STRUC

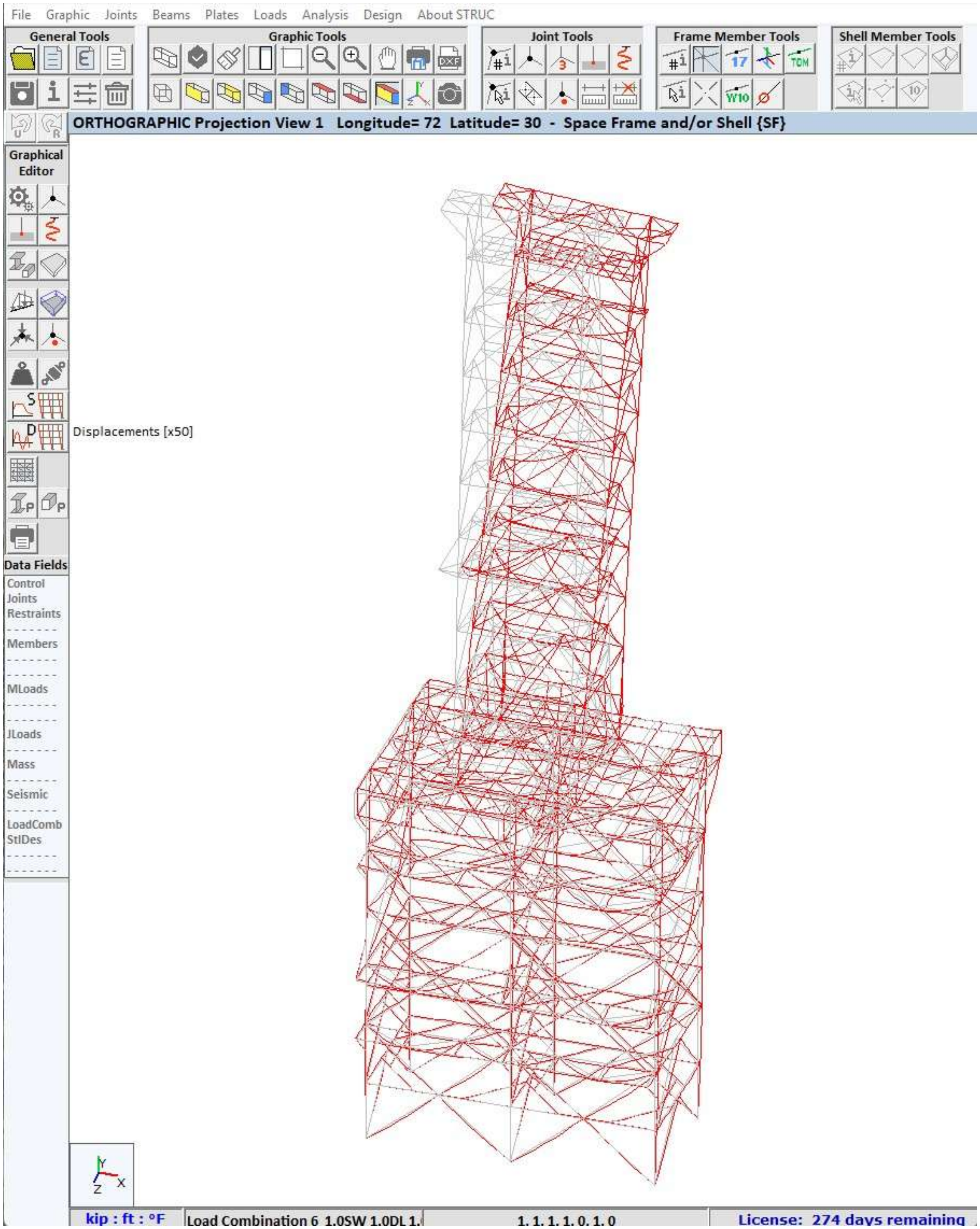
Version 2

LINEAR FINITE ELEMENT
STATIC, SEISMIC AND DYNAMIC ANALYSIS
SOFTWARE
FOR 3D STRUCTURES

STRUCTURAL STEEL VERIFICATION
CODE: AISC ASD-89 or AISC 360-10/16

REINFORCED CONCRETE DESIGN
CODE: ACI 318-19

For Windows®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Sample

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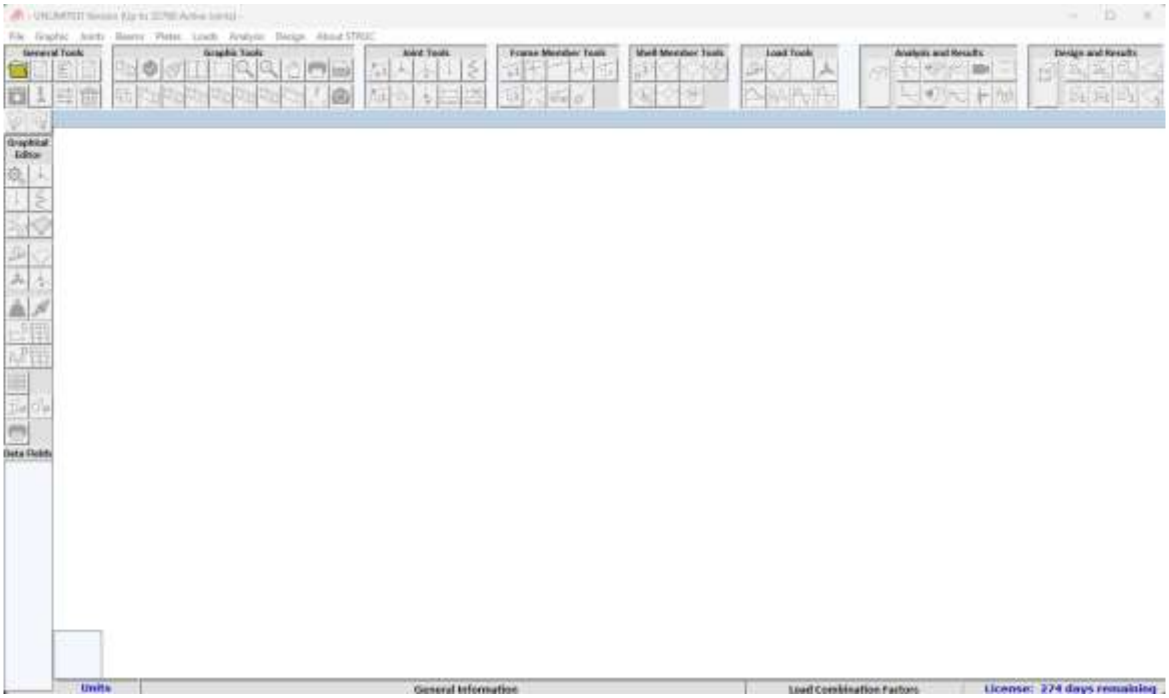
A *OPERATION MANUAL*



1 OVERVIEW

The Software is based on the structural direct stiffness method by means of a global stiffness and geometric matrix [**K**], global mass matrix [**M**] and global damping matrix [**C**] with sky band profile and band width optimization, assembled from member's local stiffness, mass, and damping matrices plus the load conditions [**F**] for Static and Seismic Loads, and [**F(t)**] for Dynamic Loads (variable throughout time). These reduced matrices are stored and processed out of core.

For Static and Seismic Analysis, the general equation to be solved for [**δ**] is in the form:

$$[\mathbf{K}] \times [\boldsymbol{\delta}] = [\mathbf{F}]$$

For Dynamic Analysis, the general equation to be solved for [**δ**], [**α**] and [**v**] (variable throughout time) is in the form:

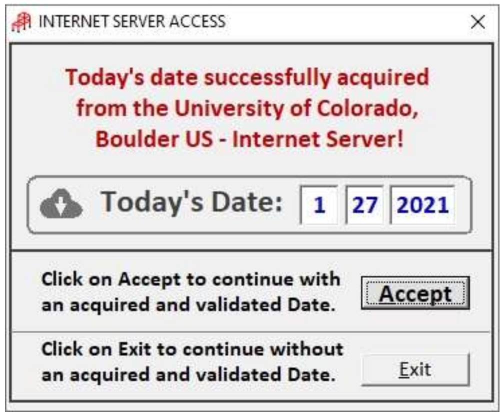
$$[\mathbf{C}] \times [\mathbf{v}] + [\mathbf{M}] \times [\boldsymbol{\alpha}] + [\mathbf{K}] \times [\boldsymbol{\delta}] = [\mathbf{F(t)}]$$

Where:

[**v**] "Time History" of Joint Global Velocities
[**α**] "Time History" of Joint Global Accelerations
[**δ**] "Static" or "Time History" of Joint Global Displacements

Analysis and design results have been cross verified through several commercial software and several related books of reference (See C Verification Examples).

The software runs under Windows® operating system. It requires at least 3 Gigabytes in RAM memory, 1920 x 1080 or higher video resolution and at least 2 Gigabytes available in hard drive. The size of a model is taken from the active joint quantity (joints free to move in any of its 6 degrees of freedom for Space Frames and Shell Structures). The greater the quantity of joints and members on the structure the larger the free space required in the hard drive. It also requires to be **"Run as administrator"** from the operating system, and one INTERNET connection to acquire the date to validate the license.



The software will obtain the computer user's name, which will appear in all written reports.

The software is available in three different versions according to its analysis capability and total cost. All versions can create an input data file and pre-analyze any structure size. However, regarding the analysis and design:

1. The LIMITED version is limited to 32 active joints.
2. The ACADEMIC version is limited to 128 active joints.
3. The UNLIMITED version offers a maximum of 32,700 joints for static analysis and 10,000 joints for dynamic analysis, and both with a maximum of 200,000 structural members.

A proprietary access code is supplied for versions 2 and 3 which must be entered during the software installation phase. This access code is linked to the system and valid only for a particular computer system and will not work in any other computer system. If the access code is missing or misspelled, the software works as the LIMITED Version.

To obtain the installation code the user must send an e-mail to the author with the identification code shown in red to the right of the "System ID No." field of the Login Password form, and a proof of purchase. This alphanumeric code is unique and will be linked to the system. Upon verification of the above information, an e-mail will be sent back with the proper installation code in accordance with the acquired software version to be installed.

Software Main Scope and Features

Chap.	Item
2.1	Text Editor and Graphical Editor Pre-Processing and Post-Processing of Input and Output data
2.1	Six available system of units for lengths, and forces and two for temperatures
2.1	Continuous Beam. Plane Truss and Frame. Space Truss, Frame and Shell elements
2.1	Generation of Joints, Restraints, Springs, Members, and Shells
2.1	AISC or EURO Frame Member Data Base for Design. Any Used defined section for analysis only
2.2	Frame Member's local plane 1-2 oriented in 3D
2.3	Up to 32,700 joints for Static analysis and 10,000 Joints for Dynamic Analysis
2.3	Automatic Joint renumbering to minimize Global Matrices Half Band Width
2.3	Fast 32-bit In-Core and Out-Of-Core Engine solution of up to 196,200 linear equations
2.3	Restraints, Spring Supports, and Induced Displacements in any of the 6 DOF's
2.4	Up to 200,000 Frame Members and Shell Members
2.4	Up to 10 types of Frame Member End Releases at any member end (4 Moments, 4 Shears, Axial, and Torsion)
2.4/2.6	Frame and Shell members with shearing deformation effects available
2.4	Tension Only verification/design Frame Members available
2.4	Materials MTOs available
2.5	Up to 2 Master Joints per Frame Member to simulate slabs in-plane rigidity
2.7	Joint Loads (forces and moments) in any of the 5 DOF'S in Global Coordinates
2.8/2.9	Frame and Shell Member with Loads along Local Planes and Global Planes (Point Loads and Trapezoidal Loads)
2.10	Up to 100 Basic Load Conditions
2.11	Up to 1,000 Load Combinations of the Basic Load Conditions
2.12	Frame Members with P-Δ effect in Static/Dynamic Analysis by Geometric Stiffness Matrix Correction
2.13	Print a user selection of output information
2.14	Concrete design by ACI 318-19 (Frame Rect. Members, Circ. Columns, and Shells in Shear and Flexure)
2.15	Parameter Designs for Framed member Steel Structures
2.15	Steel design by AISC 360-10/16 (Tension, Compression, Shear and Flexure verification)
2.14/2.15	Frame Member's deflection verification
2.16	Automatic calculation of Self-Weight and Mass of the structural system
2.17	Damping of the structural system available for Dynamic analyses
2.18	Response Spectrum defined by Code (ASCE 7-16/NSR-10) or defined by the User
2.18	Static User defined loads and forces, and ELF/Response Spectrum by ASCE 7-16
2.19	Dynamic with Time History analysis for Eigen's, Modal Superposition, Step Integration, and Steady State
C	Analysis and design results cross verified with available commercial software and several published literatures

1.1 Software Installation

Do not copy the files directly from the distribution files as they will not be correctly installed in the system.

1. Download the file "Struc.exe" from the Internet to the Hard Disk Drive of the system (this is a self-extracting file). Please visit us at "STRUC21.COM".
2. Run the file "Struc.exe" to extract the files Setup.exe, Setup.lst and Struc.CAB.
3. Run the file "Setup.exe" as "**Run as administrator**" from the Windows® operating system and follow the on-screen instructions. Do not change any destination folder.
4. Once the software is satisfactorily installed, it will create a folder called \SOFTWARE FILES\STRUC in the hard drive of the system, where the files integrating the software will be copied and an icon is created in the SOFTWARE menu; the name of this folder must not be changed during installation.
5. Just for the first execution time the software will ask the installation code in accordance with the software version acquired. The software will be installed in accordance with this version.

The installation is valid for a maximum of 365 days from the installation date. At the end of this period the user must purchase another installation code which is different from the one used last year. The software will ask for this new installation code. Another 365 license days will take effect if this new installation code is correctly entered. If it is not entered correctly then the software will be installed as a LIMITED version.

During the 365-day period the user can purchase a new and better software version. To validate this new software version just click the lower right corner where the remaining license is shown in blue. The software will ask for an especial code to change the software version. Upon entering a correct change code, the software will ask for the new installation code in accordance with the new software version which will reset the license for a new 365-day period.

List of main files integrating the Software:

STRUC.EXE Software.
AISC15.BIN Data base with the AISC 15th Edition shapes properties.
AISC15N.BIN Data base with the AISC 15th Edition shapes nomenclature.
EURO.BIN Data base with the European shapes properties.

A set of input files related to the analysis and verification examples (See Appendix B and C) are copied during installation. The "STATIC EXAMPLE" file is among this set of files. This file corresponds to the data input file for the example shown in this operation manual in Appendix B.

1.2 Identification of files generated by the software

The structural analysis is done based on the preliminary analysis and graphic check until the displacements, reactions, members internal forces, any of the Different seismic or dynamic analysis and the reinforced concrete design and/or structural steel check of the structure members are obtained. All this data is conveniently saved in the following files and stored as text files ready to be printed.

name	File with the input data for a particular structural model.
nameEXP	File containing the input data of the **name** file expanded not using data generation.
name.EQN	Original joint numbers, assigned joints and assigned equations to joint's degree of freedom.
name.STR	Input data arranged for printing.
name.ERR	List of the errors found during the Pre-analysis phase.
name.DRF	Displacements.
name.DSM	Displacements summary.
name.RCN	Reactions and applied forces.
name.RSM	Shells Reactions summary.
name.IF3	Members internal forces.
name.SIF	Shells internal forces.
name.SFS	Shells internal forces summary.
name.SST	Shells internal stresses.
name.SSS	Shells internal stresses summary.
name.EIG	Eigenvalues and Eigenvectors.
name.ESM	Eigenvalues and Eigenvectors summary.
name.MOD	Modal superposition Time History.
name.MSM	Modal superposition summary.
name.STP	Step Integration Time History.
name.SSM	Step Integration summary.
name.STS	Steady State Time History.
name.SSM	Steady State summary.
name.RSP	Response Spectrum.
name.RSM	Response Spectrum summary.
name.CON	Reinforced concrete member's design.
name.STL	Structural steel member's check.

The software generates a series of working files which are useful only during the analysis and may be, therefore, ignored and/or deleted afterwards. The software provides a tool which allows erasing temporary working files, keeping those previously listed, or erases every file except the "**name**" model Input data file.

Subspace Iteration Method	Klaus-Jurgen Bathe "Finite Element Procedures in Engineering Analysis" 1982 by Prentice-Hall, Inc., Englewood Clifs, New Jersey 07632
Step by Step Integration Method	E. L. Wilson, I. Farhoomand, and K. J. Bathe "Nonlinear Dynamic Analysis of Complex Structures," International Journal of Earth-quake Engineering and Structural Dynamics, Vol. 1, 1973, pp. 241-252.

Computation of Rayleigh Damping Coefficients for Large Systems by Indrajit Chowdhury and Shambhu P. Dasgupta.

For more information visit us at: "www.struc21.com".

1.3 Disclaimer

The author is not responsible for an improper or wrong use of this software and the corresponding generated data. Therefore, it is the user's responsibility to obtain and properly use the input data and results of the analysis and design carried out with this software.

2 SOFTWARE SCOPE

2.1 General description

The software is designed to provide the user with a tool to analyze and design, for static, seismic, or dynamic loads, plane, or space structures in reinforced concrete and/or structural steel.

The software offers two types of elements to be used in any given structure. "Frame" element type and "Shell" element type.

Frame element members:
Element defined by a two-node linear shape with constant prismatic section in all its length and on a two or three-dimensional configuration, conforming five possible types of structures as follows:

1 Continuous beam (CB) Two-dimensional and defined along the **X** global axis, and in the plane comprised by the **X-Y** global axes.

2 Plane truss (PT) Two-dimensional. Its members cannot transmit moment at their ends; they are defined in the plane comprised by the **X-Y** global axes.

3 Plane frame (PF) Two-dimensional. Its members can transmit moment at their ends; they are defined in the plane comprised by the **X-Y** global axes.

4 Space truss (ST) Three-dimensional. Its members cannot transmit moment at their ends; they are defined in the space comprised by the **X, Y** and **Z** global axes.

5 Space frame (SF) Three-dimensional. Its members can transmit moment at their ends; they are defined in the space comprised by the **X, Y** and **Z** global axes.

Shell element members:
Element defined by a four-node isoparametric quadrilateral shell with constant thickness and on a two or three-dimensional configuration, conforming two possible types of structures as follows:

1 Plane Shell (PS) Two-dimensional. Its members behave as a membrane transmitting in-plane shear forces only; they are defined in the plane comprised by the **X-Y** global axes.

2 Space Shell (SS) Three-dimensional. Its members behave as a plate transmitting in-plane shear forces and out of plane shear and moments; they are defined in the space comprised by the **X, Y** and **Z** global axes.

The structural model data file input may be created by using the software's Text Editor or Graphical Editor.

To facilitate the creation of the Structure's data file through the Text Editor, joints, restrictions, spring type supports, members (frame and shell), loads and induced displacements may be generated.

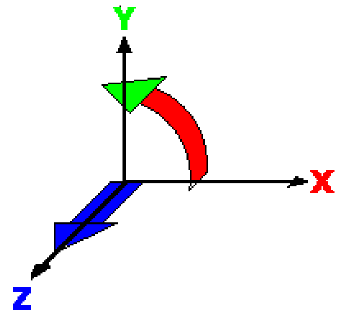
Initially, the software does a pre-analysis of the text input data file to detect possible errors or warnings. A file with all errors or warnings is created, showing the line where they are located and what is an error or warning. Depending on the type of error found the user shall correct them and start again with the pre-analysis phase until there are no errors or warnings to then continue with the analysis and design phase.

The software allows the user to choose a set of units from six different types of units for forces, six for dimensions, and two for temperatures. However, it is the user's responsibility to consistently input all data according to the set of units chosen. The design is carried out in accordance with ACI 318-19 and AISC ASD 89 or AISC 360-10/16 ASD or LRFD codes and provisions.

For Frame Members, Static, Seismic and Dynamic analyses, the software allows the user to do the analysis and design phase considering the secondary effects produced by the P-Δ effect in the direction of both the **X** global axis and the **Z** global axis. This effect will be properly carried out with displacements within the elastic region.

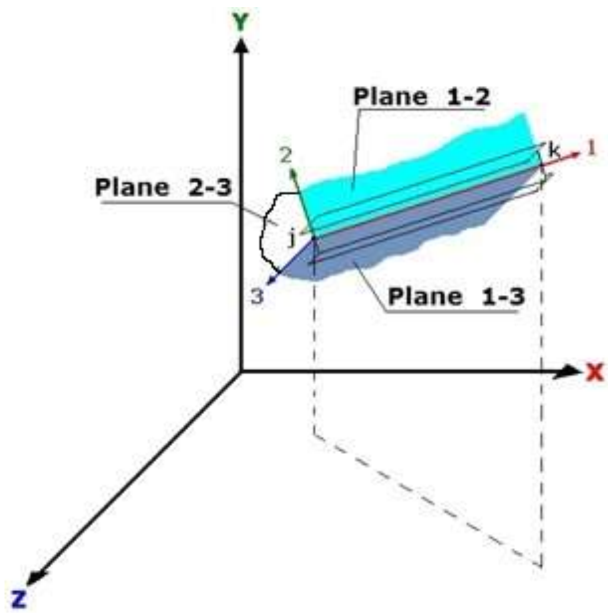
The steel shape's database of the AISC Manual, AISC15.BIN file and the European shapes, EURO.BIN file, contains the geometric properties to be used in the analysis and design phases of frame members. For a list of available shapes, see Appendix D.1 and D.2.

2.2 Global and local axes



Structure - Global axes X, Y, Z

The model must be defined within a **X, Y, Z** global axes system so that the **X** axis runs to the right; the **Y** axis goes up in vertical direction conforming the main plane **X-Y**; and the **Z** axis as perpendicular to the **X-Y** plane and according to the right-hand rule.

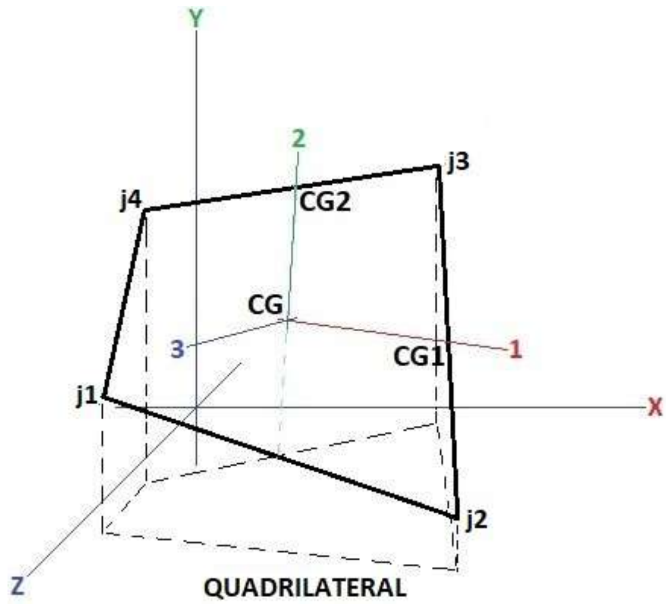


Member element - Local axes 1, 2, 3

Each member element is defined by three local axes system (**1, 2** and **3**), as follows:

Local axis **1** Along the member's central axis from the initial joint **j** to the ending joint **k.**
Local axis **2** Perpendicular to axis **1** and conforming Plane **1-2,** preferably oriented in its major bending plane.
Local axis **3** Perpendicular to axis **1** and conforming Plane **1-3** and Plane **2-3**, perpendicular to the Plane **1-2** and following the right-hand rule (from local axis 1 to axis 2 defining axis 3).

The orientation of local plane **1-2** determines each member's orientation in space and it's defined by using any two joints of the structure or using the global axes **X, Y** and **Z**, so that they identify the direction of local plane **1-2**. These joints may or may not belong to the member itself.



Shell element - Local axes 1, 2, 3

Each isoparametric quadrilateral Shell element is defined by four global joints (**j1,** j**2**, j**3** and j**4**) which defines the member local axes system (**1, 2** and **3**) orientation as follows:

Local axis **1**	From the shell's Center of Gravity (**CG**) to the **j2-j3** side's center (**CG1**).
Local axis **2**	From the shell's Center of Gravity (**CG**) to the **j4-j3** side's center (**CG2**).
Local axis **3**	Perpendicular to shell's plane and following the right-hand rule (from local axis **1** to local axis **2**).

2.3 Joints, restraints, and induced displacements

The joints numbering is free and up to a maximum of 32,700, they do not need to be consecutive. The software internally renumbers all joints to minimize the semi-band width of the global stiffness, mass and damping matrices resulting in a smaller RAM and Out of Core (HDD) consumption and a shorter execution time. In the results output the software use the original numbers assigned by the user to all joints and members.

For Frame Members, the Master Joints cannot be located coinciding on any member of the structure.

The restraints defining the type of support can take the following values:
Free to movement or rotation = 0 and default value. Restrained to movement or rotation = 1

The displacement or rotational restraints of all structural joints must be defined depending on the type of structure under analysis. The software always assumes a space frame or a space shell (6 DOF or degrees of freedom for each joint) where all joints are free to displacement and rotation. For a space frame or space shell structure only the supports restraints need to be defined (See Table 4.2 in 4.4.4).

For each possibility of displacement or rotation of each joint, the software adds one more degree of freedom (DOF), which will be assigned to an equation within the global stiffness matrix, forming as many equations to be solved as free DOF's exist in the structure.

Use the convenient restraints to define the type of structure to be analyzed to assign the exact quantity of degrees of freedom or equations to be solved which will result in a smaller RAM and Out of Core (HDD) requirements and therefore a shorter execution time.

A fast 32-bit in-core and out-of-core solution engine of the system of linear equations is available.

It is possible to define spring type supports, including displacement or rotation if the related degree of freedom has been previously defined as free to the corresponding restraint.

Any joint may have induced displacements before the analysis, of fixed magnitude and different from zero, according to the type of structure (plane trusses, space trusses, etc.). When using this option, it must be noticed that all load conditions will be equally affected by these induced displacements and that the degree of freedom related to each induced displacement must be defined as restraint free (or restraint equal to 0).

2.4 Member properties

Members numbering is free and up to a maximum of 200,000, they do not need to be consecutive, but it must be observed that the results will be given in the same order they were defined.

It is possible to use members of different types of structure within the same model, as follows:

- Plane Truss members with Plane Frame members.
- Space Truss members with Space Frame members and Shell members.

For reinforced concrete the poison ratio μ used is 0.20, and for structural steel the poison ratio μ used is 0.28. (See 4.4.6 MEMBERS mechanical properties).

Members with inertia as user-defined or software-calculated using the SH= option (See 4.4.6) will be treated as frame members, and those having only the section area defined and no calculated or defined inertia, will be treated as truss members (hinged ends, unable to transmit moment and taking only axial forces).

Shear deformation effect is not computed if member's shear areas are defined as 0.00.

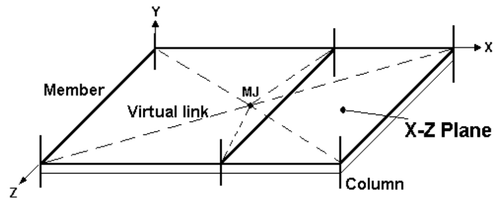
Moment and Shear end releases can be defined in either end of each structural member for plane and space frames. Axial release along local axis 1 and Torsion release around local axis 1 can also be defined.

Any member may be defined as Tension Only Member and will only be designed in accordance.

Material's MTOs are computed based on member's self-weights.

2.5 In-plane slabs stiffness

To simulate the in-plane large stiffness of a slab and/or vertical curtain in the model without using shell elements, a joint known as Master Joint (**MJ**) must be defined for those members belonging to this slab and/or vertical curtain. The MJ must be in the same stiffness plane of the slab and/or vertical curtain and may be in the center of gravity of the slab and/or vertical curtain, to facilitate the allocation in this joint, of loads parallel to the stiffness plane, like concentrated horizontal and static earthquake loads in the slabs. These loads will be automatically transferred only to the columns depending on their stiffness. Any member may have only up to 2 Master Joints (**MJ**).



The rigid planes simulated by Master Joints do not have to coincide with any of the planes formed by the global axes **X**, **Y** and **Z**.

For any joint defined as Master Joint the maximum number of joints associated belonging to the members of the slab and/or vertical curtain is 200.

2.6 Shell properties

For analysis accuracy within the double integration internal algorithm used by the software, it is recommended that Shell's minimum side length won't be less than 5 times the shell thickness, to be considered as a Sheel and not as a Solid.

Shells numbering is free and up to a maximum of 200,000, they do not need to be consecutive, but it must be observed that the results will be given in the same order they were defined.

For reinforced concrete the default poison ratio μ used is 0.20, and for structural steel the poison ratio μ used is 0.28. (See 4.4.7 SHELLS mechanical properties).

2.7 Solid properties

Under development.

2.8 Joint loads

Defined by the field JLOADS. These loads are applied only on the joints of the structural model and grouped by load conditions. They consist of forces in the direction of the three global axes **X**, **Y** and **Z** and moments around the three global axes **X**, **Y** and **Z**. (See 4.4.9 JLOADS).

2.9 Member loads

Definitions

Load Patterns:

Defined by the field MLOADS in the patterns loads library section. They are a library groups of loads to be applied over the members. For each load pattern only one type of, trapezoidal load (**WL**)**,** concentrated load (**PL**)**,** thermal load (**TL**) and global load (**WG**) is allowed. Each defined load pattern may include all four load types (**WL**, **PL**, **TL** and **WG**).

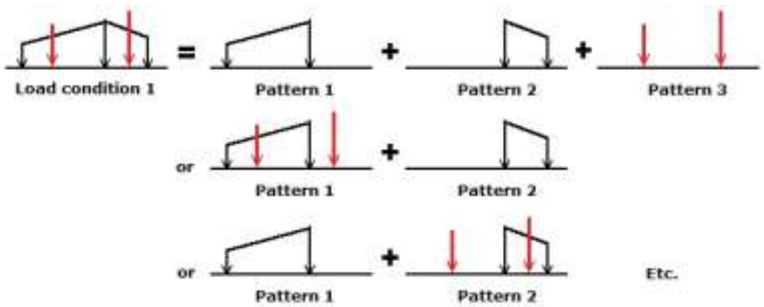
Member Loads:

Defined by the field MLOADS. These loads are grouped as Load Patterns and include:

Trapezoidal **WL**, concentrated **PL,** or thermal **TL** local loads, applied over the members and in member's main planes according to local axes conforming planes **1-2** and **1-3**.

Global uniformly distributed type **WG**, in the structure main planes and according to global axes **X, Y** and **Z**. (See 4.4.10 MLOADS).

Following is an example of a Load condition 1 to be applied to any member as required and composed by two trapezoidal loads (**WL**) and one concentrated load (**PL**) with two forces. It can be defined using different load patter arrangements as shown below.



2.10 Shell loads

Defined by the field SHLOADS. These loads are grouped as Load Patterns and include. (See 4.4.11 SHLOADS):

Membrane and Surface **WL** loads applied along shell's sides and shell's surface, thermal **TL** local loads applied on the Shell's membrane according to local axes **1** and **2**.

Global uniformly distributed type **WG** loads applied on shell's projected surface, in the structure main planes and according to global axes **X, Y** and **Z**.

2.11 Solid loads

Under development.

2.12 Load conditions

Load conditions are usually Self Weight, Dead Load, Live Load, Seismic Load, Wind Load, etc.

Each load condition may include up to 10 load patterns, which enables to construct especially complex load systems to be applied to any Frame or Shell member.

The load directions in member local coordinates are defined by each member's main planes and its orientation and direction depend upon the spatial orientation of local planes **1-2** and **1-3** of each member. (See 2.2 Local and Global Axes).

For structures defined as Plane Truss or Plane Frame, loads can only be defined in the main plane **X-Y**, which must be the same **1-2** plane of all members. For structures defined as Space Truss, Space Frame or Space Shell, loads may be defined in each member's local planes **1-2** and **1-3**, or in the structure's main planes and according to global axes **X**, **Y** and **Z**.

The self-weight may be activated in the analysis for one of the load conditions only and in the direction of one of the three global axes **X**, **Y** and **Z** only. A convenient multiplier is used to define the orientation (sign) and magnitude.

The software limits the number of basic load conditions to 100, to which an appropriate load name shall be assigned by the user preferably using short names like SW for self-weight, DL for dead loads, LL for live loads and so on. The software will conform appropriated names for all load combinations using these load condition names.

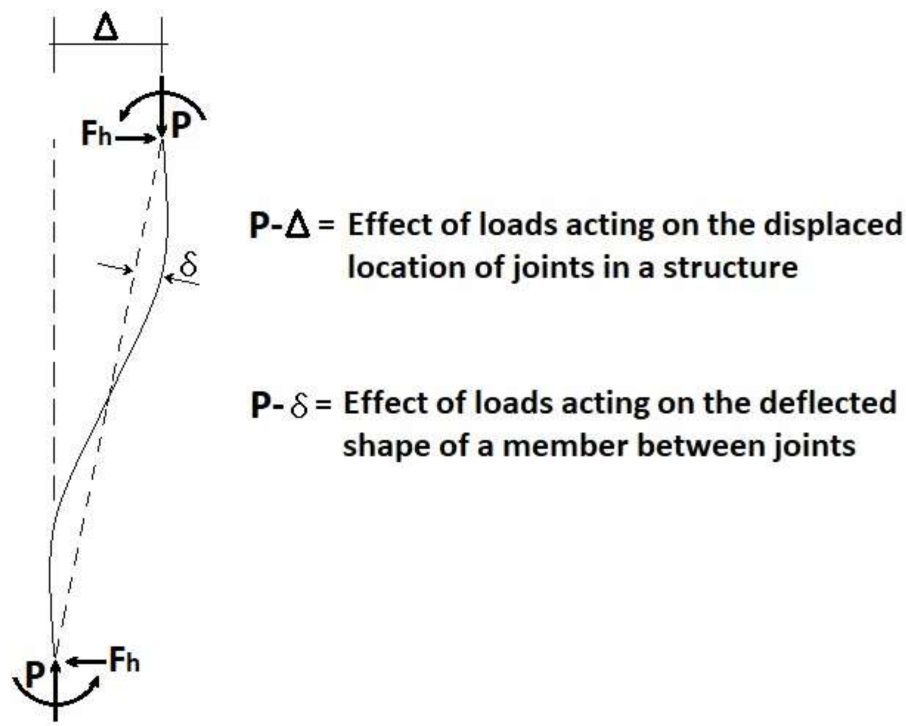
2.13 Combinations of load conditions

The software limits the number of load combinations of basic load conditions to 1,000. If no combination of load conditions is defined, the software will deliver the displacements, reactions, forces, and designs for the original load conditions only.

Names for load combinations are generated based on load condition names previously defined. See 2.12 "Load Conditions".

2.14 P-Δ second order analysis

For Frame Members, only the **P-Δ** Second Order effect is included, and the effect of P-δ won't be included. See description below.



The analysis procedure consists of performing two cycles. First cycle: a) assembly of the global stiffness matrix, b) placement of all associated Gravity loads (that remain constant during any horizontal event), and c) structural system solution to find out the Axial loads due to Gravity Loads condition only, to then compute the Member's Geometric Stiffness Correction matrix. A second and final cycle with the new Global Stiffness matrix and Geometric matrix to compute final displacements and internal forces for all load conditions and with the **P-Δ** Second Order effect.

To capture the P-δ effect it is suggested to subdivide beam/column members in several sections as needed.

For each horizontal direction or global axes **X** and **Z** the software computes a ratio factor of all displacements now including the **P-Δ** Second Order Analysis, and only for Static analysis, not ELF.

The **P-Δ** effects is valid for: Horizontal loading analysis defined by user, Equivalent Lateral Force ELF analysis, Response Spectrum RS analysis, Eigenvalues, and Dynamic analysis.

2.15 Print selection

The software allows to select the joints and load combinations (or load conditions if no combinations are defined), for which the deformed shape, reactions and applied forces will be delivered in the output.

It is also possible to select the members, in an order defined by the user, and the load combinations (or load conditions if no load combinations are defined) for which the corresponding internal forces and designs will be delivered.

2.16 Reinforced concrete member design

The design code used is ACI 318-19.

For all members defined in concrete, and for each combination of load conditions defined in field LOADCOMB, the software identifies the members working as a column as where material property RS was defined, which is the amount of reinforcement located at rectangular column sides, or lateral reinforcement type for Circular columns during the bi-axial bending design phase. (See 4.4.6.2 Design properties). All other members with materials with no RS defined or equal to 0, will be designed as beams.

For each member the software evaluates the global stress amplification factor Dg and the local stress amplification factor Dl. The software defines for all members, for each bending plane, a maximum allowed slenderness (K x L / RG) of 100.

After completing the designs corresponding to each load combination, the software identifies, for every member, the combination producing the higher reinforcement ratio for bending (beams) or bi-axial bending (columns), and the load combination producing the higher reinforcement ratio for combined shear and torsion (beams and columns); this design, together with its percentage of use and its corresponding combination numbers, is the one shown on the design lists. Each member's design yields a percentage of use which enables the user to evaluate and optimize the design quality.

The design of members identified as beams is performed using the section's characteristics, material specifications, bending moment, axial force, shear in plane **1-2** (which must be the major bending plane) and torsion, including both member ends and the maximum span moment if there is any.

The bi-axial bending design for both ends of members identified as column, is performed using the section characteristics, material specifications, axial force, the vector sum of shear in planes **1-2** and **1-3**, torsion and the two bending moments from planes **1-2** and **1-3**, respectively. The reinforcement position in the faces and sides of rectangular sections may be controlled by the RS factor as well as the lateral reinforcement type of Circular sections, which are described in the section characteristics (See 4.2.6.2 Design properties).

Limits of Reinforcement Ratios and percentage of use

Bending or bi-axial bending:

For members designed as beams in bending the corresponding reinforcement ratio and area in cm^2 or in^2 are calculated. This reinforcement will be placed in the proper face of the section in accordance with the respective moment diagram. For a minimum reinforcement ratio there is a percentage of use of 0, for a maximum reinforcement ratio without compression reinforcement there is a percentage of use of 100, and for a maximum reinforcement ratio with compression reinforcement there is a percentage of use of 175 and is the maximum allowable by the section. For designs with percentages of use over 175 the section is not sufficient (INSUFFICIENT). Is the user responsibility to accept designs with compression reinforcement, or percentages of use over 100.

For members designed as columns (Rectangular or Circular) in biaxial bending the corresponding reinforcement ratio and area in cm^2 or in^2 are calculated. For a minimum reinforcement ratio of 0.01 there is a percentage of use of 0, for a reinforcement ratio of 0.05 there is a percentage of use of 100, and for a maximum reinforcement ratio of 0.08 there is a percentage of use of 175 and is the maximum allowable by the section. For designs with percentages of use over 175 the section is not sufficient (INSUFFICIENT). The minimum reinforcement ratio used is 0.01 and maximum reinforcement ratio used is 0.05. ACI 318-19 defines a maximum reinforcement ratio of 0.08 but the software uses 0.05 for constructability reasons. Is the user responsibility to accept reinforcement ratios over 0.05 or percentages of use over 100.

Combined shear and torsion:

For beam or column members the software calculates a transverse reinforcement area for shear expressed as Av/l and a transverse reinforcement area for torsion expressed as 2At/l. Av and At are in cm^2 or in^2, l is in cm or in; so that the user chooses an appropriate distance between tie sets (or pace for spirals) and multiplies this value by the sum of Av/l and 2At/l to find the total area of one tie set or spiral. If the tie set has 2 branches the area of each branch is computed by dividing this total area by 2, etc. The software also calculates a longitudinal reinforcement area for torsion expressed as Al in cm^2 or in^2. This longitudinal reinforcement, additional to the reinforcement for bending, must be placed distributed around the entire section perimeter. For a minimum reinforcement ratio of 0 there is a percentage of use of 0, for a maximum longitudinal and transversal reinforcement ratio there is a percentage of use of 100. For designs with percentages of use over 100 the section is not sufficient (INSUFFICIENT).

Lateral reinforcement diameter (stirrups or spirals) equal to ½" (or #4) is assumed. If the actual lateral reinforcement diameter used is different from ½" (or #4), slight errors will result.

2.17 Structural steel members verification

The design codes and provisions available are AISC ASD 89 or AISC 360-10/16, ASD or LRFD.

Some values of Min. Yield Stress Fy and Tensile Stress Fu for available shapes and plates, taken from AISC Table 2-4 and Table 2-5.

ASTM Designation	Fy Yield Stress (ksi)	Fy Yield Stress (kN/m^2)	Fu Tensile Stress (ksi)	Fu Tensile Stress (kN/m^2)	Structural Shapes AISC
A36	36	248,434	58	400,209	M, S, C, MT, ST, MC, L, 2L, Plates
A53 Gr. B	35	241,533	60	414,037	HSS Pipe
A500 Gr. C	46	317,443	62	427,859	HSS Round
A500 Gr. C	50	345,047	62	427,859	HSS Rect.
A572 Gr. 50	50	345,047	65	448,562	HP, Plates
A992	50	345,047	65	448,562	W, WT

AISC ASD-89 design provisions

The software evaluates for each member, the global stress amplification factor Dg, and the local stress amplification factor Dl.

If the user does not define the slenderness factors K for each material in both planes (**1-2** and **1-3**), the software evaluates them for each member and for each bending plane, as follows:

a. If a member belongs to a Truss type structure (both ends hinged) the slenderness factor K for both planes is taken equal to 1.00.

b. If a member is not hinged at one end but the other end is hinged for any plane, the K factor for this plane is taken as 1.18.

c. If a member is not hinged at neither end for any plane, the K factor for this plane is taken as 1.32.

For each bending plane the software defines, for tension members a maximum slenderness (K x L / RG) of 240, and for compression members a maximum slenderness of 200.

