FITEM,5,-1462
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,8,3,
!LESIZE,_Y1, , ,13,3,
CMDEL,_Y
                ! Bolster Div's Inside Stringer (Bottom)
CMDEL,_Y1          ! (Forward Bolsters)

!-----------------------------------------------
!-------- Bolster Lines Outside of Stringers
!-----------------------------------------------

FLST,5,3,4,ORDE,3
FITEM,5,164
FITEM,5,169
FITEM,5,370
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
```

```
CMSEL,,_Y
LESIZE,_Y1, , ,15,1/2,          ! Div's Bottom of Bolster
CMDEL,_Y                        ! Rear (1st) Bolster
CMDEL,_Y1

FLST,5,4,4,ORDE,4
FITEM,5,649
FITEM,5,1143
FITEM,5,1146
FITEM,5,1160
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
FLST,5,4,4,ORDE,4
FITEM,5,368
FITEM,5,-369
FITEM,5,1327
FITEM,5,1355
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,20,1/5,
!LESIZE,_Y1, , ,30,1/5,         ! Div's Bottom of Bolster
CMDEL,_Y                        ! 2nd Bolster
CMDEL,_Y1

FLST,5,20,4,ORDE,20
FITEM,5,256
FITEM,5,262
FITEM,5,318
FITEM,5,345
FITEM,5,-346
FITEM,5,356
FITEM,5,363
FITEM,5,587
FITEM,5,595
FITEM,5,621
FITEM,5,649
FITEM,5,1143
FITEM,5,1146
FITEM,5,1160
FITEM,5,1220
FITEM,5,-1221
FITEM,5,1236
FITEM,5,1377
FITEM,5,1380
FITEM,5,1394
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,30,1/5,
!LESIZE,_Y1, , ,35,1/5,         ! Div's Bottom of Bolster
CMDEL,_Y                        ! Except Hoist Bolsters
CMDEL,_Y1
FLST,5,2,4,ORDE,2
FITEM,5,256
FITEM,5,262
CM,_Y1,LINE
LSEL, , , ,P51X
*GET,_z1,LINE,,COUNT
*SET,_z2,0
*DO,_z5,1,_z1
*SET,_z2,LSNEXT(_z2)
*GET,_z3,LINE,_z2,ATTR,NDIV
*GET,_z4,LINE,_z2,ATTR,SPAC
*IF,_z3,GT,0,THEN
*IF,_z4,NE,0,THEN
```

```
LESIZE,_z2,,,_z3,1/_z4
*ENDIF
*ENDIF
*ENDDO
CMSEL,S,_Y1
CMDELE,_Y1

        ! Bottom Bolster Divisions in Bolsters
        ! w/ Hoist Pivot Stiffeners
FLST,5,8,4,ORDE,8
FITEM,5,264
FITEM,5,266
FITEM,5,1164
FITEM,5,1170
FITEM,5,1181
FITEM,5,1183
FITEM,5,1193
FITEM,5,1206
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,5,1,
!LESIZE,_Y1, , ,6,1,
        ! Bolster Segment Between Hoist Pivot / Str
CMDEL,_Y
CMDEL,_Y1
FLST,5,8,4,ORDE,8
FITEM,5,593
FITEM,5,600
FITEM,5,608
FITEM,5,646
FITEM,5,1163
FITEM,5,1166
FITEM,5,-1167
FITEM,5,1208
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,5,1,
!LESIZE,_Y1, , ,6,1,
            ! Bolster Segment Inside Hoist Pivot
CMDEL,_Y
CMDEL,_Y1
FLST,5,8,4,ORDE,8
FITEM,5,605
FITEM,5,634
FITEM,5,1140
FITEM,5,1158
FITEM,5,1185
FITEM,5,1188
FITEM,5,1194
FITEM,5,1212
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,30-5-5,1/5,
!LESIZE,_Y1, , ,35-12,1/5,
        ! Bolster Lines Outside Hoist Pivot
CMDEL,_Y
CMDEL,_Y1
FLST,5,3,4,ORDE,3
FITEM,5,1185
FITEM,5,1188
FITEM,5,1194
CM,_Y1,LINE
LSEL, , , ,P51X
*GET,_z1,LINE,,COUNT
```

```
*SET,_z2,0
*DO,_z5,1,_z1
*SET,_z2,LSNEXT(_z2)
*GET,_z3,LINE,_z2,ATTR,NDIV
*GET,_z4,LINE,_z2,ATTR,SPAC
*IF,_z3,GT,0,THEN
*IF,_z4,NE,0,THEN
LESIZE,_z2,,,_z3,1/_z4
*ENDIF
*ENDIF
*ENDDO
CMSEL,S,_Y1
CMDELE,_Y1

FLST,5,2,4,ORDE,2
FITEM,5,11
FITEM,5,146
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,15,2/1,        ! Div's Top of Bolster
CMDEL,_Y                      ! Rear (1st) Bolster
CMDEL,_Y1


FLST,5,2,4,ORDE,2
FITEM,5,1360
FITEM,5,1363
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,20,1/5,
!LESIZE,_Y1, , ,30,1/5,       ! Div's Top of Bolster
CMDEL,_Y                      ! 2nd Bolster
CMDEL,_Y1

FLST,5,10,4,ORDE,10
FITEM,5,189
FITEM,5,195
FITEM,5,203
FITEM,5,209
FITEM,5,217
FITEM,5,287
FITEM,5,293
FITEM,5,298
FITEM,5,376
FITEM,5,534
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,30,5,
!LESIZE,_Y1, , ,35,5,         ! Div's Top of Bolster
CMDEL,_Y                      ! Except Hoist Bolsters
CMDEL,_Y1


          ! Top Bolster Divisions in Bolsters w/
          ! Hoist Pivot Stiffeners
FLST,5,4,4,ORDE,4
FITEM,5,597
FITEM,5,-598
FITEM,5,601
FITEM,5,604
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,5,1,
!LESIZE,_Y1, , ,6,1,
          ! Bolster Segment Between Hoist Pivot / Str
CMDEL,_Y
CMDEL,_Y1
FLST,5,4,4,ORDE,4
FITEM,5,619
FITEM,5,623
FITEM,5,-624
FITEM,5,628
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,5,1,
!LESIZE,_Y1, , ,6,1,
          ! Bolster Segment Inside Hoist Pivot
CMDEL,_Y
CMDEL,_Y1
FLST,5,4,4,ORDE,4
FITEM,5,612
FITEM,5,-613
FITEM,5,615
FITEM,5,617
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,30-5-5,1/5,
!LESIZE,_Y1, , ,35-12,1/5,
                    ! Bolster Lines Outside Hoist Pivot
CMDEL,_Y
CMDEL,_Y1

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~ Front Stringer Section
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,2,2,4,ORDE,2
FITEM,2,48
FITEM,2,57
LDELE,P51X, , ,1
FLST,5,38,4,ORDE,14
FITEM,5,188
FITEM,5,190
FITEM,5,192
FITEM,5,200
FITEM,5,1283
FITEM,5,-1284
FITEM,5,1287
FITEM,5,-1294
FITEM,5,1297
FITEM,5,-1304
FITEM,5,1307
FITEM,5,-1314
FITEM,5,1317
FITEM,5,-1324
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,7,7,
!LESIZE,_Y1, , ,10,10,
                    ! Lines Below Bolster Corners
CMDEL,_Y
CMDEL,_Y1
FLST,5,8,4,ORDE,7
FITEM,5,1293
FITEM,5,-1294
FITEM,5,1310
```

```
FITEM,5,1318
FITEM,5,-1320
FITEM,5,1323
FITEM,5,-1324
CM,_Y1,LINE
LSEL, , , ,P51X
*GET,_z1,LINE,,COUNT
*SET,_z2,0
*DO,_z5,1,_z1
*SET,_z2,LSNEXT(_z2)
*GET,_z3,LINE,_z2,ATTR,NDIV
*GET,_z4,LINE,_z2,ATTR,SPAC
*IF,_z3,GT,0,THEN
*IF,_z4,NE,0,THEN
LESIZE,_z2,,,_z3,1/_z4
*ENDIF
*ENDIF
*ENDDO
CMSEL,S,_Y1
CMDELE,_Y1

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~ Exhaust Plenum Section
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,10,4,ORDE,10
FITEM,5,1202
FITEM,5,1273
FITEM,5,1315
FITEM,5,-1316
FITEM,5,1415
FITEM,5,1418
FITEM,5,1453
FITEM,5,-1454
FITEM,5,1456
FITEM,5,1478
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,5,1,
CMDEL,_Y
CMDEL,_Y1

FLST,5,5,4,ORDE,5
FITEM,5,703
FITEM,5,1412
FITEM,5,1432
FITEM,5,1438
FITEM,5,1444
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,2,1,
CMDEL,_Y
CMDEL,_Y1

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~ Automatic Meshing
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

                        ! Mesher Options
MOPT,AMESH,DEFA
MOPT,QMESH,DEFA
MOPT,VMESH,DEFA
MOPT,TIMP,1
MOPT,PYRA,ON
MOPT,SPLIT,2        ! Split Quads on WARNING
MSHKEY,0
MSHMID,0
MSHPATTERN,0
KEYW,ACCEPT,0
MSHA,0,2D
MSHA,1,3D

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~ Pivot Structure
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

SMRTSIZE,1                    ! Fine Mesh Setting

FLST,5,2,5,ORDE,2
FITEM,5,11
FITEM,5,118
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2           ! Meshing Reinforced Section

MSHKEY,0
FLST,5,44,5,ORDE,28
FITEM,5,11
FITEM,5,18
FITEM,5,-20
FITEM,5,26
FITEM,5,33
FITEM,5,36
FITEM,5,53
FITEM,5,71
FITEM,5,118
FITEM,5,121
FITEM,5,-122
FITEM,5,125
FITEM,5,129
FITEM,5,131
FITEM,5,133
FITEM,5,137
FITEM,5,-138
FITEM,5,141
FITEM,5,-144
FITEM,5,152
FITEM,5,157
FITEM,5,253
FITEM,5,-254
FITEM,5,544
FITEM,5,-549
FITEM,5,679
FITEM,5,-689
FITEM,5,693
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y2
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2           ! Meshing Rest of Pivot Structure

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~ Rear Stringer Structure
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
```

```
SMRTSIZE,1                    ! Fine Mesh Setting

MSHKEY,0
FLST,5,19,5,ORDE,15
FITEM,5,29
FITEM,5,46
FITEM,5,51
FITEM,5,-52
FITEM,5,54
FITEM,5,-57
FITEM,5,64
FITEM,5,66
FITEM,5,139
FITEM,5,-140
FITEM,5,146
FITEM,5,-149
FITEM,5,154
FITEM,5,165
FITEM,5,669
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2

!------------------------------------------
!--------------- Front Stringer Structure
!------------------------------------------

SMRTSIZE,3                    ! Fine Mesh Setting

MSHKEY,0
FLST,5,97,5,ORDE,30
FITEM,5,14
FITEM,5,-15
FITEM,5,37
FITEM,5,39
FITEM,5,41
FITEM,5,43
FITEM,5,183
FITEM,5,342
FITEM,5,349
FITEM,5,586
FITEM,5,592
FITEM,5,-595
FITEM,5,612
FITEM,5,-626
FITEM,5,628
FITEM,5,-629
FITEM,5,631
FITEM,5,-644
FITEM,5,647
FITEM,5,-651
FITEM,5,654
FITEM,5,-658
FITEM,5,663
FITEM,5,-664
FITEM,5,667
FITEM,5,-668
FITEM,5,670
FITEM,5,-675
FITEM,5,1000
FITEM,5,-1031
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2

!------------------------------------------
!---------- All Bolster Areas incl. Inside Stringer
!------------------------------------------

SMRTSIZE,6                    ! Mesh Setting

MSHKEY,0                      ! Rear Bolster (Angle)
FLST,5,14,5,ORDE,14
FITEM,5,1
FITEM,5,5
FITEM,5,7
FITEM,5,48
FITEM,5,-49
FITEM,5,65
FITEM,5,112
FITEM,5,203
FITEM,5,562
FITEM,5,630
FITEM,5,660
FITEM,5,666
FITEM,5,677
FITEM,5,-678
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2

SMRTSIZE,1

MSHKEY,0                      ! 2nd Bolster from Back
FLST,5,17,5,ORDE,16
FITEM,5,2
FITEM,5,4
FITEM,5,47
FITEM,5,50
FITEM,5,58
FITEM,5,60
FITEM,5,63
FITEM,5,68
FITEM,5,-70
FITEM,5,199
FITEM,5,251
FITEM,5,-252
FITEM,5,553
FITEM,5,627
FITEM,5,659
FITEM,5,661
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
```

```
MSHKEY,0
FLST,5,24,5,ORDE,19
FITEM,5,8
FITEM,5,-10
FITEM,5,12
FITEM,5,-13
FITEM,5,21
FITEM,5,-25
FITEM,5,27
FITEM,5,-28
FITEM,5,117
FITEM,5,119
FITEM,5,-120
FITEM,5,123
FITEM,5,-124
FITEM,5,127
FITEM,5,-128
FITEM,5,130
FITEM,5,132
FITEM,5,134
FITEM,5,-136
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1          ! Two Bolsters in Pivot Region
CMDEL,_Y2  ! Areas Inside Pivot Meshed Previously

MSHKEY,0
FLST,5,20,5,ORDE,16
FITEM,5,72
FITEM,5,73
FITEM,5,75
FITEM,5,-77
FITEM,5,102
FITEM,5,255
FITEM,5,578
FITEM,5,585
FITEM,5,587
FITEM,5,-591
FITEM,5,706
FITEM,5,-707
FITEM,5,714
FITEM,5,-715
FITEM,5,728
FITEM,5,-729
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2                    ! 5th Bolster

MSHKEY,0
FLST,5,22,5,ORDE,20
FITEM,5,78
FITEM,5,-79
FITEM,5,81
FITEM,5,-82
FITEM,5,105
FITEM,5,256
FITEM,5,281
FITEM,5,313
FITEM,5,316
FITEM,5,567
FITEM,5,579
FITEM,5,581
FITEM,5,583
FITEM,5,-584
FITEM,5,708
FITEM,5,-710
FITEM,5,716
FITEM,5,-717
FITEM,5,725
FITEM,5,-727
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2                    ! 6th Bolster

MSHKEY,0
FLST,5,32,5,ORDE,27
FITEM,5,84
FITEM,5,87
FITEM,5,108
FITEM,5,257
FITEM,5,260
FITEM,5,263
FITEM,5,265
FITEM,5,267
FITEM,5,272
FITEM,5,277
FITEM,5,279
FITEM,5,283
FITEM,5,-284
FITEM,5,321
FITEM,5,557
FITEM,5,568
FITEM,5,570
FITEM,5,-572
FITEM,5,574
FITEM,5,-577
FITEM,5,701
FITEM,5,711
FITEM,5,-713
FITEM,5,719
FITEM,5,722
FITEM,5,-724
FITEM,5,732
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2                    ! 7th Bolster

FLST,5,4,4,ORDE,3
FITEM,5,603
FITEM,5,1464
FITEM,5,-1466
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,4,1,
```

```
        ! Sizing lines in Exhaist Hole (8th bolster)
CMDEL,_Y
CMDEL,_Y1

MSHKEY,0
FLST,5,30,5,ORDE,26
FITEM,5,74
FITEM,5,80
FITEM,5,86
FITEM,5,88
FITEM,5,93
FITEM,5,111
FITEM,5,113
FITEM,5,161
FITEM,5,258
FITEM,5,261
FITEM,5,264
FITEM,5,266
FITEM,5,268
FITEM,5,274
FITEM,5,278
FITEM,5,280
FITEM,5,282
FITEM,5,293
FITEM,5,550
FITEM,5,556
FITEM,5,558
FITEM,5,-561
FITEM,5,563
FITEM,5,-566
FITEM,5,721
FITEM,5,733
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2                ! 8th Bolster

MSHKEY,0
FLST,5,18,5,ORDE,13
FITEM,5,96
FITEM,5,-101
FITEM,5,114
FITEM,5,-116
FITEM,5,159
FITEM,5,162
FITEM,5,189
FITEM,5,201
FITEM,5,259
FITEM,5,551
FITEM,5,-552
FITEM,5,554
FITEM,5,-555
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2                ! Front (9th) Bolster

!-------------------------------------------------
!---------------- Wall Corner Section
!-------------------------------------------------

SMRTSIZE,6              ! Mesh Setting

MSHAPE,1,2D
CM,_Y,AREA
ASEL, , , ,    197
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
CM,_Y,AREA
ASEL, , , ,    158
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
CM,_Y,AREA
ASEL, , , ,    160
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
CM,_Y,AREA
ASEL, , , ,    163
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
CM,_Y,AREA
ASEL, , , ,    164
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
CM,_Y,AREA
ASEL, , , ,    166
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
CM,_Y,AREA
ASEL, , , ,    225
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2               ! Triangular Mesh on
Exhaust Hole Regions

MSHAPE,0,2D
```

```
FLST,5,95,5,ORDE,36
FITEM,5,6
FITEM,5,16
FITEM,5,30
FITEM,5,-32
FITEM,5,38
FITEM,5,61
FITEM,5,90
FITEM,5,92
FITEM,5,94
FITEM,5,145
FITEM,5,158
FITEM,5,160
FITEM,5,163
FITEM,5,-164
FITEM,5,166
FITEM,5,-182
FITEM,5,184
FITEM,5,186
FITEM,5,188
FITEM,5,190
FITEM,5,192
FITEM,5,195
FITEM,5,-198
FITEM,5,200
FITEM,5,202
FITEM,5,205
FITEM,5,-238
FITEM,5,240
FITEM,5,-250
FITEM,5,296
FITEM,5,305
FITEM,5,-306
FITEM,5,334
FITEM,5,-335
FITEM,5,376
FITEM,5,378
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y2
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2  ! Quad Mesh on Rest of Corner Areas

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~ Canopy Support Beam
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

SMRTSIZE,6                    ! Mesh Setting

FLST,5,34,5,ORDE,22
FITEM,5,326
FITEM,5,-327
FITEM,5,340
FITEM,5,344
FITEM,5,351
FITEM,5,358
FITEM,5,368
FITEM,5,371
FITEM,5,398
FITEM,5,408
FITEM,5,426
FITEM,5,428
FITEM,5,430
FITEM,5,432
FITEM,5,434
FITEM,5,441
FITEM,5,-443
FITEM,5,496
FITEM,5,498
FITEM,5,-510
FITEM,5,513
FITEM,5,-514
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2                     ! Meshing Box Beam

FLST,5,8,4,ORDE,8
FITEM,5,732
FITEM,5,1042
FITEM,5,1068
FITEM,5,1073
FITEM,5,1075
FITEM,5,1077
FITEM,5,1079
FITEM,5,1081
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,10,1,          ! 10 Div's on Fillet Lines
CMDEL,_Y
CMDEL,_Y1

FLST,5,4,5,ORDE,4
FITEM,5,453
FITEM,5,511
FITEM,5,-512
FITEM,5,515
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2          ! Meshing Rounded Fillet Areas

/UI,MESH,OFF
FLST,5,8,5,ORDE,8
FITEM,5,336
FITEM,5,348
FITEM,5,355
FITEM,5,362
FITEM,5,451
FITEM,5,458
FITEM,5,464
FITEM,5,470
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2          ! Meshing Fillet Side Areas

/UI,MESH,OFF
FLST,5,67,5,ORDE,40
```

```
FITEM,5,289
FITEM,5,291
FITEM,5,326
FITEM,5,-329
FITEM,5,336
FITEM,5,340
FITEM,5,344
FITEM,5,348
FITEM,5,351
FITEM,5,355
FITEM,5,358
FITEM,5,362
FITEM,5,368
FITEM,5,371
FITEM,5,375
FITEM,5,398
FITEM,5,408
FITEM,5,426
FITEM,5,428
FITEM,5,430
FITEM,5,432
FITEM,5,434
FITEM,5,441
FITEM,5,-444
FITEM,5,451
FITEM,5,-453
FITEM,5,457
FITEM,5,-460
FITEM,5,464
FITEM,5,467
FITEM,5,470
FITEM,5,-473
FITEM,5,477
FITEM,5,496
FITEM,5,498
FITEM,5,-515
FITEM,5,517
FITEM,5,519
FITEM,5,521
FITEM,5,-524
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y2
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2          ! Meshing Rest of Canopy Support

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~ Eyebrow of Canopy
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

SMRTSIZE,10                  ! Mesh Setting

FLST,5,35,5,ORDE,14
FITEM,5,399
FITEM,5,-407
FITEM,5,410
FITEM,5,-425
FITEM,5,427
FITEM,5,429
FITEM,5,431
FITEM,5,433
FITEM,5,435
FITEM,5,-436
FITEM,5,445
FITEM,5,-446
FITEM,5,454
FITEM,5,-455
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~ Front / Floor Corner
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

SMRTSIZE,6                   ! Mesh Setting

MSHKEY,0
FLST,5,40,5,ORDE,34
FITEM,5,15
FITEM,5,-17
FITEM,5,31
FITEM,5,183
FITEM,5,-184
FITEM,5,334
FITEM,5,-335
FITEM,5,337
FITEM,5,-338
FITEM,5,342
FITEM,5,-343
FITEM,5,345
FITEM,5,349
FITEM,5,-350
FITEM,5,352
FITEM,5,356
FITEM,5,-357
FITEM,5,359
FITEM,5,363
FITEM,5,-365
FITEM,5,370
FITEM,5,376
FITEM,5,-380
FITEM,5,382
FITEM,5,-383
FITEM,5,385
FITEM,5,-386
FITEM,5,389
FITEM,5,393
FITEM,5,-394
FITEM,5,533
FITEM,5,586
FITEM,5,592
FITEM,5,-594
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y2
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~ Floor Plate Areas
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

SMRTSIZE,3                   ! Mesh Setting

MSHKEY,0
```

```
FLST,5,57,5,ORDE,46
FITEM,5,3
FITEM,5,34
FITEM,5,-37
FITEM,5,39
FITEM,5,-43
FITEM,5,45
FITEM,5,53
FITEM,5,59
FITEM,5,62
FITEM,5,67
FITEM,5,89
FITEM,5,106
FITEM,5,126
FITEM,5,150
FITEM,5,-153
FITEM,5,155
FITEM,5,-157
FITEM,5,185
FITEM,5,191
FITEM,5,193
FITEM,5,-194
FITEM,5,204
FITEM,5,262
FITEM,5,269
FITEM,5,-271
FITEM,5,273
FITEM,5,275
FITEM,5,-276
FITEM,5,285
FITEM,5,-286
FITEM,5,342
FITEM,5,-343
FITEM,5,349
FITEM,5,-350
FITEM,5,356
FITEM,5,-357
FITEM,5,544
FITEM,5,547
FITEM,5,573
FITEM,5,582
FITEM,5,662
FITEM,5,665
FITEM,5,699
FITEM,5,-700
FITEM,5,702
FITEM,5,-705
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y2
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2

!-------------------------------------------
!---------------- Side Wall Areas
!-------------------------------------------

SMRTSIZE,7                    ! Mesh Setting

MSHKEY,0
FLST,5,39,5,ORDE,19
FITEM,5,239
FITEM,5,289
FITEM,5,-292
FITEM,5,294
FITEM,5,-295
FITEM,5,297
FITEM,5,-304
FITEM,5,307
FITEM,5,-312
FITEM,5,314
FITEM,5,-315
FITEM,5,317
FITEM,5,-320
FITEM,5,322
FITEM,5,-325
FITEM,5,690
FITEM,5,-692
FITEM,5,694
FITEM,5,-698
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y2
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2

!-------------------------------------------
!---------------- Canopy Brace
!-------------------------------------------

SMRTSIZE,7                    ! Mesh Setting

MSHKEY,0
FLST,5,11,5,ORDE,8
FITEM,5,339
FITEM,5,341
FITEM,5,478
FITEM,5,529
FITEM,5,-530
FITEM,5,535
FITEM,5,539
FITEM,5,-543
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
ACLEAR,_Y1
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2

!-------------------------------------------
!---------------- Front Wall Areas
!-------------------------------------------

SMRTSIZE,6                    ! Mesh Setting

MSHKEY,0
FLST,5,126,5,ORDE,39
FITEM,5,15
FITEM,5,-17
FITEM,5,31
FITEM,5,183
FITEM,5,-184
FITEM,5,187
FITEM,5,289
FITEM,5,291
FITEM,5,326
FITEM,5,-342
FITEM,5,344
```

```
FITEM,5,-348
FITEM,5,351
FITEM,5,-398
FITEM,5,408
FITEM,5,426
FITEM,5,428
FITEM,5,430
FITEM,5,432
FITEM,5,434
FITEM,5,441
FITEM,5,-443
FITEM,5,451
FITEM,5,458
FITEM,5,464
FITEM,5,470
FITEM,5,496
FITEM,5,498
FITEM,5,-510
FITEM,5,513
FITEM,5,-514
FITEM,5,516
FITEM,5,-521
FITEM,5,528
FITEM,5,530
FITEM,5,-536
FITEM,5,586
FITEM,5,592
FITEM,5,-594
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y2
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2

!--------------------------------------------
!------------------- Rest of Canopy
!--------------------------------------------

SMRTSIZE,7                  ! Mesh Setting

MSHKEY,0
FLST,5,157,5,ORDE,25
FITEM,5,289
FITEM,5,-292
FITEM,5,326
FITEM,5,-330
FITEM,5,336
FITEM,5,340
FITEM,5,344
FITEM,5,348
FITEM,5,351
FITEM,5,355
FITEM,5,358
FITEM,5,362
FITEM,5,368
FITEM,5,371
FITEM,5,375
FITEM,5,398
FITEM,5,-515
FITEM,5,517
FITEM,5,519
FITEM,5,521
FITEM,5,-527
FITEM,5,529
FITEM,5,532
FITEM,5,536
FITEM,5,-543
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y2
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2

!--------------------------------------------
!------------------- Exhaust Plenum
!--------------------------------------------

SMRTSIZE,1

MSHKEY,0
FLST,5,7,5,ORDE,7
FITEM,5,95
FITEM,5,645
FITEM,5,-646
FITEM,5,652
FITEM,5,-653
FITEM,5,676
FITEM,5,718
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2

SMRTSIZE,6

MSHKEY,0
FLST,5,4,5,ORDE,4
FITEM,5,83
FITEM,5,91
FITEM,5,103
FITEM,5,-104
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2

!--------------------------------------------
!------------------- Rest of Structure
!--------------------------------------------

SMRTSIZE,7                  ! Mesh Setting

MSHKEY,0
FLST,5,743,5,ORDE,11
FITEM,5,1
FITEM,5,-106
FITEM,5,108
FITEM,5,110
FITEM,5,-719
FITEM,5,721
FITEM,5,-729
FITEM,5,732
```

```
FITEM,5,-733
FITEM,5,750
FITEM,5,-764
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y2
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~   Refining Mesh on 5th Bolster
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

ALLSEL,ALL
FLST,5,18,5,ORDE,14
FITEM,5,72
FITEM,5,75
FITEM,5,-77
FITEM,5,102
FITEM,5,578
FITEM,5,585
FITEM,5,587
FITEM,5,-591
FITEM,5,706
FITEM,5,-707
FITEM,5,714
FITEM,5,-715
FITEM,5,728
FITEM,5,-729
ASEL,R, , ,P51X
CM,Bolster,AREA
ALLSEL,ALL          ! Created Bolster Component
                    ! Note : No refinement

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~   Reversing Area Normals as Required
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,11,5,ORDE,11
FITEM,5,187
FITEM,5,317
FITEM,5,323
FITEM,5,381
FITEM,5,387
FITEM,5,390
FITEM,5,392
FITEM,5,395
FITEM,5,442
FITEM,5,690
FITEM,5,694
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMDEL,_Y
AREVERSE,_Y1,0
CMDEL,_Y1
        ! Reversed Some Area Normals Inside Box

FLST,5,7,5,ORDE,6
FITEM,5,409
FITEM,5,437
FITEM,5,-439
FITEM,5,448
FITEM,5,456
FITEM,5,483
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMDEL,_Y
AREVERSE,_Y1,0
CMDEL,_Y1
        ! Reversed Some Area Normals on Canopy

FLST,5,11,5,ORDE,11
FITEM,5,97
FITEM,5,-98
FITEM,5,101
FITEM,5,114
FITEM,5,189
FITEM,5,201
FITEM,5,259
FITEM,5,551
FITEM,5,-552
FITEM,5,614
FITEM,5,626
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMDEL,_Y
AREVERSE,_Y1,0
CMDEL,_Y1
FLST,5,14,5,ORDE,12
FITEM,5,74
FITEM,5,80
FITEM,5,161
FITEM,5,258
FITEM,5,261
FITEM,5,264
FITEM,5,274
FITEM,5,293
FITEM,5,550
FITEM,5,556
FITEM,5,558
FITEM,5,-561
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMDEL,_Y
AREVERSE,_Y1,0
CMDEL,_Y1
FLST,5,14,5,ORDE,11
FITEM,5,87
FITEM,5,321
FITEM,5,557
FITEM,5,568
FITEM,5,570
FITEM,5,-572
FITEM,5,574
FITEM,5,-577
FITEM,5,701
FITEM,5,711
FITEM,5,724
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMDEL,_Y
AREVERSE,_Y1,0
CMDEL,_Y1
FLST,5,10,5,ORDE,10
FITEM,5,79
```

```
FITEM,5,313
FITEM,5,316
FITEM,5,567
FITEM,5,579
FITEM,5,581
FITEM,5,583
FITEM,5,-584
FITEM,5,708
FITEM,5,727
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMDEL,_Y
AREVERSE,_Y1,0
CMDEL,_Y1
FLST,5,8,5,ORDE,5
FITEM,5,73
FITEM,5,77
FITEM,5,585
FITEM,5,587
FITEM,5,-591
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMDEL,_Y
AREVERSE,_Y1,0
CMDEL,_Y1
FLST,5,11,5,ORDE,9
FITEM,5,8
FITEM,5,21
FITEM,5,24
FITEM,5,26
FITEM,5,123
FITEM,5,125
FITEM,5,128
FITEM,5,130
FITEM,5,-133
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMDEL,_Y
AREVERSE,_Y1,0
CMDEL,_Y1
FLST,5,10,5,ORDE,8
FITEM,5,12
FITEM,5,-13
FITEM,5,18
FITEM,5,-20
FITEM,5,27
FITEM,5,117
FITEM,5,120
FITEM,5,-122
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMDEL,_Y
AREVERSE,_Y1,0
CMDEL,_Y1
FLST,5,12,5,ORDE,12
FITEM,5,4
FITEM,5,7
FITEM,5,48
FITEM,5,-49
FITEM,5,58
FITEM,5,60
FITEM,5,68
FITEM,5,251
FITEM,5,553
FITEM,5,562
FITEM,5,627
FITEM,5,660
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMDEL,_Y
AREVERSE,_Y1,0
CMDEL,_Y1          ! Reversed Normals on Bolsters

FLST,5,19,5,ORDE,19
FITEM,5,11
FITEM,5,51
FITEM,5,64
FITEM,5,137
FITEM,5,139
FITEM,5,149
FITEM,5,165
FITEM,5,549
FITEM,5,625
FITEM,5,631
FITEM,5,-632
FITEM,5,636
FITEM,5,642
FITEM,5,651
FITEM,5,656
FITEM,5,658
FITEM,5,669
FITEM,5,672
FITEM,5,674
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMDEL,_Y
AREVERSE,_Y1,0
CMDEL,_Y1
FLST,5,20,5,ORDE,20
FITEM,5,29
FITEM,5,56
FITEM,5,-57
FITEM,5,140
FITEM,5,142
FITEM,5,148
FITEM,5,154
FITEM,5,364
FITEM,5,592
FITEM,5,618
FITEM,5,-619
FITEM,5,621
FITEM,5,628
FITEM,5,633
FITEM,5,637
FITEM,5,648
FITEM,5,663
FITEM,5,668
FITEM,5,670
FITEM,5,688
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMDEL,_Y
AREVERSE,_Y1,0
CMDEL,_Y1
CM,_Y,AREA
ASEL, , , ,   623
```

```
CM,_Y1,AREA
CMSEL,S,_Y
CMDEL,_Y
AREVERSE,_Y1,0
CMDEL,_Y1
            ! Reversed Some Normals on STR's


!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~ Correction
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

! Removing STR Area and Elements from the Inside of
! small Bolsters in the hinge pivot structure...

FLST,2,2,5,ORDE,2
FITEM,2,686
FITEM,2,-687
ACLEAR,P51X       ! Clearing Meshed Areas

FLST,2,2,5,ORDE,2
FITEM,2,686
FITEM,2,-687
ADELE,P51X        ! Deleting Areas only

FINISH
FINISH

*SET,nodes,ndinqr(0,12)
*SET,elems,elmiqr(0,12)
*SET,sol_time,(((3e-
8)*(nodes**2))+0.0005*nodes+0.022)/60

/EOF

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
```

❖ *Filename: 4_3_FEA_support_INPUT*

```
!@@@@@@@@@@@@@@@@@@@@@@@@
!         FEA of 930E Truck Box Structure
!           Support BC's Routine
!@@@@@@@@@@@@@@@@@@@@@@@@
FINISH
FINISH

/PREP7
*AFUN,RAD

DOFSEL,S,UY
DCUM,ADD,1, ,0,  ! Set DOF Accumulation to ADD
DOFSEL,ALL

*SET,dispslpe,(UyPin-UyNose)/(-3490-(-7730))
                    ! Slope of Uy along Z
*SET,intecept,UyPin-dispslpe*(-3490)

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~  Hinge Support Conditions
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

*IF,hingetyp,EQ,1,THEN

        FLST,5,4,4,ORDE,4
        FITEM,5,325
        FITEM,5,330
        FITEM,5,339
        FITEM,5,342
        LSEL,S, , ,P51X
        NSLL,S,1
        *GET,count,NODE,0,COUNT
        *GET,Nindex,NODE,0,NUM,MIN
        *DO,index,0,count+10,1
                /GOPR   ! Resume Print to Output
                *GET,Zloc,NODE,Nindex,LOC,Z
        D,Nindex,UY,(dispslpe*(Zloc)+intecept)
                *GET,Next,NODE,Nindex,NXTH
                *IF,Next,EQ,0,EXIT
                *SET,Nindex,Next
                /NOPR   ! Suspend Print to Output
        *ENDDO
        ALLSEL,ALL   ! Bearing Force on Top of Pin

        !FLST,2,4,4,ORDE,4
        !FITEM,2,325
        !FITEM,2,330
        !FITEM,2,339
        !FITEM,2,342
        !DL,P51X, ,UY,UyPin
                ! Bearing Force on Top of Pin

        FLST,2,4,4,ORDE,4
        FITEM,2,325
        FITEM,2,328
        FITEM,2,339
        FITEM,2,-340
        DL,P51X, ,UZ,
                ! Preventing Forward Movement

*ELSEIF,hingetyp,EQ,2,THEN

        *IF,CE_DONE,NE,1,THEN

        N,70000,601+(984-601)/2,-197+(-
364+197)/2,-3490,,,,
        KNODE,0, 70000
FLST,2,3,3
FITEM,2,194
FITEM,2,1018
FITEM,2,189
A,P51X

TYPE,  1
MAT,    1
REAL,     9
ESYS,     0
SECNUM,

KL,2050,.5, ,
KL,2051,.5, ,
KL,2052,.5, ,
FLST,3,3,3,ORDE,2
FITEM,3,1019
FITEM,3,-1021
NKPT,0,P51X
FLST,2,8,1
FITEM,2,17
FITEM,2,70000
FITEM,2,5
FITEM,2,5
FITEM,2,70001
FITEM,2,70002
FITEM,2,5
FITEM,2,70003
E,P51X
! Creating Element In Hinge (for CERig)

FLST,2,21,1
FITEM,2,70000
FITEM,2,17
FITEM,2,240
FITEM,2,241
FITEM,2,242
FITEM,2,243
FITEM,2,244
FITEM,2,245
FITEM,2,246
FITEM,2,247
FITEM,2,248
FITEM,2,249
FITEM,2,250
FITEM,2,251
FITEM,2,252
FITEM,2,253
FITEM,2,254
FITEM,2,255
FITEM,2,256
FITEM,2,257
FITEM,2,258
!FITEM,2,18
CERIG,P51X, ,ALL, , , ,  ! Outside Top-Rear

FLST,2,21,1
FITEM,2,70000
!FITEM,2,17
FITEM,2,315
FITEM,2,314
FITEM,2,313
FITEM,2,312
FITEM,2,311
FITEM,2,310
FITEM,2,309
FITEM,2,308
```

```
FITEM,2,307
FITEM,2,306
FITEM,2,305
FITEM,2,304
FITEM,2,303
FITEM,2,302
FITEM,2,301
FITEM,2,300
FITEM,2,299
FITEM,2,298
FITEM,2,297
FITEM,2,20
CERIG,P51X, ,ALL, , , ,    ! Outside Top-Front

FLST,2,21,1
FITEM,2,70000
FITEM,2,18
FITEM,2,259
FITEM,2,260
FITEM,2,261
FITEM,2,262
FITEM,2,263
FITEM,2,264
FITEM,2,265
FITEM,2,266
FITEM,2,267
FITEM,2,268
FITEM,2,269
FITEM,2,270
FITEM,2,271
FITEM,2,272
FITEM,2,273
FITEM,2,274
FITEM,2,275
FITEM,2,276
FITEM,2,277
!FITEM,2,19
CERIG,P51X, ,ALL, , , ,
                    ! Outside Bottom-Rear

FLST,2,21,1
FITEM,2,70000
FITEM,2,19
FITEM,2,278
FITEM,2,279
FITEM,2,280
FITEM,2,281
FITEM,2,282
FITEM,2,283
FITEM,2,284
FITEM,2,285
FITEM,2,286
FITEM,2,287
FITEM,2,288
FITEM,2,289
FITEM,2,290
FITEM,2,291
FITEM,2,292
FITEM,2,293
FITEM,2,294
FITEM,2,295
FITEM,2,296
!FITEM,2,20
CERIG,P51X, ,ALL, , , ,
                    ! Outside Bottom-Front

FLST,2,21,1
FITEM,2,70000
FITEM,2,6
FITEM,2,61
FITEM,2,60
FITEM,2,59
FITEM,2,58
FITEM,2,57
FITEM,2,56
FITEM,2,55
FITEM,2,54
FITEM,2,53
FITEM,2,52
FITEM,2,51
FITEM,2,50
FITEM,2,49
FITEM,2,48
FITEM,2,47
FITEM,2,46
FITEM,2,45
FITEM,2,44
FITEM,2,43
!FITEM,2,5
CERIG,P51X, ,ALL, , , ,    ! Inside Top-Rear

FLST,2,21,1
FITEM,2,70000
!FITEM,2,11
FITEM,2,111
FITEM,2,112
FITEM,2,113
FITEM,2,114
FITEM,2,115
FITEM,2,116
FITEM,2,117
FITEM,2,118
FITEM,2,119
FITEM,2,120
FITEM,2,121
FITEM,2,122
FITEM,2,123
FITEM,2,124
FITEM,2,125
FITEM,2,126
FITEM,2,127
FITEM,2,128
FITEM,2,129
FITEM,2,5
CERIG,P51X, ,ALL, , , ,    ! Inside Top-Front

FLST,2,21,1
FITEM,2,70000
FITEM,2,10
FITEM,2,91
FITEM,2,90
FITEM,2,89
FITEM,2,88
FITEM,2,87
FITEM,2,86
FITEM,2,85
FITEM,2,84
FITEM,2,83
FITEM,2,82
FITEM,2,81
FITEM,2,80
FITEM,2,79
FITEM,2,78
FITEM,2,77
FITEM,2,76
FITEM,2,75
FITEM,2,74
FITEM,2,73
!FITEM,2,6
CERIG,P51X, ,ALL, , , , ! Inside Bottom-Rear
```

```
        FLST,2,21,1
        FITEM,2,70000
        FITEM,2,11
        FITEM,2,110
        FITEM,2,109
        FITEM,2,108
        FITEM,2,107
        FITEM,2,106
        FITEM,2,105
        FITEM,2,104
        FITEM,2,103
        FITEM,2,102
        FITEM,2,101
        FITEM,2,100
        FITEM,2,99
        FITEM,2,98
        FITEM,2,97
        FITEM,2,96
        FITEM,2,95
        FITEM,2,94
        FITEM,2,93
        FITEM,2,92
        !FITEM,2,10
        CERIG,P51X, ,ALL, , , , ! Inside Bottom-Front

        *SET,CE_DONE,1

        *ENDIF

        D,70000,UY,((dispslpe*(-3490))+intecept)
        D,70000,UZ,0
        D,70000,ROTY,0
        D,70000,ROTZ,0

*ENDIF

!-------------------------------------------
!------- Stringer (STR) Support Conditions
!-------------------------------------------

*IF,STRtype,EQ,1,THEN
        FLST,2,32,5,ORDE,2
        FITEM,2,1000
        FITEM,2,-1031
        DA,P51X,UY,UyNose
                ! Distributed STR Support
*ELSEIF,STRtype,EQ,2,THEN
        FLST,5,16,4,ORDE,16
        FITEM,5,2002
        FITEM,5,2006
        FITEM,5,2009
        FITEM,5,2012
        FITEM,5,2015
        FITEM,5,2018
        FITEM,5,2021
        FITEM,5,2024
        FITEM,5,2027
        FITEM,5,2030
        FITEM,5,2033
        FITEI,5,2036
        FITEM,5,2039
        FITEM,5,2042
        FITEM,5,2046
        FITEM,5,2049
        LSEL,S, , ,P51X
                ! Selecting STR CenterLines
        NSLL,S,1 ! Selecting nodes attached to Lines

        *GET,count,NODE,0,COUNT
        *GET,Nindex,NODE,0,NUM,MIN
        *DO,index,0,count+10,1
                !/GOPR  ! Resume Print to Output
                *GET,Zloc,NODE,Nindex,LOC,Z

        D,Nindex,UY,(dispslpe*(Zloc)+intecept)
                *GET,Next,NODE,Nindex,NXTH
                *IF,Next,EQ,0,EXIT
                *SET,Nindex,Next
                !/NOPR  ! Suspend Print to Output
        *ENDDO
        ALLSEL,ALL
*ELSEIF,STRtype,EQ,3,THEN

        FINISH
        /PREP7

        *IF,Rub_DONE,NE,1,THEN
                ! Material #2
                UIMP,2,EX, , ,207000/100,
                        ! Modulus in N/mm^2
                        ! 1/100th of Steel
                UIMP,2,DENS, , ,0.00000786,
                        ! Density in kg/mm^3
                UIMP,2,ALPX, , , ,
                UIMP,2,REFT, , , ,
                UIMP,2,NUXY, , , ,
                UIMP,2,PRXY, , ,0.3,
                UIMP,2,GXY, , , ,
                UIMP,2,MU, , , ,
                UIMP,2,DAMP, , , ,

                MAT,    2

                ET,2,SOLID95
                KEYOPT,2,5,0
                KEYOPT,2,6,0
                KEYOPT,2,11,0
                EXTOPT,ESIZE,1,1,
                EXTOPT,ACLEAR,0
                FLST,2,32,5,ORDE,2
                FITEM,2,1000
                FITEM,2,-1031
                VEXT,P51X, , ,0,-25.4,0,,,
                ESLV,S

                *SET,Rub_DONE,1
        *ENDIF

        ALLSEL,ALL
        ALLSEL,BELOW,VOLU

        CSYS,0  ! Active CS is Global Cartesian
        NSEL,S,LOC,Y,-465.5,-465.3

        *GET,count,NODE,0,COUNT
                        ! Frame Disp. BC's
        *GET,Nindex,NODE,0,NUM,MIN
        *DO,index,0,count+10,1
                !/GOPR  ! Resume Print to Output
                *GET,Zloc,NODE,Nindex,LOC,Z

        D,Nindex,UY,(dispslpe*(Zloc)+intecept)
                *GET,Next,NODE,Nindex,NXTH
                *IF,Next,EQ,0,EXIT
                *SET,Nindex,Next
                !/NOPR  ! Suspend Print to Output
        *ENDDO
```

```
        *IF,Shim,EQ,1,THEN
        ! Adding Shim Displacements
        ! Shim Values From Optimum Slope...
                !*SET,deltamax,4.5
                !*SET,shimslpe,deltamax/(7730-
3490)

        !*SET,shimintc,deltamax*7730/(7730-3490)
                !*SET,shim_1,0.324976415
                !*SET,shim_2,0.974929245
                !*SET,shim_3,1.62488208
                !*SET,shim_4,2.2748349
                !*SET,shim_5,2.92478774

                ! Trial Shim Values
                !*SET,shim_1,0.0
                !*SET,shim_2,1.5
                !*SET,shim_3,2.0
                !*SET,shim_4,2.5
                !*SET,shim_5,3.0

                ! Trial Shim Values
                *SET,shim_1,Amt_Shim
                *SET,shim_2,Amt_Shim
                *SET,shim_3,Amt_Shim
                *SET,shim_4,Amt_Shim
                *SET,shim_5,Amt_Shim

        ! Shim Displacement Routine
        *GET,count,NODE,0,COUNT
        *GET,Nindex,NODE,0,NUM,MIN
        *DO,index,0,count+10,1
                *GET,Zloc,NODE,Nindex,LOC,Z
                !D,Nindex,UY,(shimslpe*(Zloc)+shi
mintc)
                *IF,Zloc,GE,-5280.4,THEN
                D,Nindex,UY,shim_5
                *ELSEIF,Zloc,GE,-5892.8,THEN
                D,Nindex,UY,shim_4
                *ELSEIF,Zloc,GE,-6505.2,THEN
                D,Nindex,UY,shim_3
                *ELSEIF,Zloc,GE,-7117.6,THEN
                D,Nindex,UY,shim_2
                *ELSE
                D,Nindex,UY,shim_1
                *ENDIF
                *GET,Next,NODE,Nindex,NXTH
                *IF,Next,EQ,0,EXIT
                *SET,Nindex,Next
        *ENDDO

        *ENDIF

        ALLSEL,ALL

*ENDIF

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~  Guide Pin Conditions
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,2,1,5,ORDE,1
FITEM,2,763
/GO
DA,P51X,UX,0              ! Ux=0 on Guide Pin

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~  Nose Load Cell
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

*IF,Loadcell,EQ,1,THEN
*IF,Rub_DONE,EQ,1,THEN
*IF,Ldc_DONE,NE,1,THEN

        !~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
        ! Start Making Load Cell #1
        !~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

        FLST,2,2,5,ORDE,2
        FITEM,2,593
        FITEM,2,595
        ACLEAR,P51X
        FLST,2,2,5,ORDE,2
        FITEM,2,593
        FITEM,2,595
        ADELE,P51X, , ,1
                ! Clearing and Deleting Side Areas

        KWPLAN,-1,   153,   154,   1023
        wpoff,0,0,-25.4*3
                ! Using CPlane to Cut Nose..

        FLST,2,2,6,ORDE,2
        FITEM,2,1
        FITEM,2,-2
        VCLEAR,P51X
        FLST,2,2,5,ORDE,2
        FITEM,2,1000
        FITEM,2,-1001
        ACLEAR,P51X
        VCLEAR,     3
        ACLEAR,   1002
        ACLEAR,    183
        VCLEAR,     4
        ! Clearing Mesh to Operate on Geom

        VSBW,     1        ! Cutting Volume

        FLST,3,2,3,ORDE,2
        FITEM,3,153
        FITEM,3,1075
        KGEN,2,P51X, , , ,25.4*3, , ,0  ! Copy KP's

        LSTR,   1075,   1080
        LSTR,    153,   1079
        LSTR,   1079,   1080  ! Box End Lines
        LSTR,   1079,    616
        LSTR,   1080,    621
        FLST,2,4,4
        FITEM,2,2202
        FITEM,2,2053
        FITEM,2,531
        FITEM,2,186
        AL,P51X
        FLST,2,4,4
        FITEM,2,244
        FITEM,2,2202
        FITEM,2,2055
        FITEM,2,2203
        AL,P51X
        FLST,2,5,4
        FITEM,2,2203
        FITEM,2,1149
        FITEM,2,2002
        FITEM,2,2198
        FITEM,2,192
        AL,P51X
        FLST,2,4,4
        FITEM,2,2002
        FITEM,2,2055
```

```
FITEM,2,2053
FITEM,2,2190
AL,P51X            ! Patching Up Areas

K, ,0,-440,-0.7731464844E+04,
K, ,0,-440,-0.7655253802E+04,
K, ,0,-363.8,-0.7731464844E+04,
K, ,0,-363.8,-0.7655253802E+04,

LSTR,   1083,   1084
LSTR,   1084,   1082
LSTR,   1082,   1081
LSTR,   1081,   1083
LSTR,   1083,   1079
LSTR,   1080,   1084
LSTR,   1082,   1075
LSTR,    153,   1081
FLST,2,4,4
FITEM,2,2209
FITEM,2,2208
FITEM,2,2204
FITEM,2,2055
AL,P51X
FLST,2,4,4
FITEM,2,2211
FITEM,2,2053
FITEM,2,2207
FITEM,2,2208
AL,P51X
FLST,2,4,4
FITEM,2,2211
FITEM,2,2210
FITEM,2,2206
FITEM,2,2190
AL,P51X
FLST,2,4,4
FITEM,2,2209
FITEM,2,2210
FITEM,2,2205
FITEM,2,2002
AL,P51X       ! Creating Square Pipe Areas

FLST,5,4,5,ORDE,4
FITEM,5,1000
FITEM,5,1033
FITEM,5,-1034
FITEM,5,1036
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1       ! STR Side Areas
AATT,     1,     19,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
FLST,5,5,5,ORDE,4
FITEM,5,1001
FITEM,5,-1003
FITEM,5,1149
FITEM,5,1154
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1       ! STR Bottom Areas
AATT,     1,     25,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1

R,2,1.875, , , , , ,     ! Define Pipe Thickness

FLST,5,4,5,ORDE,2
FITEM,5,1158
FITEM,5,-1161
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1       ! Pipe Thickness
AATT,     1,     2,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1

FLST,5,4,4,ORDE,4
FITEM,5,2002
FITEM,5,2053
FITEM,5,2055
FITEM,5,2190
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,4,1,
CMDEL,_Y
CMDEL,_Y1
FLST,5,4,4,ORDE,2
FITEM,5,2208
FITEM,5,-2211
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,10,1,  ! Pipe Lsize Commands
CMDEL,_Y
CMDEL,_Y1

APLOT

MSHKEY,0
FLST,5,9,5,ORDE,8
FITEM,5,183
FITEM,5,1000
FITEM,5,-1002
FITEM,5,1033
FITEM,5,-1034
FITEM,5,1036
FITEM,5,1149
FITEM,5,1154
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2  ! Re-Meshing Cleared Areas

FLST,5,4,4,ORDE,2
FITEM,5,2204
FITEM,5,-2207
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,4,1,
CMDEL,_Y
```

```
CMDEL,_Y1
MSHKEY,0
MSHAPE,1,3d
MSHKEY,0
FLST,5,4,5,ORDE,2
FITEM,5,1158
FITEM,5,-1161
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2           ! Meshing Pipe Areas

EXTOPT,ESIZE,1,1,
EXTOPT,ACLEAR,0
VSWEEP,33,1149,1150
VSWEEP,2,1001,1038
VSWEEP,4,1003,1046
VSWEEP,3,1002,1042
VSWEEP,34,1154,1155
                    ! Re-Meshing Volumes

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
! Start Making Load Cell #2
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

ACLEAR,   592    ! Clearing STR Area

FLST,3,4,4,ORDE,2
         ! Copying Load Cell End Lines
FITEM,3,2204
FITEM,3,-2207
LGEN,2,P51X, , , ,363.8-25.4,-74.746198-
25.4, ,0

FLST,3,1,3,ORDE,1
FITEM,3,1087
KGEN,2,P51X, , ,800, , , ,0
LSTR,   1089,   1087
FLST,2,4,4,ORDE,2
FITEM,2,2212
FITEM,2,-2215
ADRAG,P51X, , , , , ,   2216
         ! Dragging Load Cell Areas

KWPLAN,-1,   145,   110,   616
ADELE,   592, , ,1  ! Deleting STR Area
FLST,2,4,5,ORDE,2
FITEM,2,1162
FITEM,2,-1165
ASBW,P51X
         ! Cutting Load Cell with Work Plane

FLST,2,4,5,ORDE,2
FITEM,2,1170
FITEM,2,-1173
ADELE,P51X, , ,1
LDELE,   2216, , ,1
         ! Deleting Ends of Load Cell

LSTR,   145,   1095
LSTR,   1094,   110
LSTR,   1097,   229
LSTR,   1096,   616

FLST,2,4,4
```

```
FITEM,2,2216
FITEM,2,2229
FITEM,2,1139
FITEM,2,2219
AL,P51X
FLST,2,4,4
FITEM,2,2217
FITEM,2,395
FITEM,2,2218
FITEM,2,2232
AL,P51X
FLST,2,5,4
FITEM,2,781
FITEM,2,724
FITEM,2,2216
FITEM,2,2227
FITEM,2,2217
AL,P51X
FLST,2,4,4
FITEM,2,2229
FITEM,2,2227
FITEM,2,2232
FITEM,2,2231
AL,P51X
FLST,2,4,4
FITEM,2,2231
FITEM,2,186
FITEM,2,2218
FITEM,2,2219
AL,P51X  ! New Areas for STR Sidewall

FLST,5,5,5,ORDE,3
FITEM,5,1162
FITEM,5,-1165
FITEM,5,1170
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    19,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1  ! STR Sidewall Thickness

FLST,5,4,5,ORDE,2
FITEM,5,1166
FITEM,5,-1169
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    2,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1        ! Load Cell Thickness

FLST,5,4,4,ORDE,4
FITEM,5,2227
FITEM,5,2229
FITEM,5,2231
FITEM,5,-2232
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,S,_Y1
LESIZE,ALL,,,4,1,1
CMSEL,S,_Y
CMDELE,_Y
```

```
CMDELE,_Y1
FLST,2,4,5,ORDE,2
FITEM,2,1166
FITEM,2,-1169
ACLEAR,P51X
FLST,5,4,4,ORDE,4
FITEM,5,2225
FITEM,5,-2226
FITEM,5,2228
FITEM,5,2230
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,S,_Y1
LESIZE,ALL,,,10,1,1
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1          ! LSize for Load Cell #2

MSHKEY,0
FLST,5,4,5,ORDE,2
FITEM,5,1166
FITEM,5,-1169
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2 ! Meshing Load Cell Areas

MSHKEY,0
FLST,5,4,5,ORDE,3
FITEM,5,1162
FITEM,5,-1164
FITEM,5,1170
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2 ! Re-Meshing STR Sidewall

!FLST,2,2,5,ORDE,2
!FITEM,2,1161
!FITEM,2,1167
!ACLEAR,P51X
! Clearing Mesh on Load Cell Areas
! Making into Channel Sections...
! Very Low Torsional Stiffness...

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
! Start Making Load Cell #3
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

ACLEAR,   621
! Clearing and Deleting STR Area for 3rd LC
ADELE,   621, , ,1

FLST,3,4,5,ORDE,2
          ! Copying LC Areas Over...
FITEM,3,1158
FITEM,3,-1161
FLST,3,4,5,ORDE,2
FITEM,3,1158
FITEM,3,-1161
AGEN,2,P51X, , , ,15,854.464844+67.1, ,0

FLST,2,4,5,ORDE,2
FITEM,2,1171
FITEM,2,-1174
ACLEAR,P51X
          ! Clearing FE Mesh on LC Areas

FLST,3,3,8
FITEM,3,718.981990107,-294.6,-
6672.40301715
FITEM,3,724.27996329,-298.2,-
6877.4345793
FITEM,3,718.888997891,-436.6,-
6668.8042184
WPLANE,-1,P51X
FLST,2,4,5,ORDE,2
FITEM,2,1171
FITEM,2,-1174
ASBW,P51X
          ! Using WPlane to Cut LC Areas

FLST,2,4,5,ORDE,4
FITEM,2,1176
FITEM,2,1178
FITEM,2,1180
FITEM,2,1182
ADELE,P51X, , ,1   ! Deleting End Areas

LSTR,   1104,    52
LSTR,   1101,   634
LSTR,   1103,    48
LSTR,    635,  1102
FLST,2,4,4
FITEM,2,2220
FITEM,2,2249
FITEM,2,2223
FITEM,2,1242
AL,P51X
FLST,2,4,4
FITEM,2,1291
FITEM,2,2220
FITEM,2,2251
FITEM,2,2222
AL,P51X
FLST,2,4,4
FITEM,2,2222
FITEM,2,2242
FITEM,2,2224
FITEM,2,1173
AL,P51X
FLST,2,4,4
FITEM,2,2246
FITEM,2,2224
FITEM,2,1288
FITEM,2,2223
AL,P51X
FLST,2,4,4
FITEM,2,2242
FITEM,2,2246
FITEM,2,2249
FITEM,2,2251
AL,P51X ! Re-creating STR side area

FLST,5,5,5,ORDE,3
FITEM,5,1171
FITEM,5,-1174
FITEM,5,1176
CM,_Y,AREA
```

```
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    19,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
FLST,5,4,5,ORDE,4
FITEM,5,1175
FITEM,5,1177
FITEM,5,1179
FITEM,5,1181
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,     2,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1  ! STR and LC Thicknesses...

FLST,5,4,4,ORDE,4
FITEM,5,2240
FITEM,5,-2241
FITEM,5,2245
FITEM,5,2248
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,10,1,
CMDEL,_Y
CMDEL,_Y1
FLST,5,4,4,ORDE,4
FITEM,5,2242
FITEM,5,2246
FITEM,5,2249
FITEM,5,2251
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,S,_Y1
LESIZE,ALL,,,4,1,1
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
MSHKEY,0
FLST,5,4,5,ORDE,4
FITEM,5,1175
FITEM,5,1177
FITEM,5,1179
FITEM,5,1181
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2          ! Meshing LC Areas

FLST,5,1,4,ORDE,1
FITEM,5,2224
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,4,1,
CMDEL,_Y
CMDEL,_Y1
MSHKEY,0
CM,_Y,AREA
ASEL, , , ,    1173
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
MSHKEY,0
FLST,5,4,5,ORDE,4
FITEM,5,1171
FITEM,5,-1172
FITEM,5,1174
FITEM,5,1176
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2   ! Meshing STR Side Areas

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
! Start Making Load Cell #4
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,3,4,5,ORDE,4
                    ! Copy LC Areas Over...
FITEM,3,1175
FITEM,3,1177
FITEM,3,1179
FITEM,3,1181
AGEN,2,P51X, , , ,40,3699.9, ,0

FLST,2,4,5,ORDE,4
FITEM,2,1178
FITEM,2,1180
FITEM,2,1182
FITEM,2,-1183
ACLEAR,P51X
ACLEAR,    681     ! Clearing Meshed Areas

ADELE,    681, , ,1  ! Delete Pivot Area

KWPLAN,-1,    24,    201,    209
FLST,2,4,5,ORDE,4
FITEM,2,1178
FITEM,2,1180
FITEM,2,1182
FITEM,2,-1183
ASBW,P51X
          ! Using WPlane to Cut LC Areas

FLST,2,4,5,ORDE,4
FITEM,2,1185
FITEM,2,1187
FITEM,2,1189
FITEM,2,1191
ADELE,P51X, , ,1   ! Deleting End Areas

LSTR,    1109,    206
LSTR,     24,     20
LSTR,     24,   1111
```

```
LSTR,    199,   1110
FLST,2,6,4
FITEM,2,2237
FITEM,2,299
FITEM,2,2234
FITEM,2,2267
FITEM,2,2265
FITEM,2,2239
AL,P51X
FLST,2,4,4
FITEM,2,2258
FITEM,2,2262
FITEM,2,2265
FITEM,2,2267
AL,P51X
FLST,2,5,4
FITEM,2,2239
FITEM,2,2262
FITEM,2,2243
FITEM,2,331
FITEM,2,327
AL,P51X
FLST,2,10,4
FITEM,2,358
FITEM,2,349
FITEM,2,352
FITEM,2,28
FITEM,2,336
FITEM,2,326
FITEM,2,2243
FITEM,2,2258
FITEM,2,2234
FITEM,2,1393
AL,P51X       ! Re-Creating Pivot STR Areas

FLST,5,4,5,ORDE,4
FITEM,5,1178
FITEM,5,1180
FITEM,5,1182
FITEM,5,-1183
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,     63,  1,      0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
FLST,5,4,5,ORDE,4
FITEM,5,1184
FITEM,5,1186
FITEM,5,1188
FITEM,5,1190
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,     2,  1,      0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1        ! Shell Thicknesses

FLST,5,4,4,ORDE,4
FITEM,5,2256
FITEM,5,-2257
FITEM,5,2261
FITEM,5,2264
CM,_Y,LINE
        LSEL, , , ,P51X
        CM,_Y1,LINE
        CMSEL,,_Y
        LESIZE,_Y1, , ,10,1,
        CMDEL,_Y
        CMDEL,_Y1
        FLST,5,4,4,ORDE,4
        FITEM,5,2258
        FITEM,5,2262
        FITEM,5,2265
        FITEM,5,2267
        CM,_Y,LINE
        LSEL, , , ,P51X
        CM,_Y1,LINE
        CMSEL,,_Y
        LESIZE,_Y1, , ,4,1,
        CMDEL,_Y
        CMDEL,_Y1          ! LC   LSizing..

        MSHKEY,0
        FLST,5,8,5,ORDE,7
        FITEM,5,1178
        FITEM,5,1180
        FITEM,5,1182
        FITEM,5,-1184
        FITEM,5,1186
        FITEM,5,1188
        FITEM,5,1190
        CM,_Y,AREA
        ASEL, , , ,P51X
        CM,_Y1,AREA
        CHKMSH,'AREA'
        CMSEL,S,_Y
        AMESH,_Y1
        CMDEL,_Y
        CMDEL,_Y1
        CMDEL,_Y2
        ! Re-Meshing Pivot Areas and Load Cell

        *SET,Ldc_DONE,1
        ! Purpose: Do not re-build Load cells...

*ENDIF   ! Ldc_DONE
*ENDIF   ! Rub_Done
*ENDIF   ! Loadcell

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

*SET,dispslpe
*SET,intecept
*SET,count
*SET,Nindex
*SET,index
*SET,Zloc
*SET,Next                    ! Deleting Parameters
*SET,deltamax
*SET,shimslpe
*SET,shimintc

FINISH
FINISH

/EOF !**************************************************
!***********************************************************
```

❖ *Filename: 4_4_FEA_load_algorithm_INPUT*

```
!@@@@@@@@@@@@@@@@@@@@@@@@
!       FEA of 930E Truck Box Structure
!       Oilsand Pressure Load Algorithm
!@@@@@@@@@@@@@@@@@@@@@@@@

FINISH

/TITLE,Oilsand Load Application Algorithm

*SET,Ka,0.5                 ! Rankine Active Pressure Coefficient
*SET,tons,308.5             ! Payload (Short Tons)
*SET,density,1.6            ! Density (Metric tonnes / m^3)
*SET,G,9.81                 ! Gravity (9.81 m/sec^2)

*SET,XPeak,0                ! X Location of Peak
*SET,ZPeak,2450             ! Z Location of Peak

*SET,mass,0.9071847*tons    ! Mass (Metric Tonnes)
*SET,rho,1000*density       ! Density (kg/m^3)

/PREP7
ALLSEL,ALL
SFADELE,ALL,1,ALL
SFADELE,ALL,2,ALL
SFADELE,ALL,3,ALL
SFADELE,ALL,4,ALL
SFADELE,ALL,5,ALL
SFADELE,ALL,6,ALL           ! Clearing All Pressures

*AFUN,DEG
LOCAL,99,0,0,0,-8105,0,9,0
            ! Rotated Co-ordinate System
CSYS,99     ! Changing Active CS to Rotated CS

SFGRAD,PRES, ,X, , ,
        ! Making Sure NO Pressure Gradients
SFGRAD,PRES, ,Y, , ,
SFGRAD,PRES, ,Z, , ,

FINISH

*DIM,TRACKER,ARRAY,10000,1,1,
*DIM,FR_INT,TABLE,2000,1,1,Xloc,height,
*DIM,FL_INT,TABLE,2000,1,1,Xloc,height,

aplot
/VIEW, 1 ,1,1,1
/ANG, 1
/REP,FAST
/AUTO, 1
/REP
/USER, 1
/VIEW, 1, -0.573647192861   , 0.458489757215   , 0.678760665221
/ANG, 1,  3.44081229588
/REPLO

!/NERR,0,10000,    ! Error Message Suppression

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!     Calling Proper Component Section
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
FINISH

! Half Model Components Section
!/INPUT,4_4_FEA_algorithm_comp_INPUT,,/home/dw11589/930E_Full,:half,
```

```
! Combined Full Model Components Section
/INPUT,4_4_FEA_algorithm_comp_INPUT,,/home/dw11589/930E_Full,:comb,

! Slice Components Section
!/INPUT,4_4_FEA_algorithm_comp_INPUT,,/home/dw11589/930E_Full,:slice,

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!                Applying Load to Front Wall
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

*GET,numcomp,COMP,0,NCOMP
*IF,numcomp,GT,3,THEN

/PREP7

ALLSEL,ALL
CMSEL,S,Front              ! Select Comp = Front
ALLSEL,BELOW,AREA
        ! Selecting Elements Below Selected Areas

INDEX = 0
*DO,Xloc,0,4200,100            ! Front Wall Intercept Calculations
        *DO,Zloc,-2000,0,50
                *IF,jumpout,EQ,1,CYCLE
                *SET,surf,((22.229*mass/density+1024)*(1-((Xloc-XPeak)/4854)**2)*(1-((Zloc-ZPeak)/6671)**2))
                *SET,wall,(-2.53865*Zloc)
                *IF,surf,LT,wall,CYCLE                ! Finding height up wall
                *IF,surf,GE,wall,THEN                 ! (topsurf / wall intercept)
                        *SET,height,(-2.53865*Zloc)
                        *SET,jumpout,1
                *ENDIF
                *IF,Zloc,LT,-1277.666,THEN
                        *SET,height,3243.544
                *ENDIF
        *ENDDO
        *SET,jumpout,0
        INDEX = INDEX+1
        FR_INT(INDEX,0,1) = Xloc
        FR_INT(INDEX,1,1) = height
*ENDDO

                                        ! Speeding Up Do Loop
*GET,count,ELEM,0,COUNT
*GET,Eindex,ELEM,0,NUM,MIN

*DO,i,0,count+10,1
        !*IF,elmiqr(i,1),EQ,-1,CYCLE  ! Skip if Element is Not Selected
        *GET,Xcent,ELEM,Eindex,CENT,X       ! Calling Centroid Locations
        *GET,Ycent,ELEM,Eindex,CENT,Y
        *GET,Zcent,ELEM,Eindex,CENT,Z

        ! Pressure Calculations
        *SET,topsurf,((22.229*mass/density+1024)*(1-((Xcent-XPeak)/4854)**2)*(1-((Zcent-ZPeak)/6671)**2))
        *SET,column,(topsurf-Ycent)
        *IF,column,GT,0,THEN
                *SET,vertpres,rho*G*(1/(1000**3))*column
        *ELSE
                *SET,vertpres,0      ! Preventing Negative Pressure
        *ENDIF
        height = FR_INT(Xcent)              ! Height = F(Xlocation)
        *IF,column,GT,0,THEN
                *SET,basepres,Ka*rho*G*(1/(1000**3))*height
                *SET,horzpres,(basepres*(1-Ycent/height))
        *ELSE
                *SET,horzpres,0      ! Preventing Negative Pressure
        *ENDIF
```

```
        ! Pressure Combination
        *SET,pressure,(vertpres*0.366501226)+(horzpres*0.930417568)
        *IF,pressure*10e6,GE,0,THEN
                SFE,Eindex,1,PRES, ,-pressure, , ,     ! Apply Pressure to Elem i
        *ENDIF

        !/GOPR                                    ! Resume Print to Output
        *SET,Elemleft,(Elemleft-1)    ! Number of Elements Left
        !/NOPR                                    ! Suspend Print to Output

        *GET,Next,ELEM,Eindex,NXTH
        *IF,Next,EQ,0,EXIT
        *SET,Eindex,Next

*enddo
FINISH
*ENDIF

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!                   Applying Load to Floor
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

/PREP7

ALLSEL,ALL
CMSEL,S,Floor                             ! Select Comp = Floor
ALLSEL,BELOW,AREA                         ! Selecting Elements Below Selected Areas