For each load combination and based on: the member's length L, its slenderness in each plane, the sectional area A, the shear resisting areas A2 and A3, the moments of inertia I3 and I2 and the radii of gyration RG2 and RG3 in both planes, the modulus of elasticity E, the yield strength of the material Fy, the axial force Pu, the bending moments M1-2 and M1-3 and the shear forces V1-2 and V1-3 in both planes; the software evaluates:

1. The capacity for combined stress, axial force, bending moment in plane **1-2** and bending moment in plane **1-3**, the respective percentages of use and the total percentage of use for combined stress; the highest percentage is shown in the Combined Stress report. The pre-selected shape with a total percentage of use below 100% is considered to fill all the design requirements.

   Allowable stress = 0.60 Fy.

2. The shearing stress capacity in the planes **1-2** and **1-3** as percentages of use; the higher percentage is shown in the Shear Stress report. The pre-selected shape with a total percentage of use below 100% is considered to fill all the design requirements.

   If the shear areas A2 and A3 are not defined, the software assumes them equal to the sectional area.

Allowable stress = 0.40 Fy.

AISC 360-10/16 ASD or LRFD design provisions

Tension, Compression and Flexure capacity will be verified for every member of the structure and for each load combination finding a percentage of use for each stress type and for combined stress which shall be below 100%. In a similar way Shear capacity will be verified finding another percentage of use which shall be below 100%. Maximum deflection also will be verified which shall be lower than design parameter DC or DB. (See 4.4.19 "STLDES").

For each member of the structure the user must define Design Parameters for Tension, Compression, Flexure and Deflection to comply with the above mentioned and in accordance with section 4.4.19 "STLDES". If these parameters are not defined the software will use the total length of the member as the appropriate design parameter, and deflection verification will not be performed.

TENSION

Chapter D in General Provisions of AISC 360-10/16 will be used and assuming the following:

- Slenderness ratios above 300 shall be reported as a warning.
- Bolted connections with bolts ¾" Ø and 7/8" Ø holes.
- Length of connection at least equal to 3 x bf for all but HSS and Pipe shapes.
- Length of connection at least equal to 1.3 Pipe diameter for HSS and Pipe shapes and using a single concentric gusset plate.
- Flange connection with a minimum of 4 bolts ¾" Ø, and connection length = 9", for W, M, S and HP shapes.
- Flange connection with a minimum of 3 bolts ¾" Ø, for WT, MT and ST shapes.
- Connection using a minimum of 3 bolts per angle and per line, for L and a minimum of 7 bolts for 2L shapes and connection length = 9".
- Web connections with a minimum of 4 bolts for C and MC shapes.
- An is ~ 0.85 Ag, to account for bolt Ø discount.

COMPRESSION

Chapter E in General Provisions of AISC 360-10/16 will be used. For 2L it is assumed a bolted snug-tight only with a distance between intermediate bolt connectors less than or equal to 10 times dimension b. It is important to define in Design Parameters a proper value of K (in K L / R) for each flexural plane. Maximum slenderness ratio is 200, and 300 for Tension Only Members, which will not be checked for compression.

FLEXURE

Chapter F in General Provisions of AISC 360-10/16 will be used. Flexure capacity is verified for plane **1-2** or moment around local axis **3** and plane **1-3** or moment around local axis **2** simultaneously. All shapes assumed to be type Submerged Arc Welding (SAW). There is no maximum slenderness ratio checked. Tension Only Members will not be checked for flexure.

SHEAR

Chapter G in General Provisions of AISC 360-10/16 will be used. Shear capacity is verified for plane **1-2** or shear in local axis **2** and plane **1-3** or shear in local axis **3** simultaneously. All HSS and Pipe shapes are assumed to be type Submerged Arc Welding (SAW). There is no maximum slenderness ratio checked. Tension Only Members will not be checked for shear.

Tension, Compression and Flexure are combined and in accordance with Chapter H in General Provisions of AISC 360-10/16.

TORSION
Torsion design is out of the scope of this software version.

For deflection verification and design parameters see 4.4.19 "STLDES".

2.18 Mass of the structural system

The software evaluates the consistent or condensed Mass Matrix of the Structural System [**M**], based on the structure's geometric characteristics, material(s) density of which it is made up, dead loads defined as participant masses and the gravitational index by which the vertical loads or weights are converted into masses.

Having material's type defined in the section parameters, its weight is then automatically converted into the mass matrix of the structural system (generally defined as the load condition No. 1) therefore it is not necessary to further specify that weight will take part of the structural system's mass in the field MASS (See 4.4.14 "MASS"). Nevertheless, the weight (mass) will not be counted twice. Any additional weight corresponding to fixed masses in the structure will have to be specified as system masses (like floors, loads along members or lumped loads on the joints from masonry, fixed equipment, etc.) and always in different numbers of load conditions to those of the self-weight.

2.19 Damping of the structural system

See "Computation of Rayleigh Damping Coefficients for Large Systems by Indrajit Chowdhury and Shambhu P. Dasgupta" which states: "It is well known that if a single modal damping ratio is assigned to all modes, damping results will be unrealistic".

The damping of the structural system is computed based on the Rayleigh Damping Coefficients (**α**, **β**) which are based on the Modal Damping Ratios assigned by the user to each requested natural frequencies of vibration during the structural analysis.

The software will assign damping ratios for each mode of vibration requested by the user as linearly proportional to the frequency of the system.

The following realistic values (in red below) are suggested for each type of structural material, one for the first requested system mode of vibration and the other one for the last requested system mode of vibration.

Structural Material	Single value	First Requested system mode	Last requested system mode
Concrete	0.05	0.03	0.20
Steel	0.03	0.02	0.20

The global Damping Matrix [C] is computed as:

[C] = **α** [M] + **β** [K]

In which [M] is the global mass matrix of the system and [K] being the global stiffness matrix of the system.

Rayleigh Damping Coefficients (**α**, **β**) are then computed as an average of the next to last vibration mode and last vibration mode damping ratios data, thus making sure that all this is located within the linearly variation data section of the last damping ratios, (See reference above).

It is recommended to request the adequate number of modes to ensure that at least 90% of the total mass takes part in every horizontal direction (**X** and **Z**) thus ensuring to be in the proportionally linearly variation zone of the last 2 vibration modes of the system.

The user can also provide values for Rayleigh Damping Coefficients (**α** and **β)** which will be further used in the Damping Ratios and Damping Matrix [C] computation. (See 4.4.15 "DAMP").

2.20 Seismic analysis

a) Equivalent Lateral Force method (ELF). Static loads. See ASCE 7-16 PROVISIONS. ELF.

The software evaluates seismic forces by means of the Equivalent Lateral force (ELF) based on the mass matrix previously calculated, and according to a design spectrum defined in the ASCE 7-10/16, NSR-10 code, or based on a design spectrum defined and provided by the user for both the global **X** axis and global **Z** axis.

Two different and corresponding load conditions are defined for the two global axes. For plane frames, it is only necessary to define one load condition in the global **X** axis. The fundamental periods of the structure will be properly evaluated through the Rayleigh method and in accordance with ASCE 7-10/16 or NSR-10 code.

b) Response Spectrum method (RS). Dynamic loads. See ASCE 7-16 PROVISIONS.

The software evaluates the seismic forces throughout a Response Spectrum analysis (RS), according to a design spectrum defined in the ASCE 7-10/16, NSR-10 code, or based on a design spectrum defined and provided by the user for both the global **X** axis and global **Z** axis.

Define only one seismic load condition for both plane structures and space structures. The software evaluates the natural frequencies of vibration and the associated modes to such natural frequencies (or "Eigenvalues & Eigenvectors"), applying the "Subspace Iteration Method" using the desired number of Eigenvalues and Eigenvectors with a minimum of 2 and a maximum of structure displacement degrees of freedom "DOFs". This kind of analysis uses the stiffness matrix [K], the mass matrix [M] (consistent or condensed), and the damping matrix [C] of the whole structure and computed based on the stiffness matrix [K], the mass matrix [M] and modal damping ratios associated to the computed Eigenvalues. These natural frequencies of vibration will be further used in the Response Spectrum analysis (RS).

There are several mode combination methods available, which are:

- SAV (Sum of the Absolute of the Modal Response Values)
- SRSS (Square Root of the Sum of the Squares)
- CQC (Complete Quadratic Combination)

These forces will be applied to the entire structure and in the load condition(s) defined.

2.21 Dynamic analysis

For Dynamic analysis, the general equation to be solved for [**δ**], [**α**] and [**v**] is in the form of:

$$[\mathbf{C}] \times [\mathbf{v}] + [\mathbf{M}] \times [\boldsymbol{\alpha}] + [\mathbf{K}] \times [\boldsymbol{\delta}] = [\mathbf{F(t)}]$$

Where:

[**C**]	Global Damping matrix
[**M**]	Global Mass matrix
[**K**]	Global Stiffness matrix
[**F(t)**]	Dynamic Loads variable in time (t)
[**v**]	Time History of Joint Global Velocities
[**α**]	Time History of Joint Global Accelerations
[**δ**]	Time History of Joint Global Displacements

The software evaluates the natural frequencies of vibration and the associated modes to such frequencies (or "Eigenvalues & Eigenvectors"), using the "Subspace Iteration Method". This type of analysis uses the stiffness matrix [K], the mass matrix [M] (consistent or condensed), and the damping matrix [C] of the structure computed based on the stiffness matrix [K], the mass matrix [M] and modal damping ratios associated to the computed Eigenvalues.

To perform any dynamic analysis, the software first evaluates the number of Eigenvalues and Eigenvectors requested with a minimum of two and a maximum equal to the number of displacement degrees of freedom "DOF" of the structure. This number of vibration modes will be further used to run the different dynamic analysis of the structure. The running time of this analysis is very sensible to the number of Eigenvalues requested by the user. Thus, it is recommended to request only the adequate number to ensure that at least 90% of the total mass takes part in every horizontal direction (**X** and **Z**) in dynamic analyses.

The dynamic analyses available are:

a) "Modal Superposition" procedure

b) "Step-by-Step Integration", using Wilson's Ø Method procedure, with Ø=1.40

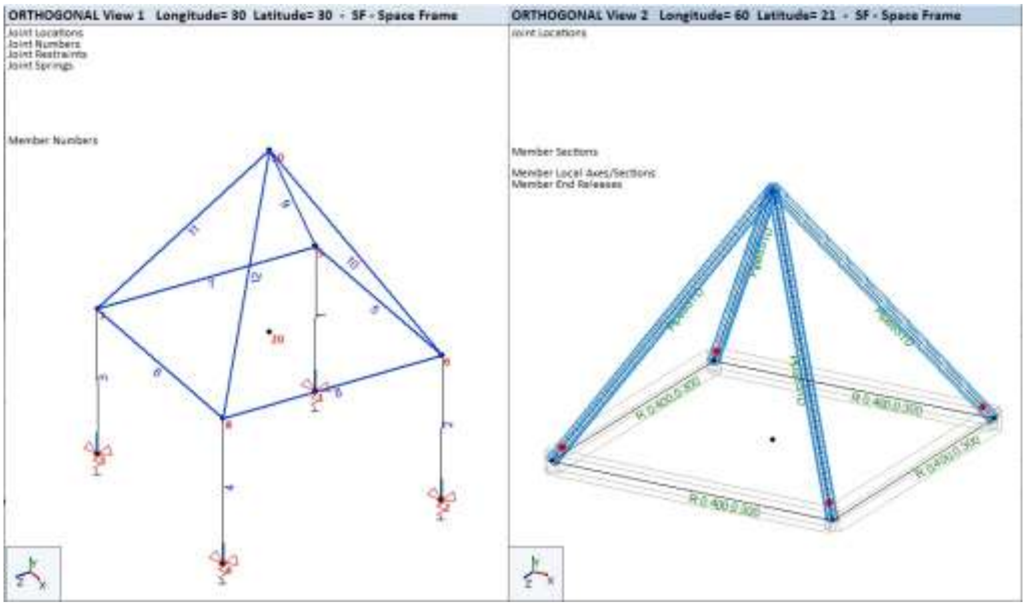
Both a) and b) Either using one or more excitation forces variable in time in any of the degrees of freedom of the structure, or throughout the use an acceleration record of the ground with respect to time (or a particular accelerograph) applied to the base of the structure.

c) "Steady State" procedure, or a forced vibration, stable in time, through the application of one forced vibration in one joint of the structure and in any global axis's direction **X, Y, Z**.

All these dynamic analyses generate a response in the time domain (Time History of Displacements, Velocities and Accelerations) defined within the excitation forces or accelerations.

In a software's future version these displacements converted to forces will be further combined with the static loads to produce an internal stress variable in time, of which the maximums will be used in the design of all members within the structure.

3 GENERAL TOOLS



The software shows the model in a single active screen or in two different screens at the same time, where only one will be the active one. The user clicks over the one chosen to be the active screen. All graphical commands will be executed over the graphic chosen as the active screen.

Using two screens allows to present in the left screen the whole model and in the right screen part of the model, or to present the model from a particular point of view in one of the screens and from another different point of view in the other screen.

Each screen has an upper caption where it is indicated if the model is presented as an ORTHOGONAL view or as a WIDE-ANGLE view. As a reference two angles, Longitude and Latitude are also shown. They show the model orientation like the terrestrial longitude and latitude.

Global axes are shown on a square located at the lower left corner of each screen and in accordance with the actual structural model orientation. The model on the screen can be rotated to the left or to the right, up or down pressing the arrow keys on the keyboard. This rotation occurs as if the user were moving around the structural model. The model and the new axes orientation is kept updated on the lower square global axis areas.

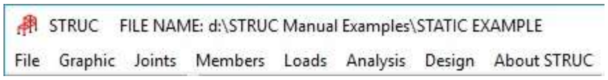
Force, dimension, and temperature units defined in the input data file are shown on the lower left corner of the screen.

Any descriptive text related to the type of graphics and load combination factors are shown on the lower central portion of the screen.

In any given time, every active graphic command is listed on the left margin of the active screen.

3.1 Pull Down Menus

A set of pull-down menus allows access of all the different functions assigned to the upper command buttons described below.



3.2 Upper Command Buttons

All the upper command buttons are oriented for the review of all the input and output data. They are grouped in 8 different categories and in accordance with their use as follows:

Top line

Open a folder to write to or read from, data of the structural model

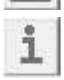
Load an existing or new data file to be edited and/or to be saved

See the error file with all the errors found by the software in the input file

See the expanded or formatted input file, a listing with the equation numbers assigned to each degree of freedom (DOF), the analysis printouts for displacements, reactions, internal forces, internal stresses, natural frequencies, percentages of mass participation, model superposition, step integration or steady state time history. Show listings with the structural design output for Reinforced Concrete or Structural Steel

Bottom line

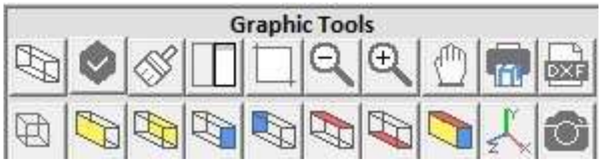
Save Text Input File



See a list with the structural model basic characteristics such as active joint and member quantities, etc.

Get Access to the general parameters such as numeric data on graphic, local axis 3, local axis or loading or displacement size, etc.

Erase intermediate files or all the working files keeping the input file only

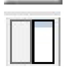


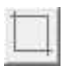
Top line

 Re-draw the model with all the original parameters over the main active screen

 Re-draw the entire model with all the original members visible

 Clean the model of all the graphical properties generated by other commands

 Show the model on two screens or on one active screen only

 Choose visible members Inside a rubber frame and using the mouse left button, or pressing the Shift button and defining the rubber frame to choose members not visible in the graphic

 Decrease the model image scale (same as mouse wheel scroll or F11)

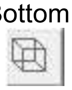
 Increase the model image scale (same as mouse wheel scroll or F12)

 Drag the model over the screen using the left button (same as pressing the "mouse wheel") and dragging the model

 Print the model image on the active screen

Generate a "DXF" file in 3D of the entire model

Bottom line

 Show the image as "ORTHOGONAL View", or "WIDE ANGLE View"

 Show the model in its frontal plane **X-Y**

 Show the model in its rear plane **X-Y**

 Show the model in its frontal plane **Z-Y**

 Show the model in its rear plane **Z-Y**

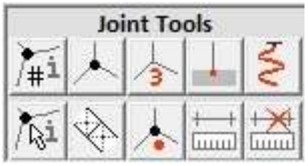
 Show the model in its upper plane **X-Z**

 Show the model in its lower plane **X-Z**

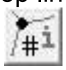
 Show the model in a 3D view (Default)

 Put the **X**, **Y** and **Z** axes in the model's origin coordinates

 Generate and save a "GIF" file of the model image in the active screen



Top line


Find in a model graphic one joint number defined


Mark in a model graphic all joint locations

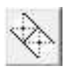

Write in a model graphic all joint numbers


Show all the joint support restrictions for displacement and rotation

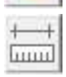

Show all joints with spring supports defined

Bottom line


Show joint information by clicking over a joint

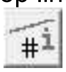

Mark in a model graphics all virtual links between the Master Joints and the Slave Joints


Show all joints with induced displacements defined


Show the distance between two joints. If this operation is repeated over the same distance, then it will be erased. This operation is suspended if the user presses the mouse right button


Erase all distances within a model's graphic

Top line

 Find in a model graphic one member number defined

 Show (Default) or hide all members in a model's graphic

 Show or hide all member numbers in a model's graphic

 Show or hide all member local axes and/or section contours in a model's graphic

 Show or hide all member's tag declared as Tension Only Members

Bottom line

 Show model information by clicking a member

 Shrink or no shrink all members from their joints

 Show or hide all member's section names in a model's graphic

 Show or hide member end releases

Top line

 Find in a model graphic one shell number defined

 Show (Default) or hide all shells in a model's graphic

 Show or hide all shell numbers in a model's graphic

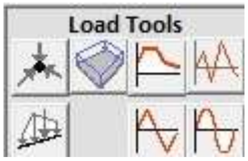
 Show or hide all shell local axes and/or section contours in a model's graphic

Bottom line

 Show model information by clicking a shell

 Shrink or no shrink all shells from their joints

 Show or hide all shell's section names in a model's graphic



Top line

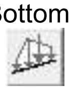
 Show or hide all joint loads per load condition in a model's graphic

 Show or hide all shell loads per load condition in a model's graphic

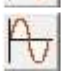
 Show or hide the Response Spectra used in the Analysis

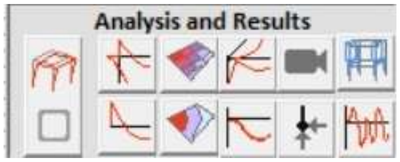
 Show or hide User defined accelerogram used in the Analysis

Bottom line

 Show or hide all member loads per load condition in a model's graphic

 Show the user defined accelerogram over a group of joints used in the Analysis

 Show the Steady State function used in the Analysis




Start the structural analysis

Top line


Show member internal forces over the model's graphic per load combination such as Shear, moment, axial force, and torsion


Show shell internal stress contour lines over the model's graphic per load combination


Show global displacements per load combination, statically or animated


Show static analysis animation parameters

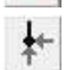

Show natural vibration modes (eigenvalues) parameters, statically or animated and start the animation

Bottom line


Shows One-member internal forces printout per load combination such as Shear, moment, axial force, and torsion


Shows One-shell internal stress contour lines per load combination


Shows One-member local displacements per load combination


Show reactions per load combination


Show One joint "Time History" graphics data (Displacement, Velocity, and Acceleration). Press "Esc" to end the process.


Start the structural design (Concrete and structural steel)

Top line


Show member percentages of use for flexure and shear for structural steel members


Show member percentages of use for deflection control in planes **1-2** and **1-3** for structural steel members


Show member percentages of use for flexure and shear for reinforced concrete members


Show shell percentages of use for flexure and shear

Bottom line


Show a list with percentage of use for structural steel members. Percentage of use for flexure and percentage of use for shear. Can be sorted by member number, flexure, or shear by clicking the corresponding list title


Show a list with member percentages of use for structural steel members, and for deflection control in plane **1-2** and plane **1-3**. Can be sorted by member number, percentages of use for deflection control in plane **1-2** and plane **1-3** by clicking the corresponding list title


Show a list with member percentage of use for reinforced concrete members. Percentage of use for flexure and percentage of use for shear. Can be sorted by member number, flexure, or shear by clicking the corresponding list title


Show a list with shell percentage of use for flexure and percentage of use for shear. Can be sorted by shell number, flexure, or shear by clicking the corresponding list title

4 BEGINING A SESSION

4.1 Defining a Model Input Data File Name

A typical session starts by creating a new structural model input data file or reading and or editing an existing structural model input data file.

In both cases click "Open File" in the Tool on the top left of the screen and choose "Drive", "Path" and input a "File Name" over which the user is going to work with.

In the example shown below the Drive chosen is "e:", the path chosen is "STRUC Manual Examples" and the File Name chosen is "STATIC EXAMPLE".

Once all this information is defined then click "**Read File**" to read the file chosen.

If the "File Name" selected is new the software loads a Template over the text editor with a minimum information needed to create a new structural model. Then the user is asked to continue using the Text Editor or the Graphical Editor. If the user decides to keep using the Text Editor, then simply continue entering data within the Text Editor. If the user decides to use the Graphical Editor, then close the Text Editor and begin creating a new file working through the Graphical Editor.

If the "File Name" selected is an existing one the software loads this file over the text editor, where it can be edited and or saved using the same file name or a new file name.

4.2 Creation and or Edition of the Input Data File using the Text Editor

By using the software's text editor, the user creates a new file or edit an existing file identified as File "**name"** containing the input data file describing a model.

The following recommendations must be observed:

1. The file must have an indicative **name** with no extension and according to WINDOWS standards.

2. The first line must contain the model's heading text.

3. After the heading text all the data must be typed in capital letters. Make sure the editor is always in capital letter condition (which is the default one).

4. Comments may be placed in any line and must be located at the right end of the data line and separated from it by at least one blank and a colon (**:**). Everything to the right of the colon is considered as a comment.

5. Comments may also be included between lines, but they must begin with a capital **C** in the first column, followed by at least one blank. Whenever the user wishes to withdraw from the model any Data Field and its corresponding data already included on the input data file, just place a **C** and a blank before the characters representing the title to make it a comment, thus, to be retired without deleting it from the file.

6. Data describing the model to be analyzed is grouped by categories using Data Fields, which are placed as titles of each group of specifically related data and starting at the first column. Some of these Data Fields are compulsory, others are not. It depends upon the type of analysis to be developed (See 4.4)

7. Lines of all other data can start in any other data column

8. A blank line must be left between all data groups headed by the respective Data Fields (See 4.4).

9. The data in each line, within each definition, must be separated by a comma (**,**).

10. In general, the data implying a numeric value and not a reference to any joint or member number, etc., may include the four basic operations in any quantity, but with the priority of multiplication and division followed by addition and subtraction, keeping the arithmetic hierarchy of the algebraic operations.

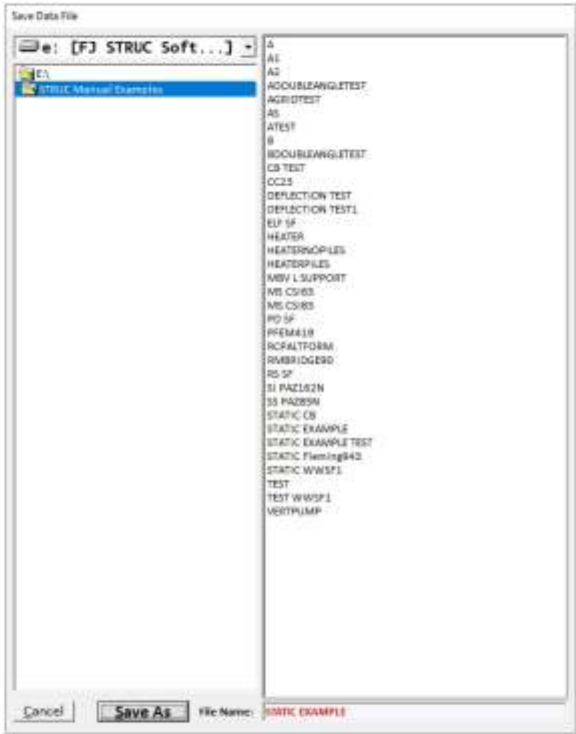
    Examples:
    `1.55 * 3 + 5` will be computed as (1.55 x 3) + 5 resulting in 9.65
    `1.55 + 3 * 5` will be computed as 1.55 + (3 x 5) resulting in 16.55

Editing e:\STRUC NEW Sample Files\STATIC EXAMPLE

Save & Exit | TEXT EDITOR | Line 1 of 128 | Exit

```
3D FRAME TEST 11/05/2010

CONTROL
L=3
C LOAD CONDITION NAMES
  1 DL
  2 LL
  3 SX
C GENERAL PARAMETERS
UF=2  UL=2  UT=1  MT=1  :UNITS  t    m  'C

JOINTS
C LENGTH UNITS USED:  m
    1   X=0                    Y=0                    Z=0
    2   X=6                    Y=0                    Z=0
    3   X=0                    Y=0                    Z=6
    4   X=6                    Y=0                    Z=6
    5   X=0                    Y=4                    Z=0
    6   X=6                    Y=4                    Z=0
    7   X=0                    Y=4                    Z=6
    8   X=6                    Y=4                    Z=6
   10   X=3                    Y=9                    Z=3
   20   X=3                    Y=4                    Z=3

RESTRAINTS
C (R) DISPLACEMENT IN AXIS, (<) ROTATION ARROUND AXIS.
C 0=FREE   1=RESTRICTED
    1   RX=1        RZ=1        <Y=1
    2   RX=1        RZ=1        <Y=1
    3   RX=1        RZ=1        <Y=1
    4   RX=1        RZ=1        <Y=1

SPRINGS
C FORCE and LENGTH UNITS USED:  t  :  m
C (S) [FORCE/LENGTH] IN AXIS,  (<) [MOMENT/radians] ARROUND AXIS
    1                         SY=10000.0000
    2                         SY=10000.0000
    3                         SY=10000.0000
    4                         SY=10000.0000

MEMBERS
NM=5
C UNITS USED:  t  :  m : 'C
  1  SH=R  T=0.3,0.3  E=1787220  W=2.4  TC=0.00001  MT=C  FC=2400  FY=24000,42000  R=0.05  RS=0.25 :R 0.3,0.3
  2  SH=R  T=0.4,0.3  E=1787220  W=2.4  TC=0.00001  MT=C  FC=2400  FY=24000,42000  R=0.05 :R 0.4,0.3
  3  SH=P  T=0.2731,0.0093  E=21000000  W=7.85  TC=0.0000117  MT=S  FY=25300 :P 0.2731,0.0093
  4  SH=A  T=2070  E=21000000  W=7.85  TC=0.0000117  MT=S  FY=25300 :Pipe8XS
  5  SH=A  T=2049  E=21000000  W=7.85  TC=0.0000117  MT=S  FY=25300 :Pipe8STD
C MEMBERS
     1     1     5  MN=1  P2=1.2
     2     2     6  MN=1  P2=1.2
     3     3     7  MN=1  P2=1.2
     4     4     8  MN=1  P2=1.2
     5     5     6  MN=2  P2=2,0  MJ=20,0
     6     7     8  MN=2  P2=2,0  MJ=20,0
     7     5     7  MN=2  P2=2,0  MJ=20,0
     8     6     8  MN=2  P2=2,0  MJ=20,0
     9     5    10  MN=5  P2=2,0  RM2=1,0  RM3=1,0
    10     6    10  MN=5  P2=2,0  RM2=1,0  RM3=1,0
    11     7    10  MN=5  P2=2,0  RM2=1,0  RM3=1,0
    12     8    10  MN=5  P2=2,0  RM2=1,0  RM3=1,0

MLOADS
NP=5  WY=-1  L=1
C 5 LOAD PATTERNS
C UNITS USED:  t  :  m : 'C
  1  WL=0,0,0  WG=0,-0.35
  2  WL=0,-0.25,0,6.557,0,0
  3  WL=0,0,0  PL=3,-0.5,0
  4  WL=0,0,0  WG=0.15
  5  WL=0,0,0  WG=0.1
C MEMBER LOADS
C LOAD CONDITION 2 :LL
     5  LP=1,3                                  L=2
     6  LP=1,3                                  L=2
     7  LP=1,3                                  L=2
     8  LP=1,3                                  L=2
     9  LP=2                                    L=2
    10  LP=2                                    L=2
    11  LP=2                                    L=2
    12  LP=2                                    L=2
C LOAD CONDITION 3 :SX
     1  LP=4                                    L=3
     3  LP=4                                    L=3
     7  LP=4                                    L=3
     9  LP=5                                    L=3
    11  LP=5                                    L=3

JLOADS
C UNITS USED:  t  :  m : 'C
   10  FX=-1.00                                                                 L=2 :LL

DISPLACEMENTS
C UNITS USED:  t  :  m : 'C
   10                 DY=-0.002800

LOADCOMB
  1  C=1.4000,1.7000
  2  C=1.0500,1.2750,1.0000
  3  C=0.0000,0.0000,4.5000
  4  C=1.0000,1.0000
  5  C=1.0000,1.0000,1.0000
C LOAD LIST FOR REACTIONS
LR=4,5
```

Once created or edited the text data file it can be saved by clicking **Save As** and will be pre-processed by the software to finally show the model of the structure to be analyzed/designed.



The Graphical Editor always:

- Creates and saves the Text File using the File Name chosen.
- Pre-process the file and, Shows the model of the structure.

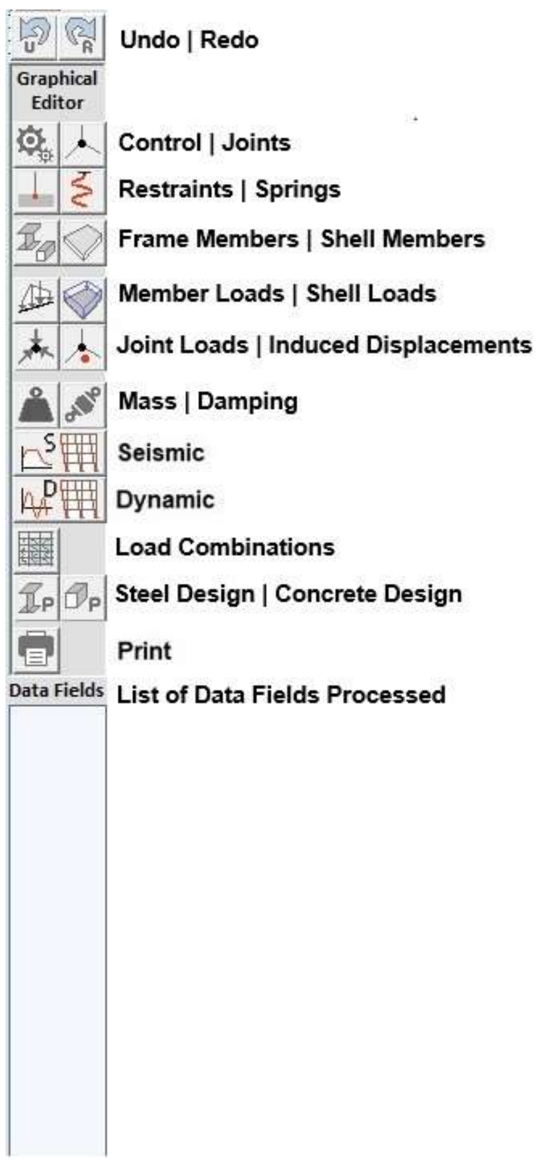
4.3 Creation and or Edition of the Input Data File using the Graphical Editor

By using the software's Graphical Editor, the user creates a new file or edit an existing file identified as "**name"** at the beginning of a session and containing the input data file describing a model.

The software will generate the input data file with all the structure information created or edited by using the tools shown below.

Following are the tools associated with the Graphical Editor:

The Undo and Redo buttons allows to undo or redo the last 10 total actions over the input data file created by the Text Editor or by the Graphical Editor's main tools located at the left of the screen and shown below.



To input or edit the data just click the appropriated tool and input or edit the data. Then inside each Graphical Tool used, click **Save & Exit** to Exit and generate the corresponding Text File.

The Text File can be reviewed or edited directly thru the **Text Editor.**

The **Graphical Editor** will generate a new Text File accordingly.

The list of Fields Processed shows the Fields (See 4.4 below) defined and processed by the Text Editor or by the Graphical Editor.

Click over "**Click On**", "**Line**" or "**Windows**" on Select Joints, Select Members, or Select Shells of the JOINTS, RESTRAINTS, SPRINGS, FRAME SECTIONS and MATERIAL PROPERTIES, SHELL SECTIONS and MATERIAL PROPERTIES, MEMBER LOADS, SHELL LOADS and JOINT LOADS tools of the Graphical Editor to select one Joint/Member/Shell or a group of Joints/Members/Shells where to create new data or edit/modify existing data.

"**Click On**" allows to *pick up* or *let go* one Joint/Member/Shell at a time.

"**Line**" allows to *pick up* a group of Members/Shells intersected by a line intersection property.

"**Windows**" allows to *pick up* a group of Joints/Members/Shells inside a window by the selection window property.

To select different groups of Joints, Members or Shells at the same time just select them by pressing the keyboard "Ctrl" key and the selection window property at the same time.

4.4 Data Fields used in the Model's Input Data File

The data inside the Text Input Data File describing a model is grouped by categories using the following fields:

	FIELD	USE
4.4.1	**HEADING TEXT**	**Compulsory**
4.4.2	**CONTROL**	**Compulsory**
4.4.3	**JOINTS**	**Compulsory**
4.4.4	**RESTRAINTS**	**Compulsory**
4.4.5	**SPRINGS**	**Optional**
4.4.6	**MEMBERS**	**Optional**
4.4.7	**SHELLS**	**Optional**
4.4.8	**SOLIDS**	**Optional**
4.4.9	**JLOADS**	**Optional**
4.4.10	**MLOADS**	**Optional**
4.4.11	**SHLOADS**	**Optional**
4.4.12	**SLOADS**	**Optional**
4.4.13	**DISPLACEMENTS**	**Optional**
4.4.14	**MASS**	**Optional**
4.4.15	**DAMP**	**Optional**
4.4.16	**SEISMIC**	**Optional**
4.4.17	**DYNAMIC**	**Optional**
4.4.18	**LOADCOMB**	**Optional**
4.4.19	**STLDES**	**Optional**
4.4.20	**CNCDES**	**Optional**
4.4.21	**PRINT**	**Optional**
4.4.22	**End of data file**	**Compulsory**

The software requires the fields and its associated data group describing the model of the structure to be strictly arranged in the input data file and separated by at least one blank line.

"**Compulsory**" fields (and associated data) are the minimum required to describe a structural model; therefore, they must be all present in the input data file.

The **"Optional"** fields (and associated data) only need to be present according to the kind of structural model and the static, seismic or dynamic analysis to be performed.

Following it will be shown how to create a file for a structural model with the data shown below and belonging to a space frame. It is going to be shown by using of the Text Editor and the Graphical Editor.

This file "STATIC EXAMPLE" is included in the example files provided with the software. See chapter B, paragraph B.1 "Verification Examples"

4.4.1 HEADING TEXT

The first line of the input data file contains the heading text that will appear in all printed reports. It is recommended, therefore, to include any relevant information.

Since this heading is all characters and not data related to the structure's model itself, it may include both capital letters and lower-case letters, this being the only exception.

The software takes only the first 90 characters.

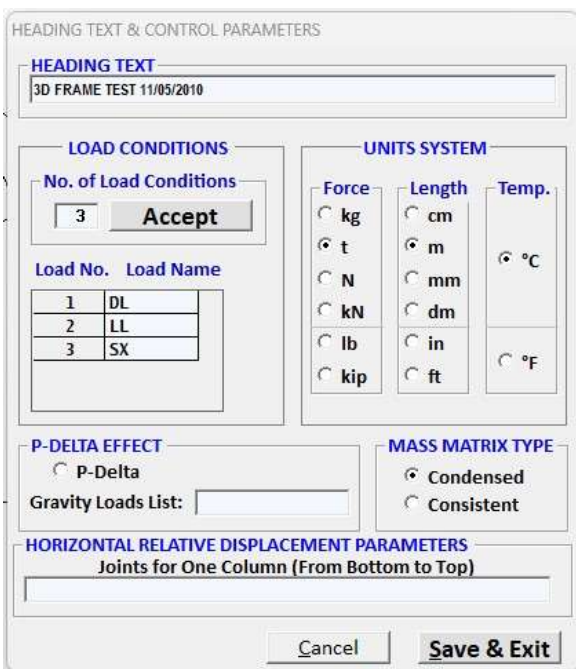
A) Using the Text Editor:

Example:
```
3D FRAME TEST 11/05/2010
```

This title will appear in every printed report generated by the software.

B) Using the Graphical Editor:

It allows the user to input all data related to the Heading Text and 4.4.2 "CONTROL" at the same time.



Click **Save & Exit** to exit and generate the Input Data File.

4.4.2 CONTROL

This field of compulsory use describes the quantity of load conditions; its short names and the unit system used within the model. If desired, the software evaluates the relative displacements between the floors and/or the local and global stress amplification factors. For that purpose, the conditions corresponding to dead load, live load and the horizontal forces in the **X** and **Z** directions must be defined, as well as the joints forming a main and representative column, from the foundation to the top of the structure. The maximum relative displacements will be evaluated for such joints.

The unit system (Forces **uf**, Dimensions **ul**, Temperature **ut**) must be adjusted according to the following charts. It is not recommended to mix force units in the Metric system with length units in the Imperial system or vice versa. It is more consequent to keep all the units within the same system, either Metric or Imperial, to obtain and manipulate coherent results.

uf	Symbol	Unit	Def.
1	kg	Kilogram	Weight
2	t	Ton	Weight
3	N	Newton	Force
4	kN	Kilo Newton	Force
5	lb	Pound	Weight
6	kip	Kip	Weight

ul	Symbol	Unit	*gi*	*Simbol*
1	cm	Centimeter	*980.665*	*cm/s²*
2	m	Meter	*9.80665*	*m/s²*
3	mm	Millimeter	*9,806.65*	*mm/s²*
4	dm	Decimeter	*98.0665*	*dm/s²*
5	in	Inch	*386.0886*	*in/s²*
6	ft	Foot	*32.17405*	*ft/s²*

ut	Symbol
1	°C
2	°F

The Ton corresponds to the metric ton, where 1 t (Weight) = 1,000 kg (Weight).

The gravitational index (***gi***) used in the analysis depends on the unit system defined for the dimensions and is calculated by the software. See unit chart for length **ul** above.

To activate the P-Δ effect analysis option, define the Gravity Load Conditions to be used in the structural analysis, usually Self Weight and any superimposed Dead Load that typically remain constant during any horizontal loading. From these Gravity Loads the software will compute the Geometric Stiffness Matrices and the total P-Δ effect.

A) Using the Text Editor:

It's made up of 2 data groups, as follows:

4.4.2.1 Number and Name of load conditions.
4.4.2.2 General control parameters.

4.4.2.1 Number and Name of each load condition. Name is optional. If it is not defined a default name will be assigned.

Syntax: L=**n**
1 **N1**
2 **N2**
n **Nn**

n Number of load conditions, must be between 1 and 100; the software will process **n** load conditions and associated output files.

N1 Name assigned to load condition No. 1, default "LC1".
N2 Name assigned to load condition No. 2, default "LC2".
Nn Name assigned to load condition No. n, default "LCn".

4.4.2.2 General control parameters

Syntax: UF=**uf** UL=**ul** UT=**ut** PD=**g1,g2,,,gi** SS=**p1,p2,,,pi** MT=**mt**

uf Force Units, default = 3 (N for Newton).
ul Length and Dimension Units, default = 2 (m for Meter).
ut Temperature Units, default = 1 (°C for Celsius).

g1 Gravity Load number 1 to Calculate the Geometric Stiffness Matrices, default = 0.
g2 Gravity Load number 2 to Calculate the Geometric Stiffness Matrices, default = 0.
gi Gravity Load number i to Calculate the Geometric Stiffness Matrices, default = 0.

The following data must be supplied for the software to evaluate the relative displacements between floors and/or the local and global stress amplification factors employed in the reinforced concrete design and in the structural steel check. If such data is omitted the relative displacements between floors are not evaluated and the local and global stress amplification factors are assumed as 1.00.

p1 Number of the first joint forming a main column starting from the foundation, default = 0.
p2 Number of the second joint forming a main column, generally located in the first aerial slab, default = 0.
pi Number of the last joint forming a main column, generally located at the roof, default = 0.

NOTE: The main column used in this definition cannot have intermediate joints between supported slabs.

mt Type of mass matrix, 0 = Consistent, 1 = Condensed or Lumped, default = 1.

Example:
```
L=3
1   DL
2   LL
3   SX
C
UF=2  UL=2  UT=1 :Units t - m - C
```

Three (3) load conditions are being defined and the software will produce the output files for 3 load conditions. Their associated names are DL for load condition 1, LL for load condition 2 and SX for load condition 3.

Next line is an empty comment

Last line defines the unit system used which is t, m y °C. The line also includes a comment.

B) Using the Graphical Editor:

See 4.4.1 Heading Text.

4.4.3 JOINTS

Under this field of compulsory use, all the joint coordinates are described. The description (X=, Y=, Z=) of each joint's coordinates can be in any order or data column and may include as many data lines as needed. (One per joint).

A) Using the Text Editor:

There is no need to repeat those coordinates which do not change from one data line to the following data line. The software automatically uses the last coordinate defined.

All coordinates can be multiplied by an **s** factor, to scale or to adapt them to any unit system.