INDEX = 0
*DO,Xloc,0,4200,100               ! Front Wall Intercept Calculations
        *DO,Zloc,3000,8500,100
                *IF,jumpout,EQ,1,CYCLE
                *SET,surf,((22.229*mass/density+1024)*(1-((Xloc-XPeak)/4854)**2)*(1-((Zloc-ZPeak)/6671)**2))
                *SET,floor,(0.158384*Zloc)
                *IF,surf,GT,floor,CYCLE                ! Finding height up floor
                *IF,surf,LE,wall,THEN                  ! (topsurf / wall intercept)
                        *SET,height,(0.158384*Zloc)
                        *SET,jumpout,1
                *ENDIF
                *IF,Zloc,GT,8005.214,THEN
                        *SET,height,1267.901
                        *SET,jumpout,1
                *ENDIF
        *ENDDO
        *SET,jumpout,0
        INDEX = INDEX+1
        FL_INT(INDEX,0,1) = Xloc
        FL_INT(INDEX,1,1) = height
*ENDDO
                                          ! Speeding Up Do Loop
*GET,count,ELEM,0,COUNT
*GET,Eindex,ELEM,0,NUM,MIN

*DO,i,0,count+10,1
        !*IF,elmiqr(i,1),EQ,-1,CYCLE  ! Skip if Element is Not Selected
        *GET,Xcent,ELEM,Eindex,CENT,X       ! Calling Centroid Locations
        *GET,Ycent,ELEM,Eindex,CENT,Y
        *GET,Zcent,ELEM,Eindex,CENT,Z

        ! Pressure Calculations
        *SET,topsurf,((22.229*mass/density+1024)*(1-((Xcent-XPeak)/4854)**2)*(1-((Zcent-ZPeak)/6671)**2))
        *SET,column,(topsurf-Ycent)
        *IF,column,GT,0,THEN
                *SET,vertpres,rho*G*(1/(1000**3))*column
        *ELSE
                *SET,vertpres,0     ! Preventing Negative Pressure
        *ENDIF
        height = FL_INT(Xcent)                ! Height = F(Xlocation)
```

```
	*IF,column,GT,0,THEN
		*SET,basepres,Ka*rho*G*(1/(1000**3))*height
		*SET,horzpres,(basepres*(1-Ycent/height))
	*ELSE
		*SET,horzpres,0	! Preventing Negative Pressure
	*ENDIF

	! Pressure Combination
	*SET,pressure,(vertpres*0.98768834)+(horzpres*0.156434465)
	*IF,pressure*10e6,GE,0,THEN
		SFE,Eindex,1,PRES, ,-pressure, , ,	! Apply Pressure to Elem i
	*ENDIF

	!/GOPR					! Resume Print to Output
	*SET,Elemleft,(Elemleft-1)	! Number of Elements Left
	!/NOPR					! Suspend Print to Output

	*GET,Next,ELEM,Eindex,NXTH
	*IF,Next,EQ,0,EXIT
	*SET,Eindex,Next
*enddo
FINISH

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!		Applying Load to Side Wall
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

/PREP7

ALLSEL,ALL
CMSEL,S,Side				! Select Comp = Side
ALLSEL,BELOW,AREA			! Selecting Elements Below Selected Areas

					! Speeding Up Do Loop
*GET,count,ELEM,0,COUNT
*GET,Eindex,ELEM,0,NUM,MIN

*DO,i,0,count+10,1
	!*IF,elmiqr(i,1),EQ,-1,CYCLE	! Skip if Element is Not Selected

	*GET,Xcent,ELEM,Eindex,CENT,X	! Calling Centroid Locations
	*GET,Ycent,ELEM,Eindex,CENT,Y
	*GET,Zcent,ELEM,Eindex,CENT,Z

	*SET,height,((22.229*mass/density+1024)*(1-((Xcent-XPeak)/4854)**2)*(1-((Zcent-ZPeak)/6671)**2))
	*SET,column,(height-Ycent)	! Vertical Pressure Calculations
	*IF,column*10e3,GT,0,THEN
		*SET,basepres,Ka*rho*G*(1/(1000**3))*height
		*SET,horzpres,(basepres*(1-Ycent/height))
	*ELSE
		*SET,horzpres,0	! Preventing Negative Pressure
	*ENDIF

	! Pressure Combination
	*SET,pressure,horzpres
		*IF,pressure*10e6,GE,0,THEN
		SFE,Eindex,1,PRES, ,-pressure, , ,	! Apply Pressure to Elem i
	*ENDIF

	!/GOPR					! Resume Print to Output
	*SET,Elemleft,(Elemleft-1)	! Number of Elements Left
	!/NOPR					! Suspend Print to Output

	*GET,Next,ELEM,Eindex,NXTH
	*IF,Next,EQ,0,EXIT
	*SET,Eindex,Next
*enddo
FINISH
```

```
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!                    Applying Load to Side Angle Pieces
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

/PREP7

ALLSEL,ALL
CMSEL,S,Angle_S                     ! Select Comp = Side Angle
ALLSEL,BELOW,AREA                   ! Selecting Elements Below Selected Areas

                                          ! Speeding Up Do Loop
*GET,count,ELEM,0,COUNT
*GET,Eindex,ELEM,0,NUM,MIN

*DO,i,0,count+10,1

        !*IF,elmiqr(i,1),EQ,-1,CYCLE  ! Skip if Element is Not Selected

        *GET,Xcent,ELEM,Eindex,CENT,X       ! Calling Centroid Locations
        *GET,Ycent,ELEM,Eindex,CENT,Y
        *GET,Zcent,ELEM,Eindex,CENT,Z

        *SET,topsurf,((22.229*mass/density+1024)*(1-((Xcent-XPeak)/4854)**2)*(1-((Zcent-ZPeak)/6671)**2))

        *SET,column,(topsurf-Ycent)  ! Vertical Pressure Calculations
        *IF,column,GT,0,THEN
                *SET,vertpres,rho*G*(1/(1000**3))*column
        *ELSE
                *SET,vertpres,0     ! Preventing Negative Pressure
        *ENDIF

        *IF,column,GT,0,THEN                ! Horizontal Approximation
                *SET,horzpres,Ka*rho*G*(1/(1000**3))*column
        *ELSE
                *SET,horzpres,0     ! Preventing Negative Pressure
        *ENDIF

                                            ! Pressure Combination
        *SET,pressure,(vertpres*0.707106781)+(horzpres*0.707106781)! 45 deg

        *IF,pressure*10e6,GE,0,THEN
                SFE,Eindex,1,PRES, ,-pressure, , ,      ! Apply Pressure to Elem i
        *ENDIF

        !/GOPR                              ! Resume Print to Output
        *SET,Elemleft,(Elemleft-1)    ! Number of Elements Left
        !/NOPR                              ! Suspend Print to Output

        *GET,Next,ELEM,Eindex,NXTH
        *IF,Next,EQ,0,EXIT
        *SET,Eindex,Next

*enddo

FINISH

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!                    Applying Load to Front Angle Pieces
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

*GET,numcomp,COMP,0,NCOMP
*IF,numcomp,GT,3,THEN
```

```
/PREP7

ALLSEL,ALL
CMSEL,S,Angle_F                         ! Select Comp = Front Angle
ALLSEL,BELOW,AREA                                   ! Selecting Elements Below Selected Areas


                                                    ! Speeding Up Do Loop
*GET,count,ELEM,0,COUNT
*GET,Eindex,ELEM,0,NUM,MIN

*DO,i,0,count+10,1

        !*IF,elmiqr(i,1),EQ,-1,CYCLE  ! Skip if Element is Not Selected

        *GET,Xcent,ELEM,Eindex,CENT,X       ! Calling Centroid Locations
        *GET,Ycent,ELEM,Eindex,CENT,Y
        *GET,Zcent,ELEM,Eindex,CENT,Z

        *SET,topsurf,((22.229*mass/density+1024)*(1-((Xcent-XPeak)/4854)**2)*(1-((Zcent-ZPeak)/6671)**2))

        *SET,column,(topsurf-Ycent)  ! Vertical Pressure Calculations
        *IF,column,GT,0,THEN
                *SET,vertpres,rho*G*(1/(1000**3))*column
        *ELSE
                *SET,vertpres,0     ! Preventing Negative Pressure
        *ENDIF

        *IF,column,GT,0,THEN                    ! Horizontal Approximation
                *SET,horzpres,Ka*rho*G*(1/(1000**3))*column
        *ELSE
                *SET,horzpres,0     ! Preventing Negative Pressure
        *ENDIF

                                                ! Pressure Combination
        *SET,pressure,(vertpres*0.8660254)+(horzpres*0.5)           ! 60 deg

        *IF,pressure*10e6,GE,0,THEN
                SFE,Eindex,1,PRES, ,-pressure, , ,      ! Apply Pressure to Elem i
        *ENDIF

        !/GOPR                                  ! Resume Print to Output
        *SET,Elemleft,(Elemleft-1)     ! Number of Elements Left
        !/NOPR                                  ! Suspend Print to Output

        *GET,Next,ELEM,Eindex,NXTH
        *IF,Next,EQ,0,EXIT
        *SET,Eindex,Next

*enddo

FINISH

*ENDIF

ALLSEL,ALL


!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!       Deleting Parameters and Display Commands
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

                                ! Display Commands (Not Needed)
EPLOT
/VIEW, 1 ,1,1,1
/ANG, 1
```

```
/REP,FAST
/AUTO, 1
/REP
/USER, 1
/VIEW, 1,  0.736873689155    , -0.272748618737    , 0.618567180837
/ANG,  1,   1.56201349016
/LIG,  1,1,1.000,  0.333241232397    , -0.895070804294    , 0.296308177969    ,  0.000000000000E+00
/REPLO
/PSF,PRES,NORM,2
/PBF,DEFA, ,1
/PSYMB,CS,0
/PSYMB,NDIR,0
/PSYMB,ESYS,0
/PSYMB,LDIR,0
/PSYMB,ECON,0
/PSYMB,XNODE,0
/PSYMB,DOT,1
/PSYMB,PCONV,
/PSYMB,LAYR,0
!*
/PBC,ALL, ,1
/VSCALE,1,6,0
/REPLOT
/REP
!*

                                        ! Deleting Parameters
TRACKER=
FR_INT=
FL_INT=
surf=
Xloc=
Zloc=
wall=
height=
jumpout=
lowelem=
highelem=
Xcent=
Ycent=
Zcent=
topsurf=
column=
vertpres=
height=
basepres=
horzpres=
pressure=
Elemleft=

CMDELE,ANGLE_F
CMDELE,ANGLE_S
CMDELE,FLOOR
CMDELE,FRONT
CMDELE,SIDE             ! Deleting Components


CSYS,0                  ! Returning to the Global Cartesian
                        ! Co-ordinate System


/EOF                                    ! End of File Marker
```

❖ *Filename: 4_4_FEA_algorithm_comp_INPUT*

```
!@@@@@@@@@@@@@@@@@@@@@@@@@@
!        FEA of 930E Truck Box Structure
!        Oilsand Pressure Load Algorithm
!        Select Components Subroutine
!@@@@@@@@@@@@@@@@@@@@@@@@@@

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!        Creating Body Half Model
!        Floor, Front, and Side Components
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
:half

FINISH
/PREP7

ALLSEL,ALL

FLST,5,54,5,ORDE,43
FITEM,5,3
FITEM,5,34
FITEM,5,-37
FITEM,5,39
FITEM,5,-43
FITEM,5,45
FITEM,5,53
FITEM,5,59
FITEM,5,62
FITEM,5,67
FITEM,5,89
FITEM,5,106
FITEM,5,126
FITEM,5,150
FITEM,5,-153
FITEM,5,155
FITEM,5,-157
FITEM,5,185
FITEM,5,191
FITEM,5,193
FITEM,5,-194
FITEM,5,204
FITEM,5,262
FITEM,5,269
FITEM,5,-271
FITEM,5,273
FITEM,5,275
FITEM,5,-276
FITEM,5,285
FITEM,5,-286
FITEM,5,343
FITEM,5,349
FITEM,5,-350
FITEM,5,544
FITEM,5,547
FITEM,5,573
FITEM,5,582
FITEM,5,662
FITEM,5,665
FITEM,5,699
FITEM,5,-700
FITEM,5,702
FITEM,5,-705
ASEL,S, , ,P51X                 ! Selecting Floor Areas

CM,floor,AREA       ! Storing Areas as Component
ALLSEL,BELOW,AREA
         ! Selecting Elements Below Selected Areas
*SET,Elemleft,elmiqr(0,13)     ! Element Counter

ALLSEL,ALL

FLST,5,12,5,ORDE,10
FITEM,5,187
FITEM,5,381
FITEM,5,384
FITEM,5,387
FITEM,5,-388
FITEM,5,390
FITEM,5,-392
FITEM,5,395
FITEM,5,-397
FITEM,5,442
ASEL,S, , ,P51X     ! Selecting Front Wall Areas

CM,Front,AREA     ! Storing Areas as Component
ALLSEL,BELOW,AREA
         ! Selecting Elements Below Selected Areas
*SET,Elemleft,(Elemleft+elmiqr(0,13))
                  ! Element Counter

ALLSEL,ALL

FLST,5,13,5,ORDE,9
FITEM,5,239
FITEM,5,289
FITEM,5,301
FITEM,5,317
FITEM,5,323
FITEM,5,690
FITEM,5,-692
FITEM,5,694
FITEM,5,-698
ASEL,S, , ,P51X

CM,Side,AREA      ! Storing Areas as Component
ALLSEL,BELOW,AREA
         ! Selecting Elements Below Selected Areas
*SET,Elemleft,(Elemleft+elmiqr(0,13))
         ! Element Counter

ALLSEL,ALL

ASEL,S, , ,    377

CM,Angle_F,AREA   ! Storing Areas as Component
ALLSEL,BELOW,AREA
         ! Selecting Elements Below Selected Areas
*SET,Elemleft,(Elemleft+elmiqr(0,13))
         ! Element Counter

FLST,5,18,5,ORDE,7
FITEM,5,32
FITEM,5,61
FITEM,5,90
FITEM,5,145
FITEM,5,205
FITEM,5,-217
FITEM,5,378
ASEL,S, , ,P51X

CM,Angle_S,AREA ! Storing Areas as Component
ALLSEL,BELOW,AREA
         ! Selecting Elements Below Selected Areas
```

```
*SET,Elemleft,(Elemleft+elmiqr(0,13))
        ! Element Counter

ALLSEL,ALL

FINISH

/EOF                    ! End of File Marker


!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!           Creating Body Slice Model
!                   Floor, Front, and Side Components
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
:slice

FINISH
/PREP7

ALLSEL,ALL
FLST,5,7,5,ORDE,7
FITEM,5,191
FITEM,5,229
FITEM,5,323
FITEM,5,325
FITEM,5,551
FITEM,5,553
FITEM,5,555
ASEL,S, , ,P51X                 ! Selecting Floor Areas

CM,floor,AREA        ! Storing Areas as Component
ALLSEL,BELOW,AREA
        ! Selecting Elements Below Selected Areas
*SET,Elemleft,elmiqr(0,13)      ! Element Counter

ALLSEL,ALL

FLST,5,5,5,ORDE,5
FITEM,5,597
FITEM,5,601
FITEM,5,603
FITEM,5,605
FITEM,5,610
ASEL,S, , ,P51X

CM,Side,AREA      ! Storing Areas as Component
ALLSEL,BELOW,AREA
        ! Selecting Elements Below Selected Areas
*SET,Elemleft,(Elemleft+elmiqr(0,13))
        ! Element Counter

FLST,5,3,5,ORDE,3
FITEM,5,211
FITEM,5,557
FITEM,5,585
ASEL,S, , ,P51X

CM,Angle_S,AREA ! Storing Areas as Component
ALLSEL,BELOW,AREA
        ! Selecting Elements Below Selected Areas
*SET,Elemleft,(Elemleft+elmiqr(0,13))
        ! Element Counter

ALLSEL,ALL
FINISH

/EOF                    ! End of File Marker


!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!    Creating Combined Frame and Body Full Model
!           Floor, Front, and Side Components
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
:comb

FINISH
/PREP7

ALLSEL,ALL

FLST,5,108,5,ORDE,86
FITEM,5,283
FITEM,5,314
FITEM,5,-317
FITEM,5,319
FITEM,5,-323
FITEM,5,325
FITEM,5,333
FITEM,5,339
FITEM,5,342
FITEM,5,347
FITEM,5,369
FITEM,5,386
FITEM,5,406
FITEM,5,430
FITEM,5,-433
FITEM,5,435
FITEM,5,-437
FITEM,5,465
FITEM,5,471
FITEM,5,473
FITEM,5,-474
FITEM,5,484
FITEM,5,542
FITEM,5,549
FITEM,5,-551
FITEM,5,553
FITEM,5,555
FITEM,5,-556
FITEM,5,565
FITEM,5,-566
FITEM,5,623
FITEM,5,629
FITEM,5,-630
FITEM,5,824
FITEM,5,827
FITEM,5,853
FITEM,5,862
FITEM,5,942
FITEM,5,945
FITEM,5,979
FITEM,5,-980
FITEM,5,982
FITEM,5,-985
FITEM,5,1314
FITEM,5,1345
FITEM,5,-1348
FITEM,5,1350
FITEM,5,-1354
FITEM,5,1356
FITEM,5,1364
FITEM,5,1370
FITEM,5,1373
FITEM,5,1378
FITEM,5,1400
```

```
FITEM,5,1417
FITEM,5,1435
FITEM,5,1459
FITEM,5,-1462
FITEM,5,1464
FITEM,5,-1466
FITEM,5,1494
FITEM,5,1500
FITEM,5,1502
FITEM,5,-1503
FITEM,5,1513
FITEM,5,1571
FITEM,5,1578
FITEM,5,-1580
FITEM,5,1582
FITEM,5,1584
FITEM,5,-1585
FITEM,5,1594
FITEM,5,-1595
FITEM,5,1652
FITEM,5,1658
FITEM,5,-1659
FITEM,5,1853
FITEM,5,1856
FITEM,5,1882
FITEM,5,1891
FITEM,5,1955
FITEM,5,1958
FITEM,5,1990
FITEM,5,-1991
FITEM,5,1993
FITEM,5,-1996
ASEL,S, , ,P51X                 ! Selecting Floor Areas

CM,floor,AREA       ! Storing Areas as Component
ALLSEL,BELOW,AREA
        ! Selecting Elements Below Selected Areas
*SET,Elemleft,elmiqr(0,13)    ! Element Counter

ALLSEL,ALL

FLST,5,24,5,ORDE,20
FITEM,5,467
FITEM,5,661
FITEM,5,664
FITEM,5,667
FITEM,5,-668
FITEM,5,670
FITEM,5,-672
FITEM,5,675
FITEM,5,-677
FITEM,5,722
FITEM,5,1496
FITEM,5,1690
FITEM,5,1693
FITEM,5,1696
FITEM,5,-1697
FITEM,5,1699
FITEM,5,-1701
FITEM,5,1704
FITEM,5,-1706
FITEM,5,1751
ASEL,S, , ,P51X     ! Selecting Front Wall Areas

CM,Front,AREA     ! Storing Areas as Component
ALLSEL,BELOW,AREA
        ! Selecting Elements Below Selected Areas
*SET,Elemleft,(Elemleft+elmiqr(0,13))
        ! Element Counter

ALLSEL,ALL

FLST,5,26,5,ORDE,18
FITEM,5,519
FITEM,5,569
FITEM,5,581
FITEM,5,597
FITEM,5,603
FITEM,5,970
FITEM,5,-972
FITEM,5,974
FITEM,5,-978
FITEM,5,1548
FITEM,5,1598
FITEM,5,1610
FITEM,5,1626
FITEM,5,1632
FITEM,5,1981
FITEM,5,-1983
FITEM,5,1985
FITEM,5,-1989
ASEL,S, , ,P51X     ! Selecting Side Wall Areas

CM,Side,AREA      ! Storing Areas as Component
ALLSEL,BELOW,AREA
        ! Selecting Elements Below Selected Areas
*SET,Elemleft,(Elemleft+elmiqr(0,13))
        ! Element Counter

ALLSEL,ALL

FLST,5,2,5,ORDE,2
FITEM,5,657
FITEM,5,1686
ASEL,S, , ,P51X

CM,Angle_F,AREA ! Storing Areas as Component
ALLSEL,BELOW,AREA
        ! Selecting Elements Below Selected Areas
*SET,Elemleft,(Elemleft+elmiqr(0,13))
        ! Element Counter

FLST,5,36,5,ORDE,14
FITEM,5,312
FITEM,5,341
FITEM,5,370
FITEM,5,425
FITEM,5,485
FITEM,5,-497
FITEM,5,658
FITEM,5,1343
FITEM,5,1372
FITEM,5,1401
FITEM,5,1454
FITEM,5,1514
FITEM,5,-1526
FITEM,5,1687
ASEL,S, , ,P51X

CM,Angle_S,AREA ! Storing Areas as Component
ALLSEL,BELOW,AREA
        ! Selecting Elements Below Selected Areas
*SET,Elemleft,(Elemleft+elmiqr(0,13))
        ! Element Counter

ALLSEL,ALL
FINISH

/EOF     ! End of File Marker
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
```

❖ *Filename: 4_5_FEA_symm_INPUT*

```
!@@@@@@@@@@@@@@@@@@@@@@@@@
!                    FEA of 930E Truck Box Structure
!                    Symmetry BC's Routine
!@@@@@@@@@@@@@@@@@@@@@@@@@
FINISH

/TITLE,Applying Symmetry Boundary Conditions

/PREP7
*AFUN,DEG

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~ View Settings
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

ERASE
APLOT
WPSTYLE,,,,,,,0
/AUTO, 1
/REP
/USER, 1
/VIEW, 1, 0.868057538878   , -0.230609820303   , -
0.439653522647
/ANG, 1, -7.45986669049
/REPLO

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~ Symmetry Conditions
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,2,106,4,ORDE,102
FITEM,2,5
FITEM,2,17
FITEM,2,40
FITEM,2,47
FITEM,2,56
FITEM,2,66
FITEM,2,70
FITEM,2,81
FITEM,2,90
FITEM,2,93
FITEM,2,95
FITEM,2,97
FITEM,2,99
FITEM,2,101
FITEM,2,103
FITEM,2,105
FITEM,2,107
FITEM,2,109
FITEM,2,111
FITEM,2,113
FITEM,2,115
FITEM,2,117
FITEM,2,119
FITEM,2,121
FITEM,2,123
FITEM,2,125
FITEM,2,134
FITEM,2,172
FITEM,2,175
FITEM,2,183
FITEM,2,193
FITEM,2,198
FITEM,2,207
FITEM,2,212
FITEM,2,224
FITEM,2,230
FITEM,2,236
FITEM,2,238
FITEM,2,246
FITEM,2,258
FITEM,2,268
FITEM,2,281
FITEM,2,300
FITEM,2,306
FITEM,2,322
FITEM,2,357
FITEM,2,377
FITEM,2,594
FITEM,2,606
FITEM,2,727
FITEM,2,-728
FITEM,2,733
FITEM,2,780
FITEM,2,810
FITEM,2,814
FITEM,2,-817
FITEM,2,855
FITEM,2,859
FITEM,2,869
FITEM,2,885
FITEM,2,-886
FITEM,2,938
FITEM,2,943
FITEM,2,-944
FITEM,2,946
FITEM,2,950
FITEM,2,952
FITEM,2,-953
FITEM,2,957
FITEM,2,960
FITEM,2,-961
FITEM,2,974
FITEM,2,982
FITEM,2,1020
FITEM,2,1023
FITEM,2,1032
FITEM,2,-1033
FITEM,2,1038
FITEM,2,1041
FITEM,2,1045
FITEM,2,1137
FITEM,2,1150
FITEM,2,1152
FITEM,2,1172
FITEM,2,1175
FITEM,2,1179
FITEM,2,1196
FITEM,2,1207
FITEM,2,1225
FITEM,2,-1226
FITEM,2,1326
FITEM,2,1343
FITEM,2,1350
FITEM,2,1364
FITEM,2,1370
FITEM,2,1389
FITEM,2,1489
FITEM,2,1491
FITEM,2,1497
FITEM,2,1499
FITEM,2,1509
FITEM,2,-1512
DL,P51X, ,UX,0
```

```
FLST,2,106,4,ORDE,102
FITEM,2,5
FITEM,2,17
FITEM,2,40
FITEM,2,47
FITEM,2,56
FITEM,2,66
FITEM,2,70
FITEM,2,81
FITEM,2,90
FITEM,2,93
FITEM,2,95
FITEM,2,97
FITEM,2,99
FITEM,2,101
FITEM,2,103
FITEM,2,105
FITEM,2,107
FITEM,2,109
FITEM,2,111
FITEM,2,113
FITEM,2,115
FITEM,2,117
FITEM,2,119
FITEM,2,121
FITEM,2,123
FITEM,2,125
FITEM,2,134
FITEM,2,172
FITEM,2,175
FITEM,2,183
FITEM,2,193
FITEM,2,198
FITEM,2,207
FITEM,2,212
FITEM,2,224
FITEM,2,230
FITEM,2,236
FITEM,2,238
FITEM,2,246
FITEM,2,258
FITEM,2,268
FITEM,2,281
FITEM,2,300
FITEM,2,306
FITEM,2,322
FITEM,2,357
FITEM,2,377
FITEM,2,594
FITEM,2,606
FITEM,2,727
FITEM,2,-728
FITEM,2,733
FITEM,2,780
FITEM,2,810
FITEM,2,814
FITEM,2,-817
FITEM,2,855
FITEM,2,859
FITEM,2,869
FITEM,2,885
FITEM,2,-886
FITEM,2,938
FITEM,2,943
FITEM,2,-944
FITEM,2,946
FITEM,2,950
FITEM,2,952
FITEM,2,-953
FITEM,2,957
FITEM,2,960
FITEM,2,-961
FITEM,2,974
FITEM,2,982
FITEM,2,1020
FITEM,2,1023
FITEM,2,1032
FITEM,2,-1033
FITEM,2,1038
FITEM,2,1041
FITEM,2,1045
FITEM,2,1137
FITEM,2,1150
FITEM,2,1152
FITEM,2,1172
FITEM,2,1175
FITEM,2,1179
FITEM,2,1196
FITEM,2,1207
FITEM,2,1225
FITEM,2,-1226
FITEM,2,1326
FITEM,2,1343
FITEM,2,1350
FITEM,2,1364
FITEM,2,1370
FITEM,2,1389
FITEM,2,1489
FITEM,2,1491
FITEM,2,1497
FITEM,2,1499
FITEM,2,1509
FITEM,2,-1512
DL,P51X, ,ROTY,0

FLST,2,106,4,ORDE,102
FITEM,2,5
FITEM,2,17
FITEM,2,40
FITEM,2,47
FITEM,2,56
FITEM,2,66
FITEM,2,70
FITEM,2,81
FITEM,2,90
FITEM,2,93
FITEM,2,95
FITEM,2,97
FITEM,2,99
FITEM,2,101
FITEM,2,103
FITEM,2,105
FITEM,2,107
FITEM,2,109
FITEM,2,111
FITEM,2,113
FITEM,2,115
FITEM,2,117
FITEM,2,119
FITEM,2,121
FITEM,2,123
FITEM,2,125
FITEM,2,134
FITEM,2,172
FITEM,2,175
FITEM,2,183
FITEM,2,193
FITEM,2,198
FITEM,2,207
```

```
FITEM,2,212
FITEM,2,224
FITEM,2,230
FITEM,2,236
FITEM,2,238
FITEM,2,246
FITEM,2,258
FITEM,2,268
FITEM,2,281
FITEM,2,300
FITEM,2,306
FITEM,2,322
FITEM,2,357
FITEM,2,377
FITEM,2,594
FITEM,2,606
FITEM,2,727
FITEM,2,-728
FITEM,2,733
FITEM,2,780
FITEM,2,810
FITEM,2,814
FITEM,2,-817
FITEM,2,855
FITEM,2,859
FITEM,2,869
FITEM,2,885
FITEM,2,-886
FITEM,2,938
FITEM,2,943
FITEM,2,-944
FITEM,2,946
FITEM,2,950
FITEM,2,952
FITEM,2,-953
FITEM,2,957
FITEM,2,960
FITEM,2,-961
FITEM,2,974
FITEM,2,982
FITEM,2,1020
FITEM,2,1023
FITEM,2,1032
FITEM,2,-1033
FITEM,2,1038
FITEM,2,1041
FITEM,2,1045
FITEM,2,1137
FITEM,2,1150
FITEM,2,1152
FITEM,2,1172
FITEM,2,1175
FITEM,2,1179
FITEM,2,1196
FITEM,2,1207
FITEM,2,1225
FITEM,2,-1226
FITEM,2,1326
FITEM,2,1343
FITEM,2,1350
FITEM,2,1364
FITEM,2,1370
FITEM,2,1389
FITEM,2,1489
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FITEM,2,1497
FITEM,2,1499
FITEM,2,1509
FITEM,2,-1512
DL,P51X, ,ROTZ,0
```

```
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~Symmetry Conditions on Load Cell
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

*IF,Loadcell,EQ,1,THEN

        FLST,2,16,4,ORDE,12
        FITEM,2,2204
        FITEM,2,-2207
        FITEM,2,2212
        FITEM,2,-2215
        FITEM,2,2221
        FITEM,2,2233
        FITEM,2,2235
        FITEM,2,-2236
        FITEM,2,2238
        FITEM,2,2244
        FITEM,2,2250
        FITEM,2,2254
        DL,P51X, ,UX,0

        FLST,2,16,4,ORDE,12
        FITEM,2,2204
        FITEM,2,-2207
        FITEM,2,2212
        FITEM,2,-2215
        FITEM,2,2221
        FITEM,2,2233
        FITEM,2,2235
        FITEM,2,-2236
        FITEM,2,2238
        FITEM,2,2244
        FITEM,2,2250
        FITEM,2,2254
        DL,P51X, ,ROTY,0

        FLST,2,16,4,ORDE,12
        FITEM,2,2204
        FITEM,2,-2207
        FITEM,2,2212
        FITEM,2,-2215
        FITEM,2,2221
        FITEM,2,2233
        FITEM,2,2235
        FITEM,2,-2236
        FITEM,2,2238
        FITEM,2,2244
        FITEM,2,2250
        FITEM,2,2254
        DL,P51X, ,ROTZ,0

*ENDIF

FINISH
FINISH
/EOF

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
```

❖ *Filename: 4_6_FEA_antisymm_INPUT*

```
!@@@@@@@@@@@@@@@@@@@@@@@@@
!           FEA of 930E Truck Box Structure
!           Anti-symmetry Frame BC's Routine
!@@@@@@@@@@@@@@@@@@@@@@@@@
FINISH

/TITLE,Applying Anti-symmetry Boundary Conditions

/PREP7
*AFUN,DEG

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~ View Settings
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

ERASE
APLOT
WPSTYLE,,,,,,,0
/AUTO, 1
/REP
/USER, 1
/VIEW, 1, 0.868057538878   , -0.230609820303   , -
0.439653522647
/ANG, 1, -7.45986669049
/REPLO

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~ Anti-Symmetry Conditions
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,2,106,4,ORDE,102
FITEM,2,5
FITEM,2,17
FITEM,2,40
FITEM,2,47
FITEM,2,56
FITEM,2,66
FITEM,2,70
FITEM,2,81
FITEM,2,90
FITEM,2,93
FITEM,2,95
FITEM,2,97
FITEM,2,99
FITEM,2,101
FITEM,2,103
FITEM,2,105
FITEM,2,107
FITEM,2,109
FITEM,2,111
FITEM,2,113
FITEM,2,115
FITEM,2,117
FITEM,2,119
FITEM,2,121
FITEM,2,123
FITEM,2,125
FITEM,2,134
FITEM,2,172
FITEM,2,175
FITEM,2,183
FITEM,2,193
FITEM,2,198
FITEM,2,207
FITEM,2,212
FITEM,2,224
FITEM,2,230
FITEM,2,236
FITEM,2,238
FITEM,2,246
FITEM,2,258
FITEM,2,268
FITEM,2,281
FITEM,2,300
FITEM,2,306
FITEM,2,322
FITEM,2,357
FITEM,2,377
FITEM,2,594
FITEM,2,606
FITEM,2,727
FITEM,2,-728
FITEM,2,733
FITEM,2,780
FITEM,2,810
FITEM,2,814
FITEM,2,-817
FITEM,2,855
FITEM,2,859
FITEM,2,869
FITEM,2,885
FITEM,2,-886
FITEM,2,938
FITEM,2,943
FITEM,2,-944
FITEM,2,946
FITEM,2,950
FITEM,2,952
FITEM,2,-953
FITEM,2,957
FITEM,2,960
FITEM,2,-961
FITEM,2,974
FITEM,2,982
FITEM,2,1020
FITEM,2,1023
FITEM,2,1032
FITEM,2,-1033
FITEM,2,1038
FITEM,2,1041
FITEM,2,1045
FITEM,2,1137
FITEM,2,1150
FITEM,2,1152
FITEM,2,1172
FITEM,2,1175
FITEM,2,1179
FITEM,2,1196
FITEM,2,1207
FITEM,2,1225
FITEM,2,-1226
FITEM,2,1326
FITEM,2,1343
FITEM,2,1350
FITEM,2,1364
FITEM,2,1370
FITEM,2,1389
FITEM,2,1489
FITEM,2,1491
FITEM,2,1497
FITEM,2,1499
FITEM,2,1509
FITEM,2,-1512
DL,P51X, ,ROTX,0
```

```
FLST,2,106,4,ORDE,102
FITEM,2,5
FITEM,2,17
FITEM,2,40
FITEM,2,47
FITEM,2,56
FITEM,2,66
FITEM,2,70
FITEM,2,81
FITEM,2,90
FITEM,2,93
FITEM,2,95
FITEM,2,97
FITEM,2,99
FITEM,2,101
FITEM,2,103
FITEM,2,105
FITEM,2,107
FITEM,2,109
FITEM,2,111
FITEM,2,113
FITEM,2,115
FITEM,2,117
FITEM,2,119
FITEM,2,121
FITEM,2,123
FITEM,2,125
FITEM,2,134
FITEM,2,172
FITEM,2,175
FITEM,2,183
FITEM,2,193
FITEM,2,198
FITEM,2,207
FITEM,2,212
FITEM,2,224
FITEM,2,230
FITEM,2,236
FITEM,2,238
FITEM,2,246
FITEM,2,258
FITEM,2,268
FITEM,2,281
FITEM,2,300
FITEM,2,306
FITEM,2,322
FITEM,2,357
FITEM,2,377
FITEM,2,594
FITEM,2,606
FITEM,2,727
FITEM,2,-728
FITEM,2,733
FITEM,2,780
FITEM,2,810
FITEM,2,814
FITEM,2,-817
FITEM,2,855
FITEM,2,859
FITEM,2,869
FITEM,2,885
FITEM,2,-886
FITEM,2,938
FITEM,2,943
FITEM,2,-944
FITEM,2,946
FITEM,2,950
FITEM,2,952
FITEM,2,-953
FITEM,2,957
FITEM,2,960
FITEM,2,-961
FITEM,2,974
FITEM,2,982
FITEM,2,1020
FITEM,2,1023
FITEM,2,1032
FITEM,2,-1033
FITEM,2,1038
FITEM,2,1041
FITEM,2,1045
FITEM,2,1137
FITEM,2,1150
FITEM,2,1152
FITEM,2,1172
FITEM,2,1175
FITEM,2,1179
FITEM,2,1196
FITEM,2,1207
FITEM,2,1225
FITEM,2,-1226
FITEM,2,1326
FITEM,2,1343
FITEM,2,1350
FITEM,2,1364
FITEM,2,1370
FITEM,2,1389
FITEM,2,1489
FITEM,2,1491
FITEM,2,1497
FITEM,2,1499
FITEM,2,1509
FITEM,2,-1512
DL,P51X, ,UY,0