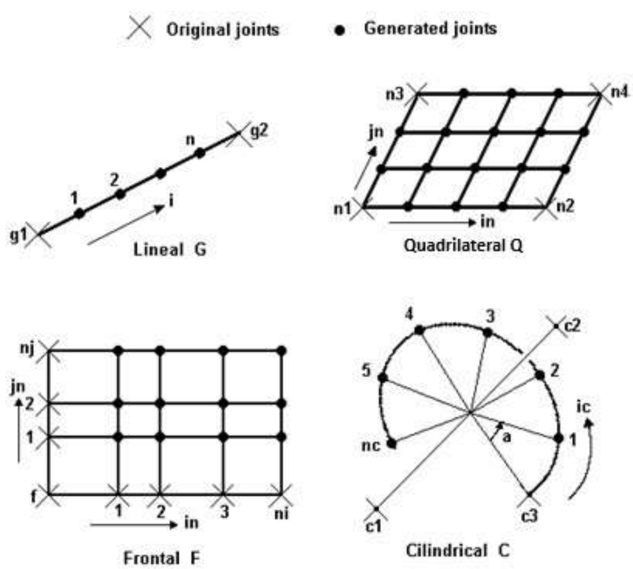
Joint coordinates can be generated. The software recognizes the following generation methods:

G Linear generation: It extends along a line, with equidistant joints between the first and the final joint. The coordinates of the first and the final joint must be previously defined.

Q Quadrilateral generation: First the joint coordinates of the four corners of a quadrilateral are defined. Then an internal grid at equal spacing is generated.

F Frontal generation: First the coordinates of the joints forming two adjacent lines of a quadrilateral are defined. Then an internal grid is generated using the two adjacent defined lines.

C Cylindrical generation: The user must define the coordinates of a rotational axis and the initial joint from where it will start the generation of the circumference or a sector of it and defined by the coordinates of the joints to be generated.



Syntax: **n** X=**x** Y=**y** Z=**z** S=**s** G=**g1,g2,i** Q=**n1,n2,n3,n4,in,jn** F=**f,ni,nj,in,jn** C=**c1,c2,c3,nc,ic,a**

n Joint number; less than or equal to 32,700; compulsory use.
x X coordinate of joint **n**
y Y coordinate of joint **n**
z Z coordinate of joint **n**
s General multiplier of all coordinates, default = 1.

Linear generation, **G**

g1 No. of the joint g1; less than or equal to 32,700.
g2 No. of the joint g2; less than or equal to 32,700 and greater than **g1.**
i Increment of the joint No., default = 1.

Quadrilateral generation, **Q**

n1 No. of the joint n1; less than or equal to 32,700.
n2 No. of the joint n2; less than or equal to 32,700 and greater than **n1**.
n3 No. of the joint n3; less than or equal to 32,700 and greater than **n1**.
n4 No. of the joint n4; less than or equal to 32,700 and greater than **n2** and **n3**.
in Increment of the joint No. from **n1** to **n2**, default = 1.
jn Increment of the joint No. from **n1** to **n3**, default = 1.

Frontal generation, **F**

f No. of the origin joint; less than or equal to 32,700.
ni Quantity of joints in the i direction.
nj Quantity of joints in the j direction.
in Increment of the joint No. in the i direction, default = 1.
jn Increment of the joint No. in the j direction, default = 1.

Cylindrical generation, **C**

c1 No. of the joint c1; less than or equal to 32,700.
c2 No. of the joint c2; less than or equal to 32,700.
c3 No. of the joint c3; less than or equal to 32,700.
nc Quantity of additional joints to be generated.
ic Increment of the joint No., default = 1.
a Angular increment in degrees, positive in the right hand direction and around the axis formed by joints **c1** to **c2**.

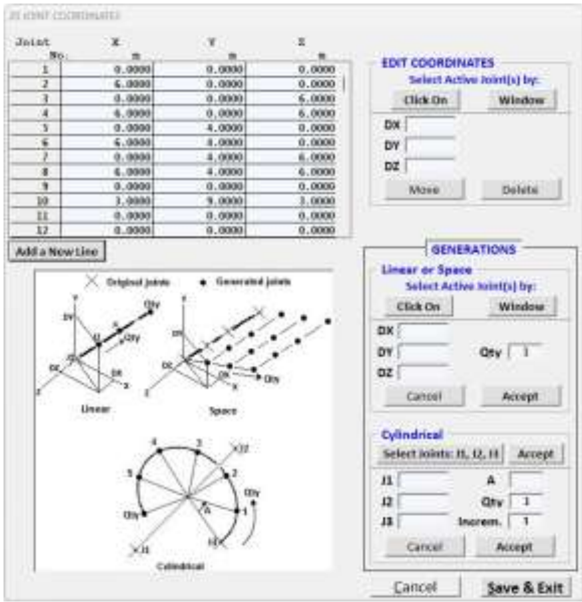
Example:

```
1    X=0   Z=0   Y=0
2    X=6
3    X=0   Z=6
4    X=6
5    X=0   Z=0   Y=4
6    X=6
7    X=0   Z=6
8    X=6
10   X=3   Z=3   Y=9
20               Y=4    :MASTER JOINT
```

The first line defines the coordinates of joint 1, and so on, up until joint 20 which is a Master Joint.

B) Using the Graphical Editor:

Input, generate or edit Joint coordinates as needed using the appropriate tools.



To create a new Joint data line on the table just click the **Z** coordinate of the last one already defined and press ENTER or click on **Add a New Line**. A new data line will be created and ready to be filled with new **X**, **Y** and **Z** coordinates for the new joint number.

It is a good practice to first create all supporting joints that later will be restrained using RESTRAINTS.

Edit Joint Coordinates allows to graphically **Move**, or **Delete** a previously selected group of joints using **Click On** or **Windows** options.

Linear, Space or Cylindrical Generation is carried out using the defined step in **X**, **Y** or **Z** global axes and the total amount of joints to be generated.

Click **Save & Exit** to exit and generate the Input Data File.

4.4.4 RESTRAINTS

This field of compulsory use defines the restraints of all the joints forming the structural model. It may include as many data lines as needed.

A) Using the Text Editor:

The software assumes that all joints have freedom of displacement and rotation in the three global axes (space frame assumed). If this is not the case, the user might describe the general restraints defining the type of structure and in all joints not restrained. (See Table 4.4.1 below).

If the model is not a Space Frame, the first line must comprise all the joints used in the model, for the software to use the convenient routines for each different type of structure.

Immediately, the restraints of the support joints must be defined.

Those joints not used and not described under this field, are totally restrained by the software.

The last restraint definition for a joint or group of joints is the one used by the software.

Syntax: **ni** **nf** **ninc** RX=**r1** RY=**r2** RZ=**r3** <X=**r4** <Y=**r5** <Z=**r6**

ni No. of the initial joint; Minor than or equal to 32,700, compulsory use.
nf No. of the final joint; Minor than or equal to 32,700, default = **ni**.
ninc Increment of the joint No., default = 1.
r1 Restraint to displacement in the **X**-axis direction, default = 0.
r2 Restraint to displacement in the **Y**-axis direction, default = 0.
r3 Restraint to displacement in the **Z**-axis direction, default = 0.
r4 Restraint to rotation about the **X**-axis, default = 0.
r5 Restraint to rotation about the **Y**-axis, default = 0.
r6 Restraint to rotation about the **Z**-axis, default = 0.

0 means freedom to displacement or rotation.
1 means restraint to displacement or rotation.

The displacement is taken in the direction of the **X**, **Y** or **Z** axis.

The rotation is taken around **X**, **Y** or **Z** axis.

The coordinates of all joints used here must have been already defined in JOINTS.

Table 4.4.1 shows the different types of general restraints of compulsory use, which describe the type of structure (DOF means degrees of freedom). Shell structures are always in 3D or 6 DOF's.

Additional to these general cases and to define the type of supports any joint may have any restraint (or freedom) to displacement or rotation to anyone of the six degrees of freedom.

Table 4.4.1

Type of Structure	Restraints Displacement | Rotation X Y Z X Y Z	No. DOF	Compulsory location
CB Continuous beam	1 0 1 1 1 0	2	Along X-axis
PT Plane truss	0 0 1 1 1 1	2	In X-Y plane
PF Plane frame	0 0 1 1 1 0	3	In X-Y plane
ST Space truss	0 0 0 1 1 1	3	In Space
SF Space frame SS Space Shell	0 0 0 0 0 0	6	In Space

Example:

```
1 4  RX=1   RZ=1   <Y=1  :HINGED SUPPORTS WITH SPRINGS IN Y
```

The first line defines the restraints for joints 1 thru 4, one by one, with these corresponding to displacements in **X** and **Z** direction, and rotation around **Y** direction; they will have a vertical spring support defined in **Y** direction (no displacement restriction in **Y** direction). It also includes a comment.

Shells are always considered as a Space Structure with 6 DOFs per joint.

B) Using the Graphical Editor:

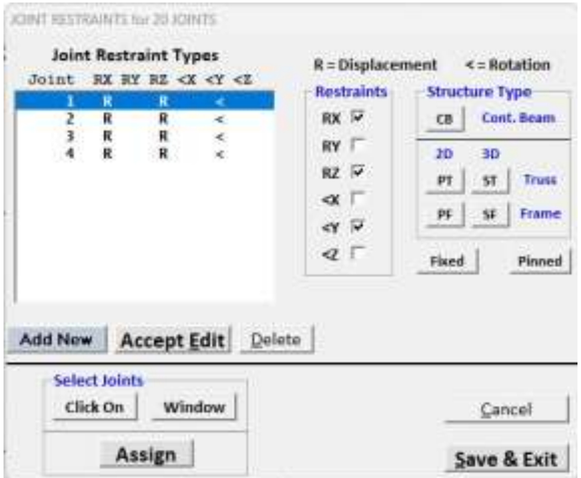
Create or edit Join Restraints as needed.

To create a new Joint Restraint, click **Add New** at the bottom left of the form, define the restraint by clicking the appropriate ones or click the "Structure Type" to quickly define them, and then click **Accept Edit** to save the creation.

To edit an existing restriction just click the listing of "Joint Restraint Types" and edit the appropriate information. Then click **Accept Edit** to save the edition.

Once created and/or selected a restraint type from the "Joint Restraint Types" list, select a joint or a group of joints by using **Click On** or **Windows** and click on **Assign** to assign this restriction type to the selected joints.

The "Joint Restraint Types" list and the model's Graphic will show these new assignments.



Click **Save & Exit** to exit and generate the Input Data File.

4.4.5 SPRINGS

If there is any spring support assigned to a joint this field is used, therefore it is optional.

Wherever a joint has been defined free to movement or rotation with the RESTRAINTS definition set equal to 0, a spring type support can be placed by defining the proper Spring constant, which is always positive.

Springs for displacements (SX, SY, SZ) are defined as force per unit of length.
Springs for rotation (<X, <Y, <Z) are defined as moment per unit of rotation in radians.

A) Using the Text Editor:

It may include as many data lines as needed.

The values corresponding to any joint must be defined just once.

Syntax: **ni** **nf** **ninc** SX=**s1** SY=**s2** SZ=**s3** <X=**s4** <Y=**s5** <Z=**s6**

ni No. of the initial joint, compulsory use.
nf No. of the final joint, default = **ni**.
ninc Increment of the joint No., default = 1.
s1 Spring constant in **X** direction, default = 0.
s2 Spring constant in **Y** direction, default = 0.
s3 Spring constant in **Z** direction, default = 0.
s4 Spring constant about **X**-axis, default = 0.
s5 Spring constant about **Y**-axis, default = 0.
s6 Spring constant about **Z**-axis, default = 0.

Example:
```
1 4  SY=10000  :100 t/0.01 m = 10000 t/m
```

Joints 1 to 4 with an increment of 1 are defined with a spring constant value of 10,000 in the **Y** direction.

B) Using the Graphical Editor:

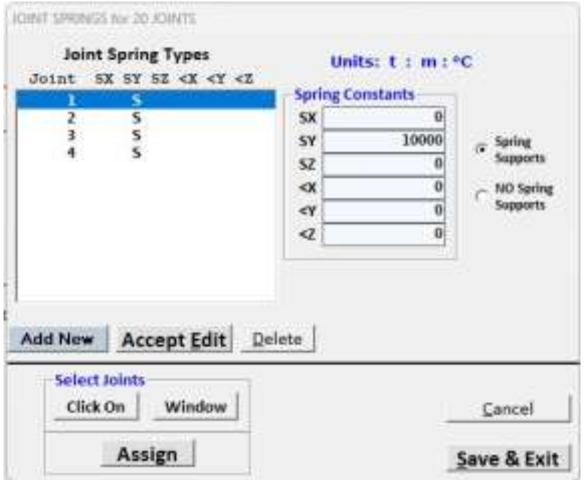
Create or edit Join Springs as needed.

To create a new Joint Spring Type, click **Add New** at the bottom left of the form, define the spring direction and its value, and then click **Accept Edit** to save the creation.

To edit an existing spring just click the listing of "Joint Spring Types" and edit the appropriate information. Then click **Accept Edit** to save the edition.

Once created and/or selected a Joint Spring type from the "Joint Spring Types" list, select a joint or a group of joints by using **Click On** or **Windows** and click on **Assign** to assign this Joint spring support type to the selected joints.

The Joint Spring Types list and the model's Graphic will show these new assignments.



Click **Save & Exit** to exit and generate the Input Data File.

4.4.6 MEMBERS

This field of compulsory use defines all members type Beam with a prismatic section conforming the structure.

A) Using the Text Editor:

It is made up of 3 data groups, defining Sections, Materials and Location, as follows:

4.4.6.1 Control line.
4.4.6.2 Sections or materials library.
4.4.6.3 Description of member characteristics.

4.4.6.1 Control line

The first data group describes how many different sections or materials are there in the sections library that will be described in the second data group. This data is compulsory. Following is the option for sectioning each member at the time of printing the members internal forces; this is optional data and if it is omitted the software delivers only the internal forces in the member's ends and in the point where the shear force is equal to zero (if that occurs). If a value different from zero is set, the number of intermediate runs will be 12.

Syntax: NM=**n** NSEC=**par**

n Quantity of different sections in the section's library; less than or equal to 512, compulsory use.
par A value greater than 0 activates the option for dividing the members into 12 sections, where the internal forces will be evaluated and shown on the members internal forces output lists and, on the shear, and moment diagrams, default = 0.

Example:
```
NM=5    NSEC=1
```

It defines those 5 types of sections and/or materials that must appear in the library; it is also defined that in every member the internal forces will be evaluated, at the ends and in 12 intermediate sections.

4.4.6.2 Sections or materials library

The second data group is made up of **n** lines, each one describing the geometric properties, the mechanical properties and the general design properties of each section type or material used in the structure.

The software gets the section name automatically as:
- Suited for General structures or Steel structures and AISC ASD-89 design. Section assigned number as defined by the user and by means of option (a). See below.
- Suited for Concrete structures and ACI 318-19 design. Section type and description as defined by the user and by means of option (b). See below.
- Suited for Steel structures and AISC ASD /LRFD design. Section Label as defined in AISC or EURO database files and by means of option (c). See below.

Syntax: **ni** ***Geometric Properties*** ***Mechanical Properties*** ***General Design Properties***

ni Number from 1 up to **n** which identifies the section number; less than or equal to 512.

Geometric Properties
There are three different options (*a, b* or *c*) to define the geometric properties:

a. **First option:** User-defined geometric properties. Implies that it is only suited for static, seismic, and dynamic analyses. Members cannot be designed using ACI 318-19 or AISC 360-10/16 ASD or LRFD provisions, they only can be designed using AISC ASD-89 design provisions since the section's dimensions are unknown.

Syntax: A=**a** AS=**a2,a3** I=**i2,i3** J=**j** S=**s2,s3** RG=**rg2,rg3** KL=**kl2,kl3**

The following data may be in any order within the data line; all this data is assumed equal to zero except the slenderness factors K (in K L / r) which is assumed equal to 1.00.

Geometric properties for all types of members
a Gross area of section.
a2 Shear area of section in plane1-2.
a3 Shear area of section in plane1-3.
i2 Inertia of section in plane 1-2 or major plane of bending.
i3 Inertia of section in plane 1-3 or secondary plane of bending.
j Torsional inertia of section around local axis 1.

Additional geometric properties required for the structural steel members design using AISC ASD 89 provisions only.
s2 Section modulus in plane 1-2.
s3 Section modulus in plane 1-3.
rg2 Radius of gyration in plane 1-2.
rg3 Radius of gyration in plane 1-3.
kl2 Slenderness factor K in plane 1-2, default = 1.00.
kl3 Slenderness factor K in plane 1-3, default = 1.00.

If **a2** and/or **a3** are defined equal to 0.00 or are not defined at all, the software does not calculate the shear deformation.

If **i2** and/or **i3** are defined equal to 0.00 or are not defined at all, the software takes the member as a truss member not able to transmit moment at their ends.

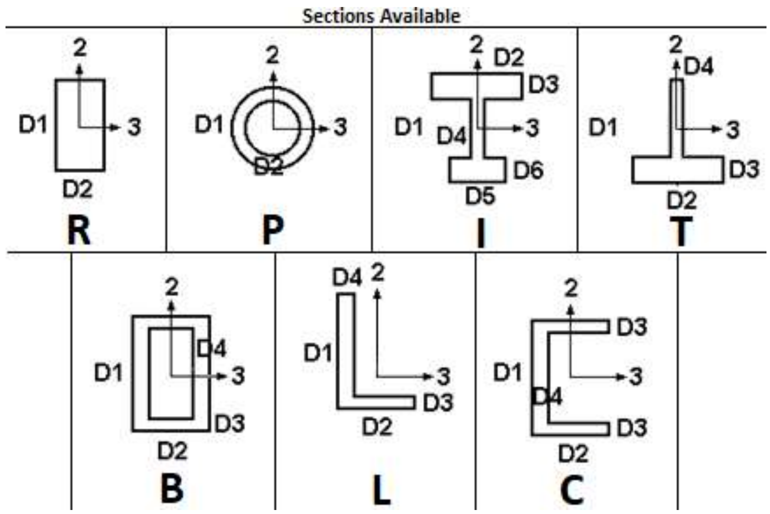
If **j** is defined equal to 0.00, the software does not calculate the torsion deformation and could indicate a possible torsional instability.

Slenderness factors **kl2** and **kl3** are only used for AISC ASD-89 design provisions. For design provisions AISC 360-10/16 ASD or LRFD these slenderness factors shall be defined in 4.4.19 STLDES Design parameters.

Example for a section with a gross area of 10 and as a truss member type due to not having defined the section inertias:
```
1 A=10
```

The section name is now the assigned section number, or = "1".

b. **Second option:** Suited for static, seismic, and dynamic analyses, and design of reinforced concrete structures using ACI 318-19 provisions, always use a section type **R** or type **P** only. Geometric properties are calculated by the software based on the following transverse section types:



Syntax: SH=**Alphanumeric** T=**D1,D2,D3,D4,D5,D6**
All the data is assumed to be zero.

Alphanumeric	Dimensions	Section shape
R	**D1** = Depth.	Rectangular (or for Concrete Design)
	D2 = Width.	
P	**D1** = Diameter	Circular tubular (or for Concrete Design)
	D2 = Wall Thickness.	(D2 = 0 for Circular Columns in Concrete Design)
I	**D1** = Depth.	I section
	D2 = Top flange Width.	
	D3 = Top flange Thickness.	
	D4 = Web Thickness.	
	D5 = Bottom flange Width.	
	D6 = Bottom flange Thickness.	

If **D5** and **D6** are equal to 0, they are assumed equal to **D2** and **D3,** respectively.

T	**D1** = Depth.	T section
	D2 = Flange Width.	
	D3 = Flange Thickness.	
	D4 = Web Thickness.	
B	**D1** = Depth.	Rectangular Tubular
	D2 = Width.	
	D3 = Horizontal walls Thickness.	
	D4 = Vertical walls Thickness.	
L	**D1** = Depth.	L section
	D2 = Width of leg in line 3 direction.	
	D3 = Thickness of leg in line 3 direction.	
	D4 = Web Thickness.	

C	**D1** = Depth. **D2** = Width. **D3** = Flanges Thickness. **D4** = Web Thickness.	C section

Example. Rectangular section. All geometric properties are computed by the software:

```
1 SH=R  T=0.30,0.30
```

Reinforced concrete squared section of height = 0.30 and width = 0.30. Section name is defined as "R0.3,0.30".

c. **Third option:** Suited for static, seismic, and dynamic analyses, and check of structural steel structures using AISC 360-10/16 ASD or LRFD provisions. Geometric properties are obtained by the software from the AISC15.BIN Data Base file (APPENDIX D.1, for American shapes) or from EURO.BIN Data Base file (APPENDIX D.2, for European shapes), corresponding to the section types listed in the respective annexes:

Syntax: SH=**L** T=**D1**

L=A Geometric properties will be extracted from the AISC15.BIN file.
D1 Number taken from the AISC15.BIN; valid from 1 to 2,091. (See APPENDIX D.1).

or
L=E Geometric properties will be extracted from the EURO.BIN file.
D1 Number taken from the EURO.BIN file; valid from 1 to 1,553. (See APPENDIX D.2).

The geometrical properties such as the gross section's area, section's modules and the inertias are presented in the input and output listings, in cm^2, cm^3 y cm^4 for metric units or in^2, in^3 and in^4 for English units.

Example:

```
4 SH=A  T=2049
```

AISC shape No. 2049 which is a 10" STD pipe. Section name taken from AISC database as "Pipe10STD". (See APPENDIX D.1).

Mechanical Properties
Syntax: E=**e** G=**g** W=**w** TC=**tc**

e Material modulus of elasticity.
g Material shear modulus.
w Material density in units of weight / volume.
tc Material thermal expansion coefficient in units of length / length / temperature.

If **e**, **w** or **tc** are not defined the software defines them internally and in accordance with material type as follows:

	Reinforced Concrete	**Structural Steel**
Poisson's Ratio μ	0.20	0.28
e (N/m^2)	2.39916×10^{10}	2.0077551×10^{11}
e (psi)	$3.479686431 \times 10^{6}$	2.9120017×10^{7}
g	e / (2 x (1 + μ))	e / (2 x (1 + μ))
w (N/m^3)	2.35360629×10^{4}	7.69823166×10^{4}
w (lb/ft^3)	1.498277×10^{2}	4.9006008×10^{2}
tc (L / L / °C)	100.000×10^{-7}	130.000×10^{-7}
tc (L / L / °F)	55.555×10^{-7}	72.222×10^{-7}

Final values are adjusted to the defined units.

Self-weight will not be computed by the software if material type in "General Design properties" (See below) is not defined or material density for this material is not defined (w=0).

For reinforced concrete, if **g** is not defined the software compute it as **e**/2.40. {e / [2 x (1 + μ)] }, with μ = 0.20. If reinforced concrete has a different value of μ then **g** should be defined consequently.

For structural steel, if **g** is not defined the software compute it as **e**/2.56. {e / [2 x (1 + μ)] }, with μ = 0.28. If structural steel has a different value of μ then **g** should be defined consequently.

For any other material, **e, g, w** and **tc** shall be defined.

Example:
```
4 SH=A  T=2049                    MT=S FY=25300                    :PIPE 10" STD
```

AISC shape No. 2049 which is a 10" STD pipe; the material is Structural Steel, with a modulus of elasticity and shear modulus computed by the software, and with Fy=25,300. There is a comment at the end of the line. Section name taken from the database as "Pipe10STD".

General Design Properties

The software can design two different types of materials: Reinforced Concrete and Structural Steel. All design properties must be in accordance with these two different types of materials.

Syntax: MT=**m** FC=**fc** R=**rc** RS=**f** FY=**fs,ff**

m Type of material:
- **S** Structural Steel.
- **C** Reinforced Concrete.
- **O** Other.

FOR TYPE **S** MATERIAL (Structural Steel)

r Not applicable.
f Not applicable.
fs Fy of structural steel.
ff Fu of structural steel. Assumed = 4,222.208 kg/cm^2 or 60 ksi

Example:
```
4 SH=A  T=2049                    MT=S FY=25300,40700              :PIPE 10" STD
```

It defines structural steel as the material type S, with steel Fy equal to 25,300 and Fu equal to 40,700.

Section name taken as "Pipe10STD" from the AISC Data Base.

NOTE:
Geometric Properties Options one and two, or options one and three (See above). May be combined in the same line. The software takes the definitions from the first one in the data line to the last one, that is the last definition prevails over the first one, etc.

Example (Combination of options three with one):
```
4  SH=A    T=692    AS=17,8    I=0,0     E=2.1E6    MT=S    FY=2530,4070
```

It defines a section labeled as No. 4, AISC type and identified with number 692 (channel 8" x 11.5 lb/ft); the software extracts the geometric properties from the AISC15.BIN file; shear areas redefined with the values 17 and 8, inertia redefined with the value 0.00 to force a truss behavior, whose members aren't able to transmit moment at their ends; mechanical properties defined and structural steel (S) material, Fy of steel is 2,530 and Fu of steel is 4,070.

Section name taken as "C8X11.5"

FOR TYPE **C** MATERIAL (Reinforced Concrete)

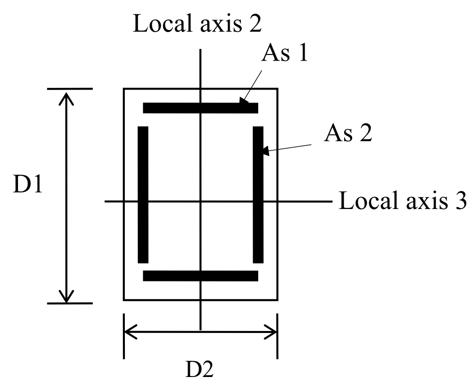
fc Concrete compressive strength f'c.
rc Reinforcement cover, from concrete face to center line of longitudinal reinforcement.
f Steel reinforcement ratio as sides to total reinforcement for rectangular column sections, or lateral reinforcement type (spirals or stirrups) for circular column sections.
fs Fy of steel reinforcement used in shear design.
ff Fy of steel reinforcement used in flexure design.

Type **R** (rectangular sections) or Type **P** (circular sections) must be used only.

If **fc** is not defined, then the software won't be able to design members using this material type.

The ratio **f** of reinforced steel placed on the sides to the total reinforced area placed on the rectangular column section is the way the software recognizes a biaxial bending column design procedure. It should be computed as follows:

f = (As 2) / (As 1 + As 2) and always less than 1.0



Rectangular Column Typical Section

As 1 is the steel reinforcement area on each face of the column section. Corners included.
As 2 is the steel reinforcement area on each side of the column section. Corners NOT included.

Spirals or stirrups are assumed as ½" (#4) diameter.

For rectangular columns sections, lateral reinforcement is assumed as stirrups.

For circular column, sections lateral reinforcement type can be defined as:

f = 1 For spirals.
f = 2 For stirrups.

Example:
```
1 SH=R  T=0.30,0.30     E=1.78722E6 MT=C FC=2400 FY=24000,42000 R=0.05 RS=0.25:COLUMNS
```

Material C defines reinforced Concrete, f'c is 2,400, Fy of steel for shear is 24,000 and Fy of steel for bending is 42,000, cover is 0.05, the ratio of steel area placed on the sides of the rectangular column section is 0.25.

Section name as "R 0.30,0.30"

4.4.6.3 Description of member characteristics

The third data group describes the label numbers assigned to each member, the member's location in the structure, the orientation of their local axes, the material type which the member is made up according to the data group previously described, the definition of Master Joints for those members which have any, the definition of end releases and the members generation from the previous data.

It may include as many lines as members definition exist.

A typical line describes:

- Member number or label (minor than or equal to 200,000).

- Member's initial joint and final joint, which define the direction of the local axis 1; the local axis 1 is oriented from the initial joint j to the final joint k. (See "Local Axes" in 2.2)

This data can only be separated by one or more blanks.

Up to here, the data order is compulsory; the following data may be in any order.

- There are two different options to orientate the plane containing the local axis 2 (See "Local Axes" in 2.2):

1. Using two joints that define the orientation of the plane 1-2 containing local axis 2.

   Example: Using joints 1 and 7 P2=**1,7**

2. Using the sign of the global axes to define the orientation of the plane **1-2** containing local axis **2**, and as follows:

   In the positive direction of global axis **X** P2=**1,0**
   In the negative direction of global axis **X** P2=**-1,0**
   In the positive direction of global axis **Y** P2=**2,0**
   In the negative direction of global axis **Y** P2=**-2,0**
   In the positive direction of global axis **Z** P2=**3,0**
   In the negative direction of global axis **Z** P2=**-3,0**

   - Those members belonging to bi-dimensional structures must have their local axes **1** and **2** in the plane formed by global axes **X** and **Y**.

   - The P2 parameters need to be defined when they are different from the P2 defined in the precedent data line.

   - Section No. according to the section's library previously defined whenever it's different from the section defined in the precedent data line.

   - Tension Only Member. Or member not to be designed to withstand compression forces.

   - Definition of member end releases. This data is assumed zero (0), that is, the members can transmit moment, shear, axial load and torsion at both ends. Defining any of these releases equal to one (1) implies for any member or group of members the possibility of, at any end or both ends, not transmitting moment or shear in planes **1-2** or **1-3**, or axial load or torsion. For members belonging to cantilevers the release corresponding to moment and shear in plane **1-2** and **1-3** at the free end must be activated.

   - Member's Master Joints if any. 2 Master Joints maximum per member, i.e., each member may belong up to two different diaphragm planes at the same time; the maximum number of joints linked to the same Master Joint is 200.

   - Generation of other members is done from the existing ones, keeping all the properties above defined except the member's label, the member's joints, and its Master Joints if any.

Syntax: **nm ni nf** MN=**m** P2=**n1,n2** TM=**tm** RM2=**r1,r2** RM3=**r3,r4** RS2=**r5,r6** RS3=**r7,r8** RAT=**r9,r10** MJ=**nm1,nm2** MG=**g1,g2,g3,g4,g5,g6**

nm Member identification No., compulsory use (less than or equal to 200,000).
ni No. of the initial joint j, compulsory use.
nf No. of the final joint k, compulsory use.
m Section No. according to the library, default = previous value.
n1 No. of origin joint of local axis **2** vector, default = previous value.
n2 No. of final joint of local axis **2** vector, default = 0 or previous value.
tm Tension Only Member, default = 0.
r1 Moment release code in plane **1-2** at j end, default = 0.
r2 Moment release code in plane **1-2** at k end, default = 0.
r3 Moment release code in plane **1-3** at j end, default = 0.
r4 Moment release code in plane **1-3** at k end, default = 0.
r5 Shear release code in plane **1-2** at j end, default = 0.
r6 Shear release code in plane **1-2** at k end, default = 0.
r7 Shear release code in plane **1-3** at j end, default = 0.
r8 Shear release code in plane **1-3** at k end, default = 0.
r9 Axial load release code, default = 0.
r10 Torsion, or Moment, release code in plane **2-3**, default = 0.
nm1 No. of the master joint for first diaphragm, default = 0.
nm2 No. of the master joint for second diaphragm, default = 0.
g1 Quantity of members to be generated, default = 0.
g2 Increment of members numbering from **nm**, default = 0.
g3 Increment of initial joint No. j based on **ni**, default = 0.
g4 Increment of final joint No. k based on **nf**, default = 0.
g5 Increment of the first master joint No., based on **nm1**, default = 0.
g6 Increment of the second master joint No., based on **nm2**, default = 0.

For release codes, 1 means release activated, and 0 means release not activated.

Example:
```
C COLUMNS
1  1  5  P2=1,2 MN=1  MG=3,1,1,1
C HORIZONTAL BEAMS
5  5  6  P2=2,0 MN=2  MG=1,1,2,2  MJ=20
7  5  7               MG=1,1,1,1  MJ=20
C ROOF BEAMS
9  5 10         MN=4  RM2=1  RM3=1
10 6 10         MN=4  RM2=1  RM3=1
11 7 10         MN=4  RM2=1  RM3=1
12 8 10         MN=4  RM2=1  RM3=1
```

The first line defines a member identified as No. 1 that starts in joint 1 and ends at joint 5, that is, its local axis **1** goes from joint 1 to joint 5. The orientation of local axis **2** is defined by the vector that goes from joint 1 to joint 2. The member's section is the No. 1. Three more members with an increment of 2 are generated, as follows: member 2 from joint 2 to 6; member 3 from joint 3 to 7; and member 4 from joint 4 to 8.

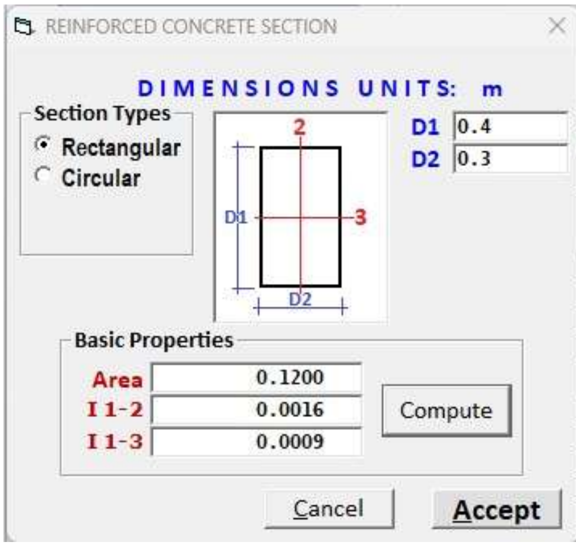
The second line defines a member identified with No. 5 that starts at joint 5 and ends at joint 6. The orientation of local axis **2** is defined by the vector running in Y direction. Its section is No. 2. Its Master Joint is 20 for the first (and only) diaphragm. No release is defined. One member is generated: member 6 from joint 7 to joint 8 (5+1=6, 5+2=7, 6+2=8).

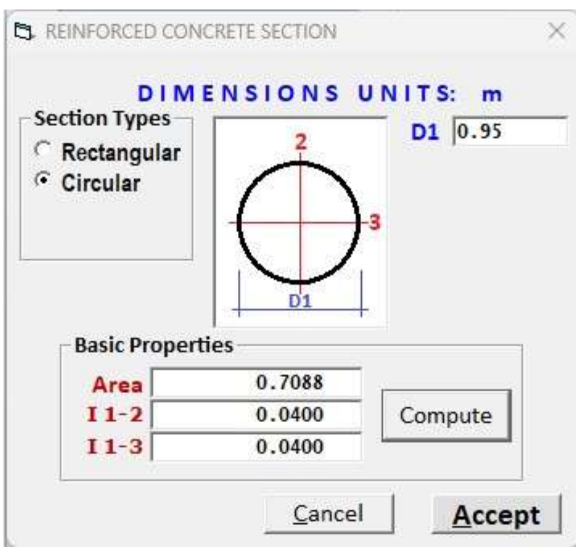
And so on up until member 12 from joint 8 to joint 10, with section No. 4, and moment end releases for initial joints 5, 6, 7 and 8 in both planes **1-2** and **1-3** (RM2=1 and RM3=1).

B) Using the Graphical Editor:

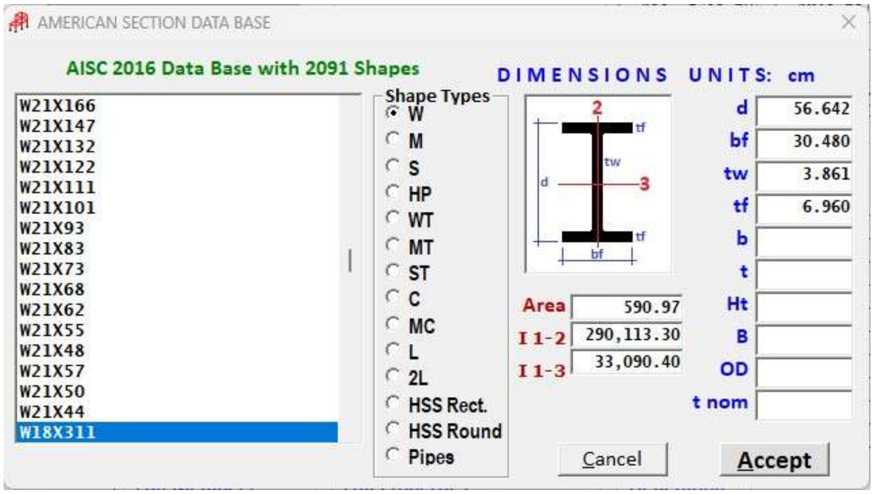
The first step is to create or edit the Section Data Base used in the whole structure. Each section may be defined with a Material Type as Concrete, Steel or Other material.

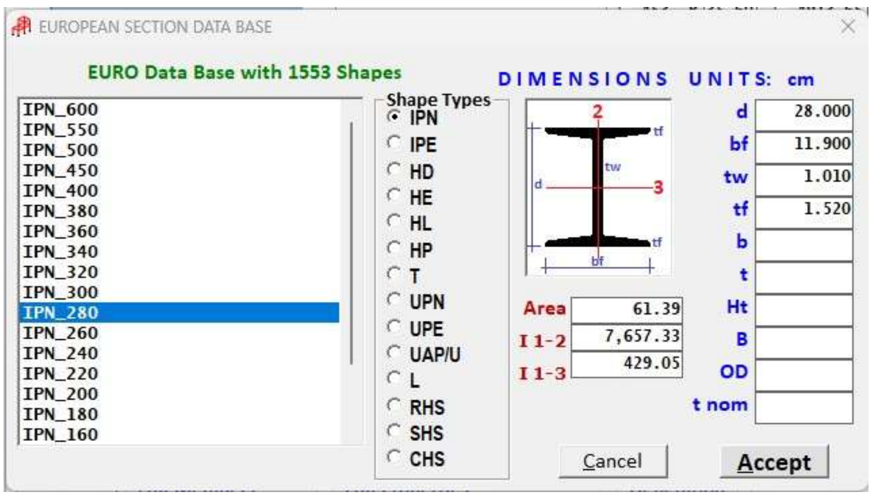
For Concrete it may be defined by its whole properties like section area, inertias, and such. Or may be defined by its dimensions and in accordance with the section type. Section types allowed for Concrete Design are R or Rectangular and P for Circular.





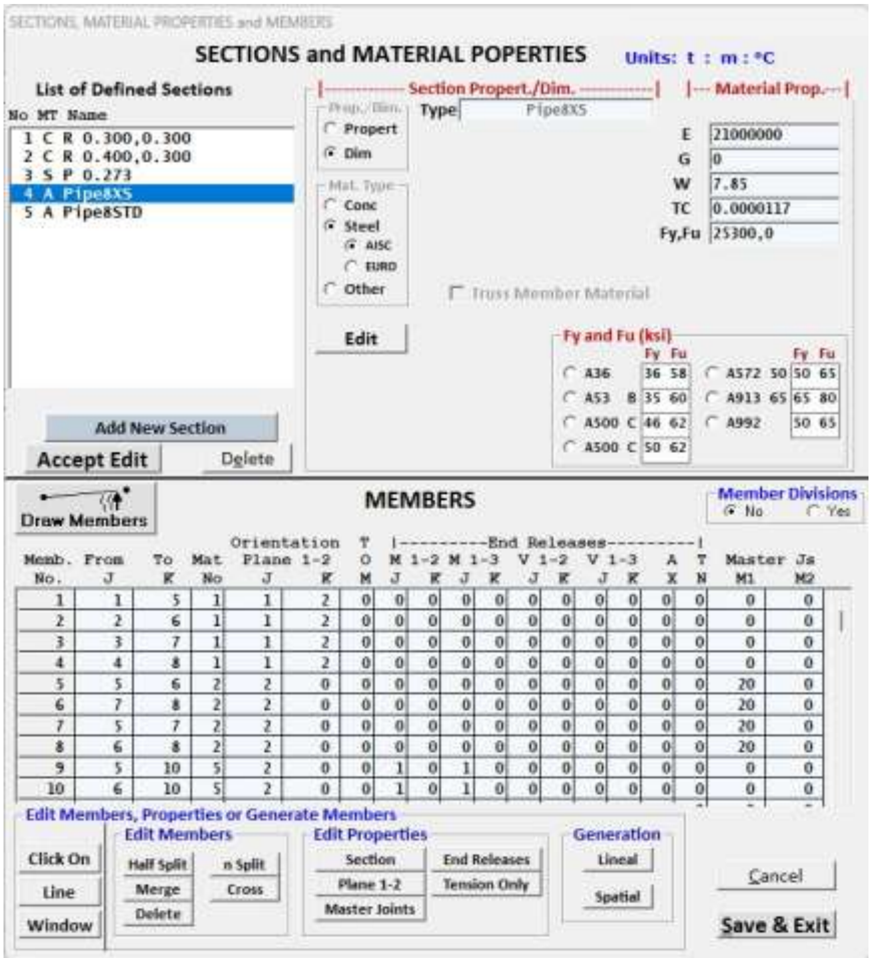
For Steel it may be defined by its whole properties like section area, inertias, and such. Or may be defined by its shape and in accordance with the list of AISC data shape or EUROPEAN data shape provided.



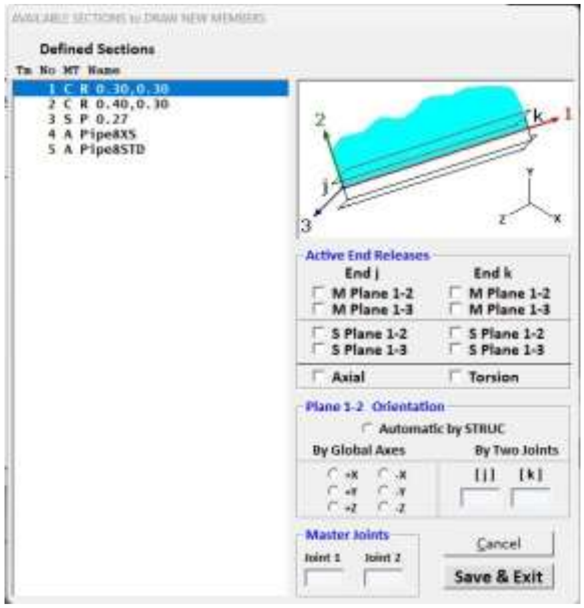


Any Steel member regardless of its shape may be defined as a Truss Member, and by doing so members associated with this section will not be able to transmit moment at their ends, only axial forces and shear forces. These member types are typically used in Struss type structures.

To create a new Section, click **Add New Section**, define the material and properties to be applied and click **Accept Edit** to save it on the Data Base list.


SECTIONS and MATERIAL POPERTIES
Units: t : m : °C
List of Defined Sections
No MT Name
1 C R 0.300,0.300
2 C R 0.400,0.300
3 S P 0.273
4 A Pipe8XS
5 A Pipe8STD
Section Propert./Dim.
Material Prop.
Propert
Dim
Type
Pipe8XS
E 21000000
G 0
W 7.85
TC 0.0000117
Fy,Fu 25300,0
Conc
Steel
AISC
EURO
Other
Truss Member Material
Edit
Fy and Fu (ksi)
Add New Section
Accept Edit
Delete
MEMBERS
Draw Members
Member Divisions
No
Yes
Edit Members, Properties or Generate Members
Click On
Line
Window
Edit Members
Half Split
n Split
Merge
Cross
Delete
Edit Properties
Section
End Releases
Plane 1-2
Tension Only
Master Joints
Generation
Lineal
Spatial
Cancel
Save & Exit

To create a new Member, click **Draw Members**.

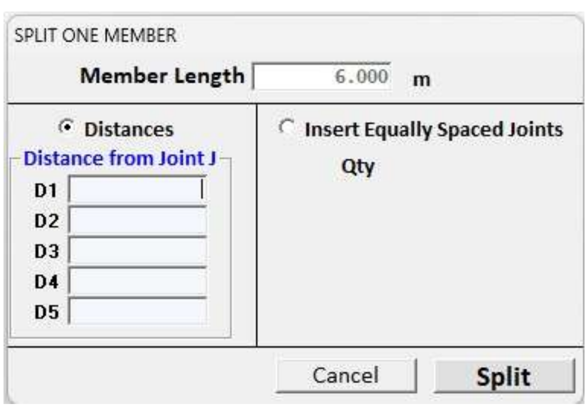


The user will be able there to choose a section from the list of already created sections, and define its properties like End Releases, Orientation of Plane **1-2** and Master Joints, to then draw a new member using the mouse cursor between the existing joints. Once created these new members close the drawing tool by clicking **Save & Exit**.

EDITING PROPERTIES

To edit/change properties of any existing member or group of members, select member(s) to edit, or member(s) intersected by a line or member(s) inside a window, and then click the button with the property to be edited, as:

n Split One Member applies only over the previously selected member, by distance from member origin at D1, D2, D3, D4 and D5 distances, n equal spaces or at the member's middle point (1/2 Split).



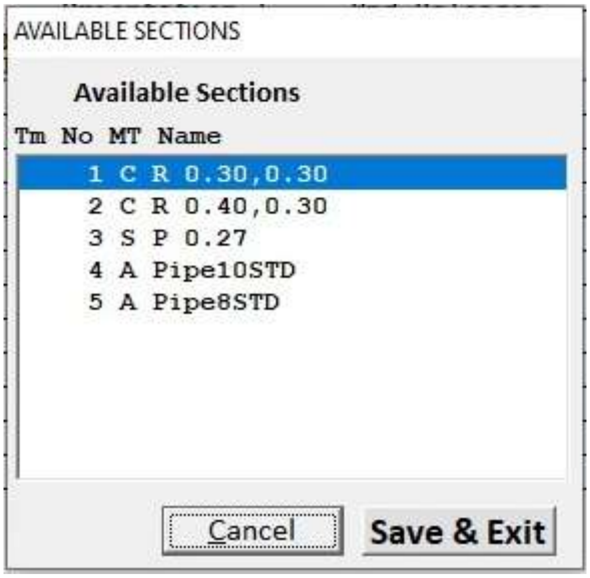
Cross or **Merge** applies over two previously selected members only.

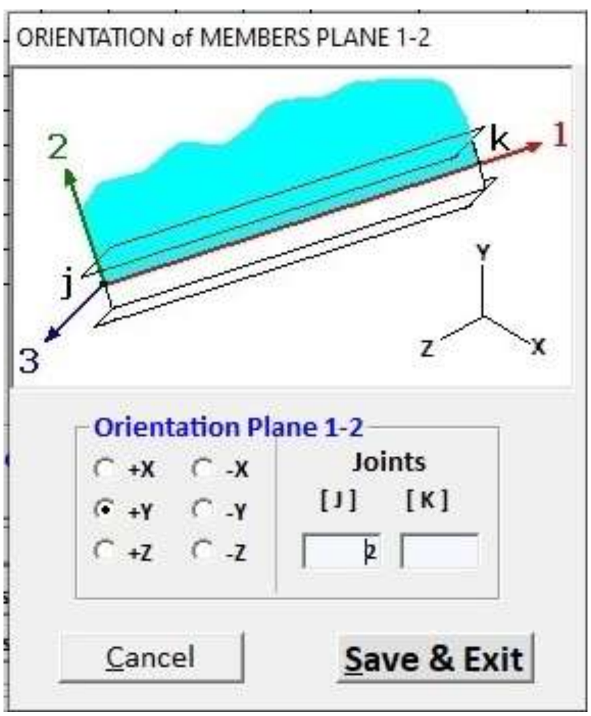
½ **Split** or **Delete** applies over several previously selected members.

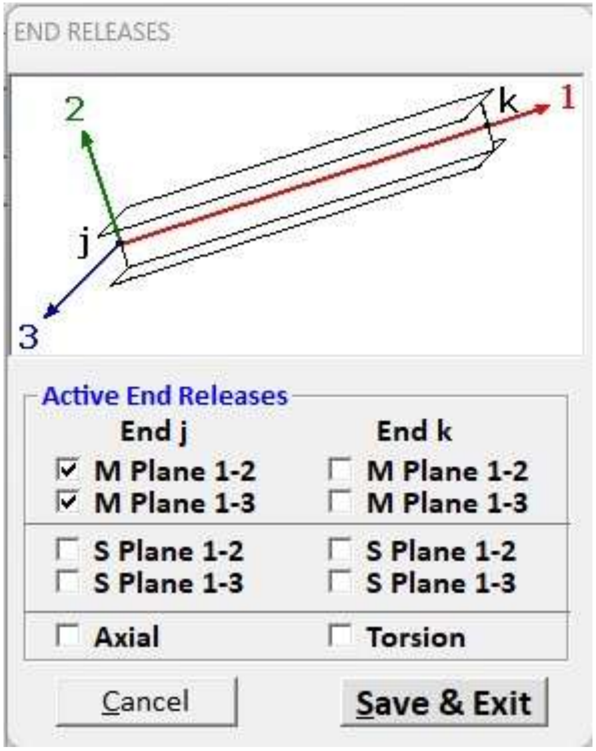
Existing members may be split or merged. Members in the same lineal orientation, adjacent or in the same plane are the only ones that may be merged.

Existing crossing members may be spited creating a new joint at the crossing point.

Following are several editable member properties, as:



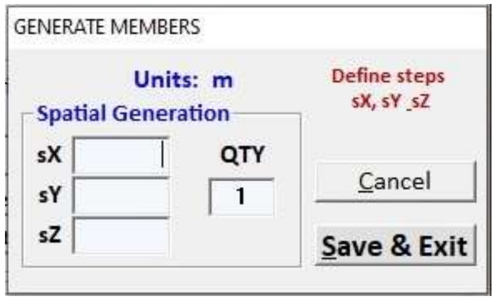




There are two types of member generation:

1- Lineal or in the same direction and orientation of the selected member.

2- Spatial or in any other direction based on the selected member or group of members.



Spatial generation is made by using distance steps in x, y and or z direction, and quantity of new members to be generated.

In both cases all new and necessary joints will be created. If these new joints already exist and are already in the required locations, they will be used, and no new joints will be created.

Click **Save & Exit** to exit and generate the Input Data File.

4.4.7 SHELLS

This field defines all isoparametric quadrilateral Shell members type with a constant thickness conforming the structure, which is always treated as in 3D configuration or 6 DOF's per joint.

A) Using the Text Editor:

It is made up of 3 data groups, defining Sections, Materials and Location, as follows:

4.4.7.1 Control line.
4.4.7.2 Materials library.
4.4.7.3 Description of plate characteristics.

4.4.7.1 Control line

The first data group describes how many different materials are there in the sections library that will be described in the second data group. This data is compulsory.

Syntax: NM=**n**

n Quantity of different materials in the material's library; less than or equal to 512; compulsory use.

Example:
```
NM=5
```

It defines those 5 types of materials that must appear in the library.

4.4.7.2 Materials library

The second data group is made up of **n** lines, each one describing the mechanical and design properties of each shell's material used in the structure.

Syntax: **ni** ***Mechanical Properties*** ***Design Properties***

ni Number from 1 up to **n** which identifies the material number; less than or equal to 512.

Mechanical Properties
Syntax: E=**e** G=**g** P=**p** W=**w** TC=**tc** T=**t** ST=**st**

e Material's modulus of elasticity.
g Material's shear modulus of elasticity.
p Material's Poisson's ratio (μ).
w Material's density in units of weight / volume.
tc Material thermal expansion coefficient in units of length / length / temperature.
t Shell's constant thickness.
st Shell's type.
st=0 for Bending, shear, and membrane stress. (Default).
st=1 for Bending and shear stress only.
st=2 for Membrane stress only.

If **e**, **g**, **w** or **tc** are not defined the software defines them internally and in accordance with material type as follows:

	Reinforced Concrete	**Structural Steel**
e (N/m^2)	2.39916×10^{10}	2.0077551×10^{11}
e (psi)	$3.479686431 \times 10^{6}$	2.9120017×10^{7}
g	e / (2 x (1 + μ))	e / (2 x (1 + μ))
w (N/m^3)	2.35360629×10^{4}	7.69823166×10^{4}
w (lb/ft^3)	1.498277×10^{2}	4.9006008×10^{2}
tc (L / L / °C)	100.000×10^{-7}	130.000×10^{-7}
tc (L / L / °F)	55.555×10^{-7}	72.222×10^{-7}

Suggested Material's Poisson's Ratio (μ) as follows:

Reinforced concrete $\mu = 0.20$
Structural Steel $\mu = 0.28$

Final μ values are adjusted to the defined units.

Design Properties
The software can design two different types of materials: Reinforced Concrete and Structural Steel. All design properties must be in accordance with these two different types of materials.

Syntax: MT=**m** FC=**fc** R=**rc** FY=**fs,ff**

m Type of material:
- **S** Structural Steel.
- **C** Reinforced Concrete.
- **O** Other.

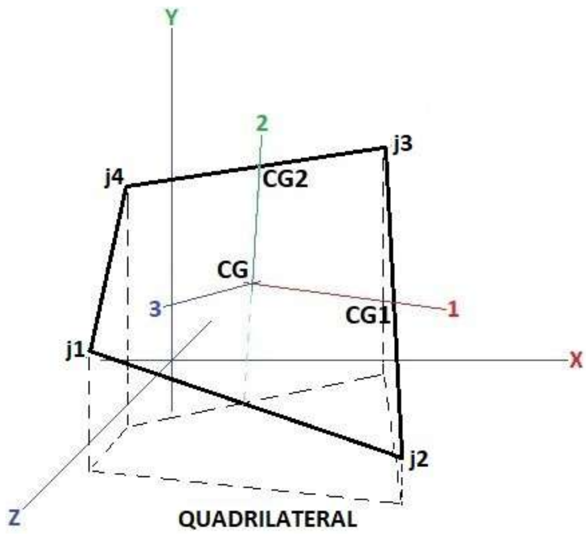
FOR TYPE **S** MATERIAL (Structural Steel)
fc Not applicable.
rc Not applicable.
fs Fy of structural steel.
ff Fu of structural steel. Assumed = 4,222.208 kg/cm^2 or 60 ksi

FOR TYPE **C** MATERIAL (Reinforced Concrete)
fc Concrete compressive strength f'c.
rc Reinforcement cover from concrete face to center line of longitudinal reinforcement.
fs Fy of steel reinforcement used in shear design.
ff Fy of steel reinforcement used in flexure design.

The software assigns the label material name automatically as the Plate Thickness.

4.4.7.3 Description of shell characteristics

The third data group describes the label numbers assigned to each shell, the shell's location in the structure, the material type which the shell is made up according to the data group previously described, and shells generation from the previous data, if any.



It may include as many lines as plates definition exist.

A typical line describes:

- Shell number or label (minor than or equal to 200,000).
- Shell joint's j1, j2, j3 and j4, which defines location and direction of the local axes 1, 2 and 3.
- Material No. according to the materials library previously defined whenever it's different from the material defined in the precedent data line.
- Generation of other shells (if any) based on the existing ones, keeping all the properties above defined except shell's identification No., and shell's joints.

Syntax: **nm** SJ**=j1,j2,j3,j4** SM=**m** SG=**g1,g2**

nm Sheel identification No.; compulsory use (less than or equal to 200,000).
j1 No. of joint **j1**, compulsory use.
j2 No. of joint **j2**, compulsory use.
j3 No. of joint **j3**, compulsory use.
j4 No. of joint **j4**, compulsory use.
m Section No. according to the library, default = previous value.
g1 Quantity of Shells to be generated in direction **j1**, **j2**, default = 0.
g2 Quantity of Shells lines to be generated in direction **j1**, **j4**, default = 0.

For generation purposes the following applies:

- Generation always using previous defined joints.
- **g1** is always defined in direction of ascending joint numbers in steps of 1.
- **g2** defined in the other orthogonal direction.

Example:

```
SHELLS
1  SJ=1,2,9,8  SM=1  SG=6,5
```

The line defines a shell identified as No. 1 that is defined by already defined joints 1, 2, 9 and 8.

The shell's material is the No. 1.

Six shells will be created in direction of joints 1 to 2 (g1=6), conforming a first-row line of 6 shells.

Five row lines of 6 shells each will be created in direction of joints 1 to 8 (g2=5) based on the previous generated row number 1, conforming a generated of 6 by 5 surface grid for a total of 30 new shells.

B) Using the Graphical Editor:

The first step is to create or edit the Section Data Base used in the whole structure. Each section may be defined with a Material Type as Concrete, Steel or Other material.

To create a new Section click **Add New Thickness**, define the material and properties to be applied and click **Accept Edit** to save it on the Data Base list.

To create a new Shell, click **Draw Shells**.

The user will be able there to choose a section to be used from the list of already created sections.

Then draw a new shell using the mouse cursor by clicking on existing joint J1 to then draw and click on existing joints J2, J3 and J4 to conform a new shell from Joint J1 to Joint J4.

EDITING PROPERTIES

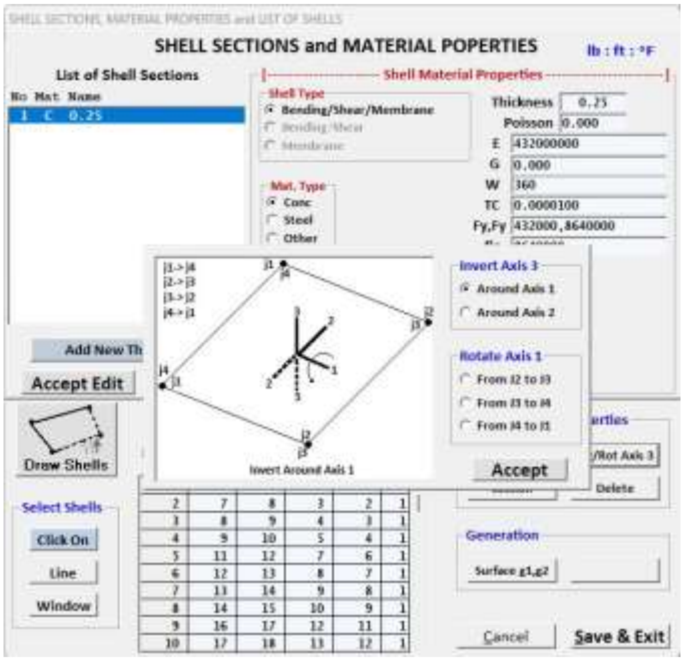
To edit/change properties of any existing shell or group of shells, select shell(s) to edit by **Click on**, shells intersected by a **Line** or shells inside a **Window**, and then click the button with the property to be edited, as:

Split in g1, g2 applies only over one existing shell with joints **j1**, **j2**, **j3** and **j4**, to then dividing it in **g1** and **g2** quantities generating new internal shells in accordance. All new joints will be generated as needed and all supporting beams (if any) will be split in accordance.

Click **Accept** to apply the edition.

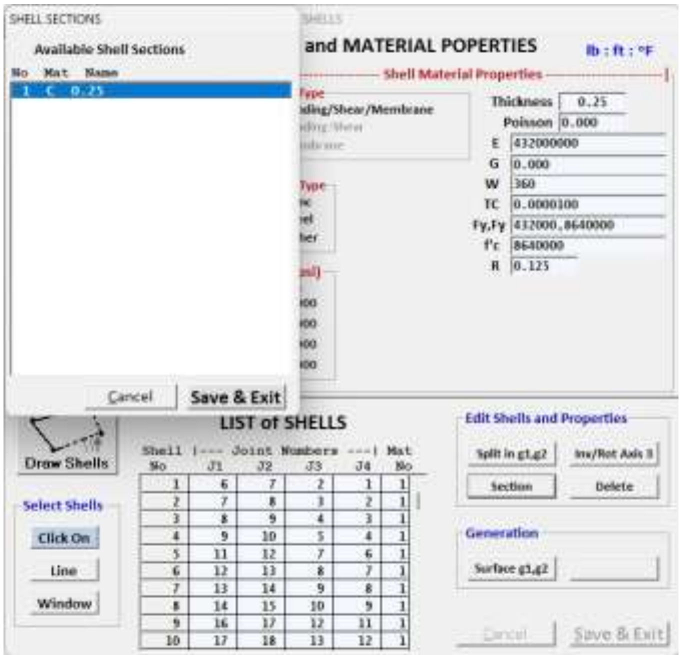
Inv/Rot Axis 3 applies over previously selected existing shell(s), to then **Invert Axis 3** around Axis 1 or Axis 2, or **Rotate Axis 1** from J2 to J3, J3 to J4 or J4 to J1.

Click **Accept** to apply the edition.



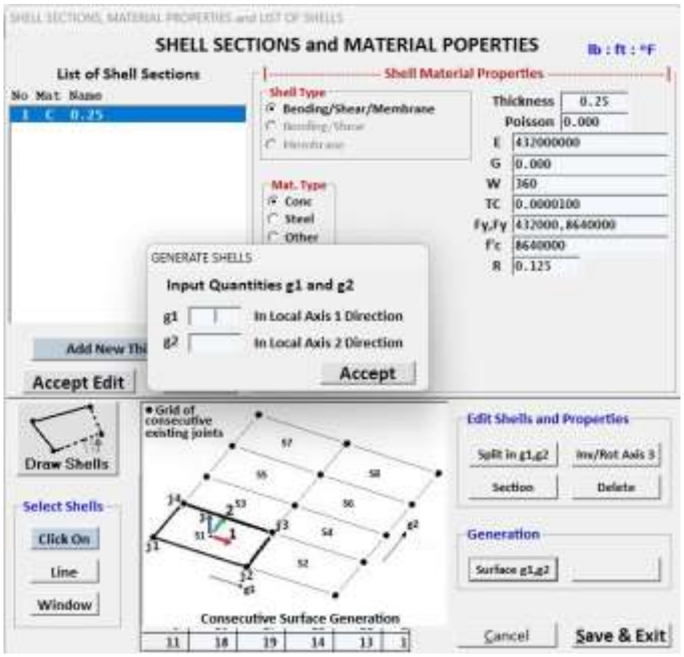
Section applies over previously selected existing shell(s), to then change or edit section number by a previously selected section from the **Shell Sections** data base.

Click **Save & Exit** to apply the edition.



Surface g1, g2 applies to one existing shell with joints **j1**, **j2**, **j3** and **j4**, to generate new shells in **g1** and **g2** quantities generating new shells in accordance. All used joints must be previously created and in a consecutive order. See **Quadrilateral Q** or **Frontal F** Joint generations in **4.4.3 Joints**.

Click **Accept** to apply the edition.



4.4.8 SOLIDS

Under development.

4.4.9 JLOADS

If the joints are subjected to any type of load force or moment this field will be used therefore it's optional. Joints may be loaded in different data lines and such loads will be algebraically added.

A) Using the Text Editor:

It may include as many lines as joint load group per load condition exist.

Syntax: **ni** **nf** **ninc** FX=**f1** FY=**f2** FZ=**f3** MX=**f4** MY=**f5** MZ=**f6** L=**l**

ni No. of the initial joint, compulsory use.
nf No. of the final joint, default = **ni**.
ninc Joints numbers increment, default = 1.

So far, the order of the data in the line is compulsory.

f1 Force in the global **X** direction, default = 0.
f2 Force in the global **Y** direction, default = 0.
f3 Force in the global **Z** direction, default = 0.
f4 Moment about global axis **X**, default = 0.
f5 Moment about global axis **Y**, default = 0.
f6 Moment about global axis **Z**, default = 0.
l No. of the load condition where these forces are applied. Maximum 100 load conditions, default = 1 or previous value.

The sign of forces must follow the direction of the global axes **X**, **Y** and **Z**, and for the moments, the right-hand rule about global axis **X**, **Y** and **Z** must be followed.

If there is a group of joint forces and moments applied only for a load condition number **l**, the first line of these joint load groups must contain a L=**l** only.

Example:
```
10  FY=-1  L=2
```

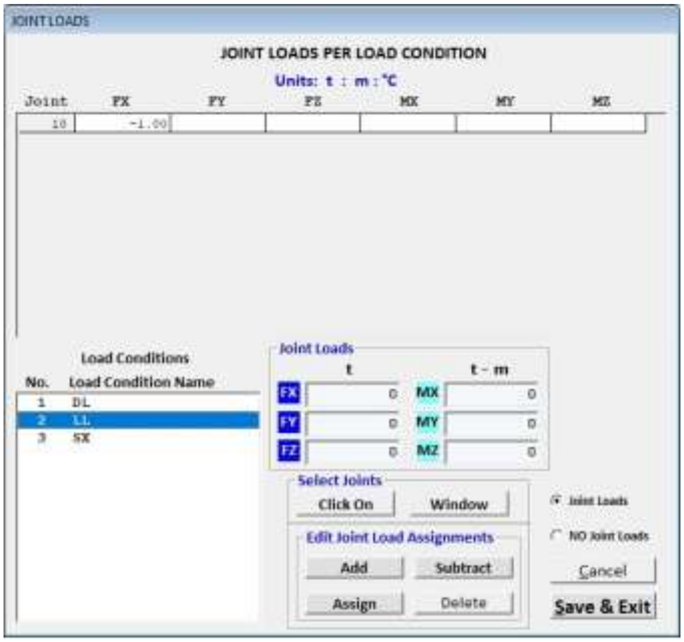
The line defines that the joint identified as No. 10 is subjected to a load with a magnitude of -1, applied in the global **Y** direction, and for the load condition No. 2.

B) Using the Graphical Editor:

To assign Joint Loads just define the Joint Forces and Moments to be applied, select the appropriate Load Condition from the list of Load Conditions and using the lower tools select the joints by clicking **Click On** or **Windows**, and apply or edit the Joint Load.

Joint Loads can be added, subtracted, assigned or deleted from the selected joints.

To edit an existing Joint Load per Load Condition just select the appropriate Load Condition then click the listing, select the joint and use the lower tools to edit the appropriate information.



Click **Save & Exit** to exit and generate the Input Data File.

4.4.10 MLOADS

If members are subjected to any type of distributed or point loads along them, this field will be used, and therefore it's optional.

A) Using the Text Editor:

It is made up of 3 data groups:

4.4.10.1	Control line
4.4.10.2	Load patterns library
4.4.10.3	Loads location on members

4.4.10.1 Control line

The first data group indicates how may load patters there are in the "Load patters library" described in the second data group. This data is compulsory.

Load patters are used to create Load Conditions (Self-weight, Dead Load, Live Load, etc.) that will be used during the analysis and design.

Self-weight is optional. If self-weight is considered in any load condition, it is defined as follows:

It must be specified in what direction the self-weight is activated, a multiplier factor which defines direction and amplification, and a load condition where to be applied. It is a good practice to define the self-weight in load condition No. 1, leaving the other load conditions (dead load inclusive) for other load conditions over the structure.

Only one self-weight activation is allowed for each analysis.

Syntax: NP=**np** **Af**=**p1** L=**l**

np Quantity of load patterns in the load patterns library. Less than or equal to 1000, default = 0. (See 2.7)

Af Alphanumeric code that may be **"WX", "WY"** or **"WZ"**, indicating the self-weight direction in global coordinates, optional use.

p1 Self-weight multiplier factor of section with density defined in "4.4.6 MEMBERS", default = 0.

l Load condition number where self-weight will be applied, default = 1.

Example:
```
NP=5  WY=-1  L=1
```

It defines that 5 load patterns must appear in the Loads patterns library and the self-weight is activated in the global **Y** direction (WY), with a self-weight multiplier factor value of -1, the negative sign indicating negative direction of **Y** axis (downward), and L=1 for load condition number 1.

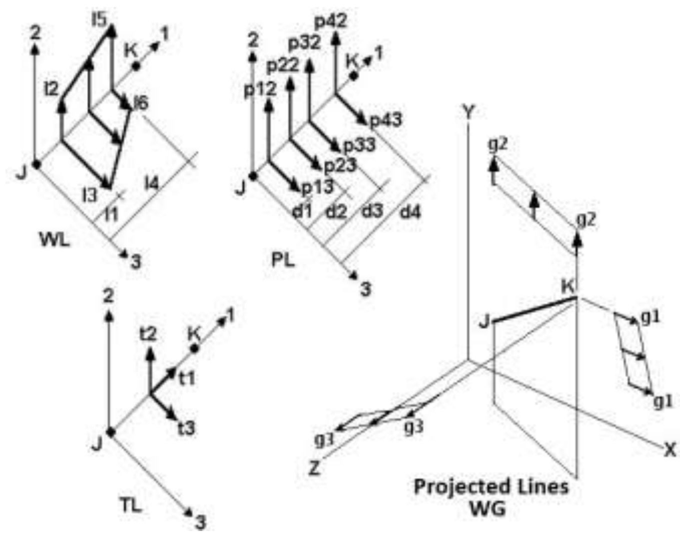
4.4.10.2 Load patterns library

The second data group may include **np** lines that describe the load patterns in local or global coordinates and are made up of many data lines as needed.

The lines must be typed in a strict ascending order from 1 to **np** load patterns (up to 1000).

The load patterns are made of loads that may be of four different types:

WL Trapezoidal member span loads in member local axes. Units of Force/Length.
PL Concentrated loads (4 maximum per each load pattern) in member local axes.
TL Thermal loads (ΔT) along the three-member local axes.
WG Uniform member span loads in the member global axes directions. Units of Force/Length.



The order of appearance in the data line is not relevant.

The sign describes the direction in which the loads are applied according to the orientation of each member's local planes **1-2** and **1-3** or the global axes **X, Y** and **Z**. (See 2.2 Global and Local Axes).

A positive temperature means a temperature increase and a negative one implies a temperature decrease.

Syntax: **nn** WL=**l1,l2,l3,l4,l5,l6** TL=**t1,t2,t3** WG=**g1,g2,g3**
PL=**d1,p12,p13,d2,p22,p23,d3,p32,p33,d4,p42,p43**

nn Load pattern identification number in ascending order from 1 and ending in **np**, compulsory use.
l1 Distance from the member's initial joint j, where trapezoidal loads appear for one or both local planes **1-2** and **1-3**, compulsory use.
l2 Value of the span load in plane **1-2** at point **l1**, default = 0.
l3 Value of the span load in plane **1-3** at point **l1**, default = 0.
l4 Distance from the member's initial joint j, where the trapezoidal loads end for one or both local planes **1-2** and **1-3**, default = 0.
l5 Value of the span load in plane **1-2** at point **l4**, default = 0.
l6 Value of the span load in plane 1-2 at point **l4**, default = 0.

If values **l4**, **l5** and **l6** are omitted, the software assumes a uniform span load starting at an **l1** distance, constant along the member up to the final joint k and with the values **l2** and **l3**.

t1 Temperature change in degrees along local axis 1; it generates tensile or compressive forces and is applied in the center of the member, default = 0.

t2 Temperature gradient per dimension in the local axis 2 direction. Must be computed as temperature difference divided by the member's dimension in the local axis 2 direction. It generates bending loads in plane **1-2** and is applied in the center of the member, default = 0.
t3 Temperature gradient per dimension in the local axis 3 direction. Must be computed as temperature difference divided by the member's dimension in the local axis 3 direction. It generates bending loads in plane **1-3** and is applied in the center of the member, default = 0.

This data must be consistent with the units used for Thermal Expansion Coefficient **TC**.

g1 Uniform span load applied in the global X direction, default = 0.
g2 Uniform span load applied in the global Y direction, default = 0.
g3 Uniform span load applied in the global Z direction, default = 0.

Span loads on member's Global projection lines.

d1 Distance from the member's initial joint j, where the first point load appears for one or both local planes **1-2** and **1-3**, default = 0.
p12 Point load in plane **1-2** located at point **d1**, default = 0.
p13 Point load in plane **1-3** located at point **d1**, default = 0.
d2 Distance from the member's initial joint j, where the second point load appears for one or both local planes **1-2** and **1-3**, default = 0.
p22 Point load in plane **1-2** located at point **d2**, default = 0.
p23 Point load in plane **1-3** located at point **d2**, default = 0.
d3 Distance from the member's initial joint j, where the third point load appears for one or both local planes **1-2** and **1-3**, default = 0.
p32 Point load in plane **1-2** located at point **d3**, default = 0.
p33 Point load in plane **1-3** located at point **d3**, default = 0.
d4 Distance from the member's initial joint j, where the fourth point load appears for one or both local planes **1-2** and **1-3**, default = 0.
p42 Point load in plane **1-2** located at point **d4**, default = 0.
p43 Point load in plane **1-3** located at point **d4**, default = 0.

Example:
```
1  WG=0,-0.35           :IN MEMBERS 5 TO 8
2  WL=0,-0.25,0,6.557,0 :IN MEMBERS 9 TO 12
3  PL=3,-0.5            :IN MEMBERS 5 TO 8
4  WG=0.15              :IN MEMBERS 1 AND 3
5  WG=0.1               :IN MEMBERS 9 AND 11
```

The first line defines pattern No.1 with a WG load type
The second line defines pattern No.2 with a WL load type
The third line defines pattern No.3 with a PL load type
The four line defines pattern No.4 with a WG load type
The fifth line defines pattern No.5 with a WG load type.

4.4.10.3 Load pattern location on members

The third data group indicates which members will be loaded with the previously defined load patterns and for which load condition. It is suggested to lump them by load condition. (See 2.7 Joint loads or Loads applied over members).

It may include as many lines as needed by the number of loaded members definitions.

Syntax: **mi mf minc** LP=**p1,p2,...,pn** L=**l**

mi No. of initial loaded member, compulsory use.
mf No. of final loaded member, default = **mi**.
minc Increment of members numbers, default = 1.
p1 Loads pattern number 1, default = 0.
p2 Loads pattern number 2, default = 0.
pn Loads pattern number **n** with a maximum of 10 load patterns, default = 0.
l Load condition number where these load patterns will be assigned. Maximum 100 load condition, default = 1 or previous load condition defined.

Example:
```
 5  6      LP=1,3  L=2
 7  8      LP=1,3
 9 11   2  LP=2
10 12   2  LP=2
 1  3   2  LP=4    L=3
 7         LP=4
 9 11   2  LP=5
```

The first line defines member 5 and 6, with load patterns 1 and 3 applied to Load Condition 2.
The second line defines member 7 and 8, with load patterns 1 and 3 applied to previous Load Condition 2. Etc.

B) Using the Graphical Editor:

The first step is to define the direction (usually in Y direction), load condition (usually the first one) and multiplier factor (usually -1.0 indicating downward direction) of the *Self-weight* of the whole structure and for those member sections with defined density (W). If the analysis is of Seismic or Dynamic type, then the Self-weight will be converted to Mass automatically.

The second step is to create or edit the Load Pattern Data Base used in the whole structure.

The loads may be of four different types:

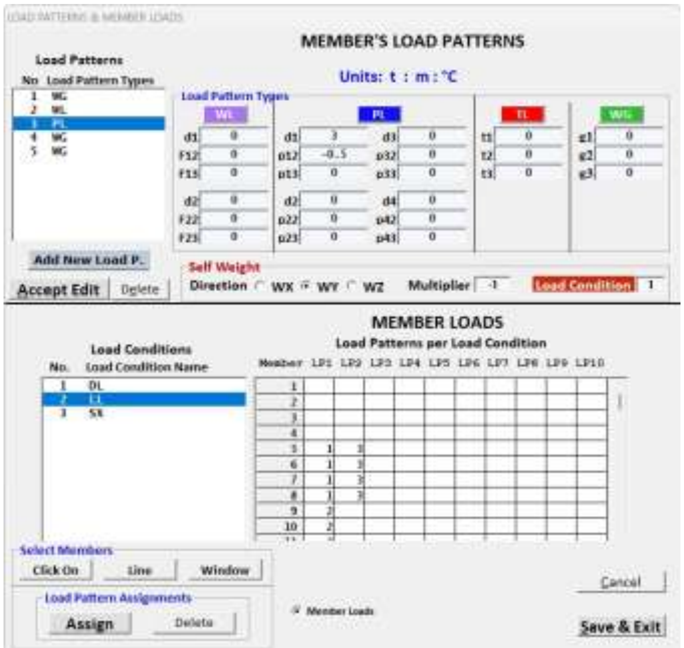
WL Trapezoidal member span loads in member local axes.
PL Concentrated loads (4 maximum per each load pattern) in member local axes.
TL Thermal loads along the member local axes.
WG Uniform member span loads in the member global axes directions.

To create a new Load Pattern, click **Add New Load P.**, define the Load Pattern type in the data and click **Accept Edit** to save it.

By clicking **WL**, **PL**, **TL** or **WG** colored buttons, the form shows a small picture of each type of load indicating the meaning of the associated input data.

To edit an existing Load Pattern just click the listing and edit the appropriate information. Then click **Accept Edit** to save the edition.

Once created the load pattern database, the user defines to which member or group of members which load patterns may be applied (or edited) and to which load condition from the list of available load conditions to apply the load patterns.



To edit an existing member or group of members Load Pattern per Load Condition just click the listing or use the lower tools and edit the appropriate information.

Click **Save & Exit** to exit and generate the Input Data File.

4.4.11 SHLOADS

If Shells are subjected to any type of distributed loads on any side or a surface, this field will be used, and therefore it's optional.

A) Using the Text Editor:

It is made up of 3 data groups:

4.4.11.1 Control line
4.4.11.2 Load patterns library
4.4.11.3 Loads location on shells

4.4.11.1 Control line

The first data group indicates how may load patters there are in the "Load patters library" described in the second data group. This data is compulsory.

Load patters are used to create Load Conditions (Self-weight, Dead Load, Live Load, etc.) that will be used during the analysis and design.

Self-weight is optional. If self-weight is considered in any load condition, it is defined as follows:

It must be specified in what direction the self-weight is activated, a multiplier factor which defines direction and amplification, and a load condition where to be applied. It is a good practice to define the self-weight in load condition No. 1, leaving the other load conditions (dead load inclusive) for other load conditions over the structure.

Only one self-weight activation is allowed for each analysis.

Syntax: NP=**np** **Af**=**p1** L=**l**

np Quantity of load patterns in the load patterns library. Less than or equal to 1,000, default = 0. (See 2.7)
Af Alphanumeric code that may be "**WX**", "**WY**" or "**WZ**", indicating the self-weight direction in global coordinates, optional use.
p1 Self-weight multiplier factor of shell section thickness with density defined in "4.4.7 SHELLS", default = 0.
l Load condition number where self-weight will be applied, default = 1.

Example:
```
NP=5  WY=-1  L=1
```

It defines that 5 load patterns must appear in the Loads patterns library. The self-weight is activated in the global **Y** direction (WY), with a self-weight multiplier factor value of -1, the negative sign indicating negative direction of **Y** axis (downward), and L=1 for load condition number 1.

4.4.11.2 Load patterns library

The second data group may include **np** lines that describe the load patterns in local or global coordinates and are made up of many data lines as needed.

The lines must be typed in a strict ascending order from 1 to **np** load patterns (up to 1,000).

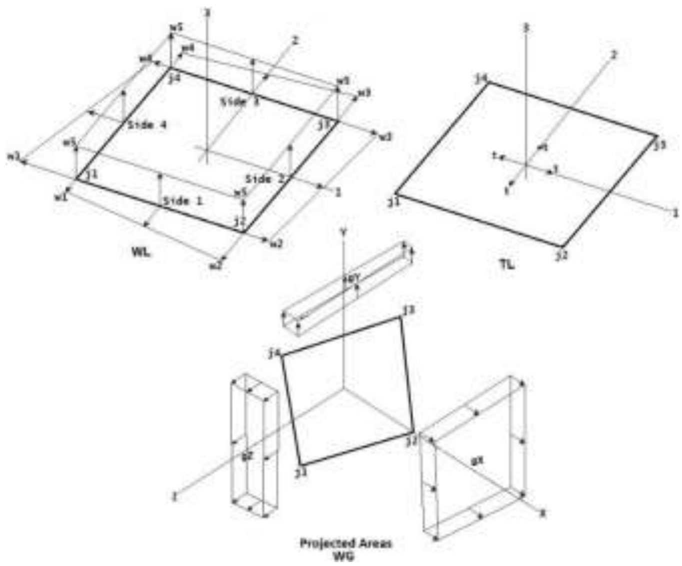
The load patterns are made of loads that may be of three different types:

WL Trapezoidal distributed surface side loads, (units of Force/Length/Thickness) on shell sides in local axes **1** and **2** directions, and a surface load in shell local axis **3** direction. Units of Force/Area.

TL Thermal load (ΔT) applied on shell surface in local axes **1** and **2** directions.

WG Uniformly distributed shell surface loads applied at shell center line defined by shell's joints (**j1**, **j2**, **j3** and **j4**) and in global axes (**X**, **Y**, **Z**) directions. Units of Force/Area.

The order of appearance in the data line is not relevant.



The sign describes the direction in which the loads are applied according to the orientation of each shell's local axes **1, 2** and **3** and global axes **X, Y** and **Z.** (See 2.2 Global and Local Axes).

A positive ΔT temperature means a temperature increase and a negative one implies a temperature decrease.

Side 1, from Joint **j1** to Joint **J2.**
Side 2, from Joint **j2** to Joint **J3.**
Side 3, from Joint **j3** to Joint **J4.**
Side 4, from Joint **j4** to Joint **J1.**

Syntax: **nn** WL=**si,wi,wk,ws** TL=**t** WG=**gX,gY,gZ**

nn Load pattern identification number in ascending order from 1 and ending in np, compulsory use.
si Shell's side i, defined by joint **ji** to joint **jk**, default = 0.
wi Surface side load in initial joint **ji**, default = 0.
wk Surface side load in final joint **jk**, default = 0.
ws Uniformly distributed surface load in local axis 3 direction, default = 0.

t Temperature change ΔT in degrees along local axes 1 and 2; it generates membrane expansion (+ sign) or contraction (- sign), default = 0.

This data must be consistent with the units used for Thermal Expansion Coefficient **TC**.

gX Uniform distributed surface load applied in the global X direction, default = 0.
gY Uniform distributed surface load applied in the global Y direction, default = 0.
gZ Uniform distributed surface load applied in the global Z direction, default = 0.

Surface loads over shell's projected areas on Global axes directions.

Example:
```
  1  WG=0,-0.35        :GLOBAL DISTRIBUTED SURFACE LOAD
  2  WL=1,-0.25,-0.25 :SURFACE SIDE LOAD
  3  WL=0,0,0,-0.50   :UNIFORMLY DISTRIBUTED SURFACE LOAD
  4  TL=30            :TEMPERAURE CHANGE
```

The first line defines a pattern No.1 with a WG load type, applied in -Y direction.
The second line defines a pattern No.2 with a WL surface side load type, applied on side 1.
The third line defines a pattern No.3 with a WL surface load type, applied in axis 3 direction.
The fourth line defines a pattern No.4 with a TL load type, as a membrane expansion.

4.4.11.3 Load pattern location on shells

The third data group indicates which shells will be loaded with the previously defined load patterns and for which load condition. It is suggested to lump them by load condition. (See 2.8 Shell loads or Loads applied over shells).

It may include as many lines as needed by the number of loaded shells definitions.

Syntax: **mi mf minc** LP=**p1,p2,...,pn** L=**l**

mi No. of initial loaded shell, compulsory use.
mf No. of final loaded shell, default = **mi**.
minc Increment of shell numbers, default = 1.
p1 Loads pattern number 1, default = 0.
p2 Loads pattern number 2, default = 0.
pn Loads pattern number **n** with a maximum of 10 load patterns, default = 0.
l Load condition number where these load patterns will be assigned. Maximum 100 load condition, default = 1 or previous load condition defined.

Example:
```
 1 21  5  LP=1,3  L=2
 7  8     LP=2,4
```

The first line defines shells 1, 6, 11, 16, and 21, with load patterns 1 and 3 applied to Load Condition 2.
The second line defines shells 7 and 8, with load patterns 2 and 4 applied to previous Load Condition 2.

B) Using the Graphical Editor:

The first step is to define the direction (usually in Y direction), load condition (usually the first one) and multiplier factor (usually -1.0 indicating downward direction) of the *Self-weight* of the whole structure and for those shells with defined density (W). If the analysis is of Seismic or Dynamic type, then the Self-weight will be converted to Mass automatically.