FLST,2,106,4,ORDE,102
FITEM,2,5
FITEM,2,17
FITEM,2,40
FITEM,2,47
FITEM,2,56
FITEM,2,66
FITEM,2,70
FITEM,2,81
FITEM,2,90
FITEM,2,93
FITEM,2,95
FITEM,2,97
FITEM,2,99
FITEM,2,101
FITEM,2,103
FITEM,2,105
FITEM,2,107
FITEM,2,109
FITEM,2,111
FITEM,2,113
FITEM,2,115
FITEM,2,117
FITEM,2,119
FITEM,2,121
FITEM,2,123
FITEM,2,125
FITEM,2,134
FITEM,2,172
FITEM,2,175
FITEM,2,183
FITEM,2,193
FITEM,2,198
FITEM,2,207
```

```
FITEM,2,212
FITEM,2,224
FITEM,2,230
FITEM,2,236
FITEM,2,238
FITEM,2,246
FITEM,2,258
FITEM,2,268
FITEM,2,281
FITEM,2,300
FITEM,2,306
FITEM,2,322
FITEM,2,357
FITEM,2,377
FITEM,2,594
FITEM,2,606
FITEM,2,727
FITEM,2,-728
FITEM,2,733
FITEM,2,780
FITEM,2,810
FITEM,2,814
FITEM,2,-817
FITEM,2,855
FITEM,2,859
FITEM,2,869
FITEM,2,885
FITEM,2,-886
FITEM,2,938
FITEM,2,943
FITEM,2,-944
FITEM,2,946
FITEM,2,950
FITEM,2,952
FITEM,2,-953
FITEM,2,957
FITEM,2,960
FITEM,2,-961
FITEM,2,974
FITEM,2,982
FITEM,2,1020
FITEM,2,1023
FITEM,2,1032
FITEM,2,-1033
FITEM,2,1038
FITEM,2,1041
FITEM,2,1045
FITEM,2,1137
FITEM,2,1150
FITEM,2,1152
FITEM,2,1172
FITEM,2,1175
FITEM,2,1179
FITEM,2,1196
FITEM,2,1207
FITEM,2,1225
FITEM,2,-1226
FITEM,2,1326
FITEM,2,1343
FITEM,2,1350
FITEM,2,1364
FITEM,2,1370
FITEM,2,1389
FITEM,2,1489
FITEM,2,1491
FITEM,2,1497
FITEM,2,1499
FITEM,2,1509
FITEM,2,-1512
DL,P51X, ,UZ,0

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~ Anti-Symmetry Conditions on Load Cell
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

*IF,Loadcell,EQ,1,THEN

        FLST,2,16,4,ORDE,12
        FITEM,2,2204
        FITEM,2,-2207
        FITEM,2,2212
        FITEM,2,-2215
        FITEM,2,2221
        FITEM,2,2233
        FITEM,2,2235
        FITEM,2,-2236
        FITEM,2,2238
        FITEM,2,2244
        FITEM,2,2250
        FITEM,2,2254
        DL,P51X, ,ROTX,0

        FLST,2,16,4,ORDE,12
        FITEM,2,2204
        FITEM,2,-2207
        FITEM,2,2212
        FITEM,2,-2215
        FITEM,2,2221
        FITEM,2,2233
        FITEM,2,2235
        FITEM,2,-2236
        FITEM,2,2238
        FITEM,2,2244
        FITEM,2,2250
        FITEM,2,2254
        DL,P51X, ,UY,0

        FLST,2,16,4,ORDE,12
        FITEM,2,2204
        FITEM,2,-2207
        FITEM,2,2212
        FITEM,2,-2215
        FITEM,2,2221
        FITEM,2,2233
        FITEM,2,2235
        FITEM,2,-2236
        FITEM,2,2238
        FITEM,2,2244
        FITEM,2,2250
        FITEM,2,2254
        DL,P51X, ,UZ,0

*ENDIF


FINISH
/EOF

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
```

❖ *Filename: 5_1_post_StressPath_INPUT*

```
!@@@@@@@@@@@@@@@@@@@@@@@@
!         FEA of 930E Truck Box Structure
!         Bolster Stress Plot
!@@@@@@@@@@@@@@@@@@@@@@@@

FINISH
/CLEAR

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~ Reading Database and Results Files
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

RESUME,July_18_4Loadcells,db,
/GRAPHICS,FULL

/POST1
INRES,
FILE,July_18_4Loadcells,rst,

SET,1,LAST,1,              ! Load Step #,Last
Substep, Scale=1

/EOF

LCDEF,1,1,,
LCDEF,2,2,,
LCDEF,3,3,,
LCDEF,4,4,,
LCASE,1,
LCOPER,ADD,4, , ,
/TITLE,LOAD CASE 5: Twist + Ore Load
LCWRITE,5, , ,../
SET,1,LAST,-1,
LCOPER,ADD,4, , ,
/TITLE,LOAD CASE 6: Inverted Twist + Ore Load
LCWRITE,6, , ,../
LCASE,2,
LCOPER,ADD,4, , ,
/TITLE,LOAD CASE 7: Uniform Frame Displacement +
Ore Load
LCWRITE,7, , ,../
SET,2,LAST,-1,
LCOPER,ADD,4, , ,
/TITLE,LOAD CASE 8: Inverted Uniform Frame
Displacement + Ore Load
LCWRITE,8, , ,../
LCASE,5
LCOPER,SUB,2, , ,
/TITLE,LOAD CASE 9: Twist + OreLoad - Uniform...
Uypin=0 UyNose=-2.0
LCWRITE,9, , ,../
LCASE,6
LCOPER,ADD,2, , ,
/TITLE,LOAD CASE 10: Inverted Twist + OreLoad +
Uniform... Uypin=0 UyNose=+2.0
LCWRITE,10, , ,../

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
! Rotating Co-oridinate System to Match Bolster Plate
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

CSKP,11,0,119,60,39,1,1,
           ! Rotating Co-ordinate System to
RSYS,11    ! align w/ Bottom of Bolster

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~ Selecting Which Bolster to Study
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

ALLSEL,ALL

FLST,5,16,5,ORDE,14
FITEM,5,96
FITEM,5,-97
FITEM,5,99
FITEM,5,-101
FITEM,5,114
FITEM,5,-116
FITEM,5,159
FITEM,5,162
FITEM,5,189
FITEM,5,201
FITEM,5,551
FITEM,5,-552
FITEM,5,554
FITEM,5,-555
ASEL,R, , ,P51X
CM,Bolster1,AREA

ALLSEL,ALL

FLST,5,28,5,ORDE,24
FITEM,5,74
FITEM,5,80
FITEM,5,86
FITEM,5,93
FITEM,5,111
FITEM,5,113
FITEM,5,161
FITEM,5,261
FITEM,5,264
FITEM,5,266
FITEM,5,268
FITEM,5,274
FITEM,5,278
FITEM,5,280
FITEM,5,282
FITEM,5,293
FITEM,5,550
FITEM,5,556
FITEM,5,558
FITEM,5,-561
FITEM,5,563
FITEM,5,-566
FITEM,5,721
FITEM,5,733
ASEL,R, , ,P51X
CM,Bolster2,AREA

ALLSEL,ALL

FLST,5,30,5,ORDE,25
FITEM,5,84
FITEM,5,108
FITEM,5,260
FITEM,5,263
FITEM,5,265
FITEM,5,267
FITEM,5,272
FITEM,5,277
FITEM,5,279
FITEM,5,283
FITEM,5,-284
```

```
FITEM,5,321
FITEM,5,557
FITEM,5,568
FITEM,5,570
FITEM,5,-572
FITEM,5,574
FITEM,5,-577
FITEM,5,701
FITEM,5,711
FITEM,5,-713
FITEM,5,719
FITEM,5,722
FITEM,5,-724
FITEM,5,732
ASEL,R, , ,P51X
CM,Bolster3,AREA

ALLSEL,ALL

FLST,5,20,5,ORDE,18
FITEM,5,78
FITEM,5,81
FITEM,5,-82
FITEM,5,105
FITEM,5,281
FITEM,5,313
FITEM,5,316
FITEM,5,567
FITEM,5,579
FITEM,5,581
FITEM,5,583
FITEM,5,-584
FITEM,5,708
FITEM,5,-710
FITEM,5,716
FITEM,5,-717
FITEM,5,725
FITEM,5,-727
ASEL,R, , ,P51X
CM,Bolster4,AREA

ALLSEL,ALL

FLST,5,18,5,ORDE,14
FITEM,5,72
FITEM,5,75
FITEM,5,-77
FITEM,5,102
FITEM,5,578
FITEM,5,585
FITEM,5,587
FITEM,5,-591
FITEM,5,706
FITEM,5,-707
FITEM,5,714
FITEM,5,-715
FITEM,5,728
FITEM,5,-729
ASEL,R, , ,P51X
CM,Bolster5,AREA

ALLSEL,ALL

FLST,5,15,5,ORDE,10
FITEM,5,21
FITEM,5,-22
FITEM,5,24
FITEM,5,-26
FITEM,5,71
FITEM,5,123
FITEM,5,-125
FITEM,5,128
FITEM,5,130
FITEM,5,-134
ASEL,R, , ,P51X
CM,Bolster6,AREA

ALLSEL,ALL

FLST,5,15,5,ORDE,12
FITEM,5,9
FITEM,5,-10
FITEM,5,12
FITEM,5,-13
FITEM,5,18
FITEM,5,-20
FITEM,5,23
FITEM,5,27
FITEM,5,117
FITEM,5,119
FITEM,5,-122
FITEM,5,127
ASEL,R, , ,P51X
CM,Bolster7,AREA

ALLSEL,ALL

FLST,5,15,5,ORDE,14
FITEM,5,2
FITEM,5,4
FITEM,5,47
FITEM,5,50
FITEM,5,58
FITEM,5,60
FITEM,5,63
FITEM,5,68
FITEM,5,-70
FITEM,5,199
FITEM,5,553
FITEM,5,627
FITEM,5,659
FITEM,5,661
ASEL,R, , ,P51X
CM,Bolster8,AREA

ALLSEL,ALL

FLST,5,12,5,ORDE,12
FITEM,5,1
FITEM,5,5
FITEM,5,7
FITEM,5,48
FITEM,5,-49
FITEM,5,65
FITEM,5,112
FITEM,5,203
FITEM,5,562
FITEM,5,630
FITEM,5,660
FITEM,5,666
ASEL,R, , ,P51X
CM,Bolster9,AREA

ALLSEL,ALL

CMSEL,S,Bolster1          ! Front Bolster
CMSEL,A,Bolster2
CMSEL,A,Bolster3
CMSEL,A,Bolster4
CMSEL,A,Bolster5
```

```
CMSEL,A,Bolster6
CMSEL,A,Bolster7
CMSEL,A,Bolster8
CMSEL,A,Bolster9              ! Rear Bolster

ALLSEL,BELOW,AREA

!*************************************************************
!*************************************************************
APLOT
/AUTO, 1
/REP
AVPRIN,0,0,

:quick

!LCASE,10
SET,1,LAST,-5,

SHELL,TOP
AVPRIN,0,0,
ETABLE,SXTOP,S,X
SHELL,bot
AVPRIN,0,0,
ETABLE,SXBOT,S,X
SADD,SEC_BEND,SXTOP,SXBOT,1,-1,0,

PLETAB,SEC_BEND,AVG

/EOF
!*************************************************************
!*************************************************************

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~ Defining Path Locations
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

!:here
!PADEL,ALL          ! Delete All Paths
!LCASE,1,                    ! Read Load Case

PATH,Bolster,2,30,200,          ! Defining Path
        ! 2 path points, 30 Data sets, 200 Data Points

!PPATH,2,0,3840,-115,-4400-(4670-4400)/2,0,
!PPATH,1,0,0,-340,-4400-(4670-4400)/2,0,
!/TITLE,Path Functions Down Centerline of Fifth Bolster

!FLST,2,2,1
!FITEM,2,42488
!FITEM,2,38822
!PPATH,P51X,1
!PDEF,STAT
!/TITLE,Path Functions Down Center of Fifth Bolster
Fillet

!PPATH,2,0,3840,-115,-7440-(7690-7440)/2,0,
!PPATH,1,0,0,-340,-7500-(7690-7500)/2,0,
!/TITLE,Path Functions Down Centerline of FRONT
Bolster

FLST,2,2,1
FITEM,2,43399
FITEM,2,42420
PPATH,P51X,1
PDEF,STAT
/TITLE,Path Functions Down Center of FRONT Bolster
Fillet

!PPATH,2,0,1030,-440+100,-7730,0,
!PPATH,1,0,943,-440+100,-4240,0,
!/TITLE,Path Functions Along Outside of STR

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~ Mapping Results to Bolster
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

PATH,Bolster

PDEF,STAT
AVPRIN,0,0,

SHELL,MID
        ! Read Results from Middle of Shell Element
PDEF,MidX,S,X,AVG
!PDEF,MidY,S,Y,AVG
!PDEF,MidZ,S,Y,AVG
!PDEF,EPELxMID,EPEL,X,AVG
!PDEF,EPELyMID,EPEL,Y,AVG
!PDEF,EPELzMID,EPEL,Z,AVG

SHELL,BOT
        ! Read Results from Bottom of Shell Element
PDEF,BotX,S,X,AVG
!PDEF,BotY,S,Y,AVG
!PDEF,EPELxBOT,EPEL,X,AVG

SHELL,TOP  ! Read Results from Top of Shell Element
PDEF,TopX,S,X,AVG
!PDEF,TopY,S,Y,NOAVG
!PDEF,EPELxTOP,EPEL,X,AVG

SHELL              ! Resume Top Shell Results

RSYS,0  ! Restoring Results to Global Cartesian
CSYS,0
DSYS,0

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~ Plottng Results on Graph
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

!/XRANGE,450,1350                    ! X Range

                                ! Plot Variable Settings
!PLPATH,MidX
!PLPATH,MidX,MidY,MidZ
PLPATH,TopX,BotX,MidX
!PLPATH,MidX,MidY,MidZ
!PLPATH,TopY,BotY,MidY
!PLPATH,EPELxMID,EPELyMID,EPELzMID
!PLPATH,EPELxBOT,EPELxTOP,EPELxMID

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

/EOF
```

❖ *Filename: 5_6_post_RubberReaction_INPUT*

```
!@@@@@@@@@@@@@@@@@@@@@@@@@
!        FEA of 930E Truck Box Structure
!        Rubber Pad Representation
!        Reaction Force Collection Routine
!@@@@@@@@@@@@@@@@@@@@@@@@@

FINISH
/CLEAR
!/NERR,0,,                    ! Warning Supression

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~ Reading Database and Results Files
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
RESUME,June_25_Shim,db
!/GRAPHICS,FULL

/POST1
INRES,
FILE,June_25_Shim,rst,

SET,1,LAST,1,                 ! Base Load Step

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!        Selecting Rubber Pad Volumes
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

ALLSEL,ALL
ALLSEL,BELOW,VOLU

ESEL,S,MAT,,2
EPLOT
/AUTO, 1
/REP
/USER, 1
/VIEW, 1, 0.475551822770   , 0.322430127329   ,-
0.818467639465
/ANG, 1, 6.72302175464
/LIG, 1,1,1.000, 0.812507096498   , -0.550668422625
, -0.191302133977   , 0.000000000000E+00
/REPLO

/ZOOM,1,RECT,1.187651,-0.473591,0.626680,-
0.021810
*SET,_ZF,1
AVPRIN,0,0,
!*
/EFACE,_ZF
PLNSOL,U,Y,0,1
!*
/DSCALE,1,1.0
/REPLOT
!*

/EOF

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!        Selecting Rubber Pad Bottom Nodes
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

:here

ALLSEL,ALL
ALLSEL,BELOW,VOLU
```

```
!NSEL,S,LOC,Y,-465.5,-465.3  ! Selecting Bottom Nodes
NSEL,R,LOC,Y,-440.5,-439.5  ! Selecting Top Nodes

*GET,count,NODE,0,COUNT
*GET,Nindex,NODE,0,NUM,MIN
*DIM,REACTION,ARRAY,count,5,1
*DO,index,1,count+10,1
        /GOPR                ! Resume Print to Output
        !*GET,Rforce,NODE,Nindex,RF,FY
        *GET,StressY,NODE,Nindex,S,Y
        ! Element Nodal Stress
        REACTION(index,1,1)=index
        REACTION(index,2,1)=Nindex
        REACTION(index,3,1)=NZ(Nindex)
        REACTION(index,4,1)=NX(Nindex)
        !REACTION(index,5,1)=Rforce
        REACTION(index,5,1)=StressY
        *GET,Next,NODE,Nindex,NXTH
        *IF,Next,EQ,0,EXIT
        *SET,Nindex,Next
        /NOPR                ! Suspend Print to Output
*ENDDO
!*CFOPEN,Reaction_Rubber_Top, ,
*CFOPEN,Reaction_Rubber_SY_Top, ,
*VWRITE,REACTION(1,1),REACTION(1,2),REACTION
(1,3),REACTION(1,4),REACTION(1,5), , , ,
(' Index ',F4.0,' Node ',F6.0,'   Zloc',F10.2,'
Xloc',F10.2,'   SY',F12.2)
*CFCLOS
count=
Nindex=
index=
Rforce=
Next=
REACTION=


ALLSEL,ALL
/EOF

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
```

❖ *Filename: 5_7_post_LoadCells_INPUT*

```
!@@@@@@@@@@@@@@@@@@@@@@@@@
!       FEA of 930E Truck Box Structure
!       Load Cell Study Algorithm...
!@@@@@@@@@@@@@@@@@@@@@@@@@
FINISH
/CLEAR
!/NERR,0,,                    ! Warning Supression

!-------------------------------------------
!--------- Reading Database and Results Files
!-------------------------------------------

RESUME,July_18_4Loadcells,db,
/GRAPHICS,FULL

/POST1
INRES,
FILE,July_18_4Loadcells,rst,

SET,1,LAST,1,                 ! Load Step #,Last
Substep, Scale=1

!-------------------------------------------
!-------- Creating Load Cell Component Areas
!-------------------------------------------

ALLSEL,ALL
FLST,5,4,5,ORDE,4
FITEM,5,1184
FITEM,5,1186
FITEM,5,1188
FITEM,5,1190
ASEL,S, , ,P51X
CM,Loadcel4,AREA

ALLSEL,ALL
FLST,5,4,5,ORDE,4
FITEM,5,1175
FITEM,5,1177
FITEM,5,1179
FITEM,5,1181
ASEL,S, , ,P51X
CM,Loadcel3,AREA

ALLSEL,ALL
FLST,5,4,5,ORDE,2
FITEM,5,1158
FITEM,5,-1161
ASEL,S, , ,P51X
CM,Loadcel2,AREA

ALLSEL,ALL
FLST,5,4,5,ORDE,2
FITEM,5,1166
FITEM,5,-1169
ASEL,S, , ,P51X
CM,Loadcel1,AREA

ALLSEL,ALL

!CMSEL,S,Loadcel1
!CMSEL,S,Loadcel2
!CMSEL,S,Loadcel3
CMSEL,S,Loadcel4

ALLSEL,BELOW,AREA
/EOF

!-------------------------------------------
!--------- Combining Load Sets..
!-------------------------------------------

LCDEF,1,1,,
LCDEF,2,2,,
LCDEF,3,3,,
LCDEF,4,4,,
LCASE,1,
LCOPER,ADD,4, , ,
/TITLE,LOAD CASE 5: Twist + Ore Load
LCWRITE,5, , ,../
SET,1,LAST,-1,
LCOPER,ADD,4, , ,
/TITLE,LOAD CASE 6: Inverted Twist + Ore Load
LCWRITE,6, , ,../
LCASE,2,
LCOPER,ADD,4, , ,
/TITLE,LOAD CASE 7: Uniform Frame Displacement +
Ore Load
LCWRITE,7, , ,../
SET,2,LAST,-1,
LCOPER,ADD,4, , ,
/TITLE,LOAD CASE 8: Inverted Uniform Frame
Displacement + Ore Load
LCWRITE,8, , ,../
LCASE,5
LCOPER,SUB,2, , ,
/TITLE,LOAD CASE 9: Twist + OreLoad - Uniform...
Uypin=0 UyNose=-2.0
LCWRITE,9, , ,../
LCASE,6
LCOPER,ADD,2, , ,
/TITLE,LOAD CASE 10: Inverted Twist + OreLoad +
Uniform... Uypin=0 UyNose=+2.0
LCWRITE,10, , ,../
```

❖ *Filename: 6_1_submodel_Main_INPUT*

```
!**********************************************************************
!**********************************************************************

!        Sub-model of Bolster-Stringer Intersection

!**********************************************************************
!**********************************************************************


!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~ Sub-Model Creation ~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~


/INPUT,6_2_submodel_geom_INPUT,,,,0         ! Creating Sub-model Solid Gemetry
SAVE                                        ! Saving sub_geom.db
/EOF

:mesh
FINISH
FINISH
/CLEAR
RESUME,sub_geom.db
/INPUT,6_3_submodel_mesh_INPUT,,,,0         ! Meshing with Solid Elments
SAVE                                        ! Saving sub_mesh.db
/EOF

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~ Shell to Solid Results Transfer ~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

:tran
FINISH
FINISH
/CLEAR
RESUME,sub_mesh.db
/INPUT,6_4_submodel_tran_INPUT,,,,0         ! Results Transfer Routine
!SAVE                                       ! Saving sub_modl.db
/EOF

!  (load sets??)
!  Solve
```

❖ *Filename: 6_2_submodel_geom_INPUT*

```
!*****************************************************************
!*****************************************************************
!          Sub-model Geometry Creation Routine
!*****************************************************************
!*****************************************************************

!------------------------------------------------------------
!~~~~~~ Cropping Geometry to Sub-model Region
!------------------------------------------------------------

FINISH
FINISH
/CLEAR
RESUME,geom.db
/TITLE,Building Sub-Model Geometry
/FILNAME,sub_geom

/PREP7

KWPLAN,-1,   175,    19,   723
KL,1357,0.5, ,
KL,1335,0.5, ,
KWPAVE,   1018              ! Moving Work Plane

FLST,2,5,5,ORDE,5
FITEM,2,120
FITEM,2,122
FITEM,2,685
FITEM,2,-686
FITEM,2,688
ASBW,P51X                   ! Cutting Areas

KWPAVE,   1019              ! Moving Work Plane

FLST,2,2,5,ORDE,2
FITEM,2,19
FITEM,2,117
ASBW,P51X                   ! Cutting Areas

KWPLAN,-1,   1018,   727,   726
KWPAVE,   1019              ! Moving Work Plane

ASBW,   1038                ! Cutting Area

FLST,5,9,5,ORDE,9
FITEM,5,119
FITEM,5,121
FITEM,5,1035
FITEM,5,-1036
FITEM,5,1039
FITEM,5,-1040
FITEM,5,1043
FITEM,5,1045
FITEM,5,1047
ASEL,S, , ,P51X             ! Selecting Areas

ALLSEL,BELOW,AREA

FLST,3,1,4,ORDE,1           ! STR Lower Edge Lines
FITEM,3,2071
LGEN,2,P51X, , , -38*(33.3/109),-38*(103.8/109), ,0
FLST,3,1,4,ORDE,1
FITEM,3,2059
LGEN,2,P51X, , , -38, , ,0
KWPLAN,-1,   1021,   727,   1029
LARC,1032,1030,727,38+38,
FLST,5,3,5,ORDE,3
FITEM,5,1039
FITEM,5,-1040
FITEM,5,1047
ASEL,U, , ,P51X
ASEL,INVE                   ! Inverting Selection

FLST,2,761,5,ORDE,29
FITEM,2,1
FITEM,2,-18
FITEM,2,20
FITEM,2,-106
FITEM,2,108
FITEM,2,110
FITEM,2,-116
FITEM,2,118
FITEM,2,123
FITEM,2,-595
FITEM,2,612
FITEM,2,-684
FITEM,2,687
FITEM,2,689
FITEM,2,-719
FITEM,2,721
FITEM,2,-729
FITEM,2,732
FITEM,2,-733
FITEM,2,750
FITEM,2,-764
FITEM,2,1000
FITEM,2,-1034
FITEM,2,1037
FITEM,2,1039
FITEM,2,-1042
FITEM,2,1044
FITEM,2,1046
FITEM,2,-1047
ADELE,P51X, , ,1            ! Deleting Unselected Areas

ALLSEL,ALL
FLST,2,20,4,ORDE,5
FITEM,2,48
FITEM,2,57
FITEM,2,428
FITEM,2,-444
FITEM,2,1502
LDELE,P51X, , ,1            ! Deleting Uneeded Lines

FLST,3,1,4,ORDE,1           ! STR Upper Edge Lines
FITEM,3,2071
LGEN,2,P51X, , , ,38*(33.3/109),38*(103.8/109), ,0
FLST,3,1,3,ORDE,1
FITEM,3,1018
KGEN,2,P51X, , , ,38, , ,0
LSTR,   1003,   1001

LSTR,   1003,   1018
LSTR,   1018,   1033
LSTR,   1001,    727
LSTR,   1001,    177
LSTR,   1002,   1019
LSTR,   1019,   1031
LSTR,    177,   1030
LSTR,    727,   1032   ! Creating Lines for STR Areas

NUMMRG,KP, , ,   ! Merging Coincident Keypoints
```

```
FLST,2,4,4
FITEM,2,2002
FITEM,2,2059
FITEM,2,2004
FITEM,2,2001
AL,P51X
FLST,2,3,4
FITEM,2,176
FITEM,2,2005
FITEM,2,2004
AL,P51X
FLST,2,4,4
FITEM,2,2000
FITEM,2,2005
FITEM,2,2071
FITEM,2,2006
AL,P51X
FLST,2,4,4
FITEM,2,2007
FITEM,2,2071
FITEM,2,2062
FITEM,2,2008
AL,P51X
FLST,2,4,4
FITEM,2,176
FITEM,2,2008
FITEM,2,2079
FITEM,2,2009
AL,P51X
FLST,2,4,4
FITEM,2,2009
FITEM,2,2059
FITEM,2,2003
FITEM,2,2078
AL,P51X                    ! STR Areas

wpoff,0,0,-383/2
FLST,2,3,5,ORDE,3
FITEM,2,119
FITEM,2,1035
FITEM,2,1045
ASBW,P51X
wpoff,0,0,383
FLST,2,3,5,ORDE,3
FITEM,2,121
FITEM,2,1036
FITEM,2,1043
ASBW,P51X   ! Cutting Bolster Areas Along Box Width

FLST,2,6,5,ORDE,6
FITEM,2,1007
FITEM,2,-1008
FITEM,2,1011
FITEM,2,1013
FITEM,2,1015
FITEM,2,-1016
ADELE,P51X, , ,1

!-----------------------------------------------
!-------------- Creating Volume Geometry
!-----------------------------------------------

KWPLAN,-1,   1007,   1019,   1004
wpoff,0,0,4.5
ASBW,   1003
wpoff,0,0,-9
ASBW,   1002
KWPLAN,-1,   1010,   1018,   1009
wpoff,0,0,4.5
ASBW,   1005
wpoff,0,0,-9
ASBW,   1000
KWPLAN,-1,   1018,   727,   1003
LARC,1014,1020,1001,38-4.5,
LARC,1012,1016,1001,38+4.5,
FLST,2,1,5,ORDE,1
FITEM,2,1001
FLST,3,1,4,ORDE,1
FITEM,3,2002
ASBL,P51X,P51X, , ,KEEP
FLST,2,1,5,ORDE,1
FITEM,2,1004
FLST,3,1,4,ORDE,1
FITEM,3,2004
ASBL,P51X,P51X, , ,KEEP
          ! Dividing STR Areas for Bolster Thickness

FLST,2,6,5,ORDE,6
FITEM,2,1001
FITEM,2,-1002
FITEM,2,1008
FITEM,2,1011
FITEM,2,1015
FITEM,2,-1016
VDRAG,P51X, , , , , ,   2019
FLST,2,6,5,ORDE,6
FITEM,2,1001
FITEM,2,-1002
FITEM,2,1008
FITEM,2,1011
FITEM,2,1015
FITEM,2,-1016
VDRAG,P51X, , , , , ,   2027
                    ! Extruding Bolster Volumes

NUMMRG,KP, , ,
! Merging Coincident KP's Lines, Areas and Volumes

KWPLAN,-1,   1021,   1020,   1003
wpoff,0,0,(1+1.5)*25.4/2
FLST,2,6,6,ORDE,2
FITEM,2,7
FITEM,2,-12
VSBW,P51X
wpoff,0,0,-(1+1.5)*25.4
FLST,2,6,6,ORDE,2
FITEM,2,1
FITEM,2,-6
VSBW,P51X
! Using WPlane to Cut Bolster Volumes for STR
Thickness.

FLST,2,3,5,ORDE,3
FITEM,2,1000
FITEM,2,1003
FITEM,2,1005
VDRAG,P51X, , , , , ,   2143
FLST,2,3,5,ORDE,3
FITEM,2,1000
FITEM,2,1003
FITEM,2,1005
VDRAG,P51X, , , , , ,   2111
FLST,2,3,5,ORDE,3
FITEM,2,1007
FITEM,2,1013
FITEM,2,1018
VDRAG,P51X, , , , , ,   2096
FLST,2,3,5,ORDE,3
FITEM,2,1007
```

```
FITEM,2,1013
FITEM,2,1018
VDRAG,P51X, , , , , ,    2070  ! Extruding STR Volumes

NUMMRG,KP, , ,
! Merging Coincident KP's Lines, Areas and Volumes

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~ Creating Weld Geometry
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

KWPLAN,-1,   1048,   1049,   1053
wpoff,0,0,8.5
FLST,2,2,6,ORDE,2
FITEM,2,3
FITEM,2,6
VSBW,P51X
KWPAVE,   1042
wpoff,0,0,-8.5
FLST,2,2,6,ORDE,2
FITEM,2,32
FITEM,2,35
VSBW,P51X
KWPLAN,-1,   1050,   1047,   1051
wpoff,0,0,8.5
FLST,2,2,6,ORDE,2
FITEM,2,2
FITEM,2,5
VSBW,P51X
KWPAVE,   1045
wpoff,0,0,-8.5
FLST,2,2,6,ORDE,2
FITEM,2,31
FITEM,2,34
VSBW,P51X
! Using CPlane to Cut STR Volumes for Weld..

KWPLAN,-1,   1074,   1096,   1073
LARC,1096,1073,1074,0.2500372547E+02,
LARC,1088,1066,1001,25.00372547,
LARC,1092,1068,1067,25.00372547,
FLST,2,4,4
FITEM,2,2179
FITEM,2,2013
FITEM,2,2014
FITEM,2,2228
AL,P51X
FLST,2,4,4
FITEM,2,2181
FITEM,2,2014
FITEM,2,2141
FITEM,2,2207
AL,P51X
FLST,2,2,6,ORDE,2
FITEM,2,1
FITEM,2,4
FLST,3,2,5,ORDE,2
FITEM,3,1007
FITEM,3,1130
VSBA,P51X,P51X  ! Cutting STR Pie Shaped Volumes

KDISTANCE,   1074,   1102
LARC,1102,1084,1074,0.5100372640E+02,
LARC,1098,1077,1001,51.0037264,
LARC,1100,1080,1067,51.0037264,
FLST,2,4,4
FITEM,2,2205
FITEM,2,2186
FITEM,2,2199
FITEM,2,2237
AL,P51X
FLST,2,4,4
FITEM,2,2165
FITEM,2,2199
FITEM,2,2204
FITEM,2,2168
AL,P51X
FLST,2,2,6,ORDE,2
FITEM,2,33
FITEM,2,36
FLST,3,2,5,ORDE,2
FITEM,3,1000
FITEM,3,1019
VSBA,P51X,P51X
        ! Cutting STR Cresent Shaped Volumes

KWPLAN,-1,   1094,   1093,   1078
wpoff,0,0,8.5
FLST,2,6,6,ORDE,2
FITEM,2,19
FITEM,2,-24
VSBW,P51X
KWPAVE,   1086
wpoff,0,0,-8.5
FLST,2,6,6,ORDE,2
FITEM,2,25
FITEM,2,-30
VSBW,P51X
! Using WPlane to Cut Bolster Volumes for Weld

LSTR,   1075,   1114
LSTR,   1073,   1115
LSTR,   1096,   1113
FLST,2,3,4
FITEM,2,2182
FITEM,2,2287
FITEM,2,2149
AL,P51X
FLST,2,3,4
FITEM,2,2286
FITEM,2,2150
FITEM,2,2178
AL,P51X
FLST,2,3,4
FITEM,2,2151
FITEM,2,2232
FITEM,2,2284
AL,P51X
FLST,2,4,4
FITEM,2,2274
FITEM,2,2149
FITEM,2,2188
FITEM,2,2150
AL,P51X
FLST,2,4,4
FITEM,2,2150
FITEM,2,2013
FITEM,2,2275
FITEM,2,2151
AL,P51X
FLST,2,5,5,ORDE,5
FITEM,2,1106
FITEM,2,-1107
FITEM,2,1109
FITEM,2,1154
FITEM,2,1226
VA,P51X
FLST,2,5,5,ORDE,5
FITEM,2,1107
FITEM,2,-1108
```

```
FITEM,2,1110
FITEM,2,1147
FITEM,2,1229
VA,P51X
LSTR,   1097,   1112
FLST,2,3,4
FITEM,2,2152
FITEM,2,2233
FITEM,2,2285
AL,P51X
FLST,2,4,4
FITEM,2,2269
FITEM,2,2152
FITEM,2,2231
FITEM,2,2151
AL,P51X
FLST,2,5,5,ORDE,5
FITEM,2,1108
FITEM,2,1111
FITEM,2,-1112
FITEM,2,1177
FITEM,2,1223
VA,P51X                          ! Top Outside Weld

LSTR,   1109,   1087
LSTR,   1106,   1084
FLST,2,3,4
FITEM,2,2206
FITEM,2,2280
FITEM,2,2153
AL,P51X
FLST,2,3,4
FITEM,2,2154
FITEM,2,2200
FITEM,2,2279
AL,P51X
FLST,2,4,4
FITEM,2,2213
FITEM,2,2258
FITEM,2,2154
FITEM,2,2153
AL,P51X
FLST,2,5,5,ORDE,4
FITEM,2,1113
FITEM,2,-1115
FITEM,2,1161
FITEM,2,1218
VA,P51X
LSTR,   1107,   1102
LSTR,   1111,   1103
FLST,2,3,4
FITEM,2,2278
FITEM,2,2236
FITEM,2,2155
AL,P51X
FLST,2,3,4
FITEM,2,2238
FITEM,2,2156
FITEM,2,2282
AL,P51X
FLST,2,4,4
FITEM,2,2155
FITEM,2,2240
FITEM,2,2156
FITEM,2,2264
AL,P51X
FLST,2,5,5,ORDE,4
FITEM,2,1116
FITEM,2,-1118
FITEM,2,1179
FITEM,2,1220
VA,P51X
FLST,2,4,4
FITEM,2,2154
FITEM,2,2155
FITEM,2,2253
FITEM,2,2186
AL,P51X
FLST,2,5,5,ORDE,5
FITEM,2,1114
FITEM,2,1116
FITEM,2,1119
FITEM,2,1188
FITEM,2,1214
VA,P51X                          ! Bottom Outside Weld

KWPLAN,-1,   1033,   1032,   1003
CSYS,4
FLST,3,6,6,ORDE,2
FITEM,3,25
FITEM,3,-30
VSYMM,Z,P51X, , , ,0,0
         ! Reflecting Weld Volumes to Inside

NUMMRG,KP, , ,
! Merging Coincident KP's Lines, Areas and Volumes


VPLOT
FINISH
FINISH
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
```

❖ *Filename: 6_3_submodel_mesh_INPUT*

```
!****************************************************************
!****************************************************************
!                    Sub-model Meshing Routine
!****************************************************************
!****************************************************************

/TITLE,Meshing Sub-model Volume with Solid
Elements
/FILNAME,sub_mesh
/PREP7

KWPAVE,   1106
wpoff,0,0,20
ALLSEL,ALL
FLST,2,6,6,ORDE,4
FITEM,2,33
FITEM,2,36
FITEM,2,51
FITEM,2,-54
VSBW,P51X            ! Cutting Bolster Volumes
                     ! To Help With Meshing

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~ Selecting Corner Piece Only
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,24,6,ORDE,22
FITEM,5,1
FITEM,5,4
FITEM,5,7
FITEM,5,12
FITEM,5,-13
FITEM,5,18
FITEM,5,-19
FITEM,5,24
FITEM,5,26
FITEM,5,30
FITEM,5,-31
FITEM,5,33
FITEM,5,-34
FITEM,5,47
FITEM,5,-50
FITEM,5,54
FITEM,5,-55
FITEM,5,60
FITEM,5,-61
FITEM,5,66
FITEM,5,68
FITEM,5,72
VSEL,S, , ,P51X
FLST,5,4,6,ORDE,4
FITEM,5,19
FITEM,5,24
FITEM,5,33
FITEM,5,54
VSEL,U, , ,P51X
ALLSEL,BELOW,VOLU

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~ Meshing Corner Piece Only
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

                     ! LSize Intersection Region
FLST,5,2,4,ORDE,2
FITEM,5,2251
FITEM,5,2273
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,5,1,  ! Weld Toe Through Thickness
CMDEL,_Y
CMDEL,_Y1
FLST,5,3,4,ORDE,3
FITEM,5,2277
FITEM,5,2279
FITEM,5,2286
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,5,0.5,          ! Weld Depth
CMDEL,_Y
CMDEL,_Y1
FLST,5,4,4,ORDE,4
FITEM,5,2005
FITEM,5,2036
FITEM,5,2055
FITEM,5,2113
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,2,1,            ! Bolster Thickness
CMDEL,_Y
CMDEL,_Y1
FLST,5,3,4,ORDE,3
FITEM,5,2039
FITEM,5,2050
FITEM,5,2110
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,8,0.5,          ! STR Thickness
CMDEL,_Y
CMDEL,_Y1
FLST,5,1,4,ORDE,1
FITEM,5,2150
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,5,0.5,          ! Weld Throat Top
CMDEL,_Y
CMDEL,_Y1
FLST,5,1,4,ORDE,1
FITEM,5,2154
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,5,2,            ! Weld Throat Bottom
CMDEL,_Y
CMDEL,_Y1
FLST,5,2,4,ORDE,2
FITEM,5,2178
FITEM,5,2200
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,3,1,            ! Weld Height
CMDEL,_Y
```

```
CMDEL,_Y1

EXTOPT,ESIZE,20,0,          ! 20 Sweep Divisions
EXTOPT,ACLEAR,1             ! Clear Source Areas

ET,2,SOLID95                ! Solid 95 Element

VSWEEP,18,1078,1074
VSWEEP,26,1107,1108
VSWEEP,60,1227,1224
VSWEEP,13,1048,1052
VSWEEP,55,1215,1216
VSWEEP,30,1114,1116
        ! Sweep Meshing Intersection Region


FLST,5,1,4,ORDE,1
FITEM,5,2190
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,5,2,         ! Pie Section Line Sizing
CMDEL,_Y
CMDEL,_Y1
FLST,5,1,4,ORDE,1
FITEM,5,2227
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,5,0.5,       ! Pie Section Line Sizing
CMDEL,_Y
CMDEL,_Y1
EXTOPT,ESIZE,5,2,           ! Sweep Divisions, Ratio
EXTOPT,ACLEAR,1
VSWEEP,31,1132,1134         ! Sweeping Pie Section

FLST,5,1,4,ORDE,1
FITEM,5,2219
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,5,2,      ! Cresent Section Line Sizing
CMDEL,_Y
CMDEL,_Y1
FLST,5,1,4,ORDE,1
FITEM,5,2246
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,5,0.5,    ! Cresent Section Line Sizing
CMDEL,_Y
CMDEL,_Y1
FLST,5,1,4,ORDE,1
FITEM,5,2215
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,10,1,     ! Cresent Section Line Sizing
CMDEL,_Y
CMDEL,_Y1
EXTOPT,ESIZE,5,2,           ! Sweep Divisions, Ratio
EXTOPT,ACLEAR,1
VSWEEP,4,1190,1189     ! Sweeping Cresent Section

FLST,5,2,4,ORDE,2
FITEM,5,2003
FITEM,5,2136
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,2,1,  ! Lsize Transition Areas
CMDEL,_Y
CMDEL,_Y1
EXTOPT,ESIZE,20,0,          ! 20 Sweep Divisions
EXTOPT,ACLEAR,1             ! Clear Source Areas
VSWEEP,47,1146,1175
VSWEEP,1,1126,1123    ! Sweeping Transition Areas

ALLSEL,ALL

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~ Meshing Bolster Corner Only
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

ALLSEL,ALL
FLST,5,14,6,ORDE,14
FITEM,5,1
FITEM,5,4
FITEM,5,13
FITEM,5,18
FITEM,5,26
FITEM,5,30
FITEM,5,-31
FITEM,5,47
FITEM,5,55
FITEM,5,60
FITEM,5,73
FITEM,5,78
FITEM,5,-79
FITEM,5,84
VSEL,S, , ,P51X
ALLSEL,BELOW,VOLU           ! Selecting Volumes

FLST,5,2,4,ORDE,2
FITEM,5,2323
FITEM,5,2350
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,2,1,      ! Outside Thickness Div's, Ratio
CMDEL,_Y
CMDEL,_Y1
FLST,5,3,4,ORDE,3
FITEM,5,2355
FITEM,5,-2356
FITEM,5,2365
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,10,3,        ! Transition Div's, Ratio
CMDEL,_Y
CMDEL,_Y1

EXTOPT,ESIZE,20,0,          ! 20 Sweep Divisions
EXTOPT,ACLEAR,1             ! Clear Source Areas

VSWEEP,84,1301,1298
VSWEEP,79,1288,1290
        ! Sweeping Bolster Transition Regions

FLST,5,3,4,ORDE,3
FITEM,5,2319
```

```
FITEM,5,2322
FITEM,5,2349
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,20,1/3,  ! LSIZE Bolster Outside Length
CMDEL,_Y
CMDEL,_Y1
FLST,5,2,4,ORDE,2
FITEM,5,2073
FITEM,5,2097
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y
LESIZE,_Y1, , ,1,1,              ! LSize on Outside Edge
CMDEL,_Y
CMDEL,_Y1

VSWEEP,73,1254,1258
VSWEEP,78,1282,1278
        ! Sweeping Bolster Outside Volumes


!------------------------------------------
!-------- Meshing Lower Straight Section Only
!------------------------------------------


ALLSEL,ALL
FLST,5,28,6,ORDE,26
FITEM,5,1
FITEM,5,4
FITEM,5,6
FITEM,5,13
FITEM,5,-14
FITEM,5,17
FITEM,5,-18
FITEM,5,25
FITEM,5,-26
FITEM,5,28
FITEM,5,30
FITEM,5,-31
FITEM,5,39
FITEM,5,-40
FITEM,5,42
FITEM,5,47
FITEM,5,55
FITEM,5,-56
FITEM,5,59
FITEM,5,-60
FITEM,5,73
FITEM,5,-74
FITEM,5,77
FITEM,5,-80
FITEM,5,83
FITEM,5,-84
VSEL,S, , ,P51X
ALLSEL,BELOW,VOLU          ! Selecting Volumes

EXTOPT,ESIZE,30,3,
EXTOPT,ACLEAR,1            ! Sweep Options

VSWEEP,59,1227,1228
VSWEEP,56,1215,1217
VSWEEP,25,1107,1106
VSWEEP,28,1114,1113
VSWEEP,40,1157,1158
VSWEEP,39,1146,1151
VSWEEP,17,1078,1079
VSWEEP,14,1048,1065
VSWEEP,6,1126,1129
VSWEEP,42,1166,1167
VSWEEP,83,1301,1300
VSWEEP,80,1288,1293
VSWEEP,74,1254,1267
VSWEEP,77,1282,1281        ! Sweeping Commands

!------------------------------------------
!-------- Meshing Upper Straight Section Only
!------------------------------------------

ALLSEL,ALL
FLST,5,28,6,ORDE,27
FITEM,5,1
FITEM,5,4
FITEM,5,-5
FITEM,5,13
FITEM,5,15
FITEM,5,-16
FITEM,5,18
FITEM,5,26
FITEM,5,-27
FITEM,5,29
FITEM,5,-31
FITEM,5,43
FITEM,5,-44
FITEM,5,46
FITEM,5,-47
FITEM,5,55
FITEM,5,57
FITEM,5,-58
FITEM,5,60
FITEM,5,73
FITEM,5,75
FITEM,5,-76
FITEM,5,78
FITEM,5,-79
FITEM,5,81
FITEM,5,-82
FITEM,5,84
VSEL,S, , ,P51X
ALLSEL,BELOW,VOLU          ! Selecting Volumes

VSWEEP,46,1186,1184
VSWEEP,5,1123,1125
VSWEEP,15,1052,1070
VSWEEP,16,1074,1075
VSWEEP,44,1175,1176
VSWEEP,43,1171,1172
VSWEEP,29,1116,1117
VSWEEP,57,1216,1221
VSWEEP,58,1224,1225
VSWEEP,27,1108,1111
VSWEEP,81,1290,1295
VSWEEP,82,1298,1297
VSWEEP,75,1258,1274
VSWEEP,76,1278,1277        ! Sweeping Commands


!------------------------------------------
!----------- Reflecting Mesh to Other Side
!------------------------------------------


ALLSEL,ALL
FLST,2,36,6,ORDE,17
FITEM,2,2
FITEM,2,-3
FITEM,2,7
FITEM,2,-12
```

```
FITEM,2,19
FITEM,2,-24
FITEM,2,32
FITEM,2,34
FITEM,2,-35
FITEM,2,37
FITEM,2,-38
FITEM,2,41
FITEM,2,45
FITEM,2,48
FITEM,2,-50
FITEM,2,61
FITEM,2,-72
VDELE,P51X, , ,1
ADELE,   1006, , ,1
FLST,2,4,4,ORDE,4
FITEM,2,2010
FITEM,2,-2011
FITEM,2,2147
FITEM,2,-2148
LDELE,P51X, , ,1   ! Deleting OtherSide Volumes, etc.

KWPAVE,   1033
CSYS,4     ! Move CPlane and set active CS to CPlane

FLST,3,42,6,ORDE,17
FITEM,3,1
FITEM,3,4
FITEM,3,-6
FITEM,3,13
FITEM,3,-18
FITEM,3,25
FITEM,3,-31
FITEM,3,39
FITEM,3,-40
FITEM,3,42
FITEM,3,-44
FITEM,3,46
FITEM,3,-47
FITEM,3,55
FITEM,3,-60
FITEM,3,73
FITEM,3,-84
VSYMM,Z,P51X, , , ,0,0   ! Reflect Volumes and Mesh

NSEL,S,LOC,Z,-1,1     ! Selcting Center Nodes
NUMMRG,NODE, , ,    ! Merging Co-incident Nodes
NUMMRG,KP, , ,
          ! Merging Co-incident KP's, Lines, Areas
ALLSEL,ALL
NUMMRG,KP, , ,
          ! Merging Co-incident KP's, Lines, Areas
NUMCMP,ELEM    ! Compressing Element Numbers
NUMCMP,NODE    ! Compressing Node Numbers

WPSTYLE,,,,,,,,0    ! Turn Off CPlane Display

! Change Active Co-ordinate System to Global Co-
ordinate System
CSYS,0

FINISH
FINISH

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
```

❖ *Filename: 6_4_submodel_tran_INPUT*

```
!*******************************************************************
!*******************************************************************
!          Boundary Condition Transfer Routine
!*******************************************************************
!*******************************************************************

/TITLE,Performing Cut Boundary Interpolation
/FILNAME,sub_modl
/PREP7

NUMOFF,NODE,200000,
        ! Offset Node Number by 200000

!-------------------------------------------------------
!------------ Selecting Cut Boundary Nodes
!-------------------------------------------------------

FLST,5,44,5,ORDE,44
FITEM,5,1044
FITEM,5,-1045
FITEM,5,1049
FITEM,5,-1050
FITEM,5,1053
FITEM,5,1056
FITEM,5,-1057
FITEM,5,1061
FITEM,5,1063
FITEM,5,1065
FITEM,5,1070
FITEM,5,1075
FITEM,5,1079
FITEM,5,1083
FITEM,5,1217
FITEM,5,1221
FITEM,5,1225
FITEM,5,1228
FITEM,5,1230
FITEM,5,1233
FITEM,5,1236
FITEM,5,1239
FITEM,5,1246
FITEM,5,1250
FITEM,5,-1251
FITEM,5,1256
FITEM,5,1260
FITEM,5,1264
FITEM,5,1267
FITEM,5,1269
FITEM,5,1273
FITEM,5,-1274
FITEM,5,1277
FITEM,5,1281
FITEM,5,1293
FITEM,5,1295
FITEM,5,1297
FITEM,5,1300
FITEM,5,1306
FITEM,5,1308
FITEM,5,1315
FITEM,5,1317
FITEM,5,1320
FITEM,5,1324
ASEL,S, , ,P51X
FLST,5,16,5,ORDE,16
FITEM,5,1044
FITEM,5,1050
FITEM,5,1056
FITEM,5,1065
FITEM,5,1070
FITEM,5,1075
FITEM,5,1079
FITEM,5,1083
FITEM,5,1217
FITEM,5,1221
FITEM,5,1225
FITEM,5,1228
FITEM,5,1230
FITEM,5,1233
FITEM,5,1236
FITEM,5,1239
ASEL,U, , ,P51X
            ! Selecting Bolster Cut Boundary Areas
NSLA,S,1     ! Selecting Nodes Attached to Areas
NWRITE,sub_bol,NODE,,0     ! Writing sub_bol.node

ALLSEL,ALL
FLST,5,10,5,ORDE,10
FITEM,5,1019
FITEM,5,1039
FITEM,5,1128
FITEM,5,1144
FITEM,5,1149
FITEM,5,1153
FITEM,5,1155
FITEM,5,1165
FITEM,5,1187
FITEM,5,1199
ASEL,S, , ,P51X   ! Selecting Stringer Top and Bottom
            ! Cut Boundary Areas
NSLA,S,1   ! Selecting Nodes Attached to Areas
NWRITE,sub_str1,NODE,,0   ! Writing sub_str1.node

ALLSEL,ALL
FLST,5,24,5,ORDE,24
FITEM,5,1027
FITEM,5,1034
FITEM,5,1044
FITEM,5,1050
FITEM,5,1056
FITEM,5,1065
FITEM,5,1070
FITEM,5,1075
FITEM,5,1079
FITEM,5,1083
FITEM,5,1125
FITEM,5,1129
FITEM,5,1142
FITEM,5,1151
FITEM,5,1158
FITEM,5,1164
FITEM,5,1167
FITEM,5,1169
FITEM,5,1172
FITEM,5,1176
FITEM,5,1184
FITEM,5,1192
FITEM,5,-1193
FITEM,5,1197
ASEL,S, , ,P51X     ! Selecting Stringer Edges
            ! Cut Boundary Areas
NSLA,S,1        ! Selecting Nodes Attached to Areas
NWRITE,sub_str2,NODE,,0   ! Writing sub_str2.node

ALLSEL,ALL
```

```
FINISH

!---------------------------------------------
!-------- Performing Cut Boundary Interpolation
!---------------------------------------------

RESUME,May_31_Rubber.db    ! Shell Element File

FLST,5,54,5,ORDE,30
FITEM,5,11
FITEM,5,18
FITEM,5,-21
FITEM,5,23
FITEM,5,-24
FITEM,5,26
FITEM,5,-27
FITEM,5,33
FITEM,5,36
FITEM,5,53
FITEM,5,71
FITEM,5,117
FITEM,5,-125
FITEM,5,129
FITEM,5,131
FITEM,5,-133
FITEM,5,137
FITEM,5,-138
FITEM,5,143
FITEM,5,151
FITEM,5,-153
FITEM,5,155
FITEM,5,253
FITEM,5,-254
FITEM,5,544
FITEM,5,-549
FITEM,5,679
FITEM,5,-689
FITEM,5,693
FITEM,5,1032
ASEL,S, , ,P51X
FLST,5,7,5,ORDE,5
FITEM,5,33
FITEM,5,129
FITEM,5,682
FITEM,5,-685
FITEM,5,1032
ASEL,U, , ,P51X
ASEL,U, , ,    143
ALLSEL,BELOW,AREA
    ! Selecting Required Areas and Elements Only

/POST1
INRES,
FILE,May_31_Rubber,rst,     ! Read in Results
SET,FIRST

/TITLE,Performing Cut Boundary Interpolation

FLST,5,6,5,ORDE,4          ! Interpolation on Bolster
FITEM,5,19
FITEM,5,117
FITEM,5,119
FITEM,5,-122
ASEL,R, , ,P51X
ALLSEL,BELOW,AREA
        ! Selecting Bolster Elements Only
CBDOF,sub_bol,NODE,,sub_bol,CBDO,,0, ,1

ALLSEL,ALL
FLST,5,54,5,ORDE,30
FITEM,5,11
FITEM,5,18
FITEM,5,-21
FITEM,5,23
FITEM,5,-24
FITEM,5,26
FITEM,5,-27
FITEM,5,33
FITEM,5,36
FITEM,5,53
FITEM,5,71
FITEM,5,117
FITEM,5,-125
FITEM,5,129
FITEM,5,131
FITEM,5,-133
FITEM,5,137
FITEM,5,-138
FITEM,5,143
FITEM,5,151
FITEM,5,-153
FITEM,5,155
FITEM,5,253
FITEM,5,-254
FITEM,5,544
FITEM,5,-549
FITEM,5,679
FITEM,5,-689
FITEM,5,693
FITEM,5,1032
ASEL,S, , ,P51X
FLST,5,7,5,ORDE,5
FITEM,5,33
FITEM,5,129
FITEM,5,682
FITEM,5,-685
FITEM,5,1032
ASEL,U, , ,P51X
ASEL,U, , ,    143
ALLSEL,BELOW,AREA
! Selecting Required Areas and Elements Only

FLST,5,3,5,ORDE,3          ! Interpolation on Stringer
FITEM,5,681
FITEM,5,686
FITEM,5,688
ASEL,R, , ,P51X
ALLSEL,BELOW,AREA
        ! Selecting STR Elements Only
!CBDOF,sub_str1,NODE,,sub_str1,CBDO,,0, ,1
!CBDOF,sub_str2,NODE,,sub_str2,CBDO,,0, ,1


CSYS,0            ! Ensuring Active CS of Global CS

CBDOF, , ,, , ,,0, ,1       ! Interpolation Command
FINISH

RESUME,sub_mesh.db

/PREP7            ! Read in Cut Boundary Contraints
/INPUT,sub_modl,cbdo,,1,0
/INPUT,sub_modl,cbdo,,:CB1,0
FINISH
```

❖ *Filename: 7_1_frame_Main_INPUT*

```
!*************************************************************
!*************************************************************
!       FEA of 930E Frame Displacements
!*************************************************************
!*************************************************************

!------------------------------------------------------------
!--------------- Geometry Creation
!------------------------------------------------------------

FINISH
FINISH
/CLEAR,START
/FILNAME,frm_geom
/INPUT,7_2_frame_geom_INPUT,,,,0
                    ! Creating Frame Solid Gemetry
/INPUT,7_3_frame_mesh_INPUT,,,,0
                    ! Meshing Geometry
SAVE                ! Saving frm_geom.db
/EOF

!------------------------------------------------------------
!----------------- FEA Loads and Solve
!------------------------------------------------------------

:FEA
FINISH
FINISH
/CLEAR
RESUME,frm_geom.db
/FILNAME,frm_FEA

        ! Strut pressures
*SET,RRpres,139.5                   ! kg/cm^2
*SET,LRpres,92.4                    ! kg/cm^2
*SET,RFpres,40.9                    ! kg/cm^2
*SET,LFpres,60.9                    ! kg/cm^2
/INPUT,7_4_frame_loads_INPUT,,,,0   ! Applying BC's

/SOLU
/TITLE,Load Set 1:
LSWRITE,1,
FINISH

/SOLU
!SOLVE
LSSOLVE,1,1,1,    ! Solve Load Steps 1 thru 1, incr 1
FINISH
SAVE                        ! Saving frm_FEA.db

/DELETE,frm_FEA,emat,
/DELETE,frm_FEA,esav,
/DELETE,frm_FEA,mntr,
/DELETE,frm_FEA,stat,
/DELETE,frm_FEA,tri,                ! Cleanup
/DELETE,frm_FEA,log,
/DELETE,frm_FEA,err,
/DELETE,frm_FEA,s01,
/DELETE,frm_FEA,s02,
/DELETE,frm_FEA,s03,
/DELETE,frm_FEA,s04,

/EOF

!------------------------------------------------------------
!------------------ Post Processing
!------------------------------------------------------------

:post

/INPUT,7_5_frame_post_INPUT,,/home/dw11589/930E
_Full/,,0              ! Post Processing

!------------------------------------------------------------
!------------------------------------------------------------
!------------------------------------------------------------
```

❖ ***Filename: 7_2_frame_geom_INPUT***

```
!****************************************************************
!****************************************************************
!        930E Frame Geometry Creation Routine
!****************************************************************
!****************************************************************

/TITLE,930E Frame Geometry

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~ Setup
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

/NOPR
KEYW,PR_SET,1
KEYW,PR_STRUC,1
/GO

/PREP7

ET,1,SHELL93         ! Defining Shell Element Type
KEYOPT,1,4,0
KEYOPT,1,5,0
KEYOPT,1,6,0

                     ! Defining Real Constants
!R,3,3, , , , , ,                ! 1/8" Exhaust Plenum
!R,5,5, , , , , ,                ! 5mm Thickness
!R,8,8, , , , , ,                ! 8mm Thickness
!R,9,9, , , , , ,                ! 9mm Thickness


                     ! Material Properties
        ! 690 MPa Tensile Strength
        ! 620 Mpa Yield Strength
        ! Elognation in 50mm - 18%
        ! Modulus is Unknown
UIMP,1,EX, , ,207000,           ! Modulus in N/mm^2
UIMP,1,DENS, , ,0.00000786,   ! Density in kg/mm^3
UIMP,1,ALPX, , , ,
UIMP,1,REFT, , , ,
UIMP,1,NUXY, , , ,
UIMP,1,PRXY, , ,.3,
UIMP,1,GXY, , , ,
UIMP,1,MU, , , ,
UIMP,1,DAMP, , , ,


!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~ Torsion Tubes and Rear Section
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

K, ,0,-280.5-640,-3490-240,
        ! KP at Center of Rear Torsion Tube

wprot,0,0,90
KWPAVE,    1
PCIRC,300, ,0,360,              ! Rear T-Tube Circle
ADELE,    1
WPCSYS,-1
FLST,3,4,4,ORDE,2
FITEM,3,1
FITEM,3,-4
LGEN,2,P51X, , ,191, , , ,0
WPSTYLE,,,,,,,,0
FLST,3,2,3,ORDE,2
FITEM,3,7
FITEM,3,9
KGEN,2,P51X, , ,457, , , ,0
LSTR,    3,    7
LSTR,    6,    2
LSTR,    9,    5
LSTR,    4,    8
LSTR,    7,    10
LSTR,    9,    11              ! Lines to Main Rail

WPSTYLE,,,,,,,,1
wprot,0,0,90
KWPAVE,    1
CSYS,4
K, ,3240,-47,0,
KWPAVE,    12
PCIRC,535.5/2, ,0,360,          ! Center T-Tube Circle
ADELE,    1


FLST,3,2,3,ORDE,2
FITEM,3,14
FITEM,3,16
KGEN,2,P51X, , , ,813-104.3281654, ,0
LSTR,    17,    14
LSTR,    18,    16             ! Lines to Main Rail

CSYS,0
FLST,3,1,3,ORDE,1
FITEM,3,17
KGEN,2,P51X, , ,460-(535.5/2), , ,0
FLST,3,1,3,ORDE,1
FITEM,3,10
KGEN,2,P51X, , ,113, , ,0
LSTR,    20,    19
KWPLAN,-1,    20,    19,    10
CSYS,4                ! Active CS is in Plane of Main Rail

wpoff,-240,-227,0
PCIRC,152/2, ,0,360,
CSYS,4
FLST,3,4,4,ORDE,2
FITEM,3,22
FITEM,3,-25
LGEN,2,P51X, , ,-273,930+25, , ,0
PCIRC,152/2+60, ,0,360,
FLST,3,4,4,ORDE,2
FITEM,3,30
FITEM,3,-33
LGEN,2,P51X, , ,-273,930+25, , ,0
FLST,2,2,5,ORDE,2
FITEM,2,1
FITEM,2,-2
ADELE,P51X          ! Pivot and Rear Strut Pin Holes


LDELE,    21
KDELE,    20          ! Deleting Construction Line

CSYS,4
K, ,15*30,227,0,
K, ,735,227,0,
K, ,735,227+864,0,
LSTR,    20,    37
LSTR,    37,    38
LSTR,    38,    34
LSTR,    20,    29
LSTR,    31,    35             ! Rear Frame Lines
```

```
FLST,2,5,4,ORDE,5
FITEM,2,30
FITEM,2,-31
FITEM,2,34
FITEM,2,36
FITEM,2,-37
LDELE,P51X, , ,1        ! Deleting Un-needed Lines
FLST,2,2,4,ORDE,2
FITEM,2,13
FITEM,2,-14
LDELE,P51X, , ,1

FLST,2,4,4
FITEM,2,12
FITEM,2,9
FITEM,2,2
FITEM,2,6
AL,P51X
FLST,2,4,4
FITEM,2,3
FITEM,2,12
FITEM,2,7
FITEM,2,11
AL,P51X
FLST,2,4,4
FITEM,2,8
FITEM,2,4
FITEM,2,11
FITEM,2,10
AL,P51X
FLST,2,4,4
FITEM,2,5
FITEM,2,1
FITEM,2,9
FITEM,2,10
AL,P51X                 ! Middle Rear T-Tube Areas

CSYS,0                  ! Active CS to Global CS

KGEN,2,7, , ,2000, , , ,0
LSTR,     7,     10
FLST,2,4,4,ORDE,2
FITEM,2,5
FITEM,2,-8
ADRAG,P51X, , , , , ,     13  ! Rear T-Tube B4 Cutting

FLST,2,8,4
FITEM,2,39
FITEM,2,38
FITEM,2,21
FITEM,2,40
FITEM,2,33
FITEM,2,32
FITEM,2,41
FITEM,2,35
AL,P51X                          ! Rear Frame Area

FLST,2,4,5,ORDE,2
FITEM,2,5
FITEM,2,-8
FLST,3,1,5,ORDE,1
FITEM,3,9
ASBA,P51X,P51X, , ,KEEP
FLST,2,4,5,ORDE,2
FITEM,2,14
FITEM,2,-17
ADELE,P51X, , ,1
LDELE,     13, , ,1
          ! Trimming Rear T-Tube with Rail Side

FLST,2,4,4
FITEM,2,23
FITEM,2,22
FITEM,2,25
FITEM,2,24
AL,P51X
FLST,2,4,4
FITEM,2,29
FITEM,2,28
FITEM,2,27
FITEM,2,26
AL,P51X
FLST,2,4,4
FITEM,2,50
FITEM,2,51
FITEM,2,46
FITEM,2,48
AL,P51X
FLST,3,3,5,ORDE,2
FITEM,3,5
FITEM,3,-7
ASBA,      9,P51X       ! Subtracting Pin Hole Areas

FLST,2,2,4,ORDE,2
FITEM,2,19
FITEM,2,-20
LDELE,P51X, , ,1
FLST,3,1,3,ORDE,1
FITEM,3,14
KGEN,2,P51X, , ,2000, , , ,0
LSTR,     14,     10
FLST,2,4,4,ORDE,2
FITEM,2,15
FITEM,2,-18
ADRAG,P51X, , , , , ,      13
FLST,2,4,5,ORDE,3
FITEM,2,5
FITEM,2,-7
FITEM,2,9
ASBW,P51X
FLST,2,4,5,ORDE,3
FITEM,2,14
FITEM,2,19
FITEM,2,-21
ADELE,P51X, , ,1
LDELE,     13, , ,1        ! Completing Center T-Tube


!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~ Main Rail Side Areas
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

CSYS,4
FLST,3,1,3,ORDE,1
FITEM,3,38
KGEN,2,P51X, , ,1636-735, , , ,0
FLST,3,1,3,ORDE,1
FITEM,3,10
KGEN,2,P51X, , ,1560,540, , ,0
LSTR,     38,     10
LSTR,     10,     11
FLST,3,1,3,ORDE,1
FITEM,3,37
KGEN,2,P51X, , ,2310,0, , ,0
LSTR,     11,     17
LSTR,     17,     37
FLST,2,5,4
FITEM,2,38
FITEM,2,20
FITEM,2,13
```

```
FITEM,2,14
FITEM,2,19
AL,P51X                          ! Rear Side Plate Area

FLST,3,1,3,ORDE,1
FITEM,3,11
KGEN,2,P51X, , ,540, , , ,0
FLST,3,1,3,ORDE,1
FITEM,3,17
KGEN,2,P51X, , ,840, , , ,0
LSTR,    17,    30
LSTR,    30,    18
LARC,11,18,36,1045,
FLST,2,4,4
FITEM,2,58
FITEM,2,59
FITEM,2,56
FITEM,2,52
AL,P51X
FLST,2,4,4
FITEM,2,19
FITEM,2,30
FITEM,2,31
FITEM,2,34
AL,P51X
ASBA,    7,    6                 ! Center Side Area

FLST,3,1,3,ORDE,1
FITEM,3,38
KGEN,2,P51X, , ,5280-735, , , ,0
FLST,3,1,3,ORDE,1
FITEM,3,45
KGEN,2,P51X, , ,27*30, , , ,0
FLST,3,1,3,ORDE,1
FITEM,3,37
KGEN,2,P51X, , ,(219*30)-735, , , ,0
LSTR,    18,    45
LSTR,    45,    46
LSTR,    46,    47
LSTR,    47,    30
FLST,2,5,4
FITEM,2,31
FITEM,2,36
FITEM,2,37
FITEM,2,42
FITEM,2,43
AL,P51X                          ! Forward Side Area

FLST,3,1,3,ORDE,1
FITEM,3,37
KGEN,2,P51X, , ,5280+1650-735, , , ,0
FLST,3,2,3,ORDE,2
FITEM,3,37
FITEM,3,-38
KGEN,2,P51X, , ,(263*30)-735, , , ,0
LSTR,    46,    50
LSTR,    50,    49
LSTR,    49,    48
LSTR,    48,    47
FLST,2,5,4
FITEM,2,42
FITEM,2,63
FITEM,2,62
FITEM,2,61
FITEM,2,60
AL,P51X                ! Side Area Near Horse Collar

WPCSYS,-1,0
DSYS,0
CSYS,0
KWPAVE,    49
wpoff,0,-1065,-2175
wprot,0,0,90
PCIRC,438/2, ,0,360,
ADELE,     14                    ! Front Tube Circle

CSYS,4
FLST,3,1,3,ORDE,1
FITEM,3,49
KGEN,2,P51X, , ,2175+1670,-585, , ,0
KWPAVE,    55
wprot,9,0,0
CSYS,4
CSYS,4
FLST,3,1,3,ORDE,1
FITEM,3,55
KGEN,2,P51X, , ,0,-305, , ,0
FLST,3,2,3,ORDE,2
FITEM,3,55
FITEM,3,-56
KGEN,2,P51X, , ,-203,0, , ,0
LSTR,     58,    56
LSTR,     56,    55
LSTR,     55,    57
LSTR,     57,    58              ! Bumper Square

LSTR,     49,    52
LSTR,     52,    57
LSTR,     58,    54
LSTR,     54,    50
FLST,2,2,4,ORDE,2
FITEM,2,66
FITEM,2,-67
FLST,3,2,4,ORDE,2
FITEM,3,74
FITEM,3,-75
LSBL,P51X,P51X, , ,DELETE
LSTR,     50,    60
LSTR,     58,    59
FLST,2,5,4
FITEM,2,66
FITEM,2,77
FITEM,2,65
FITEM,2,72
FITEM,2,61
AL,P51X
FLST,2,5,4
FITEM,2,76
FITEM,2,64
FITEM,2,73
FITEM,2,71
FITEM,2,67
AL,P51X              ! Front Portion of Main Rails