The second step is to create or edit the Load Pattern Data Base used in the whole structure.

The loads may be of three different types:

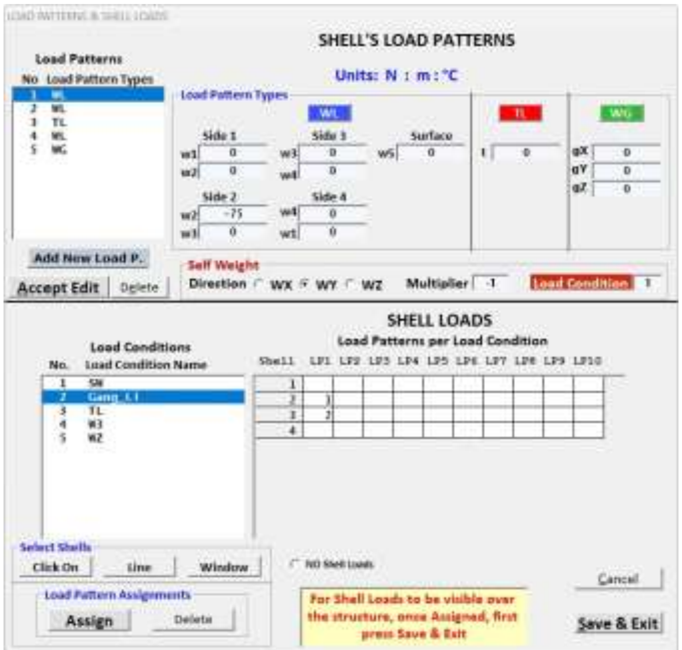
WL Trapezoidal shell span loads in shell local axes.
TL Thermal loads along the shell local axes.
WG Uniform shell surface loads in the shell global axes directions.

To create a new Load Pattern, click **Add New Load P.**, define the Load Pattern type in the data and click **Accept Edit** to save it.

By clicking **WL**, **TL** or **WG** colored buttons, the form shows a small picture of each type of load indicating the meaning of the associated input data.

To edit an existing Load Pattern just click the listing and edit the appropriate information. Then click **Accept Edit** to save the edition.

Once created the load pattern database, the user defines to which shell or group of shells which load patterns may be applied (or edited) and to which load condition from the list of available load conditions to apply the load patterns.



To edit an existing shell or group of shells Load Pattern per Load Condition just click the listing or use the lower tools and edit the appropriate information.

Click **Save & Exit** to exit and generate the Input Data File.

4.4.12 SLOADS

Under development.

4.4.13 DISPLACEMENTS

If the joints are subjected to any kind of induced displacements this field will be used, therefore it is optional. It may include as many data lines as needed.

Wherever a joint has been set free to movement using the proper RESTRAINTS definition, an induced displacement may be applied, defining its magnitude in accordance with the units of length for displacements along the three global axes **X**, **Y** and **Z**, and radians for the three rotations about global axes **X**, **Y** and **Z**.

Point loads cannot be applied on any joint with induced displacements, in the same direction and sign of the displacements. A specific displacement may not be defined more than once for the same joint.

To define a displacement equal to zero (Support type), the restraint corresponding to the associated degree of freedom must be used instead and under 4.4.4 RESTRAINTS.

A) Using the Text Editor:

Syntax: **ni** **nf** **ninc** DX=**d1** DY=**d2** DZ=**d3** <X=**d4** <Y=**d5** <Z=**d6**

ni No. of initial joint, compulsory use.
nf No. of final joint, default = **ni**.
ninc Increment of joint numbers, default = 1.
d1 Displacement in the global **X** direction, default = 0.
d2 Displacement in the global **Y** direction, default = 0.
d3 Displacement in the global **Z** direction, default = 0.
d4 Rotation about the global axis **X** in radians, default = 0.
d5 Rotation about the global axis **Y** in radians, default = 0.
d6 Rotation about the global axis **Z** in radians, default = 0.

Example:

```
10   DY=-0.0025   :Y DIRECTION IN JOINT 10
```

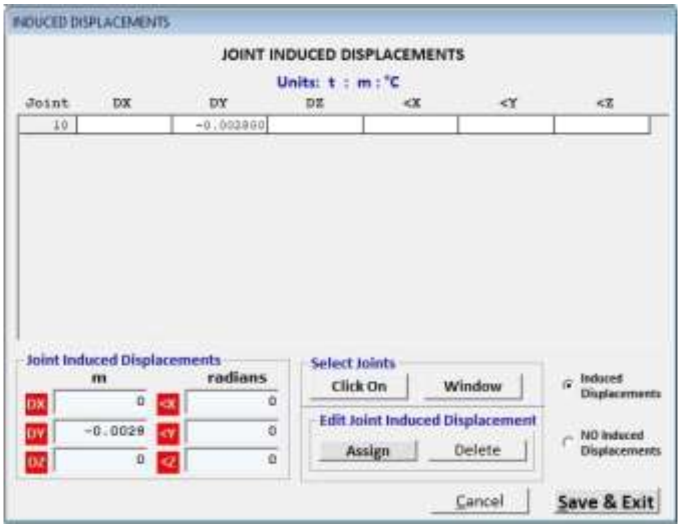
It defines that joint 10, has a induced displacement of -0.0025 in the global **Y** direction.

B) Using the Graphical Editor:

To assign Joint Induced Displacements just define the Joint displacements and rotation values to be applied, and using the lower tools select the joints and apply or edit the Joint Induced Displacement.

Joint Induced Displacements can be assigned or deleted from the selected joints.

To edit an existing Joint Induced Displacement just click the listing and or use the lower tools to edit the appropriate information.



Click **Save & Exit** to exit and generate the Input Data File.

4.4.14 MASS

This field is used if within a seismic analysis, the seismic forces are evaluated through the Equivalent Lateral Force (ELF) method or Response Spectrum (RS) method, or if in a dynamic analysis there are concentrated weights in the joints or distributed loads along the members which must be referred as involved masses in the evaluation of the mass of the system and the seismic forces.

Applied forces in the vertical direction (**Y** axis) will only be considered to convert them into concentrated masses in the joints of the structure. Such defined loads will be added algebraically to form the mass matrix [M] of the structural system.

It is important that all the concentrated weights in the structure due to fixed dead loads such as flooring and ceiling covers, dividing walls, heavy machinery, etc. are conveniently included in the analysis to have the model as realistic as possible. These concentrated weights are of special importance since they will affect greatly the calculation of the natural frequencies and the vibration modes associated, and therefore will impact all subsequent seismic or dynamic analysis.

All distributed (MLOADS/SLOADS) or concentrated (JLOADS) weights in the structure must be associated to different load condition numbers to the one assigned to the self-weight, with the purpose of including them into the total mass and involved mass calculation of the structural system. The software will not consider concentrated weights associated to load condition numbers equal to the load condition assigned to the self-weight, usually the first one.

Each load condition defined can be multiplied by an **f** factor greater than zero.

A) Using the Text Editor:

There will be as many data lines as needed to identify the load conditions which will generate the system's structural mass.

Syntax: M=**m,f**

m Load condition No. defined as a load condition generating the system's structural mass, default = 0.

f Multiplying factor of the forces in **Y** direction (downward vertical axis and positive always) of the load condition **m**, default = 1.

Example:

```
M=1,1.5
M=2,0.7
M=3
```

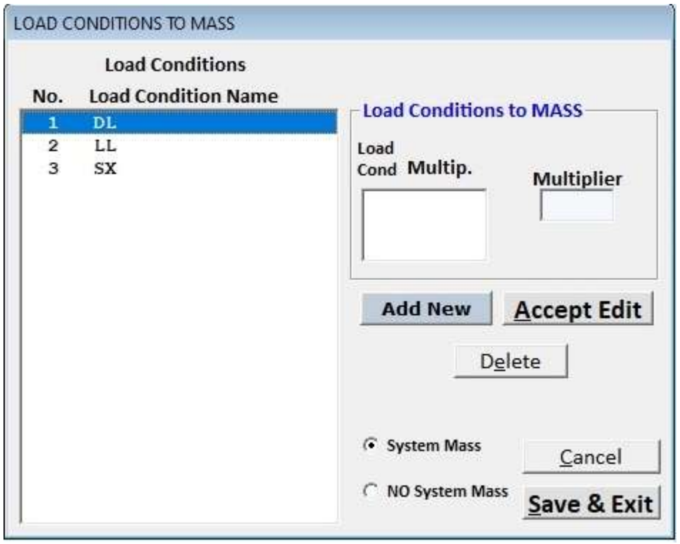
The first line defines that the loads (oriented in the global **Y** axis downward direction) in load condition No.1 will be multiplied by 1.5 and will take part in the mass matrix of the structural system.

The second line defines that the loads (oriented in the global **Y** axis downward direction) in load condition No. 2 will be multiplied by 0.7 and will take part in the mass matrix of the structural system.

The third line defines that the loads (oriented in the global **Y** axis downward direction) in load condition No.3 will be multiplied by 1.0 (default) and will take part in the mass matrix of the structural system.

B) Using the Graphical Editor:

To create a new Load Condition to Mass, click **Add New**, select the appropriate Load Condition for the list of Available Load Conditions and define the multiplier factor to be used in the conversion of loads to masses. Then click **Accept Edit** to save the edition.



To edit an existing Load Condition to Mass just click the listing and or use the lower tools to edit the appropriate information. Then click **Accept Edit** to save the edition.

Click **Save & Exit** to exit and generate the Input Data File.

4.4.15 DAMP

This field is used within a dynamic analysis, were the structure damping due to its internal frictions needs to be considered.

Damping applies for Modal Superposition, Step Integration or Steady State analyses.

The software computes the damping matrix of the system [C] as:

$$[C] = \boldsymbol{\alpha}\,[M] + \boldsymbol{\beta}\,[K]$$

In which [M] = mass matrix of the system and [K] = stiffness matrix of the system.

Damping Rayleigh coefficients **α** and **β** can be input by the user or computed by the software.

If the software computes **α** and **β** (alpha and beta) then the user provides the damping ratio for the first natural frequency of the system and the damping ratio for the last natural frequency of the system (See Eigenvalues **NR** in 4.4.17 DYNAMIC). Damping ratios for the rest of the system are then computed as linearly proportional to the frequency **ω** of the whole system. If the user defines only the damping ratio of the first natural frequency, then the software will assign this value to the rest of the natural frequencies of the system. (See 2.16 Damping of the Structural System).

A) Using the Text Editor:

With **α** and **β** to be computed by the software:
Syntax: DR=**dr1**,**drn**

dr1 Damping ratio for the first natural frequency, default = 0
drn Damping ratio for the last requested natural frequency, default = dr1

With damping Rayleigh coefficients **α** and **β** to be input by the user:
Syntax: DC=**alpha**,**beta**

alpha **α** Coefficient, default = 0
beta **β** Coefficient, default = 0

Example:
```
DC=0.035,0.009
```

Damping coefficients defined as **α** = 0.035 and **β** = 0.009, using these values the software computes the damping matrix of the system [C].

Example:
```
DR=0.05,0.20
```

Damping ratios defined as 0.05 for the first natural frequency and 0.20 for the last natural frequency of the system, using these values the software computes the damping Rayleigh coefficients **α** and **β** and then the damping matrix of the system [C].

B) Using the Graphical Editor:

The user must select whether to input **alpha** (**α**) and **beta** (**β**) coefficients or let the software compute them from the Damping Ratios associated to the first and last Eigenvalues requested for the structural system.

For **α** and **β** defined by the user. Click **User** and input the appropriate values.

For **α** and **β** computed by the software. Click **Software** and input damping ratios **dr1** and **drn**.

Click **Save & Exit** to exit and generate the Input Data File.

4.4.16 SEISMIC

This field is used if the seismic forces within an analysis are evaluated throughout the Equivalent Lateral Force (ELF) method or Response Spectrum (RS) method. The masses of the members and concentrated masses in the joints, defined in MASS, will be included in the evaluation of the fundamental periods and the lateral seismic forces.

The elastic spectrum of accelerations can be calculated by the software based on the ASCE 7-10/16 or NSR-10 code, or it can be defined by the user based on pairs of period-fraction values of the acceleration.

For spectrums calculated by code ASCE 7-10/16 or NSR-10 or defined using pairs of period-fraction values of acceleration the software will further divide the spectrum by the corresponding energy dissipation coefficient(s) **R**.

Fundamental periods "Ta" are computed using code ASCE 7-10/16 if there is no defined code.

A) Using the Text Editor:

It is made of three data lines as follows:

First line, for equivalent lateral force (ELF) method or response spectrum (RS) method.

EQUIVALENT LATERAL FORCE (ELF) METHOD
For an analysis of the seismic forces through the Equivalent Lateral Force method, the following terms are defined. See ASCE 7-16 PROVISIONS, ELF:

Seismic analysis through the Equivalent Lateral Force (DT=**1**).

Load conditions **lc1** and **lc2** are defined corresponding to the seismic forces in the **X** direction and **Z** direction. If the structure is a Plane Frame or a plane truss, defined in the global axis plane **X-Y**, then it is only necessary to define load condition **lc1** which corresponds to the forces in the **X** direction.

Syntax: DT=**d** L=**lc1,lc2**

d Type of seismic analysis. One (1) stands for Equivalent Lateral Force, default = 0.
lc1 Load condition number corresponding to the seismic forces in the **X** direction, default = 0.
lc2 Load condition number corresponding to the seismic forces in the **Z** direction, default = 0.

RESPONSE SPECTRUM (RS) METHOD
For an analysis of the seismic forces through the Response Spectrum method, the following terms are defined.

Seismic analysis through the Response Spectrum Method (DT=**2**).

The load condition number corresponding to the seismic force **lc**, required Eigenvalues number (2 or greater) and the modal combination method of the seismic forces.

Different types of modal combination **mc**:
1 = Modal combination type SAV (Sum of the Absolute of the Modal Response Values)
2 = Modal combination type SRSS (Square Root of the Sum of the Squares)
3 = Modal combination type CQC (Complete Quadratic Combination)

Only one load condition **lc** is defined for the seismic analysis, which corresponds to the seismic forces calculated by the software.

Syntax: DT=**d** L=**lc** NR=**nr** MC=**mc** PR=**pr**

d Type of seismic analysis, two (2) stands for Response Spectrum, default = 0.
lc Load condition number corresponding to the seismic force, default = 0.
nr Numbers of Eigenvalues and Eigenvectors requested, default = 2.
mc Modal combination type, default = 1 (SAV).
pr Printing flag for Modal Displacements and Base Shears printout; 1 generates the printout, 0 suppress it, default = 0.

Second line

For the Equivalent Lateral Force analysis, the Energy Dissipation coefficients must be defined in both **rx** and **rz** directions.

For Response Spectrum analysis, it's enough to define only one value (**rx**) for the Energy Dissipation coefficient. If the user defines both, the software then uses the smallest value between them.

Parameters for the calculation of the seismic forces according to the Response Spectrum and the ASCE 7-10/16 code or NSR-10 code:

The software computes the fundamental period "Ta" using Rayleigh method as:

ASCE 7-10/16 code $Ta = Ct\ h^{x}$ ***(DEFAULT)***

NSR-10 code $Ta = Ct\ h^{Alpha}$

Careful must be applied with the units of **h** and **Ct** taken from each code. For ASCE 7-10/16 **h** is in feet and for NSR-10 **h** is in meters. Therefore, values and joint coordinates must be consistent with the system of units defined within the whole analysis.

The total height **h** of the structure is obtained from the difference between the vertical coordinates of the joints **j1** and **j2** and is used in the evaluation of the structure's fundamental periods through the Rayleigh method. Therefore, joint **j1** must be the lowest one in the structure (usually at foundation level) and joint **J2** must be the highest one (Usually at roof level). These joints must represent the structure in the evaluation of the structure's total height **h**.

Syntax: CT=**ct** CX=**cx** JS=**j1,j2** RF=**rx,rz** IF=**if**

ct Coefficient Ct according to ASCE 7-10/16 or NSR-10, default = 0.
cx **x** Coefficient for ASCE 7-10/16 or Alpha Coefficient for NSR-10, default = 0.
j1 No. of the lowest joint in the structure, default = 0.
j2 No. of the highest joint in the structure, default = 0.
rx Energy Dissipation coefficient in the **X** axis direction, default = 1.
rz Energy Dissipation coefficient in the **Z** axis direction, default = 1.
if Structure Importance Coefficient or Factor, default = 1.

Third (or more) line (s)

Parameters that define the elastic acceleration Response Spectrum, and according to ASCE 7-10/16 or NSR-10, or Response Spectrum defined and provided by the user:

Option 1. Spectrum calculated by the software by means of ASCE 7-10/16 or NSR-10 code:

Syntax: ST=**st** FA=**fa** FV=**fv** SS=**aa** S1=**av**

st **ASCE10** for ASCE 7-10/16 code or **NSR10** for NSR-10 code, default = **ASCE10**.

For ASCE 7-10/16 or NSR-10 codes
fa (Fa) Coefficient of amplification of acceleration in short periods form code tables, default = 0.
fv (Fv) Coefficient of amplification of acceleration in intermediate periods from code tables, default = 0.

For ASCE 7-10/16 code
aa (Ss) Mapped spectral response acceleration parameter at short periods, default = 0.
av (S1) Mapped spectral response acceleration parameter at period of 1 s, default = 0.

For NSR-10 code
aa (Aa) Mapped coefficient of horizontal acceleration effective peak, default = 0.
av (Av) Mapped coefficient of horizontal velocity effective peak, default = 0.

Example 1:
```
DT=1    L=3,4
CT=0.047    CX=0.9    JS=1,9    RF=4,4    IF=1.25
ST=NSR10    FA=1.15    FV=1.55    SS=0.25    S1=0.25
```

First line: Seismic analysis through the (ELF) Equivalent Lateral Force method (DT=1), the seismic force in the **X** direction corresponds to load condition No. 3, and in the **Z** direction the force corresponds to load condition No. 4.

Second line: Basic parameters (CT and Alpha) for the calculation of the structure's fundamental periods; the lowest joint is No. 1 and the highest one is No. 9. The Energy Dissipation coefficient **R** in the **X** axis direction is 4 and in **Z** axis directions is 4. The structure importance coefficient is 1.25.

The third line corresponds to the parameters that define the elastic spectrum of design accelerations according to NSR-10 code.

Example 2:
```
DT=2    L=3    NR=2    MC=3
CT=0.047    CX=0.9    JS=1,9    RF=4    IF=1.25
ST=NSR10    FA=1.15    FV=1.55    SS=0.25    S1=0.25
```

First line: Seismic analysis by (RS) Response Spectrum (DT=2); the seismic forces correspond to the load condition No. 3. 2 Eigenvalues and Eigenvectors (natural frequencies of vibration) are requested. The modal combination is CQC.

Second line: Basic parameters (CT and Alpha) for the calculation of the structure's fundamental periods; the lowest joint is No. 1 and the highest one is No. 9. The Energy Dissipation Coefficient **R** is 4. The structure importance coefficient is 1.25.

The third line corresponds to the parameters that define the elastic spectrum of design accelerations according to NSR-10 code.

Option 2, Spectrum defined and provided by the user by means of pairs of values.

With NP=**n** (where "**n**" is greater than 1) the software will read "**n**" pairs of values corresponding to the periods and fractions of accelerations that define a spectrum previously calculated by the user; therefore, the importance coefficient **if**, it will be ignored.

Syntax: NP=**n**
t1,g1
t2,g2
...
tn,gn

n Number of pairs of values that define the spectrum provided by the user, greater than 1.
t1 Period 1.
g1 Fraction of acceleration 1.
t2 Period 2.
g2 Fraction of acceleration 2.
...
tn Period n.
gn Fraction of acceleration n.

Example 3:
```
DT=2    L=3    NR=2    MC=3
CT=0.047    CX=0.9    JS=1,9    R=4    IF=1.25
NP=8
0.00,0.3024
0.08039,0.756
0.38587,0.756
0.40,0.7293
0.60,0.4862
0.80,0.36465
1.00,0.29172
1.20,0.2431
```

First line: Seismic analysis by the (RS) Response Spectrum method (DT=2), the seismic forces corresponding to the load condition No. 3. Two (2) Eigenvalues and Eigenvectors are requested (natural frequencies of vibration) and the modal combination method is CQC.

Second line: Basic parameters (**Ct** and **x** or **Alpha**) to calculate the fundamental periods of the structure; the lowest joint is joint No.1 and the highest one is No. 9, the energy dissipation coefficient **R** is 4, and an importance coefficient = 1.25.

The third or more line(s) correspond to an elastic spectrum of accelerations defined by the user, and which is composed of the following 8 pairs of values.

B) Using the Graphical Editor:

There are two analysis types available:

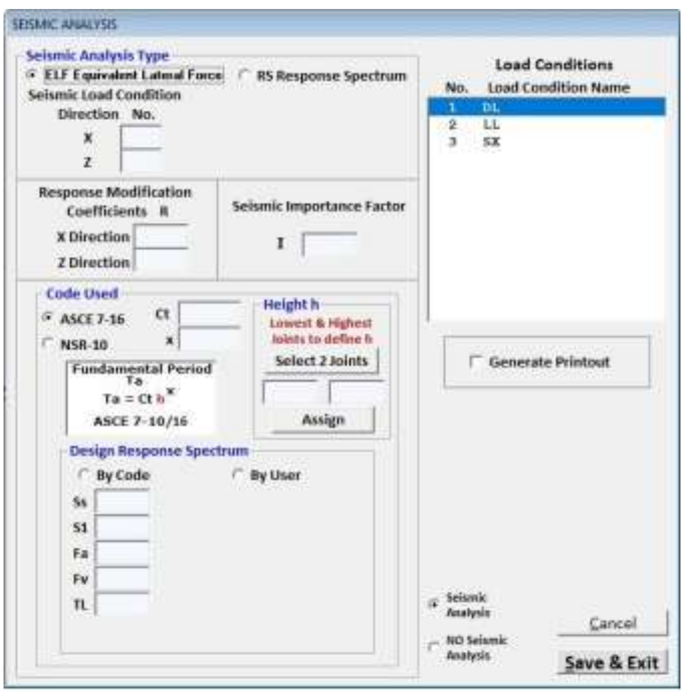
Equivalent Lateral Force (ELF) analysis
Response Spectrum (RS) analysis

Following is the common data to define for both (ELF) and (RS):

- Code Used to compute the structural fundamental period, Ta. ASCE 7-10/16 or NSR-10.
- Ct and x or alpha to compute the fundamental period, Ta.
- The total height of the structure defined by selecting two joints, usually the first one at the base of the structure and another one at the higher point of the structure which represents the total height h used to compute the fundamental period of the structure.
- The Design Response Spectrum and in accordance with the code used or defined by the user as pair of values, time-acceleration as a fraction of *g*.
- Seismic Importance Factor (I).

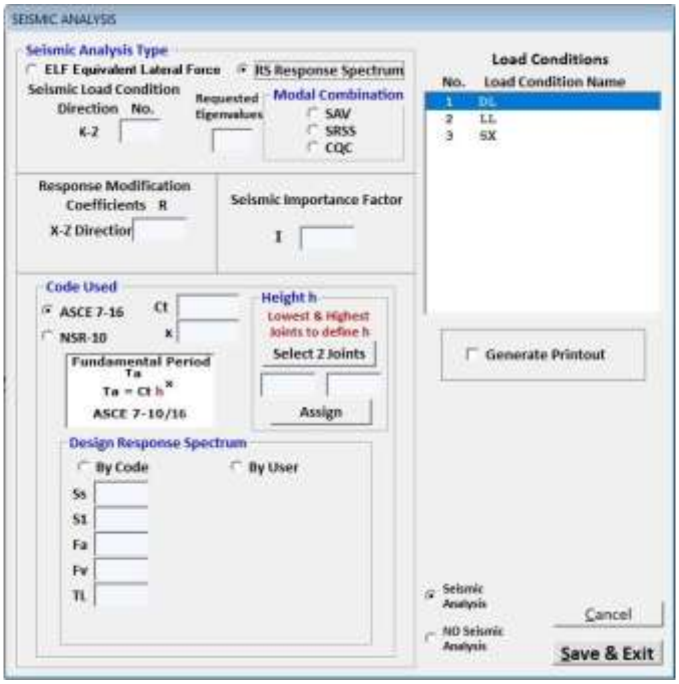
For the Equivalent Lateral Force (ELF) analysis the following data is defined:

- Seismic Load Condition Nos. in **X** and **Z** direction.
- Response Modification Coefficients in **X** direction (RX) and **Z** direction (RZ).



For the Response Spectrum (RS) analysis the following data is defined:

- Seismic Load Condition No. in **X-Z** direction.
- Response Modification Coefficient in **X-Z** direction (**R**).
- Requested number of Eigenvalues to compute.
- Modal Combination used: SAV, SRSS or CQC.
- Generation of the full Printout.



Click **Save & Exit** to exit and generate the Input Data File.

4.4.17 DYNAMIC

This field is used to define a load condition that corresponds to a Dynamic analysis.
Its information will depend on the kind of dynamic analysis to be performed.

A) Using the Text Editor:

The first common data line to all available dynamic analysis defines:

The type of dynamic analysis, the number of Eigenvalues required (2 or greater), and the number of the load condition corresponding to the dynamic forces.

Syntax: DT=**d** NR=**nr** L=**l**

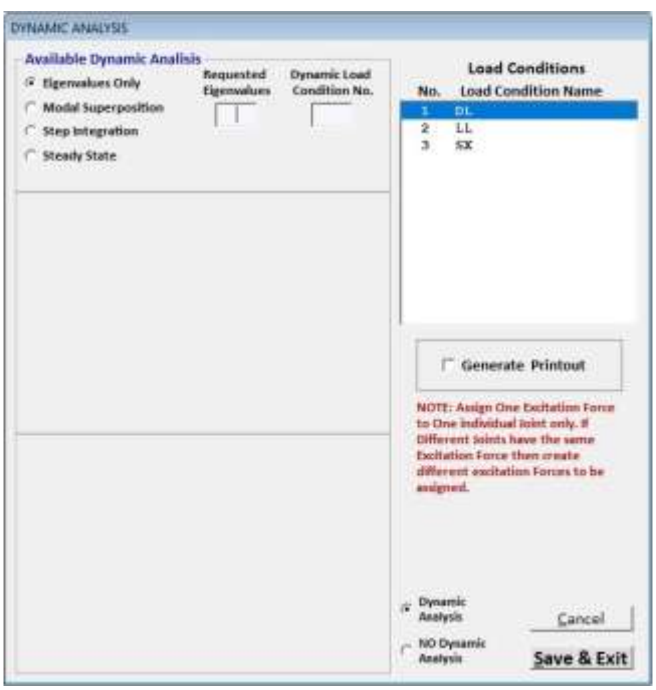
d Type of dynamic analysis, default = 1. See bellow.
nr Number of Eigenvalues and Eigenvectors requested, default = 2.
l No. of the load condition corresponding to the dynamic forces, default = 0.

Only one load condition is defined for the dynamic analysis, which corresponds to the seismic forces calculated by the software.

B) Using the Graphical Editor:

The different available types of dynamic analysis are:

d	Dynamic Analysis Type
1	Eigenvalues & Eigenvectors Only
2	Modal Superposition
3	Step Integration
4	Steady State
5	Random Vibration (*Under development*)



Click **Save & Exit** to exit and generate the Input Data File.
Dynamic analysis type 1 (DT=1) only evaluates Eigenvalues and Eigenvectors; therefore, it does not generate design forces applicable to any load condition. However, it is useful for calculating the participation percentages of the associated masses to each of the calculated Eigenvalues.

Type 2 or greater dynamic analysis, always include the calculation of the Eigenvalues and Eigenvectors (natural frequencies and vibration modes) and generate design forces applicable to load condition **lc**.

Below are described the different types of available dynamic analysis within the software, which generate design forces that will be later combined with the other design forces like dead or live loads, winds, etc.

The information needed for each of the different kind of dynamic analyses is supplied beginning in the second data line.

a. *MODAL SUPERPOSITION or STEP INTEGRATION*
For a Modal Superposition analysis, DT=2 and defined in the first line.
For a Step Integration analysis, DT=3 and defined in the first line.

Both analyses may use the consistent mass matrix or the condensed mass matrix (See 4.4.2 CONTROL).

A) Using the Text Editor:

Second line:

Amount of excitation forces **nf** located in the force's library, which are described in the third line. If the excitation occurs as an accelerogram applied in the base of the structure this value must be 1, This data is compulsory.

Time unit for the numeric integration, expressed in seconds (s). Typical values are in the order of first natural frequency divided by 20 or 0.01 s to 0.02 s. A value of 0.01 is assumed.

Point where excitation is applied:
If the excitation comes from applied forces in the structure (**nf**=0), and not at its base, then this value must be 0, and excitation forces and joints with applied excitation forces are defined.

If the excitation is applied at the base of the structure, then only one excitation force is defined, in this particular case an applied acceleration, and no joints with applied forces are defined since this acceleration will be applied to all of the joints in the structure. If **ag** has a different value of from 0, then the software will use the value to the gravitational acceleration that corresponds to the unit system used. (See 4.4.2 CONTROL).

In the definition of the excitation force ((**nf**=0 or applied acceleration) corresponding values to the fraction of the gravitational acceleration shall be used, such as the readings from a seismic acceleration graph, or an acceleration record of the ground with respect to time (or a particular accelerograph)

Printing flag for the Time History.

Syntax: NF=**nf** TI=**ti** AG=**ag** PR=**pr**

nf Amount of excitation forces that should exist in the excitation forces library; less than or equal to 512, default = 1.
ti Numeric integration time, default = 0.01 seconds.
ag Global acceleration, default = 0 equivalent to excitation forces applied to joint's structure.
pr Printing flag for the Time History printout; 1 generates the printout, 0 suppress it, default = 0.

Third line:

Excitation forces library or excitation acceleration applied at the base of the structure.

Consists of **nt** pairs of values (time vs force or acceleration) for each of the applied forces. It can be made of as many data lines as needed and up to a maximum of 3,500 data lines.

The lines must be entered in ascending order beginning from 1 to **nt** excitation forces applied.

The table that describes each excitation force consists of pairs of values (time vs force or fraction of the acceleration, or an acceleration record of the ground with respect to time from a particular accelerograph) necessary to describe the total excitation force. The force units must be consistent with the unit system used.

Every excitation force must reach an excitation time value equal and common for all the forces within the analysis. If this is not accomplished the dynamic analysis is not performed. This maximum value defines the maximum time excitation to be used in the dynamic analysis and the Time History output.

Syntax: **nt** NP=**n**
t1,f1
t2,f2
…
tn,fn

nt Excitation force identification number in ascending order beginning from 1 and up to **nf**, compulsory use.
n Number of pairs of values, greater than 1.
t1 Time value 1.
f1 Excitation force, or acceleration value, at the point **t1**; default = 0.
t2 Time value 2.
f2 Excitation force, or acceleration value, at the point **t2**; default = 0.
tn Time value n.
fn Excitation force, or acceleration value, at the point **tn**; default = 0.

Fourth line (or more)

Excitation force's location

This information describes the joints and the direction where the excitation forces will be placed. If the excitation occurs at the base of the structure, this group of information is not necessary; therefore, it is optional and depends on the kind of excitation used.

Consists of as many lines as definition of joints with existing excitation forces.

Syntax: **ni** EX=**e1** EY=**e2** EZ=**e3** <X=**e4** <Y=**e5** <Z=**e6**

ni Joint number where the excitation force is placed, compulsory.
e1 Excitation force value in the global axis **X** direction, default = 0.
e2 Excitation force value in the global axis **Y** direction, default = 0.
e3 Excitation force value in the global axis **Z** direction, default = 0.
e4 Excitation force value about the global axis **X**, default = 0.
e5 Excitation force value about the global axis **Y**, default = 0.
e6 Excitation force value about the global axis **Z**, default = 0.

Example No.1
Analysis through Modal Superposition (DT=2) and with two excitation forces placed in two different joints in the structure.

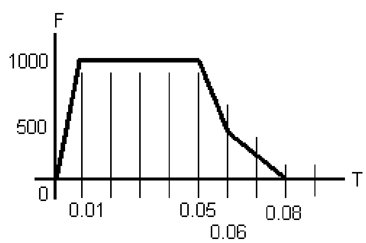
```
DT=2    NR=10    L=2
NF=2    TI=0.01    AG=0    PR=1
1   NP=5
0,0
```

```
0.01,1000
0.05,1000
0.06,500
0.08,0
2     NP=4
0,0
0.01,2000
0.05,2000
0.08,0
6     EZ=1
8     EX=2
```

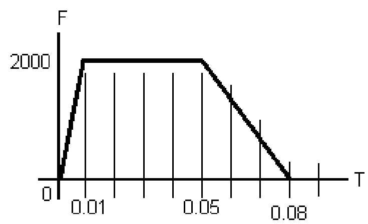
There are 10 vibration modes solicited in the first line, and the seismic forces correspond to the load condition No. 2.

In the second line, it is defined that there must be 2 excitation forces in the library, the numeric integration time is 0.01 seconds, the global acceleration at the base of the structure is 0, therefore the excitation comes from the applied forces in the structure (2 in this case). And the Time History printout is solicited.

From the third line on, 2 excitation forces are defined for a maximum analysis time of 0.08 seconds and as an example, and according to the following graphs and data table.



Excitation Force No. 1



Excitation Force No. 2

T	F
0	0
0.01	1000
0.05	1000
0.06	500
0.08	0

T	F
0	0
0.01	2000
0.05	2000
0.08	0

The last line(s) define that joint No. 6 has an excitation applied corresponding to the excitation No.1, and applied in the global axis **Z** direction and that joint No.8 has an excitation applied corresponding to the excitation force No.2 and applied in the direction of the global axis **X**.

Example No.2
Analysis through Step Integration (DT=2) and with an excitation placed at the base of the structure:

```
DT=3    NR=10    L=2
NF=1    TI=0.01    AG=1    PR=1
1    NP=2
0,0.35
2,0.35
```

In the first line, 10 modes of vibration are solicited, and the seismic forces correspond to load condition No.2.

In the second line, it is defined that there is only one excitation force in the library, the numeric integration time is 0.01 seconds, the global acceleration at the base of the structure is calculated by the software and in accordance with the unit system used, therefore the excitation is applied at the base of the structure, and the Time History output is solicited.

From the third line on, an excitation constant is defined, 0.35 times the gravitational acceleration calculated by the software and for a maximum analysis time of 2.00 seconds.

B) Using the Graphical Editor:

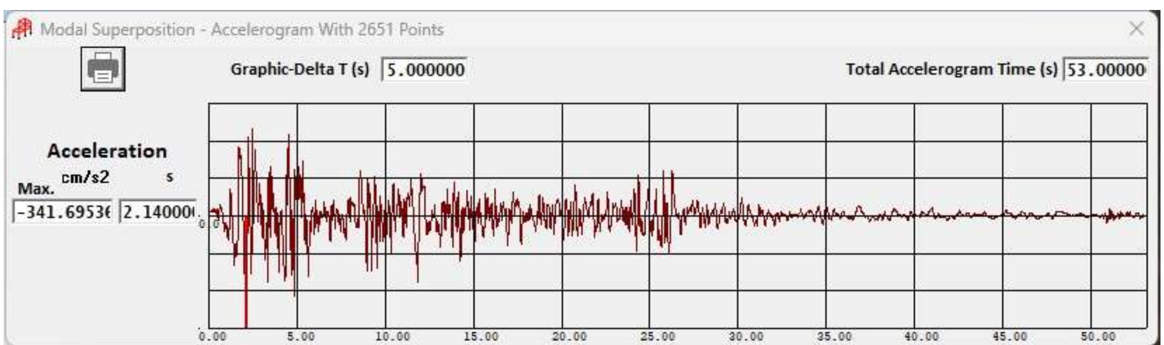
Following is the common data to define for both analysis types. Modal Superposition and Step Integration:

- Requested number of Eigenvalues to compute.
- Load combination where the Dynamic load will be assigned.
- Time unit for the numeric integration or Integration Time
- Excitation located at the base of the structure or at any joint.
- Generation of the Printout.

Excitation forces can be an Accelerogram as a table with pair of values "Time-Acceleration" or an applied force as a table with pair of values "Time-Force".

A typical accelerogram could be as follows:

Entire Accelerograph Graphic representing 2,651 points or pairs of values, from t=0.00 s to t=53.00 s:



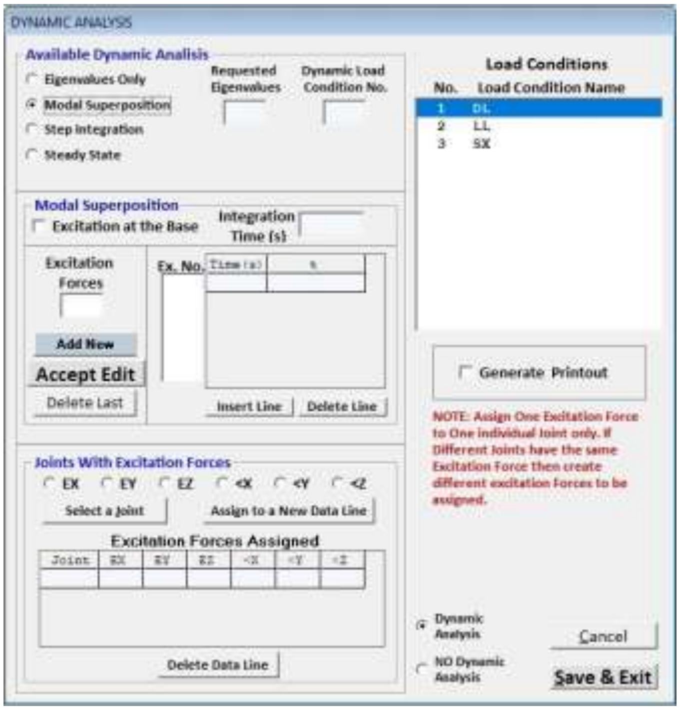
First values from t=0.00 s to t=1.00 s are shown below.

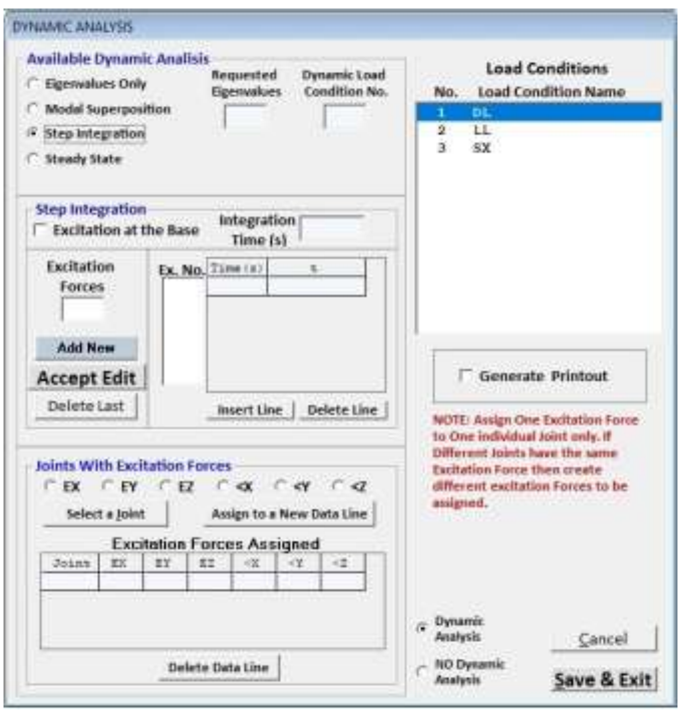
```
DYNAMIC
DT=2  NR=4  L=1  :MODAL SUPERPOSITION
NF=1  TI=0.02  AG=9.806  PR=1   :El Centro Acelerogram
1  NP=2651
0.00,0.0000000
0.02,0.0014186
0.04,0.0110501
0.06,0.0103298
0.08,0.0090142
0.10,0.0097163
0.12,0.0122779
0.14,0.0145209
0.16,0.0130875
0.18,0.0112556
0.20,0.0086948
0.22,0.0086765
0.24,0.0133696
0.26,0.0179320
0.28,0.0197425
0.30,0.0165646
0.32,0.0147041
0.34,0.0110495
0.36,0.0083573
0.38,0.0042523
0.40,0.0066819
0.42,0.0133078
0.44,0.0194249
0.46,0.0199366
0.48,0.0066844
0.50,-0.0030954
0.52,-0.0143676
0.54,0.0049926
0.56,0.0130743
0.58,0.0146728
0.60,0.0206511
0.62,0.0265171
0.64,0.0331589
0.66,0.0311817
0.68,0.0175872
0.70,0.0201272
0.72,0.0166099
0.74,0.0167523
0.76,0.0067861
0.78,-0.0025414
0.80,-0.0153095
0.82,-0.0240884
0.84,-0.0257276
0.86,-0.0342896
0.88,-0.0472561
0.90,-0.0501296
0.92,-0.0426853
0.94,-0.0366461
0.96,-0.0276387
0.98,-0.0239442
1.00,-0.0346128
```

To create a new Excitation Force, click **Add New**, populate the table with pair of values time-force for Excitations located at any joint or time-fraction of acceleration for excitation located at the base of the structure. Then click **Accept Edit** to save the edition.

If it is located at the structure base, then only one Excitation Acceleration shall be defined. If it is located at any joint, then define as many Excitation Forces as needed.

To edit any Excitation Force, click the list of Excitation Forces available and edit data over the table. Then click **Accept Edit** to save the edition.





To edit

Then select the joint and direction where the excitation force will be applied.

To select any Excitation Force joint location, click on the list of joints with assigned excitation forces and edit as needed.

Click **Save & Exit** to exit and generate the Input Data File.

b. ***STEADY STATE (Harmonic Excitation)***
To set an analysis forward through Steady State, DT=4 is defined in the first line.