CSYS,0
KDISTANCE,     57,     16
FLST,3,1,3,ORDE,1
FITEM,3,55
KGEN,2,P51X, , ,-2000, , , ,0
LSTR,     61,     55
FLST,2,4,4,ORDE,2
FITEM,2,68
FITEM,2,-71
ADRAG,P51X, , , , , ,     74
FLST,3,1,3,ORDE,1
FITEM,3,52
KGEN,2,P51X, , ,-2000, , , ,0
LSTR,     52,     66
FLST,2,6,4,ORDE,4
FITEM,2,64
```

```
FITEM,2,-65
FITEM,2,76
FITEM,2,-79
ADRAG,P51X, , , , , ,    87
KWPLAN,-1,    16,    15,    14
FLST,2,10,5,ORDE,2
FITEM,2,20
FITEM,2,-29
ASBW,P51X
FLST,2,10,5,ORDE,3
FITEM,2,36
FITEM,2,41
FITEM,2,-49
ADELE,P51X, , ,1
CSYS,0
WPCSYS,-1,0
DSYS,0    ! Center Portion of Bumper and Front Tube

FLST,2,2,4,ORDE,2
FITEM,2,74
FITEM,2,87
LDELE,P51X, , ,1   ! Deleteing Construction Line



!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~ Extruding Main Rails
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,3,2,3,ORDE,2
FITEM,3,58
FITEM,3,-59
KGEN,2,P51X, , ,190.5, , , ,0
LSTR,    62,    59
LSTR,    61,    58
FLST,2,6,4,ORDE,4
FITEM,2,64
FITEM,2,-65
FITEM,2,76
FITEM,2,-79
ADRAG,P51X, , , , , ,    74
FLST,2,3,4,ORDE,3
FITEM,2,67
FITEM,2,71
FITEM,2,73
ADRAG,P51X, , , , , ,    75
FLST,2,3,4,ORDE,2
FITEM,2,68
FITEM,2,-70
ADRAG,P51X, , , , , ,    75        ! Front Main Rail

FLST,3,1,3,ORDE,1
FITEM,3,49
KGEN,2,P51X, , ,305, , , ,0
LSTR,    87,    49
FLST,2,5,4,ORDE,3
FITEM,2,42
FITEM,2,60
FITEM,2,-63
ADRAG,P51X, , , , , ,    126
FLST,2,5,4,ORDE,5
FITEM,2,31
FITEM,2,36
FITEM,2,-37
FITEM,2,42
FITEM,2,-43
ADRAG,P51X, , , , , ,    128
FLST,2,4,4,ORDE,4
FITEM,2,19
FITEM,2,30
FITEM,2,-31
FITEM,2,34
ADRAG,P51X, , , , , ,    139
FLST,2,5,4,ORDE,5
FITEM,2,13
FITEM,2,-14
FITEM,2,19
FITEM,2,-20
FITEM,2,38
ADRAG,P51X, , , , , ,    148
FLST,2,8,4,ORDE,6
FITEM,2,21
FITEM,2,32
FITEM,2,-33
FITEM,2,35
FITEM,2,38
FITEM,2,-41
ADRAG,P51X, , , , , ,    156   ! Main Rail Outer Areas

FLST,3,1,3,ORDE,1
FITEM,3,44
KGEN,2,P51X, , ,305, , , ,0
LSTR,    115,    44
FLST,2,4,4,ORDE,4
FITEM,2,52
FITEM,2,56
FITEM,2,58
FITEM,2,-59
ADRAG,P51X, , , , , ,    181   ! Extrude Center T-Tube

FLST,3,3,3,ORDE,3
FITEM,3,22
FITEM,3,25
FITEM,3,41
KGEN,2,P51X, , ,305, , , ,0
LSTR,    121,    25
LSTR,    122,    41
LSTR,    120,    22
FLST,2,4,4,ORDE,2
FITEM,2,26
FITEM,2,-29
ADRAG,P51X, , , , , ,    190
FLST,2,4,4,ORDE,4
FITEM,2,46
FITEM,2,48
FITEM,2,50
FITEM,2,-51
ADRAG,P51X, , , , , ,    191
FLST,2,4,4,ORDE,2
FITEM,2,22
FITEM,2,-25
ADRAG,P51X, , , , , ,    192
                     ! Extrude Rear Hole Areas

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~ Closing Main Rails
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~


FLST,2,4,4
FITEM,2,209
FITEM,2,216
FITEM,2,214
FITEM,2,212
AL,P51X
FLST,2,4,4
FITEM,2,200
FITEM,2,198
FITEM,2,196
FITEM,2,193
AL,P51X
```

```
FLST,2,4,4
FITEM,2,204
FITEM,2,201
FITEM,2,208
FITEM,2,206
AL,P51X            ! Areas to Subtract from Side

NUMMRG,KP          ! Merge KP's, Lines and Areas

FLST,2,8,4
FITEM,2,165
FITEM,2,180
FITEM,2,178
FITEM,2,176
FITEM,2,174
FITEM,2,172
FITEM,2,170
FITEM,2,164
AL,P51X
FLST,3,3,5,ORDE,2
FITEM,3,85
FITEM,3,-87
ASBA,    50,P51X
FLST,2,5,4
FITEM,2,164
FITEM,2,155
FITEM,2,158
FITEM,2,147
FITEM,2,162
AL,P51X
FLST,2,4,4
FITEM,2,187
FITEM,2,189
FITEM,2,182
FITEM,2,185
AL,P51X
FLST,2,4,4
FITEM,2,147
FITEM,2,154
FITEM,2,137
FITEM,2,150
AL,P51X
FLST,2,1,5,ORDE,1
FITEM,2,62
FLST,3,1,5,ORDE,1
FITEM,3,58
ASBA,P51X,P51X, , ,KEEP
FLST,2,5,4
FITEM,2,137
FITEM,2,140
FITEM,2,142
FITEM,2,127
FITEM,2,146
AL,P51X
FLST,2,5,4
FITEM,2,136
FITEM,2,127
FITEM,2,130
FITEM,2,132
FITEM,2,134
AL,P51X            ! Closing Span of Main Rail

FLST,2,4,4
FITEM,2,122
FITEM,2,124
FITEM,2,95
FITEM,2,99
AL,P51X
FLST,2,5,4
FITEM,2,92
FITEM,2,95
FITEM,2,97
FITEM,2,80
FITEM,2,91
AL,P51X
FLST,2,6,4
FITEM,2,91
FITEM,2,80
FITEM,2,83
FITEM,2,85
FITEM,2,87
FITEM,2,89
AL,P51X                        ! Closing Front Section

LSTR,    87,    64
LSTR,    92,    66
FLST,2,4,4
FITEM,2,72
FITEM,2,90
FITEM,2,82
FITEM,2,126
AL,P51X
FLST,2,4,4
FITEM,2,93
FITEM,2,66
FITEM,2,135
FITEM,2,86
AL,P51X
FLST,2,2,5,ORDE,2
FITEM,2,21
FITEM,2,-22
ADELE,P51X
LDELE,    84, , ,1
ADELE,    89
FLST,2,2,4,ORDE,2
FITEM,2,83
FITEM,2,85
LCOMB,P51X, ,0
FLST,2,4,4
FITEM,2,134
FITEM,2,90
FITEM,2,93
FITEM,2,83
AL,P51X
FLST,2,5,4
FITEM,2,83
FITEM,2,87
FITEM,2,89
FITEM,2,91
FITEM,2,80
AL,P51X            ! Creating Transition Region

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~ Horse Collar Frontal Area
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

CSYS,0
DSYS,0
WPCSYS,-1,0
KWPAVE,    90
wprot,0,9,0
wpoff,0,0,-355
FLST,2,4,5,ORDE,4
FITEM,2,7
FITEM,2,44
FITEM,2,46
FITEM,2,86
ASBW,P51X          ! Cutting Main Rail w/ WPlane

KWPAVE,    65
```

```
CSYS,4

FLST,5,4,4,ORDE,4
FITEM,5,94
FITEM,5,98
FITEM,5,133
FITEM,5,151
LSEL,S, , ,P51X
ALLSEL,BELOW,LINE
FLST,5,94,5,ORDE,9
FITEM,5,1
FITEM,5,-6
FITEM,5,8
FITEM,5,-43
FITEM,5,45
FITEM,5,47
FITEM,5,-85
FITEM,5,87
FITEM,5,-98
ASEL,U, , ,P51X
        ! Selecting Lines only Near Intersection

K, ,0,404,0,
K, ,387,404,0,
K, ,387+153,404+157,0,
K, ,387+153,-893,0,
K, ,320,-1102,0,
K, ,0,-1102,0,
LSTR,    83,    72
LSTR,    83,    86
LSTR,    86,    91
LSTR,    91,    96
LSTR,    96,    97
LSTR,    72,    65
LSTR,    68,    97
FLST,2,10,4
FITEM,2,98
FITEM,2,159
FITEM,2,60
FITEM,2,62
FITEM,2,132
FITEM,2,136
FITEM,2,153
FITEM,2,160
FITEM,2,133
FITEM,2,151
AL,P51X              ! Area Surrounding Main Rail

FLST,3,1,3,ORDE,1
FITEM,3,86
KGEN,2,P51X, , ,150,162, , ,0
K, ,46.5*18,575,,
K, ,46.5*18,-589,,
LSTR,    91,   104
LSTR,   104,   101
LSTR,   101,   100
LSTR,   100,    86
FLST,2,5,4
FITEM,2,161
FITEM,2,132
FITEM,2,169
FITEM,2,168
FITEM,2,167
AL,P51X                      ! Outer Widthwise Area

wpoff,323,760,0
PCIRC,305/2, ,0,360,
KWPAVE,    65                ! Area for Circular
Cutout...
```

```
K, ,323,1102,,
LSTR,    100,    123
K, ,0,575,,
LSTR,    72,    129
K, ,-792,1824-293,,
LARC,123,132,129,1824-250,            ! Top Arcs
K, ,-792,960+157,,
LARC,129,135,65,960-190,

WPCSYS,-1,0
KWPAVE,    72
wprot,0,0,90
CSYS,0
WPAVE,0,0,0
CSYS,4
FLST,2,2,4,ORDE,2
FITEM,2,219
FITEM,2,-220
LSBW,P51X
LDELE,    224, , ,1
LDELE,    223, , ,1
WPCSYS,-1,0
LSTR,    137,    136
NUMMRG,KP
FLST,2,8,4
FITEM,2,60
FITEM,2,218
FITEM,2,222
FITEM,2,219
FITEM,2,221
FITEM,2,217
FITEM,2,169
FITEM,2,62
AL,P51X                          ! Top Collar Area

ASBA,    86,    46         ! Subtracting Circular Cutout

KWPLAN,-1,    65,    69,    72
CSYS,4                           ! Setting WPlane

K, ,-77,-1102-119,,
K, ,-77+126,-1102-119-147,,
LSTR,    97,    132
LSTR,    132,    135
LSTR,    135,    96
FLST,2,4,4
FITEM,2,153
FITEM,2,220
FITEM,2,223
FITEM,2,224
AL,P51X                          ! Lower Small Area

K, ,-792,-1350-97-293,,
K, ,-792,-1055-119-97-293,,
LARC,139,132,72,1055-200,
LARC,138,135,72,1350-200,
WPCSYS,-1,0
wprot,0,0,90
FLST,2,2,4,ORDE,2
FITEM,2,225
FITEM,2,-226
LSBW,P51X
FLST,2,2,4,ORDE,2
FITEM,2,229
FITEM,2,-230
LDELE,P51X, , ,1
LSTR,    140,    141
FLST,2,4,4
FITEM,2,227
FITEM,2,225
```

```
FITEM,2,228
FITEM,2,223
AL,P51X                         ! Lower Collar Area

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~ Extruding Horse Collar Frontal Area
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

WPSTYLE,,,,,,,,0
KWPLAN,-1,    65,    69,    72
CSYS,4

FLST,3,4,5,ORDE,4
FITEM,3,44
FITEM,3,46
FITEM,3,86
FITEM,3,99
AGEN,2,P51X, , , ,355, ,0    ! Copying Areas Over

LSTR,    145,   138
LSTR,     72,   152
LSTR,    137,   154
LSTR,    136,   155
LSTR,    143,   100
LSTR,    142,   101
LSTR,    104,   139
LSTR,     91,   138
LSTR,     96,   145
LSTR(    135,   148
LSTR,    141,   150
LSTR,    149,   140
LSTR,    132,   147
LSTR,     97,   146
LSTR,    153,   129
LSTR,    156,   123            ! Connecting Lines

FLST,2,4,4
FITEM,2,263
FITEM,2,234
FITEM,2,264
FITEM,2,220
AL,P51X
FLST,2,4,4
FITEM,2,227
FITEM,2,263
FITEM,2,237
FITEM,2,262
AL,P51X
FLST,2,4,4
FITEM,2,262
FITEM,2,225
FITEM,2,261
FITEM,2,238
AL,P51X
FLST,2,4,4
FITEM,2,261
FITEM,2,239
FITEM,2,260
FITEM,2,228
AL,P51X
FLST,2,4,4
FITEM,2,236
FITEM,2,259
FITEM,2,224
FITEM,2,260
AL,P51X
FLST,2,4,4
FITEM,2,259
FITEM,2,251
FITEM,2,258
FITEM,2,136
AL,P51X
FLST,2,4,4
FITEM,2,226
FITEM,2,161
FITEM,2,257
FITEM,2,258
AL,P51X
FLST,2,4,4
FITEM,2,229
FITEM,2,257
FITEM,2,167
FITEM,2,256
AL,P51X
FLST,2,4,4
FITEM,2,256
FITEM,2,255
FITEM,2,168
FITEM,2,230
AL,P51X
FLST,2,4,4
FITEM,2,255
FITEM,2,217
FITEM,2,245
FITEM,2,266
AL,P51X
FLST,2,4,4
FITEM,2,244
FITEM,2,221
FITEM,2,266
FITEM,2,254
AL,P51X
FLST,2,4,4
FITEM,2,253
FITEM,2,243
FITEM,2,219
FITEM,2,254
AL,P51X
FLST,2,4,4
FITEM,2,218
FITEM,2,252
FITEM,2,241
FITEM,2,265
AL,P51X
FLST,2,4,4
FITEM,2,222
FITEM,2,242
FITEM,2,265
FITEM,2,253
AL,P51X                         ! Creating Joining Areas

LSTR,    108,   159
LSTR,    105,   158
LSTR,    119,   157
LSTR,    160,   109
FLST,2,4,4
FITEM,2,188
FITEM,2,248
FITEM,2,267
FITEM,2,268
AL,P51X
FLST,2,4,4
FITEM,2,205
FITEM,2,250
FITEM,2,269
FITEM,2,270
AL,P51X
FLST,2,4,4
FITEM,2,249
FITEM,2,194
```

```
FITEM,2,270
FITEM,2,267
AL,P51X
FLST,2,4,4
FITEM,2,211
FITEM,2,247
FITEM,2,269
FITEM,2,268
AL,P51X                    ! Circular Cutout Pipe

ALLSEL,ALL                 ! Selecting Everything

KWPAVE,   149
FLST,2,5,5,ORDE,5
FITEM,2,43
FITEM,2,93
FITEM,2,-94
FITEM,2,97
FITEM,2,-98
ASBW,P51X          ! Cutting Main Rail w/ WPlane

LSTR,    152,    48
LSTR,    161,   146
FLST,2,4,4
FITEM,2,144
FITEM,2,125
FITEM,2,252
FITEM,2,159
AL,P51X
FLST,2,4,4
FITEM,2,273
FITEM,2,160
FITEM,2,264
FITEM,2,143
AL,P51X
FLST,2,10,4
FITEM,2,143
FITEM,2,276
FITEM,2,275
FITEM,2,131
FITEM,2,125
FITEM,2,240
FITEM,2,246
FITEM,2,232
FITEM,2,251
FITEM,2,233
AL,P51X                    ! Creating Areas to
                           ! Join with Main Rail

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~ Strut Attachment Areas
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

KWPLAN,-1,    104,    139,    101
CSYS,4
K, ,-305,,,
K, ,-305,17*19,,
K, ,-192.5,17*19,,
K, ,-192.5,17*19+185+266,,
FLST,3,1,3,ORDE,1
FITEM,3,101
KGEN,2,P51X, , ,-192.5, , , ,0
LSTR,    101,    167
LSTR,    167,    166
LSTR,    166,    165
LSTR,    165,    164
LSTR,    164,    163
LSTR,    163,    104
wprot,0,90,0
KWPAVE,    165
FLST,2,3,5,ORDE,3
FITEM,2,44
FITEM,2,100
FITEM,2,111
ASBW,P51X
KWPAVE,    166
FLST,2,3,5,ORDE,3
FITEM,2,130
FITEM,2,132
FITEM,2,-133
ASBW,P51X
LSTR,    167,    100
LSTR,    163,     91
FLST,2,3,4
FITEM,2,291
FITEM,2,161
FITEM,2,283
AL,P51X
LSTR,    169,    165
LSTR,    172,    166
FLST,2,5,4
FITEM,2,283
FITEM,2,285
FITEM,2,293
FITEM,2,282
FITEM,2,281
AL,P51X
FLST,2,4,4
FITEM,2,293
FITEM,2,280
FITEM,2,294
FITEM,2,295
AL,P51X
FLST,2,4,4
FITEM,2,132
FITEM,2,294
FITEM,2,279
FITEM,2,278
AL,P51X
FLST,2,3,4
FITEM,2,278
FITEM,2,168
FITEM,2,290
AL,P51X
LSTR,    174,    166
LSTR,    165,    168
FLST,2,3,4
FITEM,2,302
FITEM,2,296
FITEM,2,294
AL,P51X
FLST,2,3,4
FITEM,2,303
FITEM,2,286
FITEM,2,293
AL,P51X               ! Creating Areas one side

KWPAVE,    173
wpoff,-355/2,0,0               ! Moving WPlane

FLST,3,7,5,ORDE,5
FITEM,3,130
FITEM,3,132
FITEM,3,-133
FITEM,3,137
FITEM,3,-140
ARSYM,X,P51X, , , ,0,0         ! Reflecting Areas

NUMMRG,KP, , ,     ! Merging Coincident Items
```

```
FLST,2,2,5,ORDE,2
FITEM,2,106
FITEM,2,115
ADELE,P51X, , ,1
          ! Deleting Unneeded Areas on Centerline


LSTR,    181,    170
FLST,2,3,4
FITEM,2,305
FITEM,2,309
FITEM,2,321
AL,P51X
FLST,2,2,5,ORDE,2
FITEM,2,106
FITEM,2,147
AADD,P51X
LSTR,    164,    168
FLST,2,3,4
FITEM,2,307
FITEM,2,303
FITEM,2,281
AL,P51X
FLST,2,2,5,ORDE,2
FITEM,2,106
FITEM,2,140
AADD,P51X  ! Adding To Fillet Areas on Strut Mounts

WPSTYLE,,,,,,,,0
WPCSYS,-1,0
CSYS,0            ! Returning WPlane and Active CS
                  ! to Global Cartesian


/EOF

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
```

❖ *Filename: 7_3_frame_mesh_INPUT*

```
!*****************************************************************
!*****************************************************************
!          930E Frame FEA Meshing Routine
!*****************************************************************
!*****************************************************************

/TITLE,930E Frame FEA Mesh

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~ Defining Material Thicknesses
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

/PREP7

                        ! Defining Real Constants
R,13,12.7, , , , , ,          ! 12.7mm Thickness
R,19,19, , , , , ,            ! 19mm Thickness
R,25,25, , , , , ,            ! 25mm Thickness
R,28,28, , , , , ,            ! 28mm Thickness
R,30,30.5, , , , , ,          ! 30.5mm Thickness
R,32,32, , , , , ,            ! 32mm Thickness
R,33,33, , , , , ,            ! 33mm Thickness
R,36,36, , , , , ,            ! 36mm Thickness
R,38,38, , , , , ,            ! 38mm Thickness
R,41,41, , , , , ,            ! 41mm Thickness
R,42,42, , , , , ,            ! 42mm Thickness
R,45,45, , , , , ,            ! 45mm Thickness
R,46,46, , , , , ,            ! 46mm Thickness
R,51,51, , , , , ,            ! 51mm Thickness
R,127,127, , , , , ,          ! 127mm Thickness

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~ Rear Section
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,4,5,ORDE,2
FITEM,5,1
FITEM,5,-4
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    28,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1        ! Inner Rear Torsion-Tube

FLST,5,4,5,ORDE,2
FITEM,5,10
FITEM,5,-13
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    42,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1        ! Outer Rear Torsion Tube
FLST,5,4,5,ORDE,2
FITEM,5,77
FITEM,5,-80
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    42,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1

FLST,5,7,5,ORDE,3
FITEM,5,61
FITEM,5,63
FITEM,5,-68
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    38,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1        ! Perimeter Areas Rear Section

FLST,5,8,5,ORDE,4
FITEM,5,73
FITEM,5,-76
FITEM,5,81
FITEM,5,-84
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    38,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1        ! Pin Hole Inside Areas

FLST,5,2,5,ORDE,2
FITEM,5,8
FITEM,5,54
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    28,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1        ! Side Areas

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~ Center Span
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,8,5,ORDE,7
FITEM,5,48
FITEM,5,-49
FITEM,5,51
FITEM,5,53
FITEM,5,55
FITEM,5,-57
FITEM,5,59
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    45,  1,     0
CMSEL,S,_Y
```

```
CMDELE,_Y
CMDELE,_Y1        ! Top and Bottom Plate Thickness
FLST,5,2,5,ORDE,2
FITEM,5,43
FITEM,5,125
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    45,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1

FLST,5,4,5,ORDE,4
FITEM,5,5
FITEM,5,-6
FITEM,5,50
FITEM,5,62
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    25,  1,     0
CMSEL,S,_Y
CMDELE,_Y1        ! Side Plate Thickness

FLST,5,3,5,ORDE,3
FITEM,5,9
FITEM,5,58
FITEM,5,85
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    32,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1        ! Casting Side Thickness

FLST,5,8,5,ORDE,4
FITEM,5,15
FITEM,5,-18
FITEM,5,69
FITEM,5,-72
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    30,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1        ! Center Torsion Tube

FLST,5,2,5,ORDE,2
FITEM,5,122
FITEM,5,124
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    33,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1        ! Casting Near Horse Collar
```

```
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~ Horse Collar
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,4,5,ORDE,4
FITEM,5,86
FITEM,5,102
FITEM,5,105
FITEM,5,107
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    33,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                  ! Lower Section

FLST,5,4,5,ORDE,4
FITEM,5,46
FITEM,5,101
FITEM,5,104
FITEM,5,108
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    41,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                  ! Lower transition Region

FLST,5,4,5,ORDE,4
FITEM,5,7
FITEM,5,97
FITEM,5,-98
FITEM,5,109
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    46,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                  ! Areas Around Main Rail
CM,_Y,AREA
ASEL, , , ,    93
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    46,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1

FLST,5,4,5,ORDE,4
FITEM,5,113
FITEM,5,-114
FITEM,5,116
FITEM,5,-117
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    25,  1,     0
```

```
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1          ! Top Collar Top and Bottom Plates

FLST,5,4,5,ORDE,2
FITEM,5,118
FITEM,5,-121
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    19,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                    ! Circular Cutout Pipe

FLST,5,2,5,ORDE,2
FITEM,5,99
FITEM,5,103
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    33,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                    ! Top Collar Side Plates

FLST,5,13,5,ORDE,10
FITEM,5,44
FITEM,5,100
FITEM,5,110
FITEM,5,-112
FITEM,5,128
FITEM,5,-129
FITEM,5,131
FITEM,5,133
FITEM,5,-136
FITEM,5,143
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    30,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                    ! Areas Near Strut Mount

FLST,5,8,5,ORDE,7
FITEM,5,115
FITEM,5,130
FITEM,5,138
FITEM,5,-139
FITEM,5,141
FITEM,5,145
FITEM,5,-147
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    36,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                    ! Strut Support Fillets

FLST,5,5,5,ORDE,5
FITEM,5,44
FITEM,5,131
FITEM,5,133
FITEM,5,-134
FITEM,5,143
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    38,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1          ! Strut Mount Aoutside Face Areas

FLST,5,2,5,ORDE,2
FITEM,5,137
FITEM,5,144
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    51,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                         ! Top Strut Mount Areas

FLST,5,2,5,ORDE,2
FITEM,5,132
FITEM,5,142
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,   127,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1          ! Bottom Strut Mount Areas

!-----------------------------------------
!-------------------- Front Section
!-----------------------------------------

FLST,5,4,5,ORDE,4
FITEM,5,92
FITEM,5,94
FITEM,5,96
FITEM,5,126
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    45,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1          ! Top and Botton of Main Rail

FLST,5,2,5,ORDE,2
FITEM,5,123
FITEM,5,127
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    33,  1,     0
CMSEL,S,_Y
```

```
CMDELE,_Y
CMDELE,_Y1                    ! Sides of Main Rail
FLST,5,2,5,ORDE,2
FITEM,5,89
FITEM,5,95
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    33,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1

FLST,5,4,5,ORDE,3
FITEM,5,90
FITEM,5,-92
FITEM,5,96
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    25,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1      ! Top and Botton of Tapered Section

R,13,12.7, , , , , , ! 12.7mm Thickness
FLST,5,2,5,ORDE,2
FITEM,5,14
FITEM,5,21
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    13,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1        ! Sides of Tapered Section

FLST,5,4,5,ORDE,4
FITEM,5,19
FITEM,5,22
FITEM,5,87
FITEM,5,-88
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    13,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1                    ! Sides of Front Section

FLST,5,2,5,ORDE,2
FITEM,5,26
FITEM,5,28
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    19,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1        ! Top and Bottom of Front Section

FLST,2,2,5,ORDE,2
FITEM,2,31
FITEM,2,38
ADELE,P51X
LDELE,    103, , ,1
FLST,2,2,4,ORDE,2
FITEM,2,65
FITEM,2,77
LCOMB,P51X, ,0
FLST,2,2,4,ORDE,2
FITEM,2,104
FITEM,2,118
LCOMB,P51X, ,0
FLST,2,4,4
FITEM,2,104
FITEM,2,65
FITEM,2,101
FITEM,2,117
AL,P51X
FLST,2,4,4
FITEM,2,82
FITEM,2,83
FITEM,2,65
FITEM,2,86
AL,P51X              ! Repairing Front T-Tube

FLST,5,10,5,ORDE,7
FITEM,5,20
FITEM,5,23
FITEM,5,-25
FITEM,5,30
FITEM,5,-31
FITEM,5,37
FITEM,5,-40
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    19,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1        ! thickness Front T-Tube

FLST,5,8,5,ORDE,5
FITEM,5,27
FITEM,5,29
FITEM,5,32
FITEM,5,-36
FITEM,5,41
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    13,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1        ! Thickness Front Bumper

ADELE,    60, , ,1
FLST,2,4,5,ORDE,4
FITEM,2,42
FITEM,2,45
FITEM,2,47
FITEM,2,52
ADELE,P51X        ! Deleting False Areas
```

```
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~ Free Meshing
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

/VIEW, 1 ,1,1,1
/ANG, 1
APLOT
/AUTO
/REP,FAST                     ! View Commands

WPSTYLE,,,,,,,,1
MSHKEY,0
FLST,5,163,5,ORDE,2
FITEM,5,1
FITEM,5,-163
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2                     ! Free Meshing All Areas

FLST,3,163,5,ORDE,2
FITEM,3,1
FITEM,3,-163
ARSYM,X,P51X, , , ,0,0        ! Reflect Model

NUMMRG,ALL, , ,          ! Merge Coincident Items...


*SET,nodes,ndinqr(0,12)
*SET,elems,elmiqr(0,12)
*SET,sol_mins,(((3e-
8)*(nodes**2))+0.0005*nodes+0.022)

/EOF

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
```

❖ *Filename: 7_4_frame_loads_INPUT*

```
!*************************************************************
!*************************************************************
!         930E Frame FEA Loading Routine
!*************************************************************
!*************************************************************

/TITLE,930E Frame FEA Loading Conditions

/PREP7

                              ! Strut pressures
!*SET,RRpres,139.5            ! kg/cm^2
!*SET,LRpres,92.4             ! kg/cm^2
!*SET,RFpres,40.9             ! kg/cm^2
!*SET,LFpres,60.9             ! kg/cm^2

ET,2,COMBIN14                 ! Define Combin14
Element Type
KEYOPT,2,2,0
KEYOPT,2,3,0

R,999,K_Dist, , ,    ! Rubber Support Spring Stiffness
R,1999,K_Hinge, , ,  ! Hinge Pin Spring Stiffness

DOFSEL,S, ,FX,FY,FZ,MX,MY,MZ
FCUM,REPL,1,
DOFSEL,ALL                    ! Replace Force BC's

!---------------------------------------------
!--------------- Dump Body Rubber Support
!---------------------------------------------

*IF,firstpas,NE,1,THEN

ALLSEL,ALL
FLST,5,8,5,ORDE,8
FITEM,5,51
FITEM,5,53
FITEM,5,59
FITEM,5,61
FITEM,5,206
FITEM,5,-207
FITEM,5,213
FITEM,5,-214
ASEL,S, , ,P51X
ALLSEL,BELOW,AREA
NSLA,S,1
NSEL,R,LOC,Z,-4670,-7730
                  ! Selecting Nodes on Main Rail

TYPE,  2
MAT,    1
REAL,   999
ESYS,    0
SECNUM,              ! Setting Default Element Attributes

NGEN,2,100000,ALL, , , ,-5, ,1,
                  ! Generating Nodes 5mm
                  ! Below Rubber Support
EINTF,10,
         ! Define Elments between Co-incident Nodes

NSEL,R,LOC,Y,-513,-512
D,ALL, ,0, , , ,UY, , , , ,        ! Uy=0 On Top of Springs

ALLSEL,ALL
*ENDIF
```

```
!---------------------------------------------
!--------------- Dump Body Hinge Pins
!---------------------------------------------

*IF,firstpas,NE,1,THEN

FLST,5,8,5,ORDE,4
FITEM,5,81
FITEM,5,-84
FITEM,5,234
FITEM,5,-237
ASEL,S, , ,P51X
ALLSEL,BELOW,AREA
NSLA,S,1             ! Selecting Only Hinge Pin Nodes

TYPE,  2
MAT,    1
REAL,   1999
ESYS,    0
SECNUM,              ! Setting Default Element Attributes

NGEN,2,100000,ALL, , , ,-5, ,1,
                  ! Generating Nodes 5mm
                  ! Below Hinge Pin Nodes
EINTF,10,
         ! Define Elments between Co-incident Nodes

*GET,Nmax,NODE,0,NUM,MAX
D,100000,UY,0, ,Nmax,1
*SET,Nmax            ! Uy=0 On Top of Springs

ALLSEL,ALL
*ENDIF

!---------------------------------------------
!--------------- Right Rear Strut Pin
!---------------------------------------------

FLST,5,4,5,ORDE,2
FITEM,5,73
FITEM,5,-76
ASEL,S, , ,P51X
ALLSEL,BELOW,AREA
NSLA,S,1        ! Selecting Right Rear Strut Pin Nodes

                              ! Strut Force in Newtons
*SET,RRfstrut,RRpres*(100**2)*9.81*3.14/4*(0.305**2)

*GET,count,NODE,0,COUNT  ! # of Selected Nodes
*SET,fnode,RRfstrut/count    ! Netwons/node

F,ALL,FY,fnode       ! Applying Force to Nodes
*SET,fnode
*SET,count

ALLSEL,ALL

!---------------------------------------------
!--------------- Left Rear Strut Pin
!---------------------------------------------

FLST,5,4,5,ORDE,2
FITEM,5,226
FITEM,5,-229
ASEL,S, , ,P51X
```

```
ALLSEL,BELOW,AREA
NSLA,S,1        ! Selecting Left Rear Strut Pin Nodes

                                    ! Strut Force in Newtons
*SET,LRfstrut,LRpres*(100**2)*9.81*3.14/4*(0.305**2)

*GET,count,NODE,0,COUNT  ! # of Selected Nodes
*SET,fnode,LRfstrut/count      ! Netwons/node

F,ALL,FY,fnode                  ! Applying Force to
Nodes
*SET,fnode
*SET,count

ALLSEL,ALL

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~ Right Front Strut Mount
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

                                    ! Strut Force in Newtons
*SET,RFfstrut,RFpres*(100**2)*9.81*3.14/4*(0.400**2)

KSEL,S, , ,   177
NSLK,S                          ! Selecting Point Node

                    ! Applying Forces to Point Node
*AFUN,DEG
F,ALL,FY,RFfstrut*COS(9)
F,ALL,FZ,RFfstrut*SIN(9)

ALLSEL,ALL

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~ Left Front Strut Mount
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

                                    ! Strut Force in Newtons
*SET,LFfstrut,LFpres*(100**2)*9.81*3.14/4*(0.400**2)

KSEL,S, , ,   343
NSLK,S                          ! Selecting Point Node

                                ! Applying Forces to
Point Node
*AFUN,DEG
F,ALL,FY,LFfstrut*COS(9)
F,ALL,FZ,LFfstrut*SIN(9)

ALLSEL,ALL

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~ Constraining to Improve Numerical Stability
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

*IF,firstpas,NE,1,THEN

FLST,2,2,3,ORDE,2         ! Ux=0 On Side Keypoints
FITEM,2,84
FITEM,2,110
DK,P51X, ,0, ,0,UX, , , , , ,

FLST,2,2,3,ORDE,2       ! Uz=0 Near Rear Body Pin
FITEM,2,31
FITEM,2,212
DK,P51X, ,0, ,0,UZ, , , , , ,

*ENDIF

FINISH

FINISH

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~ Setting Parameters
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~


*SET,firstpas,1         ! Been through file before...

*SET,NODES
*SET,ELEMS

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
```

❖ *Filename: 7_5_frame_post_INPUT*

```
!*****************************************************************
!*****************************************************************
!          930E Frame FEA Post Processing Routine
!*****************************************************************
!*****************************************************************

/TITLE,930E Frame FEA Post Processing


!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~ Defining Paths Along Main Rails
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

ALLSEL,ALL
FLST,5,8,5,ORDE,8
FITEM,5,51
FITEM,5,53
FITEM,5,59
FITEM,5,61
FITEM,5,206
FITEM,5,-207
FITEM,5,213
FITEM,5,-214
ASEL,S, , ,P51X     ! Selecting Main Rail Areas
ALLSEL,BELOW,AREA
ESEL,A,TYPE,,2

FLST,2,2,1
FITEM,2,5528
FITEM,2,4270
PATH,RPath,2,30,40,
PPATH,P51X,1                ! Path on Right Rail

PDEF,STAT
AVPRIN,0,0,
PDEF, ,U,Y,AVG            ! Mapping Results to Path

PAGET,R_Path,TABL         ! Storing Path Items in Array

FLST,2,2,1
FITEM,2,15510
FITEM,2,14252
PATH,LPath,2,30,40,
PPATH,P51X,1                ! Path on Left Rail

PDEF,STAT
AVPRIN,0,0,
PDEF, ,U,Y,AVG            ! Mapping Results to Path

PAGET,L_Path,TABL         ! Storing Path Items in Array

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~ Writing Path Data to Text File
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

!/EOF
!:txt

!*CFOPEN,XL_Set_10_R_Path,txt, ,

*CFOPEN,XL_H62_D125_R_Path,txt, ,
*VWRITE,R_Path(1,1),R_Path(1,2),R_Path(1,3),R_Pat
h(1,4),R_Path(1,5), , , ,
(F12.4,F12.1,F12.4,F12.1,F12.4)
*CFCLOS

*CFOPEN,XL_H62_D125_L_Path,txt, ,
*VWRITE,L_Path(1,1),L_Path(1,2),L_Path(1,3),L_Path(
1,4),L_Path(1,5), , , ,
(F12.4,F12.1,F12.4,F12.1,F12.4)
*CFCLOS


!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~ Combining Load Cases to Check Linearity
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

/EOF

LCDEF,1,1,,
LCDEF,2,2,,
LCDEF,3,3,,
LCDEF,4,4,,
LCDEF,5,5,,
LCASE,1,
LCOPER,ADD,2, , ,
LCOPER,ADD,3, , ,
LCOPER,ADD,4, , ,
/TITLE,Load Case 10: Added Strut Pressures
LCWRITE,10, , ,../


!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
```

❖ *Filename: 8_1_full_Main_INPUT*

```
!**************************************************************
!**************************************************************
!  Combined 930E Frame and Dump Body FEA Model
!**************************************************************
!**************************************************************

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~ Call Frame and Body into One Database
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

! ***  Had problems with non-similiar files on re-runs...
! ***  Do not run this group again unless absolutely
! ***  necessary

!FINISH
!FINISH
!/CLEAR,START              ! Clear and Start New
!RESUME,frm_geom.db   ! Call in frame FEA model
!/FILNAM,frame

!/PREP7
!CDWRITE,ALL, , ,,, ,        ! Archive Frame FEA Model
!FINISH

!FINISH
!/CLEAR,START              ! Clear and Start New
!RESUME,mesh.db            ! Call in Dump Body FEA

!/PREP7
!ARSYM,X,ALL, , , ,0,0
                    ! Reflect Other Half of Model
!NUMMRG,ALL, , ,
                    ! Merge Co-indicent Items
!CDREAD,ALL,frame,cdb,, , ,
                    ! Read in Frame FEA Archive
!/FACE,NORMAL    ! Display Rendered Areas

!FINISH
!/FILNAM,combined
!SAVE               ! Save Combined Database
!/EOF

! ***  Had problems with non-similiar files are re-runs...
! ***  Do not run this group again unless absolutely
! ****  necessary

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~ Joining Frame and Body At Body Supports
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

:join

FINISH
FINISH
/CLEAR,START      ! Clear and Start New
RESUME,combined.db
                    ! Call in Combined Database

/INPUT,8_2_full_join_INPUT,,,,0
                    ! Join FEA Models

FINISH
/FILNAM,joined
SAVE                ! Save Joined Database

/EOF

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~ Applying Ore Load
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

:load

FINISH
FINISH
/CLEAR,START                 ! Clear and Start New
RESUME,joined.db             ! Call in Database

                             ! Apply Ore Load
/INPUT,4_4_FEA_load_algorithm_INPUT,,/home/dw11
589/930E_Full,1,

FINISH
/FILNAM,loaded
SAVE                         ! Save Joined Database

/EOF

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~ Creating Strut Support Springs
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

:strut

FINISH
FINISH
/CLEAR,START                 ! Clear and Start New
RESUME,loaded.db             ! Call in Database

        ! Set Strut Displacements as Parameters
*SET,dispRR,0
*SET,dispLR,0
*SET,dispRF,0
*SET,dispLF,0

/INPUT,8_3_full_struts_INPUT,,,,0
                             ! Create Strut Springs

FINISH
/FILNAM,solveme
SAVE               ! Save solveme Database

/EOF

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~ Adjusting Strut Support Displacements
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

:adjust
FINISH
FINISH
/CLEAR,START                 ! Clear and Start New
RESUME,solveme.db            ! Call in Database
FINISH
/FILNAM,Aug_27

/INPUT,8_4_full_adjust_INPUT,,,,0
                   ! Adjust Strut Displacements

SAVE               ! Save FILNAM Database

/EOF
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
```

❖ *Filename: 8_2_full_join_INPUT*

```
!****************************************************************
!****************************************************************
!        Joining Both FEA Models into One...
!****************************************************************
!****************************************************************

/PREP7

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~ Cutting Main Rails for Rubber Pad Support
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,2,18,5,ORDE,17
FITEM,2,5
FITEM,2,-6
FITEM,2,9
FITEM,2,50
FITEM,2,-51
FITEM,2,53
FITEM,2,59
FITEM,2,-60
FITEM,2,62
FITEM,2,85
FITEM,2,106
FITEM,2,149
FITEM,2,187
FITEM,2,-189
FITEM,2,195
FITEM,2,197
FITEM,2,220
ACLEAR,P51X
FLST,2,2,5,ORDE,2
FITEM,2,61
FITEM,2,196
ACLEAR,P51X
FLST,2,2,5,ORDE,2
FITEM,2,43
FITEM,2,182
ACLEAR,P51X
        ! Clearing Mesh on Frame Main Rails

WPCSYS,-1,0
KWPAVE,  2089
        ! Moving Wplane To End-of-Pad Location

FLST,2,2,5,ORDE,2
FITEM,2,59
FITEM,2,195
ASBW,P51X
KWPAVE,  2171
FLST,2,2,5,ORDE,2
FITEM,2,1000
FITEM,2,1011
ASBW,P51X
KWPAVE,  2170
FLST,2,2,5,ORDE,2
FITEM,2,1015
FITEM,2,-1016
ASBW,P51X
KWPAVE,  2169
FLST,2,2,5,ORDE,2
FITEM,2,1000
FITEM,2,1011
ASBW,P51X
KWPAVE,  2168
FLST,2,2,5,ORDE,2
FITEM,2,1015
FITEM,2,-1016
ASBW,P51X
KWPAVE,  2167
FLST,2,2,5,ORDE,2
FITEM,2,1000
FITEM,2,1011
ASBW,P51X
KWPAVE,  2166
FLST,2,2,5,ORDE,2
FITEM,2,1015
FITEM,2,-1016
ASBW,P51X
KWPAVE,  2165
FLST,2,2,5,ORDE,2
FITEM,2,1000
FITEM,2,1011
ASBW,P51X
KWPAVE,  2164
FLST,2,2,5,ORDE,2
FITEM,2,1015
FITEM,2,-1016
ASBW,P51X
KWPAVE,  2163
FLST,2,2,5,ORDE,2
FITEM,2,1000
FITEM,2,1011
ASBW,P51X
KWPAVE,  2162
FLST,2,2,5,ORDE,2
FITEM,2,53
FITEM,2,189
ASBW,P51X
KWPAVE,  2161
FLST,2,2,5,ORDE,2
FITEM,2,1000
FITEM,2,1050
ASBW,P51X
KWPAVE,  2160
FLST,2,2,5,ORDE,2
FITEM,2,1052
FITEM,2,-1053
ASBW,P51X
KWPAVE,  2159
FLST,2,2,5,ORDE,2
FITEM,2,1000
FITEM,2,1050
ASBW,P51X
KWPAVE,  2158
FLST,2,2,5,ORDE,2
FITEM,2,51
FITEM,2,188
ASBW,P51X
KWPAVE,  2157
FLST,2,2,5,ORDE,2
FITEM,2,1000
FITEM,2,1060
ASBW,P51X
KWPAVE,  1765
FLST,2,2,5,ORDE,2
FITEM,2,1062
FITEM,2,-1063
ASBW,P51X
! Cutting Main Rail Areas At Rubber Locations

FLST,5,40,5,ORDE,9
FITEM,5,1000
FITEM,5,1010
```

```
FITEM,5,-1011
FITEM,5,1014
FITEM,5,-1029
FITEM,5,1045
FITEM,5,-1061
FITEM,5,1064
FITEM,5,-1067
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    45,  1,      0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1          ! Restoring Area Thicknesses

FLST,5,162,5,ORDE,75
FITEM,5,1
FITEM,5,-6
FITEM,5,8
FITEM,5,-13
FITEM,5,15
FITEM,5,-18
FITEM,5,42
FITEM,5,-43
FITEM,5,45
FITEM,5,47
FITEM,5,-50
FITEM,5,52
FITEM,5,54
FITEM,5,-58
FITEM,5,60
FITEM,5,-65
FITEM,5,69
FITEM,5,-80
FITEM,5,85
FITEM,5,94
FITEM,5,98
FITEM,5,101
FITEM,5,106
FITEM,5,111
FITEM,5,115
FITEM,5,122
FITEM,5,124
FITEM,5,-125
FITEM,5,129
FITEM,5,134
FITEM,5,141
FITEM,5,-143
FITEM,5,148
FITEM,5,-153
FITEM,5,155
FITEM,5,-158
FITEM,5,182
FITEM,5,185
FITEM,5,-187
FITEM,5,190
FITEM,5,-194
FITEM,5,196
FITEM,5,-200
FITEM,5,204
FITEM,5,-215
FITEM,5,220
FITEM,5,229
FITEM,5,233
FITEM,5,236
FITEM,5,245
FITEM,5,249
FITEM,5,256
FITEM,5,258
FITEM,5,-259
FITEM,5,263
FITEM,5,268
FITEM,5,274
FITEM,5,-276
FITEM,5,384
FITEM,5,1000
FITEM,5,1010
FITEM,5,-1011
FITEM,5,1014
FITEM,5,-1029
FITEM,5,1039
FITEM,5,1041
FITEM,5,1043
FITEM,5,-1061
FITEM,5,1064
FITEM,5,-1067
FITEM,5,1415
FITEM,5,2031
FITEM,5,2033
FITEM,5,2035
FITEM,5,-2036
ASEL,S, , ,P51X
        ! Selecting Only Frame Main Rail Areas
ALLSEL,BELOW,AREA

SMRTSIZE,10                ! SmartSize = Coarse

MSHKEY,0
FLST,5,19,5,ORDE,19
FITEM,5,196
FITEM,5,1014
FITEM,5,1016
FITEM,5,1018
FITEM,5,1020
FITEM,5,1022
FITEM,5,1024
FITEM,5,1026
FITEM,5,1028
FITEM,5,1045
FITEM,5,1047
FITEM,5,1049
FITEM,5,1051
FITEM,5,1053
FITEM,5,1055
FITEM,5,1057
FITEM,5,1059
FITEM,5,1061
FITEM,5,1065
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
MSHKEY,0
FLST,5,19,5,ORDE,19
FITEM,5,61
FITEM,5,1010
FITEM,5,-1011
FITEM,5,1015
FITEM,5,1017
FITEM,5,1019
FITEM,5,1021
FITEM,5,1023
FITEM,5,1025
```

```
FITEM,5,1027
FITEM,5,1029
FITEM,5,1046
FITEM,5,1048
FITEM,5,1050
FITEM,5,1052
FITEM,5,1054
FITEM,5,1056
FITEM,5,1058
FITEM,5,1064
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
SMRTSIZE,1                    ! SmartSize = Fine
MSHKEY,0
FLST,5,6,5,ORDE,6
FITEM,5,43
FITEM,5,182
FITEM,5,1000
FITEM,5,1060
FITEM,5,1066
FITEM,5,-1067
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2
SMRTSIZE,3                    ! Smartsize = Med-Fine
MSHKEY,0
FLST,5,12,5,ORDE,12
FITEM,5,5
FITEM,5,-6
FITEM,5,9
FITEM,5,50
FITEM,5,60
FITEM,5,62
FITEM,5,85
FITEM,5,106
FITEM,5,149
FITEM,5,187
FITEM,5,197
FITEM,5,220
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2  ! Re-Meshing Frame Main Rail Areas

ALLSEL,ALL

!------------------------------------------
!--------- Creating Rubber Pad Connection
!------------------------------------------

/PREP7
FLST,5,125,5,ORDE,34
FITEM,5,61
FITEM,5,196
FITEM,5,294
FITEM,5,383
FITEM,5,-384
FITEM,5,423
FITEM,5,-424
FITEM,5,892
FITEM,5,-893
FITEM,5,1000
FITEM,5,1010
FITEM,5,-1011
FITEM,5,1014
FITEM,5,-1029
FITEM,5,1038
FITEM,5,1040
FITEM,5,1042
FITEM,5,1045
FITEM,5,-1061
FITEM,5,1064
FITEM,5,-1067
FITEM,5,1280
FITEM,5,-1311
FITEM,5,1325
FITEM,5,1415
FITEM,5,1452
FITEM,5,-1453
FITEM,5,1905
FITEM,5,-1906
FITEM,5,2030
FITEM,5,2032
FITEM,5,2034
FITEM,5,2037
FITEM,5,-2068
ASEL,S, , ,P51X
ALLSEL,BELOW,AREA
           ! Selecting Only Areas Near Rubber pad

LSTR,  2087,  1154
LSTR,  2119,  1158
LSTR,  2090,  1155
LSTR,  2124,  1159
FLST,2,4,4
FITEM,2,2156
FITEM,2,2243
FITEM,2,2242
FITEM,2,4050
AL,P51X
FLST,2,4,4
FITEM,2,2155
FITEM,2,2240
FITEM,2,4035
FITEM,2,2239
AL,P51X
FLST,2,5,4
FITEM,2,2144
FITEM,2,2242
FITEM,2,3967
FITEM,2,3966
FITEM,2,2239
AL,P51X
LSTR,  2121,  1163
LSTR,  2120,  1167
LSTR,  2116,  1162
LSTR,  2115,  1166
LSTR,  2132,  1158
LSTR,  2132,  1162
LSTR,  2131,  1159
LSTR,  2131,  1163
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FLST,2,3,4
FITEM,2,2243
FITEM,2,2261
FITEM,2,4071
AL,P51X
FLST,2,3,4
FITEM,2,2261
FITEM,2,2162
FITEM,2,2262
AL,P51X
FLST,2,3,4
FITEM,2,2262
FITEM,2,4068
FITEM,2,2255
AL,P51X
FLST,2,3,4
FITEM,2,2240
FITEM,2,4072
FITEM,2,2259
AL,P51X
FLST,2,3,4
FITEM,2,2259
FITEM,2,2161
FITEM,2,2260
AL,P51X
FLST,2,3,4
FITEM,2,2260
FITEM,2,4070
FITEM,2,2257
AL,P51X
FLST,2,4,4
FITEM,2,2168
FITEM,2,2255
FITEM,2,2256
FITEM,2,4042
AL,P51X
FLST,2,4,4
FITEM,2,2167
FITEM,2,2258
FITEM,2,4027
FITEM,2,2257
AL,P51X
LSTR,   2114,   1171
LSTR,   2113,   1175
LSTR,   2112,   1170
LSTR,   2111,   1174
FLST,2,4,4
FITEM,2,2258
FITEM,2,4025
FITEM,2,2265
FITEM,2,2173
AL,P51X
FLST,2,4,4
FITEM,2,4018
FITEM,2,2265
FITEM,2,2266
FITEM,2,2179
AL,P51X
FLST,2,4,4
FITEM,2,2180
FITEM,2,2264
FITEM,2,4023
FITEM,2,2263
AL,P51X
FLST,2,4,4
FITEM,2,2174
FITEM,2,4039
FITEM,2,2256
FITEM,2,2263
AL,P51X
LSTR,   2110,   1179
LSTR,   2108,   1183
LSTR,   2109,   1178
LSTR,   2107,   1182
FLST,2,4,4
FITEM,2,2186
FITEM,2,4020
FITEM,2,2264
FITEM,2,2267
AL,P51X
FLST,2,4,4
FITEM,2,2192
FITEM,2,2268
FITEM,2,4013
FITEM,2,2267
AL,P51X
FLST,2,4,4
FITEM,2,2266
FITEM,2,4016
FITEM,2,2269
FITEM,2,2185
AL,P51X
FLST,2,4,4
FITEM,2,4010
FITEM,2,2270
FITEM,2,2191
FITEM,2,2269
AL,P51X
LSTR,   2106,   1187
LSTR,   2105,   1191
LSTR,   2104,   1186
LSTR,   2103,   1190
FLST,2,4,4
FITEM,2,2198
FITEM,2,4008
FITEM,2,2268
FITEM,2,2271
AL,P51X
FLST,2,4,4
FITEM,2,2271
FITEM,2,2272
FITEM,2,4005
FITEM,2,2204
AL,P51X
FLST,2,4,4
FITEM,2,2270
FITEM,2,4006
FITEM,2,2197
FITEM,2,2273
AL,P51X
FLST,2,4,4
FITEM,2,2273
FITEM,2,3999
FITEM,2,2274
FITEM,2,2203
AL,P51X
LSTR,   2099,   1195
LSTR,   2100,   1199
LSTR,   2098,   1194
LSTR,   2097,   1198
LSTR,    191,   2098
LSTR,    282,   2099
FLST,2,4,4
FITEM,2,2272
FITEM,2,2199
FITEM,2,2280
FITEM,2,4003
AL,P51X
FLST,2,3,4
FITEM,2,2210
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FITEM,2,2280
FITEM,2,2275
AL,P51X
FLST,2,4,4
FITEM,2,2220
FITEM,2,2276
FITEM,2,3988
FITEM,2,2275
AL,P51X
FLST,2,4,4
FITEM,2,2278
FITEM,2,3986
FITEM,2,2219
FITEM,2,2277
AL,P51X
FLST,2,3,4
FITEM,2,2279
FITEM,2,2209
FITEM,2,2277
AL,P51X
FLST,2,4,4
FITEM,2,2279
FITEM,2,3996
FITEM,2,2187
FITEM,2,2274
AL,P51X
LSTR,   2101,   1203
LSTR,   2102,   1207
LSTR,   2096,   1202
LSTR,   2095,   1206
FLST,2,4,4
FITEM,2,2276
FITEM,2,2226
FITEM,2,3990
FITEM,2,2281
AL,P51X
FLST,2,4,4
FITEM,2,2278
FITEM,2,3983
FITEM,2,2225
FITEM,2,2283
AL,P51X
FLST,2,4,4
FITEM,2,3992
FITEM,2,2281
FITEM,2,2232
FITEM,2,2282
AL,P51X
FLST,2,4,4
FITEM,2,3982
FITEM,2,2284
FITEM,2,2231
FITEM,2,2283
AL,P51X
LSTR,    283,   2094
LSTR,   2094,   1211
LSTR,   1215,   2092
LSTR,   2086,   1214
LSTR,   2093,   1210
LSTR,   2093,    192
FLST,2,4,4
FITEM,2,2282
FITEM,2,2227
FITEM,2,3994
FITEM,2,2285
AL,P51X
FLST,2,3,4
FITEM,2,2238
FITEM,2,2285
FITEM,2,2286
AL,P51X
FLST,2,4,4
FITEM,2,2248
FITEM,2,2287
FITEM,2,3976
FITEM,2,2286
AL,P51X
FLST,2,4,4
FITEM,2,3975
FITEM,2,2288
FITEM,2,2247
FITEM,2,2289
AL,P51X
FLST,2,3,4
FITEM,2,2290
FITEM,2,2237
FITEM,2,2289
AL,P51X
FLST,2,4,4
FITEM,2,3979
FITEM,2,2284
FITEM,2,2215
FITEM,2,2290
AL,P51X
LSTR,   1764,   1219
LSTR,   1763,   1218
FLST,2,4,4
FITEM,2,2287
FITEM,2,3973
FITEM,2,2291
FITEM,2,2254
AL,P51X
FLST,2,4,4
FITEM,2,3964
FITEM,2,2288
FITEM,2,2253
FITEM,2,2292
AL,P51X
LSTR,   1765,   1218
LSTR,   1765,   1219
FLST,2,3,4
FITEM,2,3264
FITEM,2,2292
FITEM,2,2293
AL,P51X
FLST,2,3,4
FITEM,2,2293
FITEM,2,2250
FITEM,2,2294
AL,P51X
FLST,2,3,4
FITEM,2,3263
FITEM,2,2294
FITEM,2,2291
AL,P51X                 ! Areas for Left Rubber pad

FLST,2,94,5,ORDE,22
FITEM,2,1016
FITEM,2,1018
FITEM,2,1020
FITEM,2,1022
FITEM,2,1024
FITEM,2,1026
FITEM,2,1028
FITEM,2,1045
FITEM,2,1047
FITEM,2,1049
FITEM,2,1051
FITEM,2,1053
FITEM,2,1055
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FITEM,2,1057
FITEM,2,1059
FITEM,2,1061
FITEM,2,-1063
FITEM,2,1065
FITEM,2,1067
FITEM,2,-1109
FITEM,2,2037
FITEM,2,-2068
VA,P51X              ! Left Rubber Pad Volume

LSTR,   1039,   1058
LSTR,   1037,   1156
LSTR,   1040,   1069
LSTR,   1038,   1157
LSTR,   1157,   1071
LSTR,   1071,   1161
LSTR,   1161,   1036
LSTR,   1034,   1165
LSTR,   1033,   1164
LSTR,   1035,   1160
LSTR,   1160,   1073
LSTR,   1073,   1156
FLST,2,5,4
FITEM,2,2295
FITEM,2,2139
FITEM,2,2297
FITEM,2,2672
FITEM,2,2669
AL,P51X
FLST,2,4,4
FITEM,2,2153
FITEM,2,2296
FITEM,2,1899
FITEM,2,2295
AL,P51X
FLST,2,3,4
FITEM,2,2306
FITEM,2,2101
FITEM,2,2296
AL,P51X
FLST,2,3,4
FITEM,2,2159
FITEM,2,2306
FITEM,2,2305
AL,P51X
FLST,2,3,4
FITEM,2,2305
FITEM,2,2098
FITEM,2,2304
AL,P51X
FLST,2,4,4
FITEM,2,2165
FITEM,2,2303
FITEM,2,1893
FITEM,2,2304
AL,P51X
FLST,2,4,4
FITEM,2,2154
FITEM,2,2298
FITEM,2,2297
FITEM,2,1900
AL,P51X
FLST,2,3,4
FITEM,2,2299
FITEM,2,2100
FITEM,2,2298
AL,P51X
FLST,2,3,4
FITEM,2,2299
FITEM,2,2160
FITEM,2,2300
AL,P51X
FLST,2,3,4
FITEM,2,2300
FITEM,2,2096
FITEM,2,2301
AL,P51X
FLST,2,4,4
FITEM,2,2301
FITEM,2,2166
FITEM,2,2302
FITEM,2,1894
AL,P51X
LSTR,   1031,   1168
LSTR,   1029,   1172
LSTR,   1032,   1169
LSTR,   1030,   1173
FLST,2,4,4
FITEM,2,2303
FITEM,2,1890
FITEM,2,2171
FITEM,2,2307
AL,P51X
FLST,2,4,4
FITEM,2,2177
FITEM,2,2307
FITEM,2,1887
FITEM,2,2308
AL,P51X
FLST,2,4,4
FITEM,2,2302
FITEM,2,1891
FITEM,2,2172
FITEM,2,2309
AL,P51X
FLST,2,4,4
FITEM,2,2178
FITEM,2,2310
FITEM,2,1888
FITEM,2,2309
AL,P51X
LSTR,   1027,   1176
LSTR,   1025,   1180
LSTR,   1028,   1177
LSTR,   1026,   1181
FLST,2,4,4
FITEM,2,2183
FITEM,2,1884
FITEM,2,2308
FITEM,2,2311
AL,P51X
FLST,2,4,4
FITEM,2,2311
FITEM,2,1881
FITEM,2,2312
FITEM,2,2189
AL,P51X
FLST,2,4,4
FITEM,2,2313
FITEM,2,1882
FITEM,2,2314
FITEM,2,2190
AL,P51X
FLST,2,4,4
FITEM,2,2310
FITEM,2,1885
FITEM,2,2184
FITEM,2,2313
AL,P51X
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LSTR,   1023,   1184
LSTR,   1021,   1188
LSTR,   1024,   1185
LSTR,   1022,   1189
FLST,2,4,4
FITEM,2,2312
FITEM,2,1878
FITEM,2,2195
FITEM,2,2315
AL,P51X
FLST,2,4,4
FITEM,2,2315
FITEM,2,2316
FITEM,2,1875
FITEM,2,2201
AL,P51X
FLST,2,4,4
FITEM,2,2314
FITEM,2,1879
FITEM,2,2196
FITEM,2,2317
AL,P51X
FLST,2,4,4
FITEM,2,2202
FITEM,2,2318
FITEM,2,2317
FITEM,2,1876
AL,P51X
LSTR,     17,   468
LSTR,    468,   1192
LSTR,    405,   1196
LSTR,     99,   471
LSTR,    471,   1193
LSTR,    406,   1197
FLST,2,4,4
FITEM,2,2316
FITEM,2,2147
FITEM,2,2319
FITEM,2,1872
AL,P51X
FLST,2,3,4
FITEM,2,2319
FITEM,2,2193
FITEM,2,2320
AL,P51X
FLST,2,4,4
FITEM,2,2217
FITEM,2,2321
FITEM,2,1869
FITEM,2,2320
AL,P51X
FLST,2,4,4
FITEM,2,2318
FITEM,2,1873
FITEM,2,2148
FITEM,2,2322
AL,P51X
FLST,2,3,4
FITEM,2,2205
FITEM,2,2322
FITEM,2,2323
AL,P51X
FLST,2,4,4
FITEM,2,2323
FITEM,2,1870
FITEM,2,2324
FITEM,2,2218
AL,P51X
LSTR,    401,   1200
LSTR,    397,   1204
LSTR,    402,   1201
LSTR,    398,   1205
FLST,2,4,4
FITEM,2,2321
FITEM,2,1866
FITEM,2,2223
FITEM,2,2325
AL,P51X
FLST,2,4,4
FITEM,2,2229
FITEM,2,2326
FITEM,2,1863
FITEM,2,2325
AL,P51X
FLST,2,4,4
FITEM,2,2224
FITEM,2,1867
FITEM,2,2324
FITEM,2,2327
AL,P51X
FLST,2,4,4
FITEM,2,1864
FITEM,2,2327
FITEM,2,2230
FITEM,2,2328
AL,P51X
LSTR,     30,   393
LSTR,    393,   1208
LSTR,    389,   1212
LSTR,    390,   1213
LSTR,    394,   1209
LSTR,    394,     93
FLST,2,4,4
FITEM,2,2326
FITEM,2,2211
FITEM,2,2329
FITEM,2,1858
AL,P51X
FLST,2,3,4
FITEM,2,2221
FITEM,2,2330
FITEM,2,2329
AL,P51X
FLST,2,4,4
FITEM,2,2245
FITEM,2,2331
FITEM,2,853
FITEM,2,2330
AL,P51X
FLST,2,4,4
FITEM,2,2328
FITEM,2,2212
FITEM,2,1859
FITEM,2,2334
AL,P51X
FLST,2,3,4
FITEM,2,2233
FITEM,2,2333
FITEM,2,2334
AL,P51X
FLST,2,4,4
FITEM,2,2246
FITEM,2,2332
FITEM,2,873
FITEM,2,2333
AL,P51X
LSTR,    506,   1216
LSTR,    507,   1217
LSTR,   1217,   1355
LSTR,   1355,   1216
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FLST,2,4,4
FITEM,2,2331
FITEM,2,2251
FITEM,2,2335
FITEM,2,826
AL,P51X
FLST,2,3,4
FITEM,2,2338
FITEM,2,2625
FITEM,2,2335
AL,P51X
FLST,2,3,4
FITEM,2,2234
FITEM,2,2338
FITEM,2,2337
AL,P51X
FLST,2,3,4
FITEM,2,2337
FITEM,2,2628
FITEM,2,2336
AL,P51X
FLST,2,4,4
FITEM,2,2252
FITEM,2,2336
FITEM,2,828
FITEM,2,2332
AL,P51X             ! Areas for Right Rubber Pad

FLST,2,94,5,ORDE,22
FITEM,2,1011
FITEM,2,1015
FITEM,2,1017
FITEM,2,1019
FITEM,2,1021
FITEM,2,1023
FITEM,2,1025
FITEM,2,1027
FITEM,2,1029
FITEM,2,1046
FITEM,2,1048
FITEM,2,1050
FITEM,2,1052
FITEM,2,1054
FITEM,2,1056
FITEM,2,1058
FITEM,2,1064
FITEM,2,1066
FITEM,2,1110
FITEM,2,-1153
FITEM,2,1280
FITEM,2,-1311
VA,P51X             ! Right Rubber Pad Volume

ALLSEL,ALL

WPSTYLE,,,,,,,,0
ET,3,SOLID95        ! Defining Solid Elements

UIMP,3,EX, , ,270000/1000,   ! Mater #3 = Rubber
UIMP,3,DENS, , ,7.86e-06/100,
UIMP,3,ALPX, , , ,
UIMP,3,REFT, , , ,
UIMP,3,NUXY, , , ,
UIMP,3,PRXY, , ,0.3,
UIMP,3,GXY, , , ,
UIMP,3,MU, , , ,
UIMP,3,DAMP, , , ,

VATT,    3,    13,  3,     0
                    ! Setting Volume Attributes

MSHKEY,0
MSHAPE,1,3d
FLST,5,2,6,ORDE,2
FITEM,5,1
FITEM,5,-2
CM,_Y,VOLU
VSEL, , , ,P51X
CM,_Y1,VOLU
CHKMSH,'VOLU'
CMSEL,S,_Y
VMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2           ! Meshing Rubber Connection

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~ Hinge Pin Connecting Scheme
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

ET,4,COMBIN14       ! Element Type 4
KEYOPT,4,2,0        ! Combination Spring Damper
KEYOPT,4,3,0
! Chosen because can set spring constant as constant
! Other elements need material, Xsection, etc..