The software admits only one excitation in the structure due to a forced vibration that corresponds to the following general equation of vibration: **Fc** x COS(***WR*** x T) + **Fs** x SIN(***WR*** x T).

The software uses two different algorithms to solve the general system of equations of movement; the differences between these solving algorithms lie in the total execution time solving the system. The algorithm used (and thus the execution time) depends on the total number of joints in the structure (equations).

If the structure has less than 9,600 equations, the fast-solving algorithm "In Core" is used; if the structure exceeds 9,600 equations, a very slow solving algorithm "Out of Core" is used.

A) Using the Text Editor:

Second line:

The function for the applied vibration, **Fc** x COS(***WR*** *x T)* + **Fs** x SIN(***WR*** *x T)*, is described for the general equation of vibration as follows:

Fc value or **Fs** value expressed in units of force.

The excitation frequency ***WR***, expressed in Cycles Per Second (CPS)

Time unit for the numeric integration, expressed in seconds

Total excitation time, expressed in seconds

Syntax: FC=**fc** FS=**fs** WR=**wr** TI=**ti** TT=**tt** PR=**pr**

fc Force coefficient that affects the COS function, default = 0.
fs Force coefficient that affects the SIN function, default = 0.
wr Excitation frequency value in CPS, default = 0.
ti Numerical integration time, default = 0.01 seconds.
tt Total numerical integration time, default = 1 second.
pr Printing flag for Time History; 1 generates the impression, 0 will delete it, default = 0

Third line:
Excitation force's location

The second group of information describes the joint and the direction where the vibration function is located; such function (previously defined) is placed by defining only one value from **e1** to **e6** and equal to 1.

Excitation force's location

this information describes the joint and the direction where the vibration function is located.

Syntax: **ni** EX=**e1** EY=**e2** EZ=**e3** <X=**e4** <Y=**e5** <Z=**e6**

ni Joint number where the vibration function in placed, compulsory use.
e1 Vibration function in the global axis **X** direction, default = 0.
e2 Vibration function in the global axis **Y** direction, default = 0.

e3 Vibration function in the global axis **Z** direction, default = 0.
e4 Vibration function about the global axis **X**, default = 0.
e5 Vibration function about the global axis **Y**, default = 0.
e6 Vibration function about the global axis **Z**, default = 0.

Example:
```
DT=4    NR=10    L=2
FC=1000   WR=1.65  TI=0.01  TT=2  PR=1
168    EZ=1
```

In the first line, 10 vibration modes are solicited, and the seismic forces correspond to load condition No. 2.

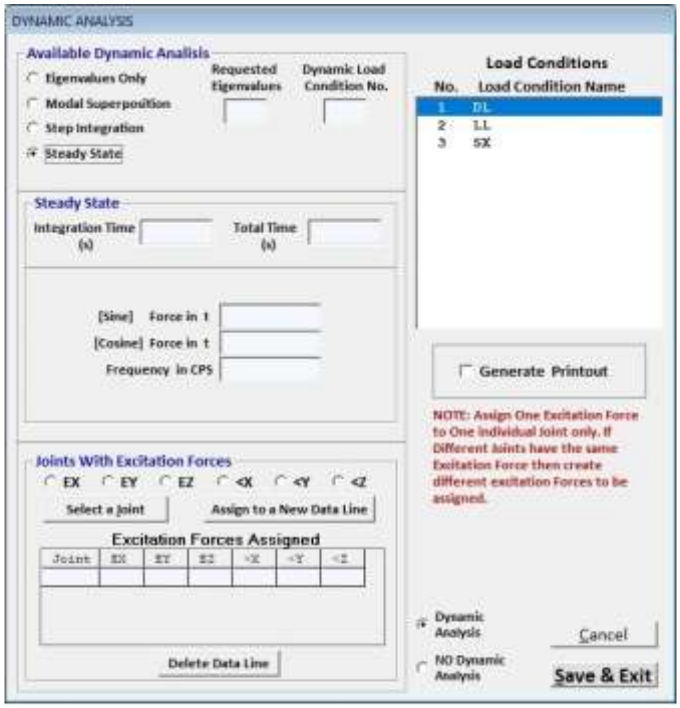
In the second line, the COS coefficient FC is defined as 1,000, the excitation frequency WR is 1.65 CPS, the numerical integration time TI is 0.01 seconds, the total numerical integration time TT is 2 seconds, and the Time History impression is solicited.

In the third line, it is defined that joint No.168 has an applied excitation corresponding to the vibration function which is applied in the global axis **Z** direction.

B) Using the Graphical Editor:

Following is the data to define for Steady State analysis type:

- Requested number of Eigenvalues to compute.
- Load combination where the Dynamic load will be assigned.
- Time unit for the numeric integration or Integration Time
- Total time for the integration analysis.
- Force associated with the Sine harmonic function.
- Force associated with the Cosine harmonic function.
- Frequency of the harmonic function.
- Generation of the Printout.



Then select the joint and direction where the excitation force will be applied.

To edit the Excitation Force joint location, click on the list of joints with assigned excitation force and edit as needed.

Click **Save & Exit** to exit and generate the Input Data File.

4.4.18 LOADCOMB

The software limits the quantity of load combinations to 1000. The number of lines will depend on the quantity of load combinations defined.

When there is no LOADCOMB field defined the software will deliver the respective results for each load condition individually.

Names assigned to each load combination are made of using the load condition names the user defined in 4.4.2 "CONTROL" and the factors defined here for each load combination.

Blanks are not allowed in the load combination assigned names.

A) Using the Text Editor:

Syntax: **n** C=**c1,c2,...,cn**

n Combination number; this number must start with 1 and continue in strict increasing order, less than or equal to 1,000, compulsory use.
c1 Multiplier for load condition No. 1, default = 0.
c2 Multiplier for load condition No. 2, default = 0.
cn Multiplier for load condition No. **n**, default = 0.

Then the load combinations to be used in the Reaction calculation will be defined.

Syntax: LR=**r1,r2,...,rn**

r1 Load combination number to be used in the Reaction calculation, default = 0.
r2 Load combination number to be used in the Reaction calculation, default = 0.
rn Load combination number to be used in the Reaction calculation, default = 0.

Example:

```
1  C=1.4,1.7
2  C=1.05,1.275,1
3  C=0,0,4.5        :INELASTIC MAXIMUM DRIFT CONTROL
4  C=1,1
5  C=1,1,1
LR=4,5
```

The first line defines the combination No. 1 corresponds to the load condition No. 1 multiplied by 1.4 plus load condition No. 2 multiplied by 1.7.

The second line defines the combination No. 2 corresponds to the load condition No. 1 multiplied by 1.05 plus load condition No. 2 multiplied by 1.275 plus load condition No. 3 multiplied by 1.

The third line defines the combination No. 3 corresponds to the load condition No. 1 multiplied by 0 plus load condition No. 2 multiplied by 0 plus load condition No. 3 multiplied by 4.5. This line has a comment.

The fourth line defines the combination No. 4 corresponds to the load condition No. 1 multiplied by 1 plus load condition No. 2 multiplied by 1.

The fifth line defines the combination No. 5 corresponds to the load condition No. 1 multiplied by 1 plus load condition No. 2 multiplied by 1 plus load condition No. 3 multiplied by 1.

The software assigns names for each load combination as follows (See load condition assigned names in example in 4.4.2 "CONTROL"):

Load combination 1: 1.4DL 1.7LL
Load combination 2: 1.05DL 1.275 LL 1SX
Load combination 3: 4.5SX
Load combination 4: 1DL 1LL
Load combination 5: 1DL 1LL 1SX

Next line defines Load Combinations 4 and 5 will be used in the Reaction calculation (LR=).

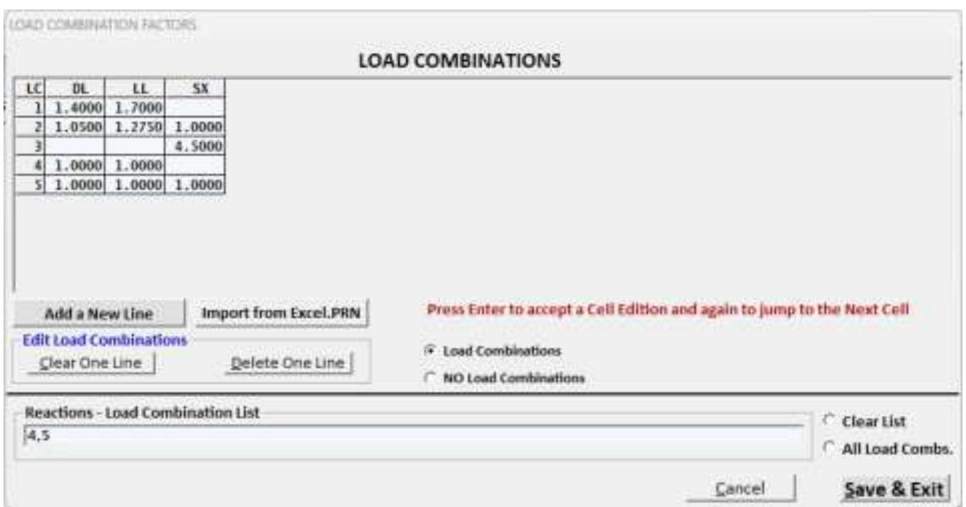
B) Using the Graphical Editor:

To create a new Load Combination data line just click the last column of the last one already defined, and press ENTER. A new data line will be created and ready to be filled with new Load Combination factors.

To edit an existing data line, click the data to be edited and enter new values.

Data lines can be clear of values to start over this same data line, or deleted from the data table.

The user may develop and maintain a whole set of load combinations using a Excel spreadsheet, and then export the whole list to a ".PRN" file format to be read by this form directly into the Load Combination List by clicking "Import from Excel .PRN", and following the instructions.



Click **Save & Exit** to exit and generate the Input Data File.

4.4.19 STLDES

The software has no restriction on the number of design parameters defined for the structural steel design. There will be as many lines as design parameters used.

The software performs a design based on the AISC ASD 89 or AISC 360-10/16 ASD or LRFD, and on the AISC [15th Edition] shape database. The result is a verification of each metallic shape capacity for combined stress and deflection, assigning for each case a percentage of use preferably less than 100. Every member with a percentage of use above 100 will be tagged as INSUFFICIENT.

Stress:
Every structural member within this title will be verified for Tension, Compression, Flexure and Shear, and in accordance with the load combinations previously defined. It is also verified the slenderness in accordance with the applicable design provisions. Torsion verification is not covered in this software version.

In using the AISC 360-10/16 design provisions it is the user responsibility to assign all the corresponding design parameters. Members with no assigned design parameter will be verified using the member total length between its joints as the corresponding design parameter.

Based on AISC 360-10/16 the software computes the Lateral-torsional Buckling modification factor Cb (See AISC 360-10/16 general provisions equation F1-1) when both ends of the segment are braced. Therefore, this condition must be part of the structural model by means of using joints at each end of the beam segment to be designed and using two design parameters to define the unbraced length for top beam flange (FT) and bottom beam flange (FB).

In using AISC ASD 89 Edition it is only needed to define K (for K L / r), for both member planes as a design parameter. All members will be designed using its total length as a design parameter. Members with no assigned design parameter will be verified using K = 1.0 as a design parameter.

Deflection:
Deflection verification will be applied to members with the corresponded design parameters defined and in accordance with AISC 360-10/16 "Allowable Strength Design" (ASD). This verification will not be applied if AISC 360-10/16 "Load Resistance Factor Design" (LRFD) design provision is defined.

The result is a verification of the Span/Deflection ratio compared to the maximum allowable deflection ratio for cantilever beams (usually 125) or regular beams (usually 250) defined by the user. A percentage of use for each member local plane will be assigned preferably less than 100. Two joint numbers must be assigned for each main beam divided in small beams. It is not acceptable to define the same joint numbers for different main beams within the model.

A) Using the Text Editor:

It is made up of 3 data groups in the following order:

4.4.17.1 Load list for design
4.4.17.2 Design provisions
4.4.17.3 Design parameters

4.4.17.1 Load list for design

The user may use a list of load combination numbers to be used in the steel design phase. If it is not defined the software will use all load combinations defined in 4.4.18 LOADCOMB.

Syntax: LL=**l1,l2,…,ln**

l1 Load combination No 1 to be used in the design phase
l2 Load combination No 2 to be used in the design phase
.
ln Load combination No n to be used in the design phase

4.4.17.2 Design provisions

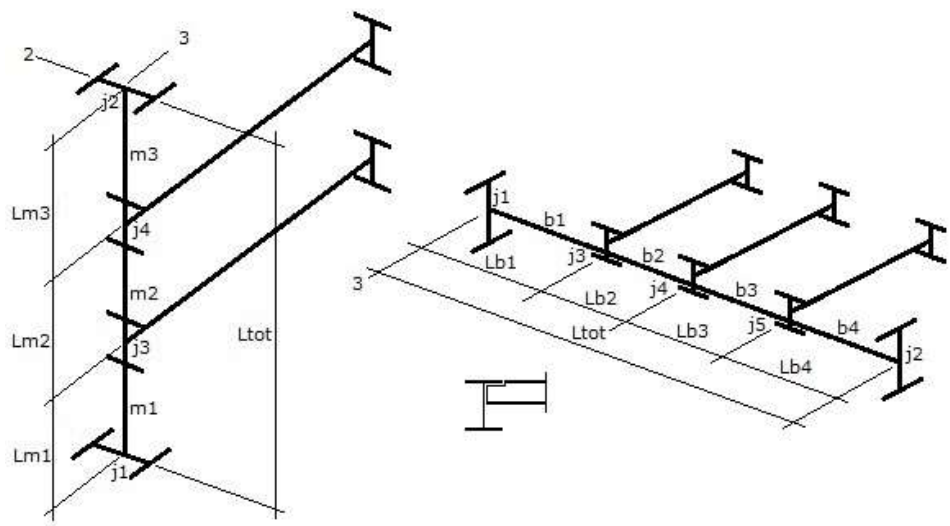
The user must choose AISC ASD 89 Edition design provisions for "Allowable Strength Design" or (ASD)AISC 360-10/16 design provisions type with provisions for "Allowable Strength Design" (ASD) or "Load Resistance Factor Design" (LRFD).

Syntax: DP=**dp**

dp **ASD89**, for AISC ASD 89 provisions
dp **ASD10**, for AISC 360-10 ASD provisions
dp **ASD16**, for AISC 360-16 ASD provisions
dp **LRFD0**, for AISC 360-10 LRFD provisions
dp **LRFD6**, for AISC 360-16 LRFD provisions

4.4.17.3 Design parameters and deflection control

Provisions for AISC 360-10/16:
The design is governed by the member unbraced length for each stress type (Tension, Compression, Flexure), and Deflection control. It is not necessary to define design parameters for Shear. All the above is achieved by defining the unbraced length using two appropriated joint numbers .



It is important to keep in mind that all these design parameters are defined using each member local coordinate system **1**, **2** and **3**. Parameters are grouped as follows:

- Tension TN
- Compression C3 and C2, K3 and K2
- Flexure FT and FB
- Deflection (DC or DB), DJ

Above sketch:

Shows for column members m1, m2 and m3 with equal lengths Lm1, Lm2 and Lm3:

- The compression and tension parameter around axis line **3** or plane **1-2** is defined using the total unbraced column length (Ltot) defined using joints j1 and j2.
- The compression and tension parameter around axis line **2** or plane **1-3** is defined using the member unbraced length defined using joints j1 and j3 or j3 and j4 or j4 and j2.
- The column effective length for compression around axis line **3** or plane **1-2** and around axis line **2** or plane **1-3** is computed based on parameters K3 and K2 defined by the user.

Shows beams b1, b2, b3 and b4, with different lengths Lb1, Lb2, Lb3 and Lb4:

- Flexure design parameter around axis line **3** or plane **1-2** for the top beam flange is defined using the beam unbraced upper length. For beam b1 joints are j1 and j3, for beam b2 joints are j3 and j4, etc.
- Flexure design parameter around axis line **3** or plane **1-2** for the bottom beam flange is defined using the beam unbraced lower length. For beam b1 joints are j1 and j2, for beam b2 joints are j1 and j2, etc.

There are two different deflection verifications. Cantilever beams using parameter DC and regular beams using parameter DB. It is not allowed to use both parameters in the same beams at the same time.

For cantilever beams the parameter used for both planes **1-2** and **1-3** is the total cantilever length defined using two joint numbers j1 and j2, and the maximum allowable deflection ratio (**dc**) is usually equal to 150.

For regular beams (See sketch above beams b1, b2, b3 and b4) the parameter used for both planes **1-2** and **1-3** is the total beam length defined using two joint numbers j1 and j2, and the maximum allowable deflection ratio (**db**) is usually from 200 to 300.

The design parameters are assigned to member groups as follows:

Syntax: **mi mf inc** K3=**kl3** K2=**kl2** TN=**ji,jf** C3=**ji,jf** C2=**ji,jf** FT=**ji,jf** FB=**ji,jf** DJ=**ji,jf** (DC=**dc** or DB=**db**)

mi	Initial member number, compulsory use
mf	Final member number, default = **mi**
minc	Member number increment, default = 1
kl3	Effective Length Factor K around axis line **3** or plane **1-2**, default=1
kl2	Effective Length Factor K around axis line **2** or plane **1-3**, default=1
ji	Initial joint number used to define the unbraced length for tension, compression, flexure, or deflection control, compulsory use.
jf	Final joint number used to define the unbraced length for tension, compression, flexure, or deflection control, compulsory use.
dc	Maximum allowable deflection ratio for cantilever beams, compulsory use
db	Maximum allowable deflection ratio for regular beams, compulsory use

Example:

```
LL=4,5
LD=4,5
DP=ASD10
C
9  12  TN=10,12  C3=8,18  C2=10,20  FT=6,14  FB=5,15  DB=300
 9  DJ=5,10
```

```
10  DJ=6,10
11  DJ=7,10
12  DJ=8,10
```

Load combinations 4 and 5 are defined to be used in the design phase of all structural steel members (LL=), and load combinations 4 and 5 are defined to be used in the deflection verification phase of all structural steel members (LD=).

Next line defines ASD, AISC 360-10/16 as the design provisions to be used.

The fourth line is a comment ("C ").

The fifth line defines for members 9 to 12 in steps of 1, parameter for tension, compression, flexure and torsion, as the unbraced lengths using initial and final joints. Beam type deflection control maximum allowable ratio is also defined.

The sixth line defines beam 9 deflection control joints as 5 and 10.

The seventh line defines beam 10 deflection control joints as 6 and 10.

The eighth line defines beam 11 deflection control joints as 7 and 10.

The ninth line defines beam 12 deflection control joints as 8 and 10.

Provisions for AISC ASD 89 Edition:

For AISC ASD 89 provisions see 2.12.

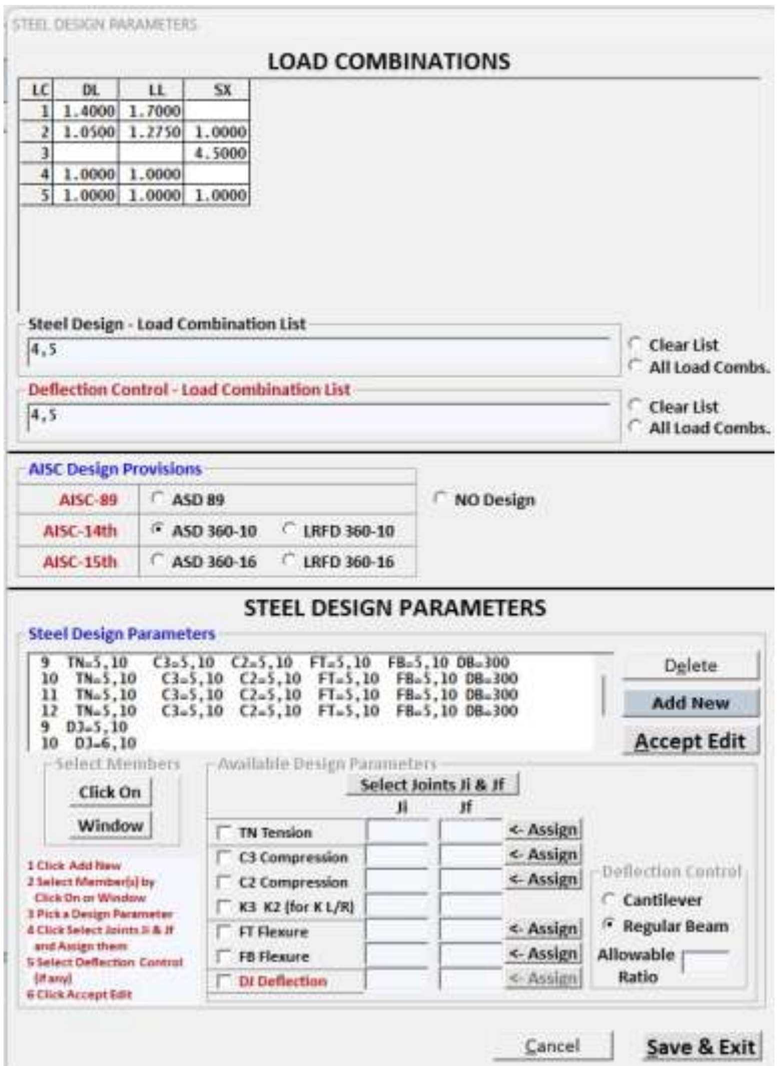
B) Using the Graphical Editor:

If "NO Design" is selected, then NO Steel design will be performed. Select the Design Provisions to use during the design phase.

Available design provisions are AISC ASAD-89 and AISC ASD 360-10/16, AISC LRFD 360-10/16.

Fill in the first line with the Load Combinations to be used for the Steel Design phase and the other one with the Load Combinations to be used for the Deflection Control phase. Always separated by a coma (,).

If No Load Combinations are defined, then all Load Combinations available will be used.



To create a new Steel Design Parameter, click **Add New**, select a member or group of members by **Click On** or **Windows**, then select the appropriate design parameters and for each one of the design parameters selected select joints **Ji** and **Jf** from the structure graphic or **K3** and **K2** values (for K L / R) and assign them by clicking on **<- Assign**, to the appropriate design parameter.

For Deflection Control select member type (cantilever or regular member) and define a value for the allowable Ratio. Then click **Accept Edit** to save the edition.

To edit an existing data line, click the data line to be edited and enter new values. Then click **Accept Edit** to save the edition.

Data lines no longer needed can be deleted from the data table.

Click **Save & Exit** to exit and generate the Input Data File.

4.4.20 CNCDES

The software performs a design based on the ACI 318-19 provisions. The result is a verification of each section's capacity, assigning for each case a percentage of use. All members to be designed as reinforced concrete beams or columns are defined in 4.4.6 MEMBERS.

Bending or bi-axial bending:

For members designed as beams in bending the corresponding reinforcement ratio is calculated. For a minimum reinforcement ratio there is a percentage of use of 0, for a maximum reinforcement ratio without compression reinforcement there is a percentage of use of 100, and for a maximum reinforcement ratio with compression reinforcement there is a percentage of use of 175 and is the section reinforcement maximum allowable. For designs with percentages of use over 175 the section is not sufficient (INSUFFICIENT).

For members designed as columns in biaxial bending the corresponding reinforcement ratio is calculated. For a minimum reinforcement ratio of 0.01 there is a percentage of use of 0, for a reinforcement ratio of 0.05 there is a percentage of use of 100, and for a maximum reinforcement ratio of 0.08 there is a percentage of use of 175 and is the section reinforcement maximum allowable. For designs with percentages of use over 175 the section is not sufficient (INSUFFICIENT). The minimum reinforcement ratio used is 0.01 and maximum reinforcement ratio used is 0.05. ACI 318-19 defines a maximum reinforcement ratio of 0.08 but the software uses 0.05 with a percentage of use of 100 for constructability reasons.

Combined shear and torsion:

For beam or column members the software calculates a transverse reinforcement shear ratio and a transverse reinforcement torsional ratio. For a minimum reinforcement ratio of 0 there is a percentage of use of 0, for a maximum longitudinal and transversal reinforcement ratio there is a percentage of use of 100. For designs with percentages of use over 100 the section is not sufficient (INSUFFICIENT).

4.4.18.1 Load list for design

The user may use a list of load combinations to be used in the reinforced concrete design phase. If it is not defined the software will use all load combinations defined in 4.4.18 LOADCOMB.

A) Using the Text Editor:

Syntax: LL=**l1,l2,…,ln**

l1 Load combination No 1 to be used in the design phase
l2 Load combination No 2 to be used in the design phase
.
ln Load combination No n to be used in the design phase

Example:

```
LL=1,2,3
```

It is defined load combinations 1, 2 and 3 to be used in the reinforced concrete member's design.

B) Using the Graphic Editor:

Select the Design Provisions to use during the design phase.

If NO Design is selected, then NO Concrete design will be performed.

If ACI 318-19 is selected, then ACI 318-19 design provisions will be used.

Fill in the line with the Load Combinations to be used for the Concrete Design phase. Always separated by a comma (,).

If No Load Combinations are defined, then all Load Combinations available will be used.

Click **Save & Exit** to exit and generate the Input Data File.

4.4.21 PRINT

The software has no restriction on the number of selections of the data corresponding to the joints or members, to be printed. There will be as many lines as selections desired.

If the PRINT field does not appear, the software will deliver the results corresponding to each Joint, Member and Shell of the structure and according with the 4.4.18 LOADCOMB.

When any selection is defined, the software assumes the rest of the joints and members are suppressed, being necessary to define only those the user wants to include in the final printout.

In the same order that the members are described, the results from the analysis and the reinforced concrete design and/or structural steel check will be printed.

A) Using the Text Editor:

Syntax: NT=**nt** ID=**id1,id2,id3** SW=**sw** CM=**c1,c2,...,cn**

nt Selection type, default = previous type.
nt=1 Displacements.
nt=2 Reactions and applied forces.
nt=3 Not used.
nt=4 Not used.
nt=5 Members described in the 4.4.6 MEMBERS title
nt=6 Shells described in the 4.4.7 SHELLS title
id1 First identifier that may correspond to a joint, member or shell number, according to its **nt**, compulsory use.
id2 Last identifier that may correspond to a joint, member or shell number, according to its **nt**; **id2** must always be greater than **id1** and minor than the maximum number of joints, members or shells defined, default = **id1.**
id3 Identifiers' increment value, default = 1.
sw Safe that allows to include or suppress the information in the final output lists, default = previous value. It takes the following values:
sw=1 includes in the final print.
sw=0 suppress from the final print.
c1 Identifier No. of the first load combination to be included, default = 0.
c2 Identifier No. of the second load combination to be included, default = 0.
cn Identifier No. of the last load combination to be included, default = 0.

When the identifiers list from **c1** to **cn** does not appear, the software prints all the combinations described in 4.4.18 LOADCOMB.

The software takes them in ascending order, and they must not surpass the number of combinations described in 4.4.18 LOADCOMB.

Members grouped within the same **Alpha** will be printed in a series of continue pages.

Example:
```
NT=2  ID=1,2  SW=1         :REACTIONS JOINTS 1 AND 2
NT=5  ID=1,2  SW=1  CM=2   :INTERNAL FORCES MEMBERS 1 AND 2 FOR COMB 2 ONLY
```

The first line describes that the reactions for joints 1 and 2, for all the load combinations, will be included on the printed reports.

The second line describes that the internal forces for members 1 and 2 identified, and for load combination No. 2, will be included on the printed reports.

B) Using the Graphical Editor:

There are three types of Printing Parameters: Displacements, Reactions & Forces and Member Internal Forces.

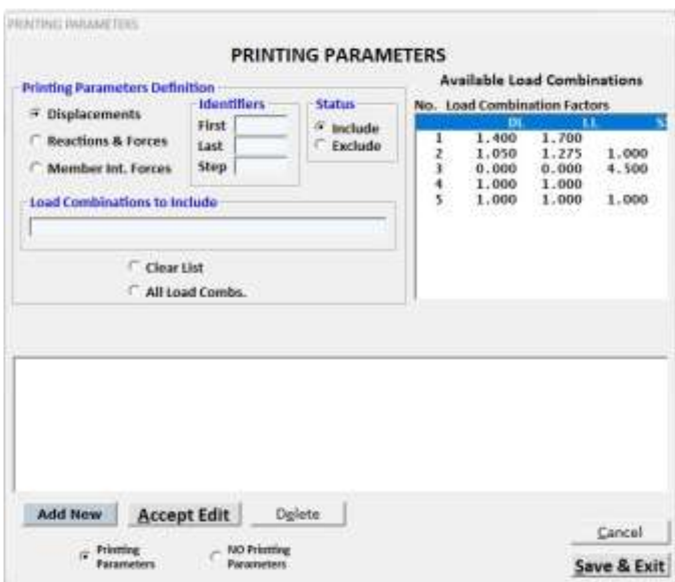
To create a new Printing Parameter, click **Add New**, select a Printing Parameter type, then define the appropriate range of Identifiers (Joint numbers for Displacements and Reactions and Member numbers for Member Internal Forces), and select if this group is included or not on the printing reports.

Fill in the line with the Load Combinations to be included in the printing reports. Always separated by a coma (,). If No Load Combinations are defined, then all Load Combinations available will be used and included on the printing reports.

Then click **Accept Edit** to save the edition.

To edit an existing data line, click the data to be edited and enter new values. Then click **Accept Edit** to save the edition.

Data lines can be deleted from the data table.



Click **Save & Exit** to exit and generate the Input Data File.

4.4.22 End of the data file

A) Using the Text Editor:

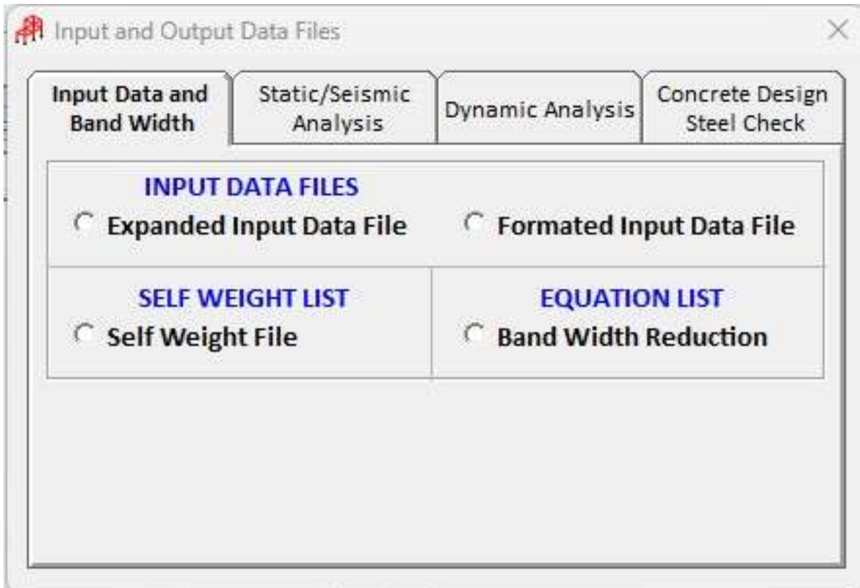
The last data line must be at least one blank line after all of the information previously described; compulsory use.

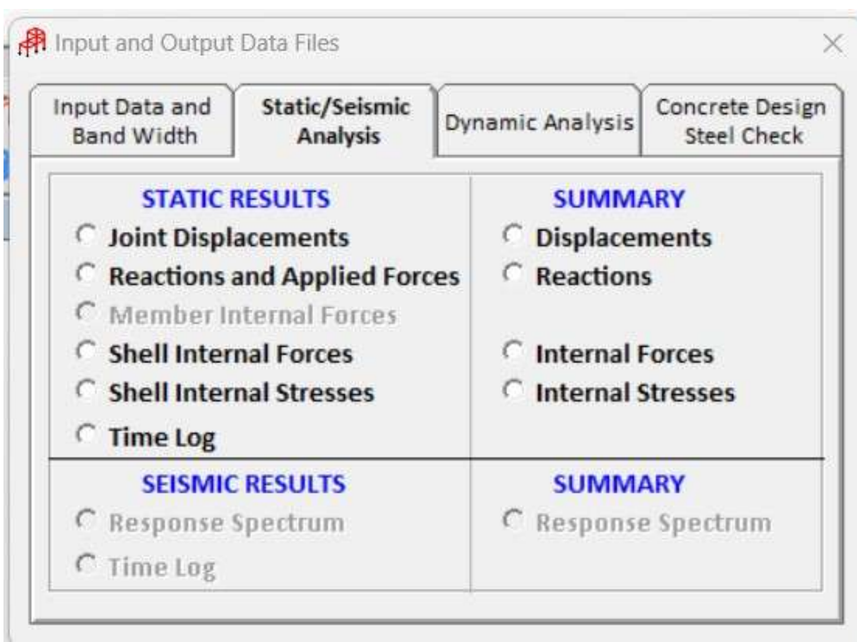
B) Using the Graphical Editor:

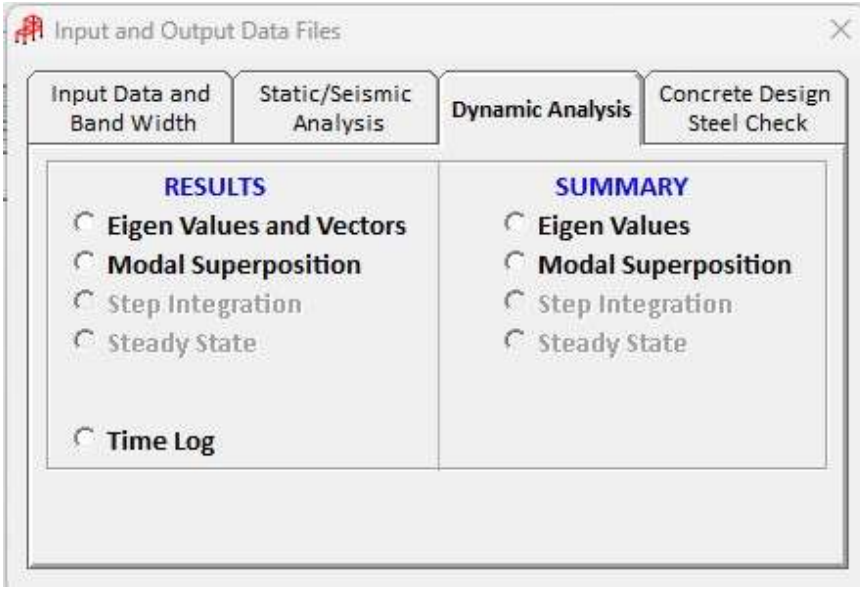
The graphic editor always adds this last and blank data line.

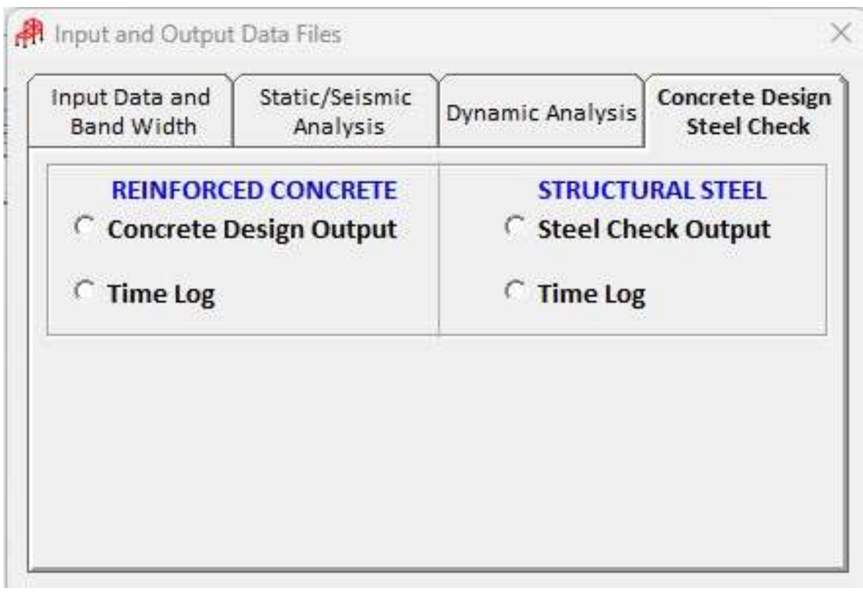
5 OUTPUT FILES AND RESULTS IDENTIFICATION

Text Input Data files and Output Data files for Static Analysis, Seismic/Dynamic Analysis and Concrete/Steel Design Output can be accessed by using the appropriate tool form the **General Tools** Tool Bar.






Input and Output Data Files
Input Data and Band Width
Static/Seismic Analysis
Dynamic Analysis
Concrete Design Steel Check
RESULTS
Eigen Values and Vectors
Modal Superposition
Step Integration
Steady State
Time Log
SUMMARY
Eigen Values
Modal Superposition
Step Integration
Steady State


Input and Output Data Files
Input Data and Band Width
Static/Seismic Analysis
Dynamic Analysis
Concrete Design Steel Check
REINFORCED CONCRETE
Concrete Design Output
Time Log
STRUCTURAL STEEL
Steel Check Output
Time Log

5.1 Global displacements and summary of the displacements (Global Displacement Summary)

Some Data Output samples are shown.

Printed in files "**name.DRF**" and "**name.DSM**".

The positive direction of global axes **X**, **Y** and **Z** are kept for Displacements, and Rotations in radians are positive according to the right-hand rule about the global axes **X**, **Y** and **Z**.

```
□E:\STRUC 2021\ STRUC Ver. 1-2021   File: E:\STRUC NEW Sample Files\STATIC EXAMPLE.DRF         Page 1
By: F. JANNAUT        Licenced to: CopyRight F. JANNAUT          Date: 01-27-2021

3D FRAME TEST 11/05/2010

                 G L O B A L     D I S P L A C E M E N T S

Load Combination 1 of 5   1.4DL 1.7LL
Joint   Disp X      Disp Y      Disp Z      Rot X       Rot Y       Rot Z
          m           m           m          rad         rad         rad
    1     0        -0.00429328    0       -0.00096772    0        0.00443812
    2     0        -0.00403828    0       -0.00096731    0        0.00250309
    3     0        -0.00429328    0        0.00096772    0        0.00443812
    4     0        -0.00403828    0        0.00096731    0        0.00250309
    5  -0.01015503 -0.00534589 -6.0054E-06  0.00195460 -7.2606E-06 -0.00130649
    6  -0.01015503 -0.00502748  6.0068E-06  0.00196286 -7.2606E-06  0.00261097
    7  -0.01015503 -0.00534589  6.0065E-06 -0.00195460  7.2605E-06 -0.00130649
    8  -0.01015503 -0.00502748 -6.0048E-06 -0.00196286  7.2605E-06  0.00261097
   10  -0.01055192 -0.00868000    0           0           0        1.1103E-04
   20  -0.01016103 -0.01106287    0           0           0       -1.6399E-04
```

```
□E:\STRUC 2021\ STRUC Ver. 1-2021   File: E:\STRUC NEW Sample Files\STATIC EXAMPLE.DSM         Page 1
By: F. JANNAUT        Licenced to: CopyRight F. JANNAUT          Date: 01-27-2021

3D FRAME TEST 11/05/2010

             G L O B A L   D I S P L A C E M E N T S   S U M M A R Y

Load Combination 1 of 5   1.4DL 1.7LL
    Direction   Value  Unit   Joint
    Min  X    -0.010552  m      10
    Max  X     0.000000  m       1
    Min  Y    -0.011063  m      20
    Max  Y    -0.004038  m       2
    Min  Z    -0.000006  m       5
    Max  Z     0.000006  m       6
    Min RX    -0.001963 rad      8
    Max RX     0.001963 rad      6
    Min RY    -0.000007 rad      5
    Max RY     0.000007 rad      8
    Min RZ    -0.001306 rad      5
    Max RZ     0.004438 rad      3
```

The relative displacements between floors (drift) follow the same rule of signs applied to displacements.

5.2 Reaction and applied forces

Printed in file "**name. RCN**".

The reactions keep the positive direction of the global axes **X**, **Y** and **Z**, and the positive direction for moments according to the right hand rule about the global axes **X**, **Y** and **Z**.

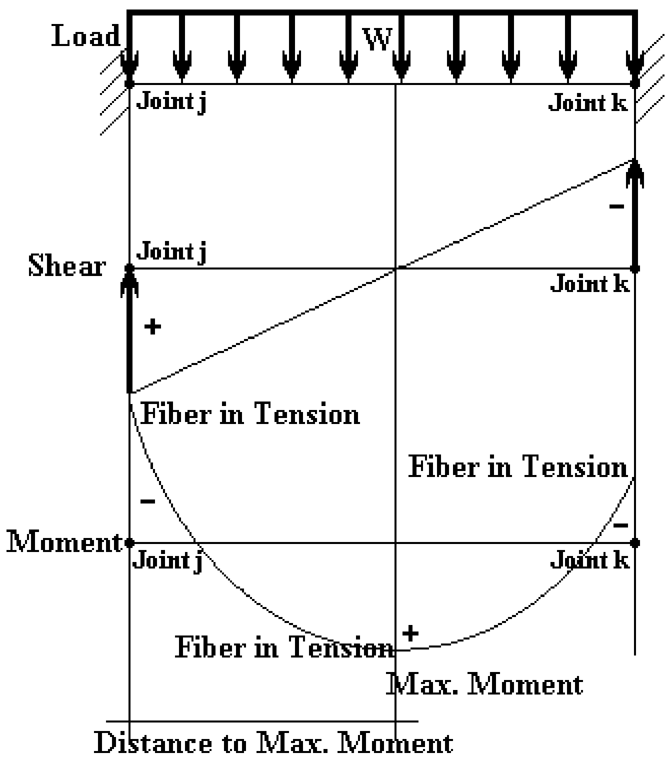
```
E:\STRUC 2021\ STRUC Ver. 1-2021   File: E:\STRUC NEW Sample Files\STATIC EXAMPLE.RCN        Page 1
By: F. JANNAUT        Licenced to: CopyRight F. JANNAUT         Date: 01-27-2021

3D FRAME TEST 11/05/2010

        R E A C T I O N S   A N D   A P P L I E D   F O R C E S

Load Combination 1 of 5  1.4DL 1.7LL
Joint     Force X     Force Y     Force Z       Mom X       Mom Y       Mom Z
            t           t           t          t - m       t - m       t - m
   1       0.866      42.933       0.441       0           0.002       0
   2      -0.016      40.383       0.442       0           0.002       0
   3       0.866      42.933      -0.441       0          -0.002       0
   4      -0.016      40.383      -0.442       0          -0.002       0
   5      18.918       0          18.918       0           0           0
   6     -18.918       0          18.918       0           0           0
   7      18.918       0         -18.918       0           0           0
   8     -18.918       0         -18.918       0           0           0
  10      -1.700    -129.370       0           0           0           0
TOTAL      0          37.261       0           0           0           0
```

5.3 Members Internal forces.

Printed in file "**name.IF3**".

The internal forces for each member defined in the print and for each combination of load conditions requested, are shown grouped by each bending plane referred to each member local axes **1**, **2** and **3**, forming plane **1-2** and plane **1-3**. The axial force in the local axis **1** direction and the torsional moment about local axis **1** are also included.

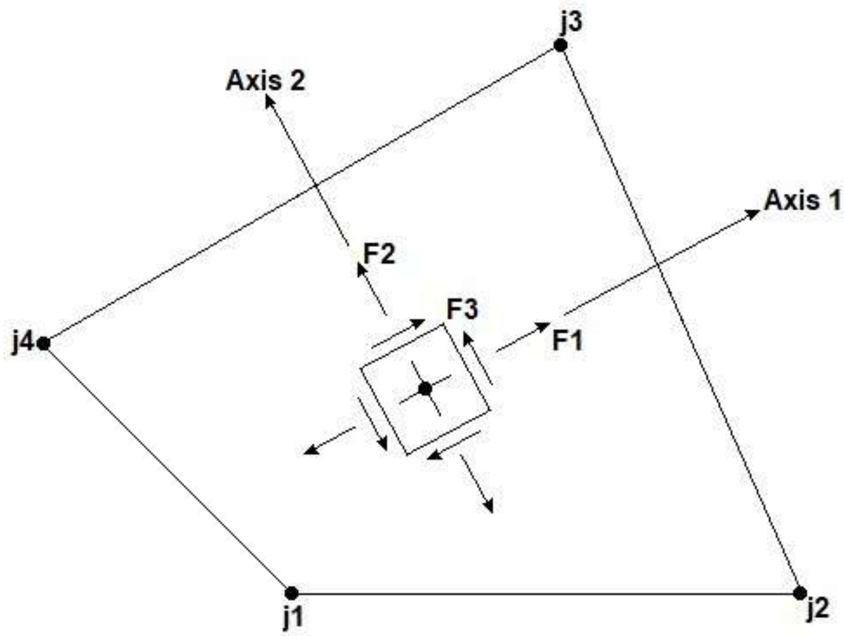
The distance indicated is 0.000 at joint **J** and extends to joint **K** in the local axis **1** direction. If the shear force in any of planes **1-2 or 1-3** equals zero within the span, the corresponding maximum positive moment is shown together with the distance from joint **J** where that occurs. If the forces along the member at regular intervals were also requested then the distance, shear and moment values for each bending plane are also shown.



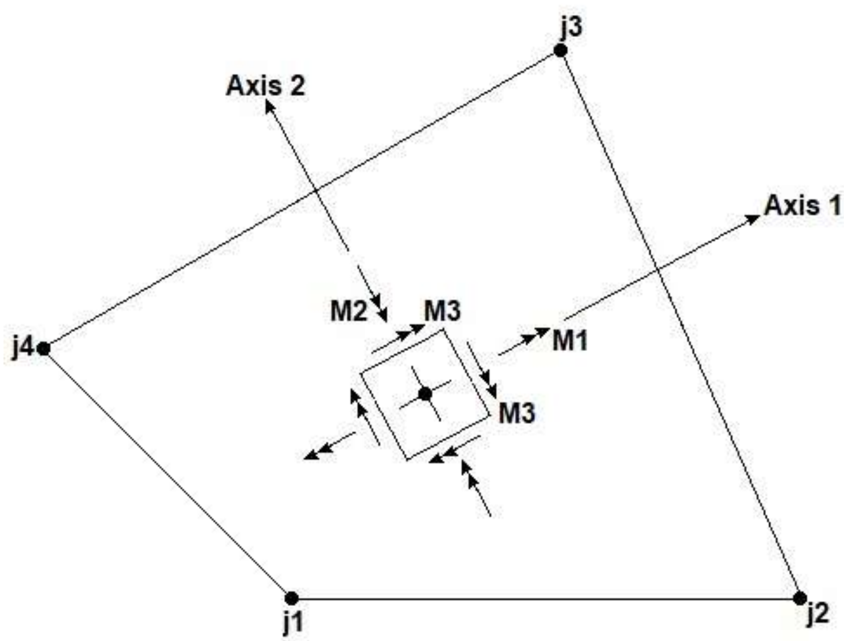
The shear forces and moments for each local bending plane (**1-2** and **1-3**) have the signs shown above on the respective diagram of shear and moment.

```
E:\STRUC 2021\ STRUC Ver. 1-2021   File: E:\STRUC NEW Sample Files\STATIC EXAMPLE.IF3         Page 1
By: F. JANNAUT        Licenced to: CopyRight F. JANNAUT         Date: 01-27-2021

3D FRAME TEST 11/05/2010

 Load Combinations
    1 1.4DL 1.7LL
    2 1.05DL 1.275LL 1.0SX
    3 4.5SX
    4 1.0DL 1.0LL
    5 1.0DL 1.0LL 1.0SX

 M   L          M E M B E R S      I N T E R N A L      F O R C E S
 E   C
 M   m            Axial  |- P L A N E  1-2 -| |- P L A N E  1-3 -|   Torsion
 B   b  Dist.     Force     Shear     Moment     Shear     Moment    Moment
          m         t         t        t - m       t        t - m     t - m

 1            Joints: 1 to 5   Material: 1   Name: R 0.300,0.300
     1  0.000    42.933     0.866     0          -0.441     0           0.002
        4.000   -41.723     0.866     3.465      -0.441    -1.763      -0.002

     2  0.000    43.189    -0.297     0          -0.332     0          -0.059
        1.980               0        -0.294      -0.332    -0.658
        4.000   -42.282     0.303     0.012      -0.332    -1.328       0.059

     3  0.000    49.453    -4.260     0          -0.007     0          -0.269
        4.000   -49.453    -1.560   -11.642      -0.007    -0.028       0.269

     4  0.000    27.622     0.528     0          -0.278     0           0
        4.000   -26.758     0.528     2.112      -0.278    -1.111       0

     5  0.000    38.612    -0.419     0          -0.279     0          -0.059
        2.791               0        -0.584      -0.279    -0.780
        4.000   -37.748     0.181    -0.475      -0.279    -1.117       0.059
```

5.4 Shells Internal Forces



MEMBRANE FORCES



BENDING FORCES

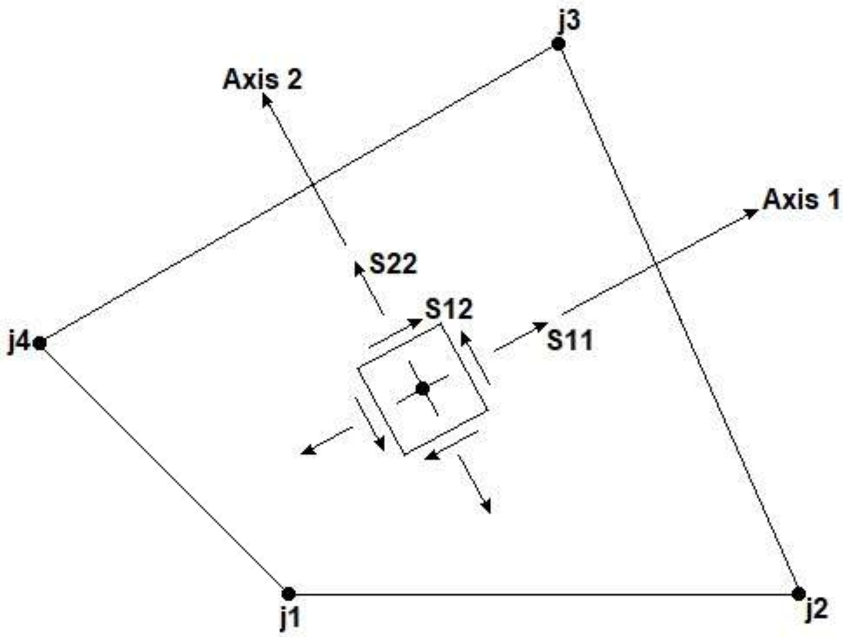
Printed in file "**name.SIF** and file "**name.SFS**".

.

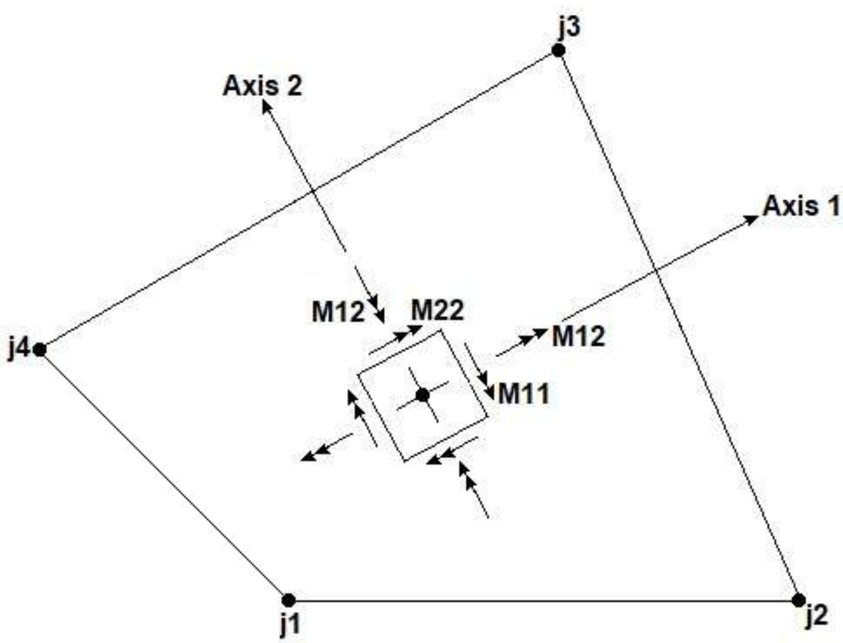
```
C:\STRUC 2024\ STRUC Ver. 1-2023   File: SHELLS\STATIC 256 DENSE GENERATED PLATES 10 10 1.SIF Page 22
By: F. JANNAUT        Licenced to: CopyRight F. JANNAUT          Date: 07-17-2024

DENSE SHELLS MATLAB EXAMPLE 10.10.1 TEST 08/25/2023


       L                    S H E L L S     I N T E R N A L     F O R C E S
       c
       m              F1           F2           F3          M1          M2          M3
MEMB   b  Joint       lb           lb           lb          lb-ft       lb-ft       lb-ft
 252   1   284   -35665.625     393.159      218.038    -261.323     357.780       0
           285    36743.842    -352.754     -411.614     109.635    -318.092       0
           268    26084.820    -399.924     -218.038     155.894    -834.297       0.074
           267   -27163.037     359.518      411.614    -215.348    -189.223       0.092

 253   1   285   -36743.842     304.746      351.797    -109.635     318.092       0
           286    37552.148    -267.650     -185.548     153.628    -360.638       0
           269    26975.431    -296.609     -351.797     200.392    -724.706       0.055
           268   -27783.736     259.514      185.548     -63.049     -72.349       0.074

 254   1   286   -37552.148     219.641      125.730    -153.628     360.638       0
           287    38142.109    -185.132     -217.879      56.667    -327.941       0
           270    27646.007    -226.706     -125.730     103.297    -614.244       0.037
           269   -28235.968     192.196      217.879    -106.847      44.657       0.055

 255   1   287   -38142.109     137.124      158.062     -56.667     327.941       0
           288    38476.703    -104.149      -82.884      50.707    -362.106       0
           271    28145.244    -129.423     -158.062      97.849    -502.369       0.018
           270   -28479.839      96.449       82.884      -9.889     160.055       0.037

 256   1   288   -38476.703      56.141       23.067     -50.707     362.106       0
           289    38602.044     -24.004      -29.909       0        -331.105       0
           272    28434.938     -63.493      -23.067      46.801    -389.157       0
           271   -28560.279      31.357       29.909      -3.556     275.382       0.018
```

```
C:\STRUC 2024\ STRUC Ver. 1-2023   File: SHELLS\STATIC 256 DENSE GENERATED PLATES 10 10 1.SFS Page 1
By: F. JANNAUT        Licenced to: CopyRight F. JANNAUT          Date: 07-17-2024

DENSE SHELLS MATLAB EXAMPLE 10.10.1 TEST 08/25/2023

 Load Combinations
    1 1.0DL

 S H E L L S   I N T E R N A L   F O R C E S   S U M M A R Y

    M I N I M U M   A N D   M A X I M U M   E N V E L O P E

                  Force    Units     Shell   Joint    LC   Name
     F1 Min.  -38476.703 lb           256     288      1   1.0DL
     F1 Max.   38602.044 lb           256     289      1   1.0DL

     F2 Min.   -6627.981 lb           194     207      1   1.0DL
     F2 Max.    6458.090 lb           179     207      1   1.0DL

     F3 Min.   -2047.546 lb           241     257      1   1.0DL
     F3 Max.    2047.546 lb           241     273      1   1.0DL

     M1 Min.   -1614.174 lb-ft         16      16      1   1.0DL
     M1 Max.    1562.979 lb-ft         16      34      1   1.0DL

     M2 Min.   -1719.504 lb-ft        242     258      1   1.0DL
     M2 Max.    1710.236 lb-ft        226     257      1   1.0DL

     M3 Min.       0     lb-ft        248     281      1   1.0DL
     M3 Max.       0.461 lb-ft        225     257      1   1.0DL
```

5.5 Shells Internal Stresses



MEMBRANE STRESSES



BENDING STRESSES

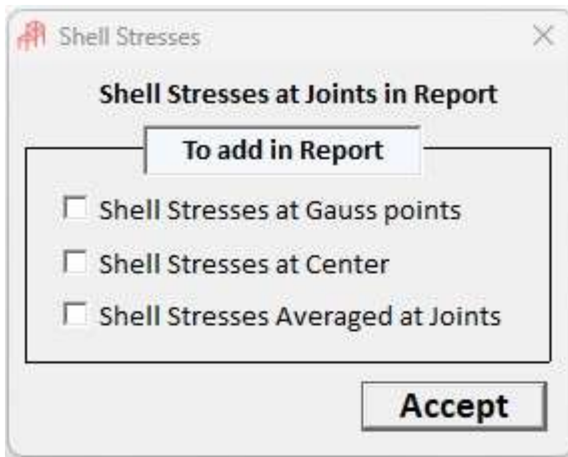
The following is taken from "CALCULATION OF ELEMENT STRAINS AND STRESSES chapter 28 Stress Recovery, 28.2 Calculation of Element Strains and Stresses":

To compute element nodal stresses, first evaluates stresses at the four Gauss (G) interaction points used in the element stiffness integration rule and then use a bilinear extrapolation to the four element node points or joints.

Empirical evidence indicates that this approach generally delivers better stress values for quadrilateral elements whose geometry departs substantially from the rectangular shape. This is backed up by "super convergence" results in finite element approximation theory. For rectangular elements there is no difference. This is the approach used by STRUC.

Internal stresses are always shown at Joints. Internal stresses may be added as an option at Gauss points (G), at the shell element (Center) point, and Averaged at Joints, as shown below.

Printed in file "**name.SST**" and file "**name.SSS**".



The Report always include Shell Stresses at Joints.

To add shell stresses at the four Gauss interaction points, and or at the Center, and or as an Averaged at Joints, just select them from the list and click **Accept** to generate the Report.

```
C:\STRUC 2024\ STRUC Ver. 1-2023   File: SHELLS\STATIC 256 DENSE GENERATED PLATES 10 10 1.SST Page 43
By: F. JANNAUT        Licenced to: CopyRight F. JANNAUT          Date: 07-17-2024

DENSE SHELLS MATLAB EXAMPLE 10.10.1 TEST 08/25/2023


       L            S H E L L S     I N T E R N A L     S T R E S S E S
       c
       m              S11         S22          S12          M11          M22          M12
MEMB   b  Joint    lb/ft/ft    lb/ft/ft     lb/ft/ft     lb-ft/ft     lb-ft/ft     lb-ft/ft
 253   1   285    72420.162     -36.302     8976.502     -628.074      -29.735     -254.217
           286    72420.162     -11.180   -10019.903     -628.074      -30.009     -228.573
           269    45898.282     -11.180   -10011.134     -592.272      -30.009     -228.669
           268    45898.282     -36.302     8985.271     -592.272      -29.735     -254.312
           285G   66815.429     -30.993     4963.943     -620.509      -29.793     -248.818
           286G   66815.429     -16.489    -6003.637     -620.509      -29.951     -234.013
           269G   51503.015     -16.489    -5998.574     -599.838      -29.951     -234.068
           268G   51503.015     -30.993     4969.005     -599.838      -29.793     -248.873
         CENTER   59159.222     -23.741     -517.316     -610.173      -29.872     -241.443

 254   1   286    73762.801     -11.180     9258.353     -637.833      -30.009     -207.200
           287    73762.801     -32.992   -10005.890     -637.833      -29.774     -178.343
           270    46866.978     -32.992   -10013.503     -597.544      -29.774     -178.261
           269    46866.978     -11.180     9250.740     -597.544      -30.009     -207.118
           286G   68079.045     -15.790     5185.731     -629.319      -29.959     -201.085
           287G   68079.045     -28.383    -5936.485     -629.319      -29.824     -184.424
           270G   52550.734     -28.383    -5940.881     -606.058      -29.824     -184.377
           269G   52550.734     -15.790     5181.335     -606.058      -29.959     -201.037
         CENTER   60314.890     -22.086     -377.575     -617.688      -29.892     -192.731

 255   1   287    74650.423     -32.992     9502.046     -638.725      -29.774     -111.939
           288    74650.423      -9.216    -9938.626     -638.725      -30.335      -85.081
           271    47508.278      -9.216    -9930.327     -601.227      -30.335      -85.276
           270    47508.278     -32.992     9510.345     -601.227      -29.774     -112.135
           287G   68914.613     -27.967     5395.503     -630.801      -29.893     -106.305
           288G   68914.613     -14.240    -5828.575     -630.801      -30.216      -90.798
           271G   53244.088     -14.240    -5823.783     -609.151      -30.216      -90.911
           270G   53244.088     -27.967     5400.294     -609.151      -29.893     -106.418
         CENTER   61079.351     -21.104     -214.140     -619.976      -30.055      -98.608

 256   1   288    75091.883      -9.216     9687.739     -641.858      -30.335      -60.362
           289    75091.883     -31.919    -9840.251     -641.858      -29.794      -32.483
           272    47827.829     -31.919    -9848.176     -602.935      -29.794      -32.294
           271    47827.829      -9.216     9679.815     -602.935      -30.335      -60.173
           288G   69330.310     -14.013     5559.315     -633.632      -30.221      -54.430
           289G   69330.310     -27.121    -5715.176     -633.632      -29.909      -38.335
           272G   53589.401     -27.121    -5719.751     -611.160      -29.909      -38.226
           271G   53589.401     -14.013     5554.739     -611.160      -30.221      -54.321
         CENTER   61459.856     -20.567      -80.218     -622.396      -30.065      -46.328
```

Stresses Minimum and Maximum Envelope is always computed at Joints

```
C:\STRUC 2024\ STRUC Ver. 1-2023   File: SHELLS\STATIC 256 DENSE GENERATED PLATES 10 10 1.SSS Page 1
By: F. JANNAUT        Licenced to: CopyRight F. JANNAUT          Date: 07-17-2024

DENSE SHELLS MATLAB EXAMPLE 10.10.1 TEST 08/25/2023

 Load Combinations
    1 1.0DL

 S H E L L S   I N T E R N A L   S T R E S S E S   S U M M A R Y

     M I N I M U M   A N D   M A X I M U M   E N V E L O P E

              S T R E S S E S   A T   J O I N T S

                 Stress      Units     Shell  Joint   LC  Name
    S11 Min.  -17354.411 lb/ft/ft      144    153     1  1.0DL
    S11 Max.   75091.883 lb/ft/ft      256    289     1  1.0DL

    S22 Min.   -3380.779 lb/ft/ft       15     33     1  1.0DL
    S22 Max.       0     lb/ft/ft      241    256     1  1.0DL

    S12 Min.  -10882.750 lb/ft/ft      210    224     1  1.0DL
    S12 Max.    9687.739 lb/ft/ft      256    288     1  1.0DL

    M11 Min.    -641.858 lb/ft/ft      256    288     1  1.0DL
    M11 Max.      96.770 lb/ft/ft       16     17     1  1.0DL

    M22 Min.     -64.691 lb/ft/ft      240    255     1  1.0DL
    M22 Max.    2037.002 lb/ft/ft       16     34     1  1.0DL

    M12 Min.   -1398.923 lb/ft/ft      226    240     1  1.0DL
    M12 Max.       0     lb/ft/ft       16     17     1  1.0DL
```

Shells Internal Stresses Contour Lines under development.

5.6 Eigenvalues and Eigenvectors

Printed in file "**name.EIG**".

The values for the Eigenvalues, the frequencies **ω** in rad/s, cycles per second (CPS), and periods in seconds are presented for each mode of vibration requested.

The percentages of participation in the total mass of the structure are presented for each mode of vibration requested, and for each direction of the global axes **X**, **Y** and **Z**.

The normalized Mode Shapes are presented for each mode of vibration requested and for each of the global axe's **X**, **Y** and **Z**, therefore these displacements are not of real significance to the units of distance used in the structure, they only represent the shapes of the modes of vibration.

```
E:\STRUC 2021\ STRUC Ver. 1-2021   File: E:\STRUC NEW Sample Files\EIGEN EMP1.EIG          Page 1
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EDIFICIO DE MATERIAS PRIMAS  kg-cm  ANALISIS DE VERIFICACION  11-10-94 04-24-95

 19 Iteration Cicles Performed
Total Self Weight      =     1,094,318.19561 kg
Participating Weight   =     1,066,094.19561 kg
Gravitational Index (g) =          980.66500 cm/s2

        10   M O D E S    R E Q U E S T E D - Using LUMPED Mass Matrix
```

MODE	Eigv. Error	Eigenvalue	rad/s	CPS	Period (s)	MODE
1	0.000000	29.3859	5.4209	0.8628	1.159072	1
2	0.000000	32.7558	5.7233	0.9109	1.097832	2
3	0.000000	44.2523	6.6522	1.0587	0.944522	3
4	0.000000	210.6048	14.5122	2.3097	0.432958	4
5	0.000000	234.6442	15.3181	2.4380	0.410180	5
6	0.000000	308.4746	17.5634	2.7953	0.357742	6
7	0.000000	327.4290	18.0950	2.8799	0.347233	7
8	0.000000	474.3974	21.7807	3.4665	0.288475	8
9	0.000000	593.0246	24.3521	3.8758	0.258014	9
10	0.000000	676.9244	26.0178	4.1409	0.241496	10

M A S S   P A R T I C I P A T I O N   F A C T O R S (in %)

MODE	X	Y	Z	Summ-X	Summ-Y	Summ-Z	MODE
1	74.531	0.000	0.589	74.531	0.000	0.589	1
2	0.807	0.001	83.990	75.338	0.001	84.579	2
3	5.950	0.001	0.394	81.288	0.002	84.973	3
4	7.768	0.000	0.041	89.056	0.002	85.014	4
5	0.034	0.003	6.770	89.090	0.005	91.784	5
6	0.103	0.003	0.001	89.193	0.008	91.784	6
7	0.010	0.000	0.002	89.203	0.008	91.787	7
8	0.361	0.000	0.004	89.564	0.009	91.791	8
9	0.016	0.000	1.150	89.580	0.009	92.941	9
10	3.979	0.007	0.868	93.558	0.016	93.809	10

For each mode of vibration requested, the maximum value and the envelope of these values, are presented in the "**name.ESM**" file.

```
E:\STRUC 2021\ STRUC Ver. 1-2021   File: E:\STRUC NEW Sample Files\EIGEN EMP1.ESM            Page 1
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EDIFICIO DE MATERIAS PRIMAS  kg-cm  ANALISIS DE VERIFICACION  11-10-94 04-24-95

              10   M O D E S   R E Q U E S T E D

  M A X I M U M   V A L U E S

Mode 1    1.159072 s
 Direction   Value     Joint
        X    0.050957   164
        Y    0.002328    57
        Z    0.018169   166
     RotX    0.000007    31
     RotY    0.000013   133
     RotZ    0.000019    61

Mode 2    1.097832 s
 Direction   Value     Joint
        X    0.005135   166
        Y    0.005224    57
        Z    0.047320   167
     RotX    0.000026    28
     RotY    0.000004   169
     RotZ    0.000003   146

Mode 3    0.944522 s
 Direction   Value     Joint
        X    0.033721   135
        Y    0.004868    57
        Z    0.060558   170
     RotX    0.000022    31
     RotY    0.000048   166
     RotZ    0.000017    55
```

5.7 Response Spectrum

Printed in file "**name.RSP**".

Table with the Design Spectrum values are presented, as a fraction of (g), as length per second squared and as length per second squared and divided by the Response Modification Coefficient R.

For each mode of vibration requested, a table with the acceleration values read from the Design Spectrum with the Modal Modification Factor used to scale the shape modes to real values of displacement.

For each of the global axes **X**, **Y**, and **Z**, a table with the base shears and totals calculated in accordance with the modal combination type chosen. (See 4.4.16 SEISMIC).

```
E:\STRUC 2021\ STRUC Ver. 1-2021   File: E:\STRUC NEW Sample Files\RS SF.RSP
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RS SF June 22 2011

              R E S P O N S E   S P E C T R U M   A N A L Y S I S

 Participating Weight          = 59.80800 t
 Response Modification Coef. R = 5.00

            User Defined  RESPONSE SPECTRUM
   Time         (g)        SPEC ACCEL   SPEC ACCEL / R
    s         Fraction       m/s2          m/s2
   0.00000    0.3000000    2.941995     0.588399
   0.15000    0.7500000    7.354988     1.470998
   0.39000    0.7500000    7.354988     1.470998
   0.40000    0.7312500    7.171113     1.434223
   0.45000    0.6500000    6.374323     1.274865
   0.50000    0.5850000    5.736890     1.147378
   0.55000    0.5318180    5.215353     1.043071
   0.60000    0.4875000    4.780742     0.956148
   0.65000    0.4500000    4.412993     0.882599
   0.70000    0.4178570    4.097777     0.819555
   0.75000    0.3900000    3.824594     0.764919
   0.80000    0.3656250    3.585556     0.717111
   0.85000    0.3441180    3.374645     0.674929
   0.90000    0.3250000    3.187161     0.637432
   1.00000    0.3000000    2.941995     0.588399

 MODE    Eigenvalue       Freq      Period       (g) / R    SPEC ACCEL / R     MODAL
  No.                    rad/s        s          Fraction       m/s2         MOD FACTOR
  1       237.88558    15.42354   0.407376      0.143853     1.410713        1.83921
  2       253.13916    15.91035   0.394912      0.148158     1.452934        5.52671
  3       419.40400    20.47936   0.306806      0.150000     1.470998        0.03373
  4     1,214.44742    34.84892   0.180298      0.150000     1.470998       -0.15929
  5     1,357.43854    36.84343   0.170537      0.150000     1.470998        0.43691

                  M O D A L   D I S P L A C E M E N T S
Mode 1  Period =   0.407376 s
 Joint   X          Y          Z          RotX       RotY       RotZ
         m          m          m          rad        rad        rad
    1    0          0          0          0          0          0
    2   -0.000988   0.000005   0.001545   0.000202   0.000102   0.000112
    3   -0.001683   0.000008   0.002785   0.000142   0.000164   0.000072
    4   -0.002095   0.000009   0.003539   0.000071   0.000195   0.000038
    5    0          0          0          0          0          0
    6   -0.000988   0.000027   0.001109   0.000154   0.000125   0.000051
    7   -0.001683   0.000043   0.002118   0.000122   0.000166   0.000082
    8   -0.002095   0.000047   0.002754   0.000063   0.000195   0.000035
    9    0          0          0          0          0          0
   10   -0.000985   0.000008   0.000493   0.000051   0.000126   0.000062
   12    0          0          0          0          0          0
   13   -0.000467  -0.000025   0.001543   0.000110   0.000099   0.000060
   14   -0.000858  -0.000039   0.002784   0.000158   0.000164   0.000045
   15   -0.001111  -0.000043   0.003539   0.000067   0.000195   0.000026
   16    0          0          0          0          0          0
   17   -0.000466  -0.000007   0.001109   0.000086   0.000117   0.000029
   18   -0.000858  -0.000011   0.002117   0.000135   0.000165   0.000051
   19   -0.001111  -0.000012   0.002754   0.000060   0.000195   0.000024
   20    0          0          0          0          0          0
   21   -0.000465   0.000000   0.000493   0.000041   0.000129   0.000035
   23    0          0          0          0          0          0
   24    0.000070  -0.000005   0.001537   0.000134   0.000097  -0.000001
   25    0          0          0          0          0          0
   26    0.000071  -0.000004   0.001106   0.000103   0.000092  -0.000004
```

5.8 Reinforced concrete design and/or review in structural steel Data

For reinforced concrete design data printed in file "**name.CON**" a table with steel ratios (Rho), area of reinforcement, tension (and compression face if any **[AsOp]**) and percentages of use for flexure and shear-torsion for beams, and two tables with similar data for Columns, one for bi-axial bending and other for shear and torsion.

```
E:\STRUC 2021\ STRUC Ver. 1-2021   File: FrmDesign.CON                              Page 1
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3D FRAME TEST 11/05/2010

 Load Combinations
    1 1.4DL 1.7LL
    2 1.05DL 1.275LL 1.05X
    3 4.55X

                         D E S I G N   P R O V I S I O N S: ACI-318-19

 M             B E A M   T Y P E   C O N C R E T E   M E M B E R S   D E S I G N
 E     |------------- F L E C T I O N ------------|  |--- S H E A R   A N D   T O R S I O N ---|
 M
 B Dist Comb  Use      Mu 1-2   Rho       As   [AsOp]  Comb  Use     Vu 1-2       Tu      Av+2At   Al
     m         %       t - m              cm2     cm2          %       t          t - m   cm2/ m   cm2

 5 Dg=1.00  Dl=1.00   h=0.400 m  bw=0.300 m  cover=0.050 m
   0.00  3   48.19   1.156E+01 0.0092   9.66   0.00    3    0.00 -3.964E+00  2.224E-02   4.38   0.00
   3.14  1    0.00   4.011E+00 0.0034   3.52   0.00
   6.00  3   53.07  -1.222E+01 0.0098  10.28   0.00    3    0.00 -3.964E+00 -2.224E-02   4.38   0.00

 6 Dg=1.00  Dl=1.00   h=0.400 m  bw=0.300 m  cover=0.050 m
   0.00  3   48.19   1.156E+01 0.0092   9.66   0.00    3    0.00 -3.964E+00 -2.224E-02   4.38   0.00
   3.14  1    0.00   4.011E+00 0.0034   3.52   0.00
   6.00  3   53.07  -1.222E+01 0.0098  10.28   0.00    3    0.00 -3.964E+00  2.224E-02   4.38   0.00

 7 Dg=1.00  Dl=1.00   h=0.400 m  bw=0.300 m  cover=0.050 m
   0.00  1    0.00  -1.769E+00 0.0034   3.52   0.00    3    0.00        0.00       0.00   4.38   0.00
   3.00  1    0.00   3.998E+00 0.0034   3.52   0.00
   6.00  1    0.00  -1.769E+00 0.0034   3.52   0.00    3    0.00        0.00       0.00   4.38   0.00

 8 Dg=1.00  Dl=1.00   h=0.400 m  bw=0.300 m  cover=0.050 m
   0.00  1    0.00  -1.761E+00 0.0034   3.52   0.00    3    0.00        0.00       0.00   4.38   0.00
   3.00  1    0.00   4.006E+00 0.0034   3.52   0.00
   6.00  1    0.00  -1.761E+00 0.0034   3.52   0.00    3    0.00        0.00       0.00   4.38   0.00
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 M   C O L U M N   T Y P E   C O N C R E T E   M E M B E R S   D E S I G N
 E      |------------------ B I - A X I A L   B E N D I N G ----------------|
 M
 B Dist Comb  Use       Pu        Mu 1-2     Mu 1-3      Rho     As face   As side
     m         %        t         t - m      t - m                 cm2       cm2

 1 Dg=1.00  Dl=1.01   h=0.300 m  bw=0.300 m  cover=0.050 m  Rs=0.250
   0.00  3    0.00   4.945E+01       0.00        0.00 0.0100      3.38      1.13
   4.00  3   56.74  -4.945E+01 -1.164E+01 -2.802E-02 0.0327     11.03      3.68

 2 Dg=1.00  Dl=1.01   h=0.300 m  bw=0.300 m  cover=0.050 m  Rs=0.250
   0.00  3    0.00   5.964E+01       0.00        0.00 0.0100      3.38      1.13
   4.00  3   69.73  -5.964E+01 -1.235E+01  4.879E-02 0.0379     12.79      4.26

 3 Dg=1.00  Dl=1.01   h=0.300 m  bw=0.300 m  cover=0.050 m  Rs=0.250
   0.00  3    0.00   4.945E+01       0.00        0.00 0.0100      3.38      1.13
   4.00  3   56.74  -4.945E+01 -1.164E+01  2.802E-02 0.0327     11.03      3.68

 4 Dg=1.00  Dl=1.01   h=0.300 m  bw=0.300 m  cover=0.050 m  Rs=0.250
   0.00  3    0.00   5.964E+01       0.00        0.00 0.0100      3.38      1.13
   4.00  3   69.73  -5.964E+01 -1.235E+01 -4.879E-02 0.0379     12.79      4.26

 M   C O L U M N   T Y P E   C O N C R E T E   M E M B E R S   D E S I G N
 E      |----- S H E A R   A N D   T O R S I O N -----|
 M
 B Dist Comb  Use     Vu Max.      Tu        Av+2At     Al
     m         %        t         t - m      cm2/ m     cm2

 1 Dg=1.00  Dl=1.01   h=0.300 m  bw=0.300 m  cover=0.050 m
   0.00  3   34.85   4.260E+00 -2.686E-01    8.79     3.46
   4.00  3   33.95   1.560E+00  2.686E-01    8.79     3.46
```

For structural steel check data printed in file "**name.STL**" a table with percentages of use for Axial loading, Flexure in plane **1-2** and plane **1-3** and total percentage of use, a table with percentages of use for Shear and a table with percentages of use for Deflection Checking.

```
E:\STRUC 2021\ STRUC Ver. 1-2021   File: FrmDesign.STL                                  Page 1
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3D FRAME TEST 11/05/2010

 Load Combinations
    4 1.0DL 1.0LL
    5 1.0DL 1.0LL 1.0SX

          D E S I G N   P R O V I S I O N S: AISC ASD 360-10 14th Edition


 M            S T E E L   T Y P E    M E M B E R S   D E S I G N
 E     |---------------- C O M B I N E D   S T R E S S ------------------|
 M
 B Dist Comb   Pu          Mu 1-2     Mu 1-3      Pu   Mu 1-2  Mu 1-3   Use
    m        t             t - m      t - m       %       %       %    %TOT

 9 Slenders: Plane 1-2=87.5 Plane 1-3=87.5  Dg=1.00  Dl=1.01  Pipe8STD
   0.00  5  4.398E+01       0.00       0.00   84.78    0.00    0.00   84.78
   2.28  5  4.398E+01  7.590E-01  2.341E-01   84.78   14.70    4.53  101.87 INSUFFICIENT
   6.56  5  4.398E+01 -7.813E-01 -2.267E-01   84.78   15.13    4.39  102.13 INSUFFICIENT

 10 Slenders: Plane 1-2=87.5 Plane 1-3=87.5  Dg=1.00  Dl=1.01  Pipe8STD
   0.00  5  4.368E+01       0.00       0.00   84.20    0.00    0.00   84.20
   2.13  5  4.368E+01  5.141E-01       0.00   84.20    9.96    0.00   93.05
   6.56  5  4.368E+01 -8.170E-01  1.117E-01   84.20   15.82    2.16  100.18 INSUFFICIENT

 11 Slenders: Plane 1-2=87.5 Plane 1-3=87.5  Dg=1.00  Dl=1.01  Pipe8STD
   0.00  5  4.398E+01       0.00       0.00   84.78    0.00    0.00   84.78
   2.28  5  4.398E+01  7.590E-01 -2.341E-01   84.78   14.70    4.53  101.87 INSUFFICIENT
   6.56  5  4.398E+01 -7.813E-01  2.267E-01   84.78   15.13    4.39  102.13 INSUFFICIENT

 12 Slenders: Plane 1-2=87.5 Plane 1-3=87.5  Dg=1.00  Dl=1.01  Pipe8STD
   0.00  5  4.368E+01       0.00       0.00   84.20    0.00    0.00   84.20
   2.13  5  4.368E+01  5.141E-01       0.00   84.20    9.96    0.00   93.05
   6.56  5  4.368E+01 -8.170E-01 -1.117E-01   84.20   15.82    2.16  100.18 INSUFFICIENT
E:\STRUC 2021\ STRUC Ver. 1-2021   File: FrmDesign.STL                                  Page 1
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3D FRAME TEST 11/05/2010

 M   S T E E L   T Y P E    M E M B E R S   D E S I G N
 E     |---------- S H E A R   S T R E S S -----------|
 M
 B Dist Comb   Vu 1-2      Vu 1-3   Vu 1-2  Vu 1-3   Use
    m            t           t        %       %     %TOT

 9 Pipe8STD
   0.00  5  6.688E-01  1.716E-01    2.91    0.06    2.97
   6.56  5 -6.339E-01 -2.407E-01    2.75    0.09    2.84

 10 Pipe8STD
   0.00  4  5.225E-01  4.003E-04    2.27    0.00    2.27
   6.56  5 -4.821E-01  1.703E-02    2.09    0.01    2.10

 11 Pipe8STD
   0.00  5  6.688E-01 -1.716E-01    2.91    0.06    2.97
   6.56  5 -6.339E-01  2.407E-01    2.75    0.09    2.84

 12 Pipe8STD
   0.00  4  5.225E-01 -4.003E-04    2.27    0.00    2.27
   6.56  5 -4.821E-01 -1.703E-02    2.09    0.01    2.10
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 M   S T E E L   T Y P E    M E M B E R S   D E S I G N
 E     |---- D E F L E C T I O N   C H E C K I N G ----|
 M
 B  Comb Def 1-2   Comb Def 1-3        Def 1-2      Def 1-3
          m              m                %            %

 9  Beam Type  DB = 300
     5  0.0043      5  0.0011          19.69         5.15

 10  Beam Type  DB = 300
     4  0.0030      5  0.0005          13.84         2.37

 11  Beam Type  DB = 300
     5  0.0043      5  0.0011          19.69         5.15

 12  Beam Type  DB = 300
     4  0.0030      5  0.0005          13.84         2.37
```

B *EXAMPLES OF STATIC AND SEISMIC ANALYSIS*

Six different examples will be shown as follows:

1. Space frame with static loads. (File created in this manual).
2. Space frame with seismic loads. Equivalent Lateral Force (ELF).
3. Space frame with seismic loads. Response Spectrum (RS).
4. Space frame with P-Δ analysis.
5. Space frame with static loads. Deflection verification.
6. Space Shells with static loads.

The first one belongs to a static analysis of a space frame structure used in the data examples all along this manual.

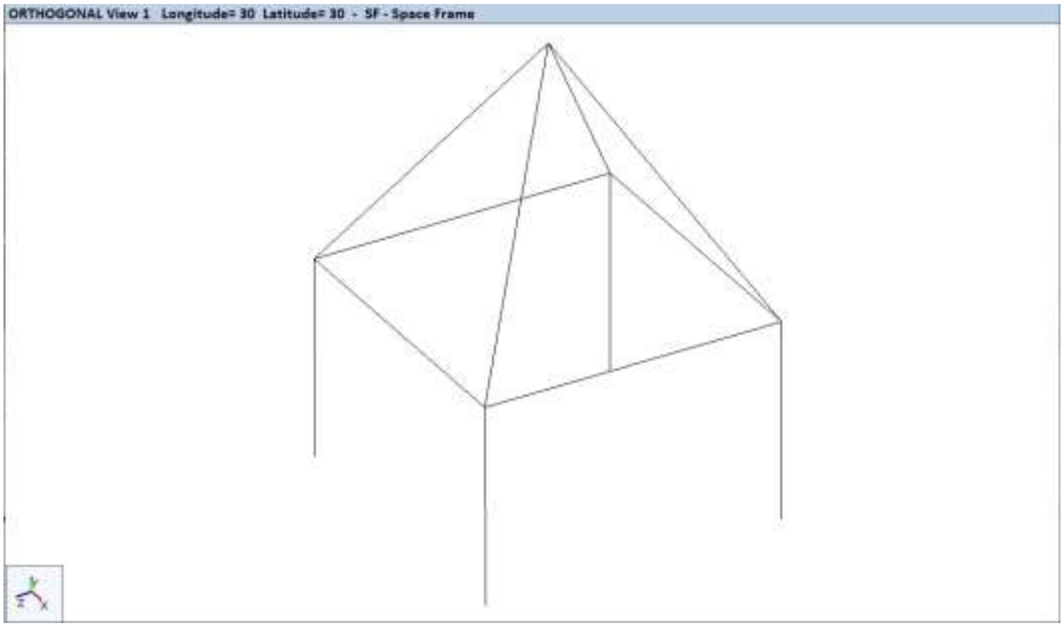
The next two examples belong to a seismic analysis on the same structure in order to illustrate the capabilities of the software performing one seismic analysis of type "Equivalent Lateral Force (ELF)" and one seismic analysis of type "Response Spectrum (RS)". In both analyses, the design spectrum is defined by the user, there are 4 Eigenvalues requested in the Response Spectrum analysis and the modal combination used is the combination type "CQC".