R,1999,100000, , ,  ! 100000 N/mm Spring Constant

TYPE,   4
MAT,      1
REAL,   1999
ESYS,     0
SECNUM,
TSHAP,LINE                ! Element type Settings

FLST,4,4,1,ORDE,4
        ! Defining Nodes in Centers of Circles
FITEM,4,19195
FITEM,4,19207
FITEM,4,87831
FITEM,4,104653
NGEN,2,2000000,P51X, , , ,-167/2, ,1,
FLST,4,4,1,ORDE,4
FITEM,4,1121
FITEM,4,5091
FITEM,4,10716
FITEM,4,14686
NGEN,2,2000000,P51X, , , ,-152/2, ,1,

FLST,5,81,1,ORDE,5
        ! Right-Hinge Body Outer-Side Wagon Wheel
FITEM,5,19207
FITEM,5,-19210
FITEM,5,19430
FITEM,5,-19505
FITEM,5,2019207
NSEL,R, , ,P51X
*GET,count,NODE,0,COUNT
*GET,Nindex,NODE,0,NUM,MIN
*GET,Nmaster,NODE,0,NUM,MAX
*DO,index,0,count+10,1
        E,Nindex,Nmaster
        *GET,Next,NODE,Nindex,NXTH
        *IF,Next,EQ,Nmaster,EXIT
        *SET,Nindex,Next
*ENDDO
ALLSEL,ALL,NODE           ! Select All Nodes

        ! Right-Hinge Body Inner-Side Wagon Wheel
FLST,5,81,1,ORDE,9
FITEM,5,19195
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FITEM,5,-19196
FITEM,5,19200
FITEM,5,-19201
FITEM,5,19233
FITEM,5,-19251
FITEM,5,19263
FITEM,5,-19319
FITEM,5,2019195
NSEL,R, , ,P51X
*GET,count,NODE,0,COUNT
*GET,Nindex,NODE,0,NUM,MIN
*GET,Nmaster,NODE,0,NUM,MAX
*DO,index,0,count+10,1
        E,Nindex,Nmaster
        *GET,Next,NODE,Nindex,NXTH
        *IF,Next,EQ,Nmaster,EXIT
        *SET,Nindex,Next
*ENDDO
ALLSEL,ALL,NODE              ! Select All Nodes


! Right-Hinge Frame Outer-Side Wagon Wheel
FLST,5,25,1,ORDE,3
FITEM,5,5078
FITEM,5,-5101
FITEM,5,2005091
NSEL,R, , ,P51X
*GET,count,NODE,0,COUNT
*GET,Nindex,NODE,0,NUM,MIN
*GET,Nmaster,NODE,0,NUM,MAX
*DO,index,0,count+10,1
        E,Nindex,Nmaster
        *GET,Next,NODE,Nindex,NXTH
        *IF,Next,EQ,Nmaster,EXIT
        *SET,Nindex,Next
*ENDDO
ALLSEL,ALL,NODE              ! Select All Nodes

! Right-Hinge Frame Inner-Side Wagon Wheel
FLST,5,25,1,ORDE,3
FITEM,5,1120
FITEM,5,-1143
FITEM,5,2001121
NSEL,R, , ,P51X
*GET,count,NODE,0,COUNT
*GET,Nindex,NODE,0,NUM,MIN
*GET,Nmaster,NODE,0,NUM,MAX
*DO,index,0,count+10,1
        E,Nindex,Nmaster
        *GET,Next,NODE,Nindex,NXTH
        *IF,Next,EQ,Nmaster,EXIT
        *SET,Nindex,Next
*ENDDO
ALLSEL,ALL,NODE              ! Select All Nodes


! Left-Hinge Body Outer-Side Wagon Wheel
FLST,5,81,1,ORDE,3
FITEM,5,87810
FITEM,5,-87889
FITEM,5,2087831
NSEL,R, , ,P51X
*GET,count,NODE,0,COUNT
*GET,Nindex,NODE,0,NUM,MIN
*GET,Nmaster,NODE,0,NUM,MAX
*DO,index,0,count+10,1
        E,Nindex,Nmaster
        *GET,Next,NODE,Nindex,NXTH
        *IF,Next,EQ,Nmaster,EXIT
        *SET,Nindex,Next
*ENDDO
ALLSEL,ALL,NODE              ! Select All Nodes

        ! Left-Hinge Body Inner-Side Wagon Wheel
FLST,5,81,1,ORDE,3
FITEM,5,104632
FITEM,5,-104711
FITEM,5,2104653
NSEL,R, , ,P51X
*GET,count,NODE,0,COUNT
*GET,Nindex,NODE,0,NUM,MIN
*GET,Nmaster,NODE,0,NUM,MAX
*DO,index,0,count+10,1
        E,Nindex,Nmaster
        *GET,Next,NODE,Nindex,NXTH
        *IF,Next,EQ,Nmaster,EXIT
        *SET,Nindex,Next
*ENDDO
ALLSEL,ALL,NODE              ! Select All Nodes


! Left-Hinge Frame Outer-Side Wagon Wheel
FLST,5,25,1,ORDE,3
FITEM,5,14673
FITEM,5,-14696
FITEM,5,2014686
NSEL,R, , ,P51X
*GET,count,NODE,0,COUNT
*GET,Nindex,NODE,0,NUM,MIN
*GET,Nmaster,NODE,0,NUM,MAX
*DO,index,0,count+10,1
        E,Nindex,Nmaster
        *GET,Next,NODE,Nindex,NXTH
        *IF,Next,EQ,Nmaster,EXIT
        *SET,Nindex,Next
*ENDDO
ALLSEL,ALL,NODE              ! Select All Nodes

! Left-Hinge Frame Inner-Side Wagon Wheel
FLST,5,25,1,ORDE,3
FITEM,5,10715
FITEM,5,-10738
FITEM,5,2010716
NSEL,R, , ,P51X
*GET,count,NODE,0,COUNT
*GET,Nindex,NODE,0,NUM,MIN
*GET,Nmaster,NODE,0,NUM,MAX
*DO,index,0,count+10,1
        E,Nindex,Nmaster
        *GET,Next,NODE,Nindex,NXTH
        *IF,Next,EQ,Nmaster,EXIT
        *SET,Nindex,Next
*ENDDO
ALLSEL,ALL,NODE              ! Select All Nodes

        ! Couple all but ROTX on Center Nodes of
        ! Wagon Wheels to Closest Center Nodes
                              ! Right Outer
CP,1,UX,2005091,2019207
CP,2,UY,2005091,2019207
CP,3,UZ,2005091,2019207
CP,4,ROTY,2005091,2019207
CP,5,ROTZ,2005091,2019207
                              ! Right Inner
CP,6,UX,2001121,2019195
CP,7,UY,2001121,2019195
CP,8,UZ,2001121,2019195
CP,9,ROTY,2001121,2019195
CP,10,ROTZ,2001121,2019195
                              ! Left Outer
```

```
CP,11,UX,2087831,2014686
CP,12,UY,2087831,2014686
CP,13,UZ,2087831,2014686
CP,14,ROTY,2087831,2014686
CP,15,ROTZ,2087831,2014686
                                        ! Left Inner
CP,16,UX,2104653,2010716
CP,17,UY,2104653,2010716
CP,18,UZ,2104653,2010716
CP,19,ROTY,2104653,2010716
CP,20,ROTZ,2104653,2010716


*SET,count                              ! Deleting Parameters
*SET,Nindex
*SET,Nmaster
*SET,index
*SET,Next

ALLSEL,ALL

FINISH

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

/EOF
```

❖ *Filename: 8_3_full_struts_INPUT*

```
!*****************************************************************
!*****************************************************************
!        Creating Strut Supports...
!*****************************************************************
!*****************************************************************

/PREP7

!------------------------------------------------------------------
!~~~~~~~~~~~~~ Rear Strut Rigid Regions
!------------------------------------------------------------------

FLST,5,8,5,ORDE,4
FITEM,5,73
FITEM,5,-76
FITEM,5,208
FITEM,5,-211
ASEL,R, , ,P51X
ALLSEL,BELOW,AREA

FLST,3,2,3,ORDE,2
                ! Copy KP's to Center of Strut Pins
FITEM,3,28
FITEM,3,292
KGEN,2,P51X, , ,305/2,-152/2, , ,0

LSTR,   292,  1221
LSTR,  1221,   221
LSTR,    28,  1220
LSTR,  1220,   126
FLST,2,3,4
FITEM,2,2339
FITEM,2,507
FITEM,2,2340
AL,P51X
FLST,2,3,4
FITEM,2,2342
FITEM,2,199
FITEM,2,2341
AL,P51X                    ! Creating Triangle Areas

FLST,5,2,5,ORDE,2
FITEM,5,1154
FITEM,5,-1155
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,    1,    13,  1,     0
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
MSHKEY,0
FLST,5,2,5,ORDE,2
FITEM,5,1154
FITEM,5,-1155
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2   ! Mesh Triangles to "use" center Nodes

FLST,2,362,1,ORDE,11
FITEM,2,2104655
FITEM,2,1144
FITEM,2,-1167
FITEM,2,5030
FITEM,2,-5053
FITEM,2,6307
FITEM,2,-6570
FITEM,2,2104678
FITEM,2,-2104699
FITEM,2,2104727
FITEM,2,-2104753
CERIG,P51X, ,ALL, , , ,      ! Right Rear Rigid Region

FLST,2,362,1,ORDE,11
FITEM,2,2104654
FITEM,2,10739
FITEM,2,-10762
FITEM,2,14625
FITEM,2,-14648
FITEM,2,15902
FITEM,2,-16165
FITEM,2,2104656
FITEM,2,-2104677
FITEM,2,2104700
FITEM,2,-2104726
CERIG,P51X, ,ALL, , , ,      ! Left Rear Rigid Region

!------------------------------------------------------------------
!~~~~~~~~~~~~~~~ Rear Strut Springs
!------------------------------------------------------------------

ALLSEL,ALL

R,2999,10000, , ,            ! 10000 N/mm Reduced
Spring Constant

FLST,4,2,1,ORDE,2
        ! Copy Nodes down from Rear Strut
FITEM,4,2104654  !L
FITEM,4,2104655  !R
NGEN,2,1000000,P51X, , , ,-1500-850, ,1,
                   ! Rigid Region Master Nodes
TYPE,  4
MAT,     1
REAL,  2999
ESYS,     0
SECNUM,
TSHAP,LINE                   ! Element type Settings

FLST,2,2,1
FITEM,2,2104654
FITEM,2,3104654
E,P51X                       ! Left Rear Strut Spring

FLST,2,2,1
FITEM,2,2104655
FITEM,2,3104655
E,P51X                       ! Right Rear Strut Spring

                   ! Left Rear Strut Displacement
D,3104654, , , , , ,ALL, , , , ,
D,3104654, ,dispLR, , , ,UY, , , , ,

                   ! Right Rear Strut Displacement
D,3104655, , , , , ,ALL, , , , ,
D,3104655, ,dispRR, , , ,UY, , , , ,
```

```
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~ Front Strut Rigid Regions
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,5,10,5,ORDE,10
FITEM,5,131
FITEM,5,-132
FITEM,5,137
FITEM,5,142
FITEM,5,144
FITEM,5,265
FITEM,5,-266
FITEM,5,271
FITEM,5,275
FITEM,5,277
ASEL,S, , ,P51X
ALLSEL,BELOW,AREA


FLST,3,2,3,ORDE,2
        ! Creating KP for Front Strut Moment Arms
FITEM,3,104
FITEM,3,139
KGEN,2,P51X, , ,56*25.4, , , ,0
FLST,3,2,3,ORDE,2
FITEM,3,341
FITEM,3,-342
KGEN,2,P51X, , ,-56*25.4, , , ,0

LSTR,    341,   1224
LSTR,   1224,   1225
LSTR,   1225,    342
LSTR,    139,   1223
LSTR,   1223,   1222
LSTR,   1222,    104          ! Lines for Moment Arms

KL,2344,.5, ,
KWPAVE,   1226
FLST,2,2,4,ORDE,2
FITEM,2,2344
FITEM,2,2347
LSBW,P51X
WPSTYLE,,,,,,,0    ! Cut Outer Most Line w/ WPlane
                   ! to ensure node in center of edge

FLST,2,5,4
FITEM,2,2351
FITEM,2,2352
FITEM,2,2345
FITEM,2,578
FITEM,2,2343
AL,P51X
FLST,2,5,4
FITEM,2,2346
FITEM,2,257
FITEM,2,2348
FITEM,2,2349
FITEM,2,2350
AL,P51X                       ! Creating Areas

FLST,5,2,5,ORDE,2
FITEM,5,1156
FITEM,5,-1157
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CMSEL,S,_Y
CMSEL,S,_Y1
AATT,     1,     13,  1,      0
```

```
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1          ! Setting Element Attributes

SMRTSIZE,1          ! Smartsize Setting

MSHKEY,0
FLST,5,2,5,ORDE,2
FITEM,5,1156
FITEM,5,-1157
CM,_Y,AREA
ASEL, , , ,P51X
CM,_Y1,AREA
CHKMSH,'AREA'
CMSEL,S,_Y
AMESH,_Y1
CMDEL,_Y
CMDEL,_Y1
CMDEL,_Y2                      ! Meshing Moment Arms

FLST,5,2,5,ORDE,2
FITEM,5,131
FITEM,5,265
ASEL,U, , ,P51X

FLST,2,314,1,ORDE,39
FITEM,2,3104660
FITEM,2,4277
FITEM,2,-4286
FITEM,2,4294
FITEM,2,-4301
FITEM,2,7781
FITEM,2,8384
FITEM,2,8390
FITEM,2,-8393
FITEM,2,8408
FITEM,2,8535
FITEM,2,-8539
FITEM,2,8547
FITEM,2,-8551
FITEM,2,9090
FITEM,2,-9094
FITEM,2,9109
FITEM,2,-9113
FITEM,2,9128
FITEM,2,9136
FITEM,2,-9138
FITEM,2,9184
FITEM,2,-9225
FITEM,2,9237
FITEM,2,-9239
FITEM,2,9377
FITEM,2,-9400
FITEM,2,9424
FITEM,2,-9427
FITEM,2,9444
FITEM,2,-9472
FITEM,2,9520
FITEM,2,-9543
FITEM,2,3104658
FITEM,2,3104659
FITEM,2,3104724
FITEM,2,-3104791
FITEM,2,3104866
FITEM,2,-3104933
CERIG,P51X, ,ALL, , , ,
          ! Right Front Strut Rigid Region

FLST,2,314,1,ORDE,42
FITEM,2,3104661
```

```
FITEM,2,13872
FITEM,2,-13881
FITEM,2,13889
FITEM,2,-13896
FITEM,2,17376
FITEM,2,17979
FITEM,2,17985
FITEM,2,-17988
FITEM,2,18003
FITEM,2,18130
FITEM,2,-18134
FITEM,2,18142
FITEM,2,-18146
FITEM,2,18685
FITEM,2,-18689
FITEM,2,18704
FITEM,2,-18708
FITEM,2,18723
FITEM,2,18731
FITEM,2,-18733
FITEM,2,18779
FITEM,2,-18820
FITEM,2,18832
FITEM,2,-18834
FITEM,2,18972
FITEM,2,-18995
FITEM,2,19019
FITEM,2,19027
FITEM,2,-19029
FITEM,2,19039
FITEM,2,-19064
FITEM,2,19076
FITEM,2,-19078
FITEM,2,19115
FITEM,2,-19138
FITEM,2,3104656
FITEM,2,-3104657
FITEM,2,3104662
FITEM,2,-3104723
FITEM,2,3104792
FITEM,2,-3104865
CERIG,P51X, ,ALL, , , ,
        ! Left Front Strut Rigid Region

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~ Front Strut Spring Elements
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

ALLSEL,ALL

*AFUN,DEG

! Rigid Region Master Nodes
! Copy Nodes down from Rear Strut

FLST,4,2,1,ORDE,2
FITEM,4,3104661 !L
FITEM,4,3104660 !R
NGEN,2,1000000,P51X, , , ,-2500*COS(9),-
2500*SIN(9),1,

TYPE,  4
MAT,    1
REAL,  2999
ESYS,    0
SECNUM,
TSHAP,LINE                    ! Element type Settings

FLST,2,2,1
FITEM,2,3104660
FITEM,2,4104660
E,P51X                        ! Right Front Strut Spring

FLST,2,2,1
FITEM,2,3104661
FITEM,2,4104661
E,P51X                        ! Left Front Strut Spring


                    ! Left Front Strut Displacement
D,4104661, , , , , ,ALL, , , , ,
D,4104661, ,displF*COS(9), , , ,UY, , , , ,
D,4104661, ,displF*SIN(9), , , ,UZ, , , , ,

                    ! Right Front Strut Displacement
D,4104660, , , , , ,ALL, , , , ,
D,4104660, ,dispRF*COS(9), , , ,UY, , , , ,
D,4104660, ,dispRF*SIN(9), , , ,UZ, , , , ,

LPLOT

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~ Additional Restraints to Improve Stability
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FLST,2,2,3,ORDE,2
FITEM,2,36
FITEM,2,227
DK,P51X, ,0, ,0,UZ, , , , , ,
        ! Uz=0 on Two Center Torsion Tube KPs

FLST,2,2,3,ORDE,2
FITEM,2,5
FITEM,2,16
/GO
DK,P51X, ,0, ,0,UX, , , , , ,
        ! Ux=0 on Rear and Center Torsion
        ! Tube Centerline KPs

FINISH

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
```

❖ *Filename: 8_4_full_adjust_INPUT*

```
!****************************************************************
!****************************************************************
! Combined 930E Frame and Dump Body FEA Model
!****************************************************************
!****************************************************************
FINISH
/SOLU                ! Set Strut Displacements

!-----------------------------------------------------
/TITLE,Load Set 1: Ore Load Only
!-----------------------------------------------------

*SET,frntdiff,0                  ! Newtons
*SET,reardiff,0                  ! Newtons

*SET,dispLF,(frntdiff/2)/100000
*SET,dispRF,-(frntdiff/2)/100000
*SET,dispLR,(reardiff/2)/100000
*SET,dispRR,-(reardiff/2)/100000

                     ! Left Front Strut Displacement
D,4104661, , , , , ,ALL, , , , ,
D,4104661, ,dispLF*COS(9), , , ,UY, , , , ,
D,4104661, ,dispLF*SIN(9), , , ,UZ, , , , ,
                     ! Right Front Strut Displacement
D,4104660, , , , , ,ALL, , , , ,
D,4104660, ,dispRF*COS(9), , , ,UY, , , , ,
D,4104660, ,dispRF*SIN(9), , , ,UZ, , , , ,
                     ! Left Rear Strut Displacement
D,3104654, , , , , ,ALL, , , , ,
D,3104654, ,dispLR, , , ,UY, , , , ,
                     ! Right Rear Strut Displacement
D,3104655, , , , , ,ALL, , , , ,
D,3104655, ,dispRR, , , ,UY, , , , ,

LSWRITE,1,
SFEDELE,ALL,ALL,PRES

!-----------------------------------------------------
/TITLE,Load Set 2: Rack Front Difference Only
!-----------------------------------------------------

*SET,frntdiff,271155             ! Newtons
*SET,reardiff,0                  ! Newtons

*SET,dispLF,(frntdiff/2)/100000
*SET,dispRF,-(frntdiff/2)/100000
*SET,dispLR,(reardiff/2)/100000
*SET,dispRR,-(reardiff/2)/100000

                     ! Left Front Strut Displacement
D,4104661, , , , , ,ALL, , , , ,
D,4104661, ,dispLF*COS(9), , , ,UY, , , , ,
D,4104661, ,dispLF*SIN(9), , , ,UZ, , , , ,
                     ! Right Front Strut Displacement
D,4104660, , , , , ,ALL, , , , ,
D,4104660, ,dispRF*COS(9), , , ,UY, , , , ,
D,4104660, ,dispRF*SIN(9), , , ,UZ, , , , ,
                     ! Left Rear Strut Displacement
D,3104654, , , , , ,ALL, , , , ,
D,3104654, ,dispLR, , , ,UY, , , , ,
                     ! Right Rear Strut Displacement
D,3104655, , , , , ,ALL, , , , ,
D,3104655, ,dispRR, , , ,UY, , , , ,

LSWRITE,2,

!-----------------------------------------------------
/TITLE,Load Set 3: Rack Rear Difference Only
!-----------------------------------------------------

*SET,frntdiff,0                  ! Newtons
*SET,reardiff,-326134            ! Newtons

*SET,dispLF,(frntdiff/2)/100000
*SET,dispRF,-(frntdiff/2)/100000
*SET,dispLR,(reardiff/2)/100000
*SET,dispRR,-(reardiff/2)/100000

                     ! Left Front Strut Displacement
D,4104661, , , , , ,ALL, , , , ,
D,4104661, ,dispLF*COS(9), , , ,UY, , , , ,
D,4104661, ,dispLF*SIN(9), , , ,UZ, , , , ,
                     ! Right Front Strut Displacement
D,4104660, , , , , ,ALL, , , , ,
D,4104660, ,dispRF*COS(9), , , ,UY, , , , ,
D,4104660, ,dispRF*SIN(9), , , ,UZ, , , , ,
                     ! Left Rear Strut Displacement
D,3104654, , , , , ,ALL, , , , ,
D,3104654, ,dispLR, , , ,UY, , , , ,
                     ! Right Rear Strut Displacement
D,3104655, , , , , ,ALL, , , , ,
D,3104655, ,dispRR, , , ,UY, , , , ,

LSWRITE,3,

!-----------------------------------------------------
/TITLE,Load Set 4: Lean to One side Only
!-----------------------------------------------------

*SET,frntdiff                    ! Newtons
*SET,reardiff                    ! Newtons

*SET,dispLF,5
*SET,dispRF,-5
*SET,dispLR,5
*SET,dispRR,-5

                     ! Left Front Strut Displacement
D,4104661, , , , , ,ALL, , , , ,
D,4104661, ,dispLF*COS(9), , , ,UY, , , , ,
D,4104661, ,dispLF*SIN(9), , , ,UZ, , , , ,
                     ! Right Front Strut Displacement
D,4104660, , , , , ,ALL, , , , ,
D,4104660, ,dispRF*COS(9), , , ,UY, , , , ,
D,4104660, ,dispRF*SIN(9), , , ,UZ, , , , ,
                     ! Left Rear Strut Displacement
D,3104654, , , , , ,ALL, , , , ,
D,3104654, ,dispLR, , , ,UY, , , , ,
                     ! Right Rear Strut Displacement
D,3104655, , , , , ,ALL, , , , ,
D,3104655, ,dispRR, , , ,UY, , , , ,

LSWRITE,4,
FINISH

/EOF

!****************************************************************
```

❖ *Filename: 8_5_full_post_INPUT*

```
!*****************************************************************
!*****************************************************************
! Combined 930E Frame and Dump Body FEA Model
!          Post Processing Routine...
!*****************************************************************
!*****************************************************************

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~~~~~~~ Read in Results File
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

RESUME,Aug_24,db,
!/GRAPHICS,FULL

/POST1
INRES,
FILE,Aug_24,rst,

!SET,1,LAST,1,              ! Load Step #,Last
Substep, Scale=1

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~ Combining Load Cases to Check Linearity
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

!SET,2,LAST,5/1.355755,
!LCWRITE,1, , ,../
!SET,3,LAST,-5/1.63067,
!LCWRITE,2, , ,../
!LCOPER,ADD,1, , ,
!/TITLE,LOAD CASE 3: Combined Results
!LCWRITE,3, , ,../
!LCDEF,4,4,,     ! Frame FEA Load Case Operations

/EOF

!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
!~~~~~~~~~ Selecting Which Bolster to Study
!~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

ALLSEL,ALL

FLST,5,382,5,ORDE,153
FITEM,5,281
FITEM,5,-282
FITEM,5,284
FITEM,5,-285
FITEM,5,287
FITEM,5,-290
FITEM,5,292
FITEM,5,-293
FITEM,5,298
FITEM,5,-308
FITEM,5,324
FITEM,5,327
FITEM,5,-330
FITEM,5,338
FITEM,5,340
FITEM,5,343
FITEM,5,345
FITEM,5,348
FITEM,5,-362
FITEM,5,364
FITEM,5,-368
FITEM,5,373
FITEM,5,376
FITEM,5,-382
FITEM,5,385
FITEM,5,388
FITEM,5,391
FITEM,5,-397
FITEM,5,399
FITEM,5,-405
FITEM,5,407
FITEM,5,-408
FITEM,5,410
FITEM,5,-416
FITEM,5,439
FITEM,5,441
FITEM,5,-442
FITEM,5,469
FITEM,5,479
FITEM,5,481
FITEM,5,483
FITEM,5,531
FITEM,5,-532
FITEM,5,535
FITEM,5,-541
FITEM,5,543
FITEM,5,-548
FITEM,5,552
FITEM,5,554
FITEM,5,557
FITEM,5,-564
FITEM,5,573
FITEM,5,593
FITEM,5,596
FITEM,5,601
FITEM,5,830
FITEM,5,-852
FITEM,5,854
FITEM,5,-861
FITEM,5,863
FITEM,5,-865
FITEM,5,867
FITEM,5,-871
FITEM,5,907
FITEM,5,910
FITEM,5,939
FITEM,5,-941
FITEM,5,946
FITEM,5,957
FITEM,5,-958
FITEM,5,981
FITEM,5,986
FITEM,5,-997
FITEM,5,999
FITEM,5,1001
FITEM,5,-1009
FITEM,5,1012
FITEM,5,-1013
FITEM,5,1312
FITEM,5,-1313
FITEM,5,1315
FITEM,5,-1316
FITEM,5,1318
FITEM,5,-1321
FITEM,5,1323
FITEM,5,-1324
FITEM,5,1329
FITEM,5,-1339
FITEM,5,1355
FITEM,5,1358
FITEM,5,-1361
```

```
FITEM,5,1369
FITEM,5,1371
FITEM,5,1374
FITEM,5,1376
FITEM,5,1379
FITEM,5,-1393
FITEM,5,1395
FITEM,5,-1399
FITEM,5,1404
FITEM,5,1407
FITEM,5,-1413
FITEM,5,1416
FITEM,5,1418
FITEM,5,1420
FITEM,5,-1426
FITEM,5,1428
FITEM,5,-1434
FITEM,5,1436
FITEM,5,-1437
FITEM,5,1439
FITEM,5,-1445
FITEM,5,1468
FITEM,5,1470
FITEM,5,-1471
FITEM,5,1498
FITEM,5,1508
FITEM,5,1510
FITEM,5,1512
FITEM,5,1560
FITEM,5,-1561
FITEM,5,1564
FITEM,5,-1570
FITEM,5,1572
FITEM,5,-1577
FITEM,5,1581
FITEM,5,1583
FITEM,5,1586
FITEM,5,-1593
FITEM,5,1602
FITEM,5,1622
FITEM,5,1625
FITEM,5,1630
FITEM,5,1859
FITEM,5,-1881
FITEM,5,1883
FITEM,5,-1890
FITEM,5,1892
FITEM,5,-1894
FITEM,5,1896
FITEM,5,-1900
FITEM,5,1920
FITEM,5,1923
FITEM,5,1952
FITEM,5,-1954
FITEM,5,1959
FITEM,5,1970
FITEM,5,-1971
FITEM,5,1992
FITEM,5,1997
FITEM,5,-2008
FITEM,5,2010
FITEM,5,-2021
ASEL,R, , ,P51X
CM,ALL_BOL,AREA                    ! All Bolsters

FLST,5,36,5,ORDE,26
FITEM,5,376
FITEM,5,-381
FITEM,5,394
FITEM,5,-396
FITEM,5,439
FITEM,5,442
FITEM,5,469
FITEM,5,481
FITEM,5,539
FITEM,5,831
FITEM,5,-832
FITEM,5,834
FITEM,5,-835
FITEM,5,1407
FITEM,5,-1412
FITEM,5,1423
FITEM,5,-1425
FITEM,5,1468
FITEM,5,1471
FITEM,5,1498
FITEM,5,1510
FITEM,5,1568
FITEM,5,1860
FITEM,5,-1861
FITEM,5,1863
FITEM,5,-1864
ASEL,R, , ,P51X
CM,Bolster1,AREA

CMSEL,S,ALL_BOL

FLST,5,64,5,ORDE,56
FITEM,5,354
FITEM,5,360
FITEM,5,365
FITEM,5,-366
FITEM,5,368
FITEM,5,373
FITEM,5,391
FITEM,5,393
FITEM,5,441
FITEM,5,538
FITEM,5,541
FITEM,5,544
FITEM,5,546
FITEM,5,548
FITEM,5,554
FITEM,5,558
FITEM,5,560
FITEM,5,562
FITEM,5,573
FITEM,5,830
FITEM,5,836
FITEM,5,838
FITEM,5,-841
FITEM,5,843
FITEM,5,-846
FITEM,5,849
FITEM,5,1001
FITEM,5,1013
FITEM,5,1385
FITEM,5,1391
FITEM,5,1396
FITEM,5,-1397
FITEM,5,1399
FITEM,5,1404
FITEM,5,1420
FITEM,5,1422
FITEM,5,1470
FITEM,5,1567
FITEM,5,1570
FITEM,5,1573
FITEM,5,1575
FITEM,5,1577
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```
FITEM,5,1583
FITEM,5,1587
FITEM,5,1589
FITEM,5,1591
FITEM,5,1602
FITEM,5,1859
FITEM,5,1865
FITEM,5,1867
FITEM,5,-1870
FITEM,5,1872
FITEM,5,-1875
FITEM,5,1878
FITEM,5,2011
FITEM,5,2021
ASEL,R, , ,P51X
CM,Bolster2,AREA

CMSEL,S,ALL_BOL

FLST,5,68,5,ORDE,58
FITEM,5,324
FITEM,5,364
FITEM,5,367
FITEM,5,388
FITEM,5,537
FITEM,5,540
FITEM,5,543
FITEM,5,545
FITEM,5,547
FITEM,5,552
FITEM,5,557
FITEM,5,559
FITEM,5,563
FITEM,5,-564
FITEM,5,601
FITEM,5,837
FITEM,5,848
FITEM,5,850
FITEM,5,-852
FITEM,5,854
FITEM,5,-857
FITEM,5,860
FITEM,5,981
FITEM,5,991
FITEM,5,-993
FITEM,5,999
FITEM,5,1002
FITEM,5,-1004
FITEM,5,1012
FITEM,5,1355
FITEM,5,1395
FITEM,5,1398
FITEM,5,1418
FITEM,5,1566
FITEM,5,1569
FITEM,5,1572
FITEM,5,1574
FITEM,5,1576
FITEM,5,1581
FITEM,5,1586
FITEM,5,1588
FITEM,5,1592
FITEM,5,-1593
FITEM,5,1630
FITEM,5,1866
FITEM,5,1877
FITEM,5,1879
FITEM,5,-1881
FITEM,5,1883
FITEM,5,-1886
FITEM,5,1889
FITEM,5,1992
FITEM,5,2002
FITEM,5,-2004
FITEM,5,2010
FITEM,5,2012
FITEM,5,-2014
FITEM,5,2020
ASEL,R, , ,P51X
CM,Bolster3,AREA

CMSEL,S,ALL_BOL

FLST,5,44,5,ORDE,40
FITEM,5,358
FITEM,5,-359
FITEM,5,361
FITEM,5,-362
FITEM,5,385
FITEM,5,536
FITEM,5,561
FITEM,5,593
FITEM,5,596
FITEM,5,847
FITEM,5,859
FITEM,5,861
FITEM,5,863
FITEM,5,-864
FITEM,5,988
FITEM,5,-990
FITEM,5,996
FITEM,5,-997
FITEM,5,1005
FITEM,5,-1007
FITEM,5,1389
FITEM,5,-1390
FITEM,5,1392
FITEM,5,-1393
FITEM,5,1416
FITEM,5,1565
FITEM,5,1590
FITEM,5,1622
FITEM,5,1625
FITEM,5,1876
FITEM,5,1888
FITEM,5,1890
FITEM,5,1892
FITEM,5,-1893
FITEM,5,1999
FITEM,5,-2001
FITEM,5,2007
FITEM,5,-2008
FITEM,5,2015
FITEM,5,-2017
ASEL,R, , ,P51X
CM,Bolster4,AREA

CMSEL,S,ALL_BOL

FLST,5,40,5,ORDE,32
FITEM,5,352
FITEM,5,-353
FITEM,5,355
FITEM,5,-357
FITEM,5,382
FITEM,5,535
FITEM,5,858
FITEM,5,865
FITEM,5,867
FITEM,5,-871
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FITEM,5,986
FITEM,5,-987
FITEM,5,994
FITEM,5,-995
FITEM,5,1008
FITEM,5,-1009
FITEM,5,1383
FITEM,5,-1384
FITEM,5,1386
FITEM,5,-1388
FITEM,5,1413
FITEM,5,1564
FITEM,5,1887
FITEM,5,1894
FITEM,5,1896
FITEM,5,-1900
FITEM,5,1997
FITEM,5,-1998
FITEM,5,2005
FITEM,5,-2006
FITEM,5,2018
FITEM,5,-2019
ASEL,R, , ,P51X
CM,Bolster5,AREA

CMSEL,S,ALL_BOL

FLST,5,34,5,ORDE,24
FITEM,5,288
FITEM,5,301
FITEM,5,-302
FITEM,5,304
FITEM,5,-306
FITEM,5,308
FITEM,5,351
FITEM,5,403
FITEM,5,-405
FITEM,5,408
FITEM,5,410
FITEM,5,-414
FITEM,5,1319
FITEM,5,1332
FITEM,5,-1333
FITEM,5,1335
FITEM,5,-1337
FITEM,5,1339
FITEM,5,1382
FITEM,5,1432
FITEM,5,-1434
FITEM,5,1437
FITEM,5,1439
FITEM,5,-1443
ASEL,R, , ,P51X
CM,Bolster6,AREA

CMSEL,S,ALL_BOL

FLST,5,34,5,ORDE,28
FITEM,5,289
FITEM,5,-290
FITEM,5,292
FITEM,5,-293
FITEM,5,298
FITEM,5,-300
FITEM,5,303
FITEM,5,307
FITEM,5,397
FITEM,5,399
FITEM,5,-402
FITEM,5,407
FITEM,5,415
FITEM,5,-416
FITEM,5,1320
FITEM,5,-1321
FITEM,5,1323
FITEM,5,-1324
FITEM,5,1329
FITEM,5,-1331
FITEM,5,1334
FITEM,5,1338
FITEM,5,1426
FITEM,5,1428
FITEM,5,-1431
FITEM,5,1436
FITEM,5,1444
FITEM,5,-1445
ASEL,R, , ,P51X
CM,Bolster7,AREA

CMSEL,S,ALL_BOL

FLST,5,34,5,ORDE,32
FITEM,5,282
FITEM,5,284
FITEM,5,327
FITEM,5,330
FITEM,5,338
FITEM,5,340
FITEM,5,343
FITEM,5,348
FITEM,5,-350
FITEM,5,479
FITEM,5,531
FITEM,5,-532
FITEM,5,833
FITEM,5,907
FITEM,5,939
FITEM,5,941
FITEM,5,1313
FITEM,5,1315
FITEM,5,1358
FITEM,5,1361
FITEM,5,1369
FITEM,5,1371
FITEM,5,1374
FITEM,5,1379
FITEM,5,-1381
FITEM,5,1508
FITEM,5,1560
FITEM,5,-1561
FITEM,5,1862
FITEM,5,1920
FITEM,5,1952
FITEM,5,1954
ASEL,R, , ,P51X
CM,Bolster8,AREA

CMSEL,S,ALL_BOL

FLST,5,28,5,ORDE,28
FITEM,5,281
FITEM,5,285
FITEM,5,287
FITEM,5,328
FITEM,5,-329
FITEM,5,345
FITEM,5,392
FITEM,5,483
FITEM,5,842
FITEM,5,910
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FITEM,5,940
FITEM,5,946
FITEM,5,957
FITEM,5,-958
FITEM,5,1312
FITEM,5,1316
FITEM,5,1318
FITEM,5,1359
FITEM,5,-1360
FITEM,5,1376
FITEM,5,1421
FITEM,5,1512
FITEM,5,1871
FITEM,5,1923
FITEM,5,1953
FITEM,5,1959
FITEM,5,1970
FITEM,5,-1971
ASEL,R, , ,P51X
CM,Bolster9,AREA

ALLSEL,ALL

CMSEL,S,Bolster1            ! Front Bolster
CMSEL,A,Bolster2
CMSEL,A,Bolster3
CMSEL,A,Bolster4
CMSEL,A,Bolster5
CMSEL,A,Bolster6
CMSEL,A,Bolster7
CMSEL,A,Bolster8
CMSEL,A,Bolster9            ! Rear Bolster

ALLSEL,BELOW,AREA

!-------------------------------------------
!------------- Plotting Bending Stresses
!-------------------------------------------

/POST1

SHELL,TOP
AVPRIN,0,0,
ETABLE,SXTOP,S,X
SHELL,bot
AVPRIN,0,0,
ETABLE,SXBOT,S,X
SADD,SEC_BEND,SXTOP,SXBOT,1,-1,0,

!/TITLE, Bending Stresses
PLETAB,SEC_BEND,AVG

!-------------------------------------------
!-------- Defining Paths Along Main Rails
!-------------------------------------------

:test
!LCASE,3
!SET,4,LAST,1,

ALLSEL,ALL
FLST,5,36,5,ORDE,8
FITEM,5,1011
FITEM,5,1015
FITEM,5,-1029
FITEM,5,1045
FITEM,5,-1059
FITEM,5,1061
FITEM,5,1064
FITEM,5,-1067

ASEL,R, , ,P51X           ! Selecting Main Rail Areas
ALLSEL,BELOW,AREA

FLST,2,2,1
FITEM,2,151976
FITEM,2,153615
PATH,LPath,2,30,40,
PPATH,P51X,1                 ! Path on Left Rail

PDEF,STAT
AVPRIN,0,0,
PDEF, ,U,Y,AVG              ! Mapping Results to Path

PAGET,L_Path,TABL           ! Storing Path Items in Array

FLST,2,2,1
FITEM,2,152758
FITEM,2,153550
PATH,RPath,2,30,40,
PPATH,P51X,1                 ! Path on Right Rail

PDEF,STAT
AVPRIN,0,0,
PDEF, ,U,Y,AVG              ! Mapping Results to Path

PAGET,R_Path,TABL           ! Storing Path Items in Array

!-------------------------------------------
!------------ Writing Path Data to Text File
!-------------------------------------------

!/EOF
!:txt

*CFOPEN,XL_couple_R_Path,txt, ,
*VWRITE,R_Path(1,1),R_Path(1,2),R_Path(1,3),R_Pat
h(1,4),R_Path(1,5), , , ,
(F12.4,F12.1,F12.4,F12.1,F12.4)
*CFCLOS

*CFOPEN,XL_couple_L_Path,txt, ,
*VWRITE,L_Path(1,1),L_Path(1,2),L_Path(1,3),L_Path(
1,4),L_Path(1,5), , , ,
(F12.4,F12.1,F12.4,F12.1,F12.4)
*CFCLOS


/EOF

!-------------------------------------------
```