The fourth example belongs to a static analysis with P-Δ effect, over a space frame. Comparison results are shown between a first order analysis and a P-Δ analysis.

The fifth example belongs to a space frame with static loads illustrating the software's deflection verification capabilities.

The last example belongs to a plane shell in vertical orientation with static loads at the lower end, to illustrate the capabilities of the software performing a general static analysis with deflections, reactions, internal forces and internal stresses.

B.1 Space Frame with static loads used in this manual.

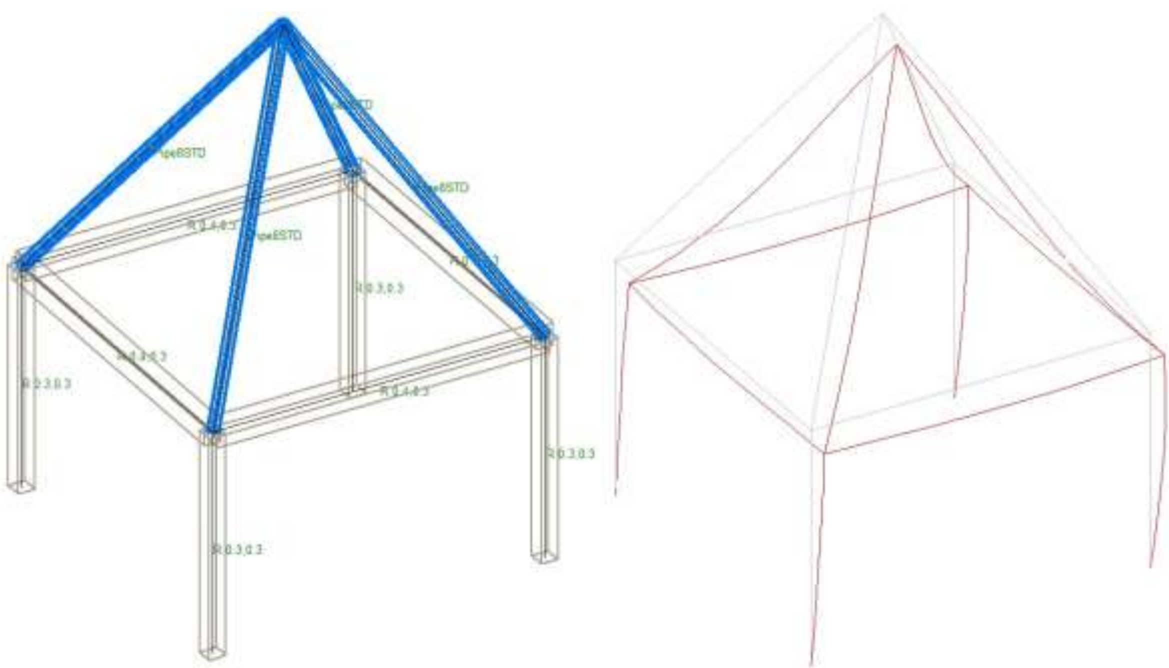


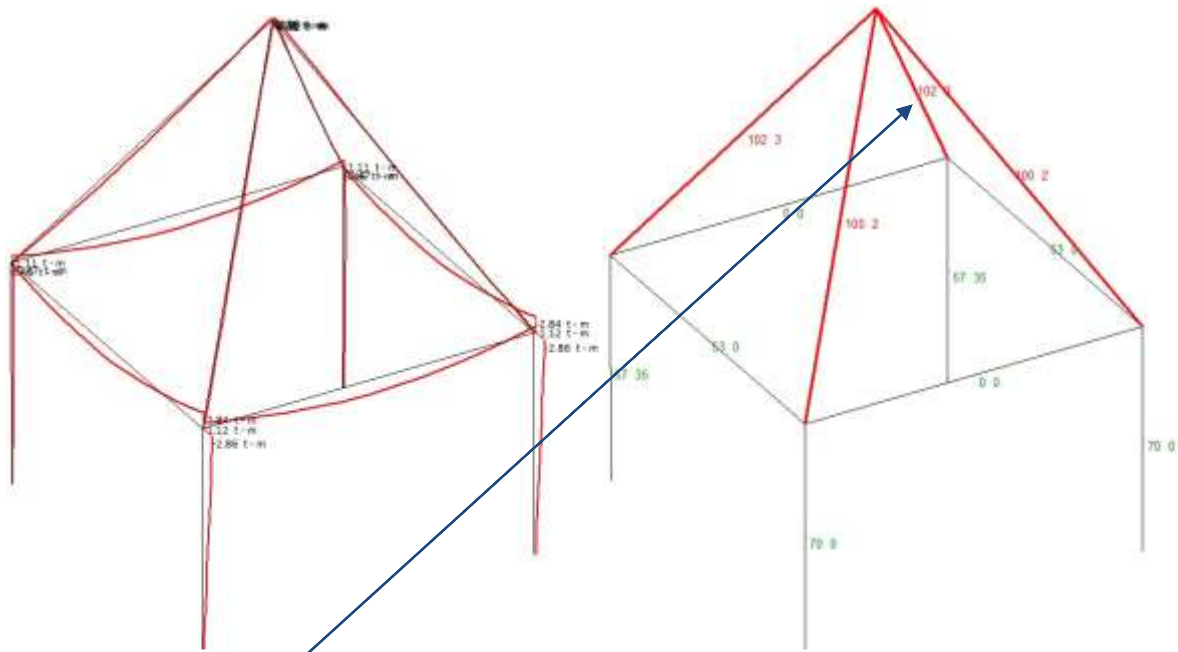
Input data file: "STATIC EXAMPLE"

```
3D FRAME TEST 11/05/2010

CONTROL
L=3
C LOAD CONDITION NAMES
  1 DL
  2 LL
  3 SX
C GENERAL PARAMETERS
UF=2  UL=2  UT=1  MT=1 : t   m ˚C

JOINTS
C LENGTH UNITS USED:  m
    1   X=0                      Y=0                       Z=0
    2   X=6                      Y=0                       Z=0
    3   X=0                      Y=0                       Z=6
    4   X=6                      Y=0                       Z=6
    5   X=0                      Y=4                       Z=0
    6   X=6                      Y=4                       Z=0
    7   X=0                      Y=4                       Z=6
    8   X=6                      Y=4                       Z=6
   10   X=3                      Y=9                       Z=3
   20   X=3                      Y=4                       Z=3

RESTRAINTS
C (R) DISPLACEMENT IN AXIS, (<) ROTATION ARROUND AXIS.
C 0=FREE   1=RESTRICTED
    1   RX=1        RZ=1        <Y=1
    2   RX=1        RZ=1        <Y=1
    3   RX=1        RZ=1        <Y=1
    4   RX=1        RZ=1        <Y=1

SPRINGS
C FORCE and LENGTH UNITS USED:  t  :  m
C (S) [FORCE/LENGTH] IN AXIS,  (<) [MOMENT/radians] ARROUND AXIS
```

```
    1                      SY=10000.0000
    2                      SY=10000.0000
    3                      SY=10000.0000
    4                      SY=10000.0000

MEMBERS
NM=5
C UNITS USED:  t  :  m : °C
  1  SH=R  T=0.3,0.3  E=1787220  W=2.4  TC=0.00001  MT=C  FC=2400  FY=24000,42000  R=0.05
RS=0.25 :R 0.300,0.300
  2  SH=R  T=0.4,0.3  E=1787220  W=2.4  TC=0.00001  MT=C  FC=2400  FY=24000,42000  R=0.05 :R
0.400,0.300
  3  SH=P  T=0.2731,0.0093  E=21000000  W=7.85  TC=0.0000117  MT=S  FY=25300 :P
0.2731,0.0093
  4  SH=A  T=2048  E=21000000  W=7.85  TC=0.0000117  MT=S  FY=25300 :Pipe10STD
  5  SH=A  T=2049  E=21000000  W=7.85  TC=0.0000117  MT=S  FY=25300 :Pipe8STD
C MEMBERS
     1     1     5  MN=1  P2=1,2
     2     2     6  MN=1  P2=1,2
     3     3     7  MN=1  P2=1,2
     4     4     8  MN=1  P2=1,2
     5     5     6  MN=2  P2=2,0  MJ=20,0
     6     7     8  MN=2  P2=2,0  MJ=20,0
     7     5     7  MN=2  P2=2,0  MJ=20,0
     8     6     8  MN=2  P2=2,0  MJ=20,0
     9     5    10  MN=5  P2=2,0  RM2=1,0  RM3=1,0
    10     6    10  MN=5  P2=2,0  RM2=1,0  RM3=1,0
    11     7    10  MN=5  P2=2,0  RM2=1,0  RM3=1,0
    12     8    10  MN=5  P2=2,0  RM2=1,0  RM3=1,0

MLOADS
NP=5  WY=-1  L=1
C 5 LOAD PATTERNS
C UNITS USED:  t  :  m : °C
  1  WL=0,0,0  WG=0,-0.35
  2  WL=0,-0.25,0,6.557,0,0
  3  WL=0,0,0  PL=3,-0.5,0
  4  WL=0,0,0  WG=0.15
  5  WL=0,0,0  WG=0.1
C MEMBER LOADS
C LOAD CONDITION 2 :LL
     5  LP=1,3                                 L=2
     6  LP=1,3                                 L=2
     7  LP=1,3                                 L=2
     8  LP=1,3                                 L=2
     9  LP=2                                   L=2
    10  LP=2                                   L=2
    11  LP=2                                   L=2
    12  LP=2                                   L=2
C LOAD CONDITION 3 :SX
     1  LP=4                                   L=3
     3  LP=4                                   L=3
     7  LP=4                                   L=3
     9  LP=5                                   L=3
    11  LP=5                                   L=3

JLOADS
C UNITS USED:  t  :  m : °C
   10  FX=-1.00                                 L=2 :LL

DISPLACEMENTS
C UNITS USED:  t  :  m : °C
   10              DY=-0.002800

LOADCOMB
  1  C=1.4000,1.7000
```

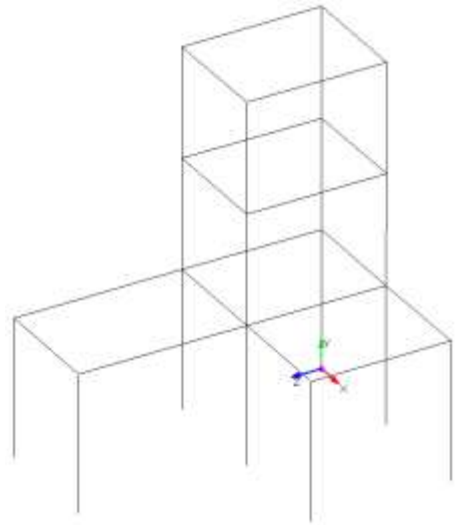
```
   2  C=1.0500,1.2750,1.0000
   3  C=0.0000,0.0000,4.5000
   4  C=1.0000,1.0000
   5  C=1.0000,1.0000,1.0000
LR=4,5

CNCDES
C ACI 318-19 CONCRETE DESIGN PROVISIONS
C CONCRETE DESIGN LOAD COMBINATIONS
LL=1,2,3

STLDES
C AISC 360-10 DESIGN PROVISIONS
C STEEL DESIGN LOAD COMBINATIONS
LL=4,5
C STEEL DEFLECTION CONTROL LOAD COMBINATIONS
LD=4,5
DP=ASD10
C AISC 360-10 DESIGN PARAMETERS
 9  TN=5,10   C3=5,10  C2=5,10  FT=5,10  FB=5,10 DB=300
 10  TN=5,10   C3=5,10  C2=5,10  FT=5,10  FB=5,10 DB=300
 11  TN=5,10   C3=5,10  C2=5,10  FT=5,10  FB=5,10 DB=300
 12  TN=5,10   C3=5,10  C2=5,10  FT=5,10  FB=5,10 DB=300
 9  DJ=5,10
 10  DJ=6,10
 11  DJ=7,10
 12  DJ=8,10

End of File
```

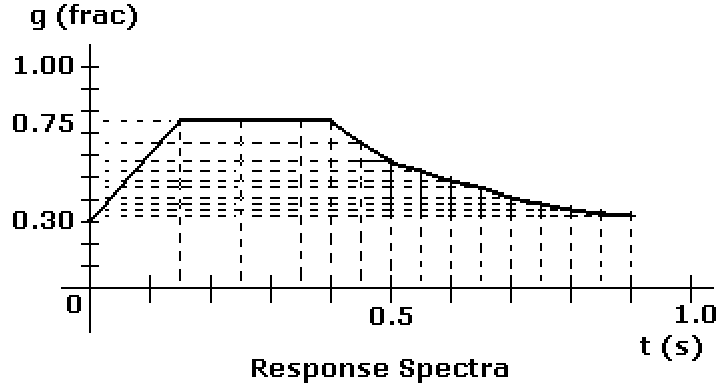




```
MEMBER No.       9             S T E E L             Pipe8STD
   JOINT J       5
   JOINT K      10

   Fy:        25,300.00 t / m2              Area:       0.00506 m2
    E:    21,000,000.00 t / m2      I3 Plane 1-2:       0.00003 m4
    W:          0.03976 t / m       I2 Plane 1-3:       0.00003 m4

 END RELEASES           J   K                        J   K
    Moment Plane 1-2    1   0   Shear Plane 1-2    0   0
    Moment Plane 1-3    1   0   Shear Plane 1-3    0   0
               Axial      0            Torsion      0

 Slenders: Plane 1-2=87.5 Plane 1-3=87.5  Dg=1.00  Dl=1.01  Pipe8STD

        D E S I G N   P R O V I S I O N S: AISC ASD 360-16 15th Edition
              S T E E L   T Y P E    M E M B E R S   D E S I G N
       |---------------- C O M B I N E D   S T R E S S -----------------|

   Dist Comb   Pu          Mu 1-2     Mu 1-3      Pu    Mu 1-2  Mu 1-3   Use
    m           t          t - m      t - m       %       %       %     % Tot
   0.00  5  4.392E+01       0.00       0.00     84.66    0.00    0.00   84.66
   2.28  5  4.392E+01  7.595E-01  2.344E-01   84.66   14.71    4.54  101.77 INSUFFICIENT
   6.56  5  4.392E+01 -7.798E-01 -2.260E-01   84.66   15.10    4.38  101.98 INSUFFICIENT

       |---------- S H E A R   S T R E S S -----------|
   Dist Comb   Vu 1-2     Vu 1-3   Vu 1-2  Vu 1-3   Use
    m            t          t        %       %     % Tot
   0.00  5  6.690E-01  1.717E-01    3.00    0.00    3.00
   6.56  5 -6.336E-01 -2.406E-01    2.94    0.00    2.94

       |---- D E F L E C T I O N   C H E C K I N G ----|
    Comb Def 1-2   Comb Def 1-3       Def 1-2     Def 1-3
           m              m              %           %
 Beam Type  DB = 300
     5  0.0043      5  0.0011        19.72        5.17
```

B.2 Space Frame with seismic loads, Equivalent Lateral Force.





All members:
E = 2.0E6 t/m^2.
W = 2.40 t/m^3

R = 5.0 (X and Z directions)
IF = 1.0
Response Spectra defined by user (14 points)

Input data file: "ELF SF"

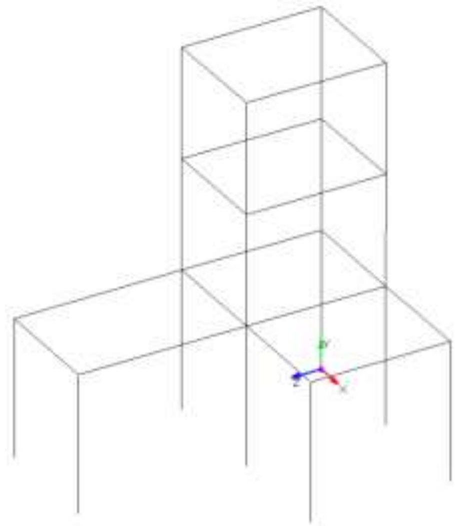
```
ELF SF June 22 2011

CONTROL
L=3
UF=2  UL=2  UT=1  :t - m

JOINTS
 1   X=0      Y=0      Z=0     S=1
 2            Y=5
 3            Y=9
 4            Y=13
 5   X=4      Y=0
 6            Y=5
 7            Y=9
 8            Y=13
 9   X=8      Y=0
10            Y=5
12   X=0      Y=0      Z=5
13            Y=5
14            Y=9
15            Y=13
16   X=4      Y=0
17            Y=5
18            Y=9
19            Y=13
20   X=8      Y=0
21            Y=5
23   X=0      Y=0      Z=11
24            Y=5
25   X=4      Y=0
26            Y=5
```

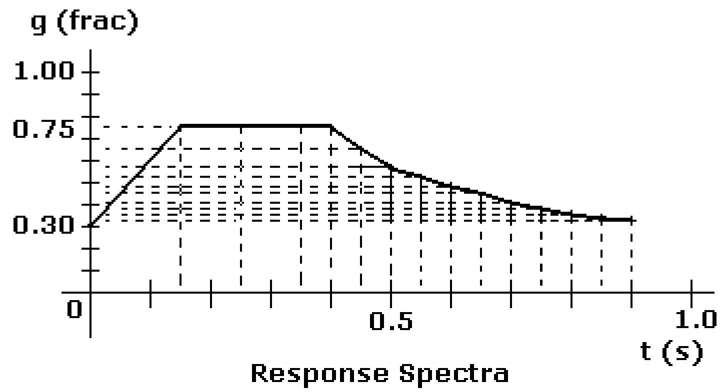
```
RESTRAINTS
 1  9 4  RX=1  RY=1  RZ=1  <X=1  <Y=1  <Z=1
12 20 4  RX=1  RY=1  RZ=1  <X=1  <Y=1  <Z=1
23 25 2  RX=1  RY=1  RZ=1  <X=1  <Y=1  <Z=1

MEMBERS
NM=2
C MATERIALS
1  SH=R   T=0.4,0.4   E=2.0E6   MT=C
2  SH=R   T=0.5,0.4   E=2.0E6   MT=C
C COLUMNS
 1   1   2  MN=1  P2=1,0   MG=2,1,1,1
 4   5   6                 MG=2,1,1,1
 7   9  10
 9  12  13                 MG=2,1,1,1
12  16  17                 MG=2,1,1,1
15  20  21
17  23  24
18  25  26
C BEAMS X DIRECTION
21   2   6  MN=2  P2=2,0   MG=1,1,4,4
23  13  17                 MG=1,1,4,4
25  24  26
31   3   7
33  14  18
41   4   8
44  15  19
C BEAMS Z DIRECTION
51   2  13
52  13  24
53   6  17
54  17  26
55  10  21
61   3  14
62   7  18
71   4  15
72   8  19

MLOADS
WY=-1  L=1

MASS
M=1

SEISMIC
DT=1  L=2,3  :Equivalent Lateral Force
CT=0.047  CX=0.9  JS=1,4  RF=5,5  IF=1.0
NP=14
0.0,0.3
0.15,0.75
0.39,0.75
0.4,0.73125
0.45,0.65
0.5,0.585
0.55,0.531818
0.6,0.4875
0.65,0.45
0.7,0.417857
0.75,0.39
0.8,0.365625
0.85,0.344118
0.9,0.325

C End of File
```

Data taken from "Reactions and Applied Forces" listing

Load Cond.	Period (s)	Sa (g)	R	Red. Sa (g)	Base Shear (t)	Direction
2	0.3894	0.7500	5.000	0.1500	8.971	X
3	0.3971	0.7366	5.000	0.1473	8.810	Z

B.3 Space Frame with seismic loads, Response Spectrum





All members:
E = 2.0E6 t/m^2.
W = 2.40 t/m^3

R = 5.0 (X and Z directions)
IF = 1.0
Response Spectra defined by user (14 points)
Modes Requested = 4
Modal combination type: CQC

Input data file: "RS SF"

```
RS SF June 22 2011

CONTROL
L=2
1  DW
2  RS
UF=2  UL=2  UT=1  MT=1  :t - m

JOINTS
 1   X=0       Y=0       Z=0     S=1
 2             Y=5
 3             Y=9
 4             Y=13
 5   X=4       Y=0
 6             Y=5
 7             Y=9
 8             Y=13
 9   X=8       Y=0
10             Y=5
12   X=0       Y=0       Z=5
13             Y=5
14             Y=9
15             Y=13
16   X=4       Y=0
17             Y=5
18             Y=9
19             Y=13
20   X=8       Y=0
21             Y=5
```

```
23   X=0      Y=0      Z=11
24            Y=5
25   X=4      Y=0
26            Y=5

RESTRAINTS
 1  9 4  RX=1  RY=1  RZ=1  <X=1  <Y=1  <Z=1
12 20 4  RX=1  RY=1  RZ=1  <X=1  <Y=1  <Z=1
23 25 2  RX=1  RY=1  RZ=1  <X=1  <Y=1  <Z=1

MEMBERS
NM=2
C MATERIALS
1  SH=R   T=0.4,0.4   E=2.0E6   MT=C
2  SH=R   T=0.5,0.4   E=2.0E6   MT=C
C COLUMNS
 1   1   2  MN=1  P2=1,0   MG=2,1,1,1
 4   5   6                 MG=2,1,1,1
 7   9  10
 9  12  13                 MG=2,1,1,1
12  16  17                 MG=2,1,1,1
15  20  21
17  23  24
18  25  26
C BEAMS X DIRECTION
21   2   6  MN=2  P2=2,0   MG=1,1,4,4
23  13  17                 MG=1,1,4,4
25  24  26
31   3   7
33  14  18
41   4   8
44  15  19
C BEAMS Z DIRECTION
51   2  13
52  13  24
53   6  17
54  17  26
55  10  21
61   3  14
62   7  18
71   4  15
72   8  19

MLOADS
WY=-1  L=1

MASS
M=1

SEISMIC
DT=2  L=2  NR=5  MC=3  PR=1 :Response Spectrum
CT=0.047  CX=0.9  JS=1,4  RF=5,5  IF=1.0
NP=15
0.0,0.3
0.15,0.75
0.39,0.75
0.4,0.73125
0.45,0.65
0.5,0.585
0.55,0.531818
0.6,0.4875
0.65,0.45
0.7,0.417857
0.75,0.39
0.8,0.365625
0.85,0.344118
```

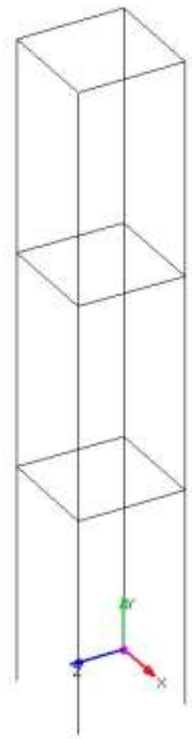
```
0.9,0.325
1,0.3
```

```
                    S U B S P A C E   I T E R A T I O N
 5 Modes Requested Using Lumped Mass Matrix; 13 Iteration Cicles Performed

          Total Self Weight =             67.488 t
 Total Participating Weight =             59.80800 t
    Gravitational Index (g) =      9.80665  m/s2

 MODE  Eigv. Error      Eigenvalue      rad/s       CPS        Period (s)    MODE
  1     0.000000         237.8856     15.4235     2.4547       0.407376      1
  2     0.000000         253.1392     15.9103     2.5322       0.394912      2
  3     0.000000         419.4040     20.4794     3.2594       0.306806      3
  4     0.000000       1,214.4474     34.8489     5.5464       0.180298      4
  5     0.000000       1,357.4385     36.8434     5.8638       0.170537      5

         M A S S   P A R T I C I P A T I O N   F A C T O R S  (in %)
 MODE        X          Y         Z             Summ-X     Summ-Y     Summ-Z    MODE
  1       15.614      0.000    62.796           15.614      0.000     62.796     1
  2       64.330      0.000    18.502           79.944      0.000     81.298     2
  3        3.077      0.000     2.664           83.021      0.000     83.962     3
  4        9.861      0.000     2.131           92.883      0.000     86.093     4
  5        2.309      0.000    13.124           95.191      0.000     99.217     5

                                     Subspace Eigensolution Time :    0.056 s

      User Defined    R E S P O N S E   S P E C T R U M   A N A L Y S I S
 Response Modification Coef. R = 5.00

CQC       B A S E   S H E A R   C O M B I N E D
                X              Y              Z
                t              t              t
                7.651          0.013          7.425

                                          Response Spectrum Time :    0.025 s
```

Mode	Period (s)	Mass Particip. (%)	
		X	**Z**
1	0.407392	15.614	62.796
2	0.394960	79.944	81.298
3	0.306942	83.021	83.962
4	0.180330	92.883	86.093
5	0.170555	95.191	99.217

Base Shear CQC (t)	Direction
7.651	**X**
7.425	**Z**

B.4 Space Frame with P-Δ analysis.

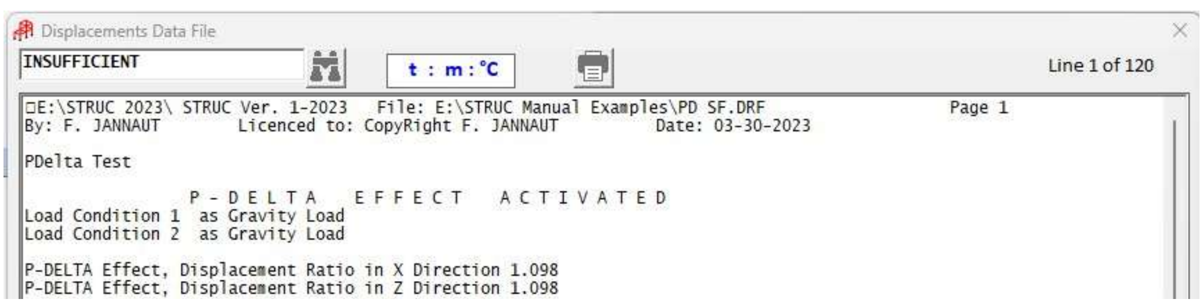


All members:
E = 2.0E6 t/m^2.

Input data file: "PD SF"

```
PDelta Test

CONTROL
L=4
1  DL
2  LL
3  EX
4  EZ
UF=2  UL=2  UT=1  PD=1,2

JOINTS
 1   X=0      Y=0      Z=0    S=1
13            Y=18            G=1,13,4
 2   X=3      Y=0      Z=0
14            Y=18            G=2,14,4
 3   X=0      Y=0      Z=3
15            Y=18            G=3,15,4
 4   X=3      Y=0
16            Y=18            G=4,16,4

RESTRAINTS
1 4  RX=1  RY=1  RZ=1  <X=1  <Y=1  <Z=1

MEMBERS
NM=2
C MATERIALS
1  SH=R   T=0.3,0.3   E=2E6   :COLUMNS
```

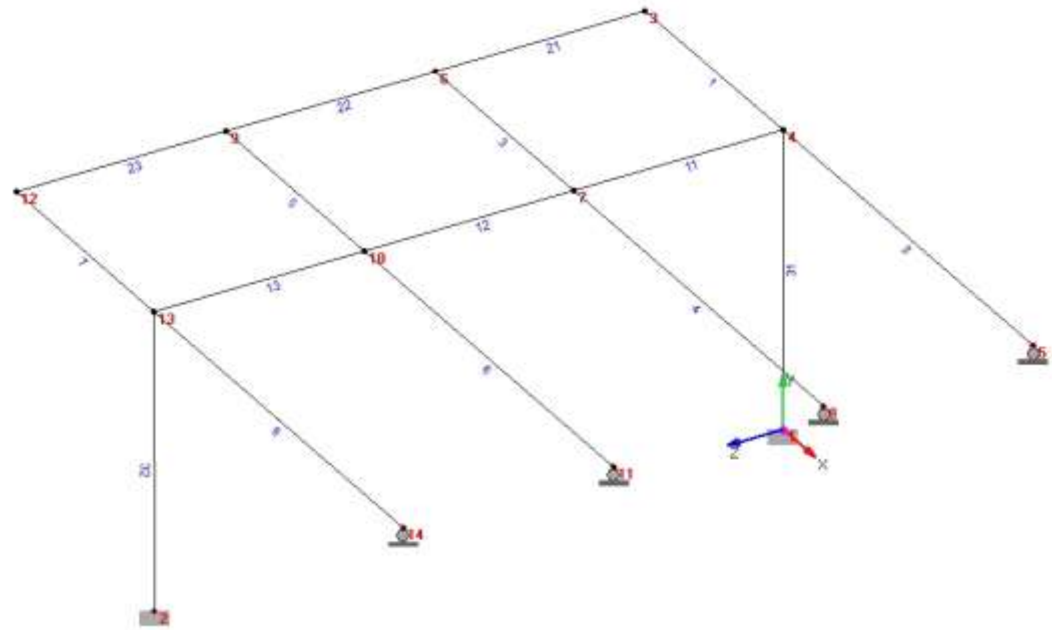
```
2   SH=R    T=0.4,0.3    E=2E6    :BEAMS
C MEMBERS
 1    1    5   MN=1   P2=1,0   MG=2,1,4,4
 4    2    6                   MG=2,1,4,4
 7    3    7                   MG=2,1,4,4
10    4    8                   MG=2,1,4,4
21    5    6   MN=2   P2=2,0   MG=2,1,4,4
24    7    8                   MG=2,1,4,4
27    5    7                   MG=2,1,4,4
30    6    8                   MG=2,1,4,4

MLOADS
NP=2
1  WL=0,-1  :DL
2  WL=0,-3  :LL
C
21 32  LP=1  L=1
21 32  LP=2  L=2

JLOADS
 5    7  2  FX=0.6  L=3
 9   11  2  FX=1.2
13   15  2  FX=1.8
C
 5    6     FZ=0.6  L=4
 9   10     FZ=1.2
13   14     FZ=1.8

LOADCOMB
1  C=1
2  C=0,1
3  C=0,0,1
4  C=0,0,0,1
5  C=1,1,1
6  C=1,1,0,1
C LOAD LIST FOR REACTIONS
LR=1,2,3,4,5,6
```



Horizontal Force Factor

	X Direction	Z Direction
NO P-Δ Analysis	1.000	1.000
With P-Δ Analysis	1.098	1.098

B.5 Space Frame with static loads. Deflection verification.

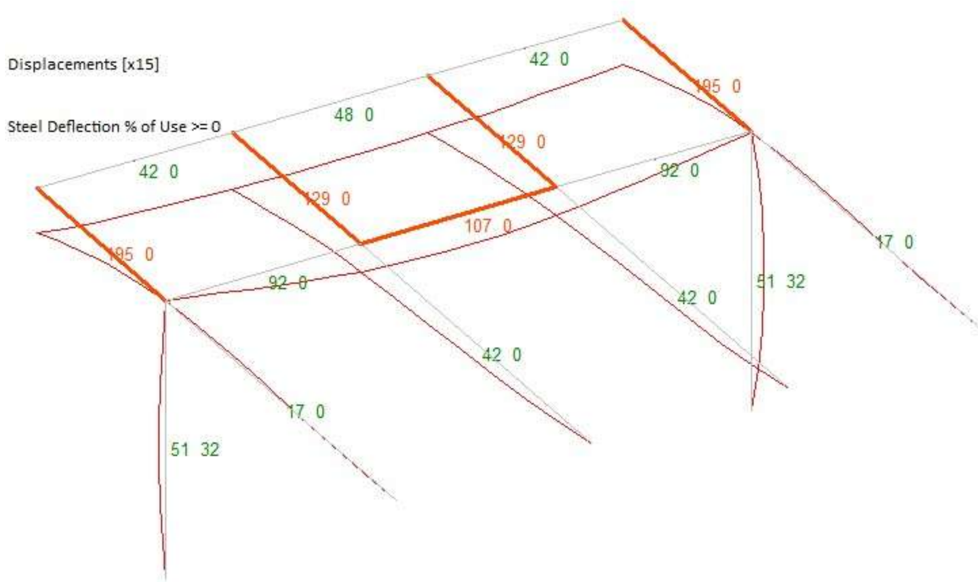


Input data file: "DEFLECTION TEST"

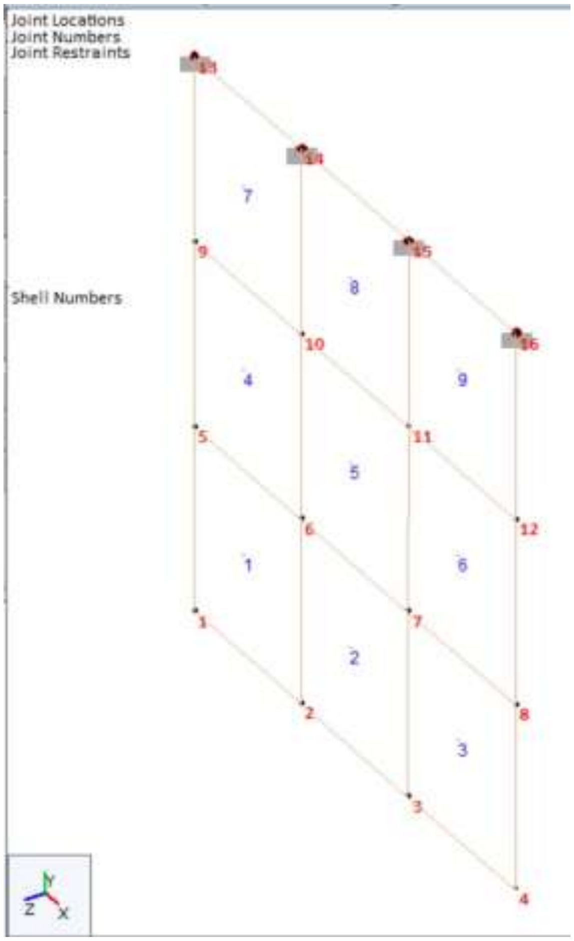
```
DEFLECTION TEST

CONTROL
L=2
1  SW
2  LL
UF=1  UL=1  UT=1

JOINTS
 1   X=0      Y=0      Z=0    S=100 :M TO CM
 2                     Z=10.5
 3   X=-4     Y=5      Z=0
 4   X=0
 5   X=7.2
 6   X=-4              Z=3.5
 7   X=0
 8   X=7.2
 9   X=-4              Z=7
10   X=0
11   X=7.2
12   X=-4              Z=10.5
13   X=0
14   X=7.2

RESTRAINTS
1  2   RX=1  RY=1  RZ=1  <X=1  <Y=1  <Z=1
5 14  3 RX=1  RY=1  RZ=1

MEMBERS
NM=4
C MATERIALS
1  SH=A   T=211   E=2.1E6   MT=S   FY=2520  :W14X30
2  SH=A   T=138   E=2.1E6   MT=S   FY=2520  :W21X48
3  SH=A   T=212   E=2.1E6   MT=S   FY=2520  :W14X26
4  SH=A   T=238   E=2.1E6   MT=S   FY=2520  :W12X26
```

```
C MEMBERS
C BEAMS
 1    3    4  MN=3   P2=2,0  RM2=1
 2    4    5
 3    6    7                RM2=1
 4    7    8
 5    9   10                RM2=1
 6   10   11
 7   12   13                RM2=1
 8   13   14
11    4    7  MN=2
12    7   10
13   10   13
21    3    6  MN=4           RM2=1
22    6    9
23    9   12                RM2=0,1
31    1    4  MN=1   P2=1,2  RM2=1  RM3=1  RAT=0,1
32    2   13                RM2=1  RM3=1  RAT=0,1

MLOADS
NP=1   WY=-1  L=1
1  WL=0,-14
C
1  8  LP=1  L=2

LOADCOMB
1  C=1
2  C=0,1
4   C=1,1
LR=1,2,3

STLDES
LL=1,2,3
LD=1,2,3
DP=ASD10
 1  7  2  FT=4,3   FB=4,3   DC=150
 2  8  2  FT=4,5   FB=4,5   DB=300
11 13     FT=4,7   FB=4,13  DB=300  DJ=4,13
21 23     FT=3,12  FB=3,12  DB=300  DJ=3,12
31        C3=1,4   C2=1,4   DB=300  DJ=1,4
32        C3=1,4   C2=1,4   DB=300  DJ=2,13
```

Deflection verification for Load Combination No. 3



B.6 Space Shells with static loads.

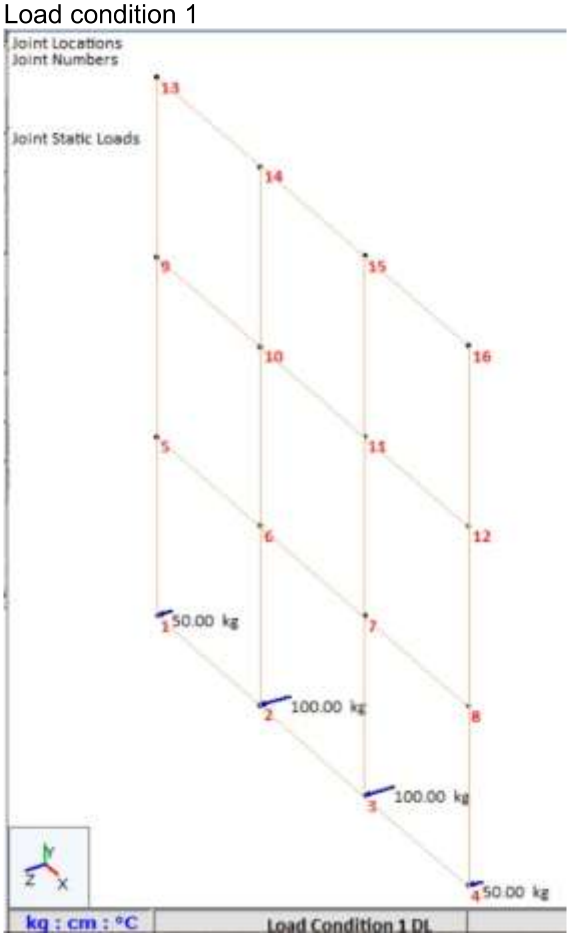


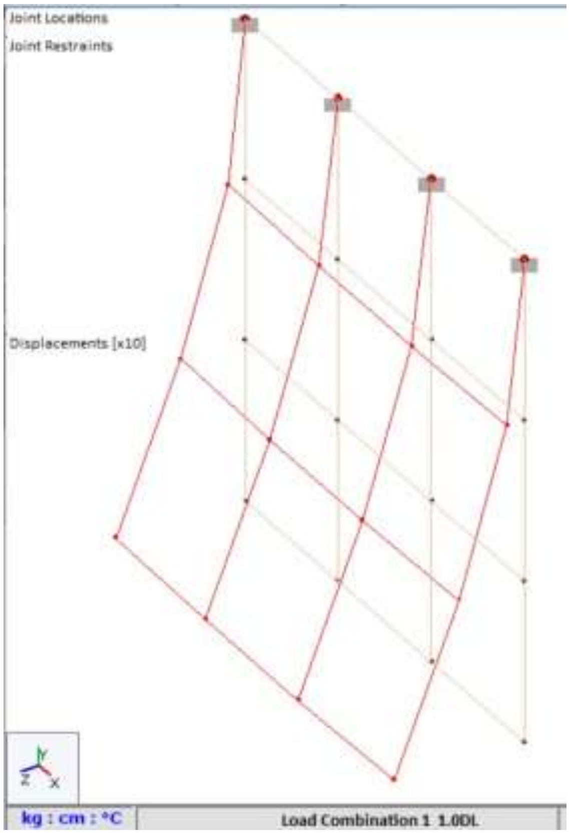
Input data file: "STATIC 9 PLATE V"

```
SHELLS FJ TEST II 03/31/2024

CONTROL
L=3
C LOAD CONDITION NAMES
  1 DL
  2 LL
  3 EX
C GENERAL PARAMETERS
UF=1  UL=1  UT=1  MT=1  :UNITS  kg   cm  ˚C

JOINTS
C LENGTH UNITS USED:  cm
    1   X=0        Y=0         Z=0
    4   X=60
   13   X=0        Y=60
   16   X=60                       Q=1,4,13,16,1,4

RESTRAINTS
C (R) DISPLACEMENT IN AXIS, (<) ROTATION ARROUND AXIS.
C 0=FREE   1=RESTRICTED
  13   16    RX=1   RY=1   RZ=1   <X=1   <Y=1   <Z=1
```

```
SHELLS
NM=1
C UNITS USED:  kg  :  cm : °C
C E = 1.9612E7 kg/cm2
C Poisson's ratio = 0.25
C Thickness = 0.5 cm
C Type 0 = Bending, Shear & Membrane
  1  E=1.9612E7   P=0.25  T=0.5  ST=0
C PLATES
  1  SJ=1,2,6,5    SM=1   SG=3,3

JLOADS
C UNITS  kg
  1  4  3 FX=0    FY=0    FZ=50     L=1
  2  3    FX=0    FY=0    FZ=100    L=1
  1                       FZ=50     L=2
  4                       FZ=50     L=3

End of File
```

Load condition 1





C:\STRUC 2024\ STRUC Ver. 1-2023 File: C:\SHELLS\STATIC 9 PLATE V.DRF Page 1
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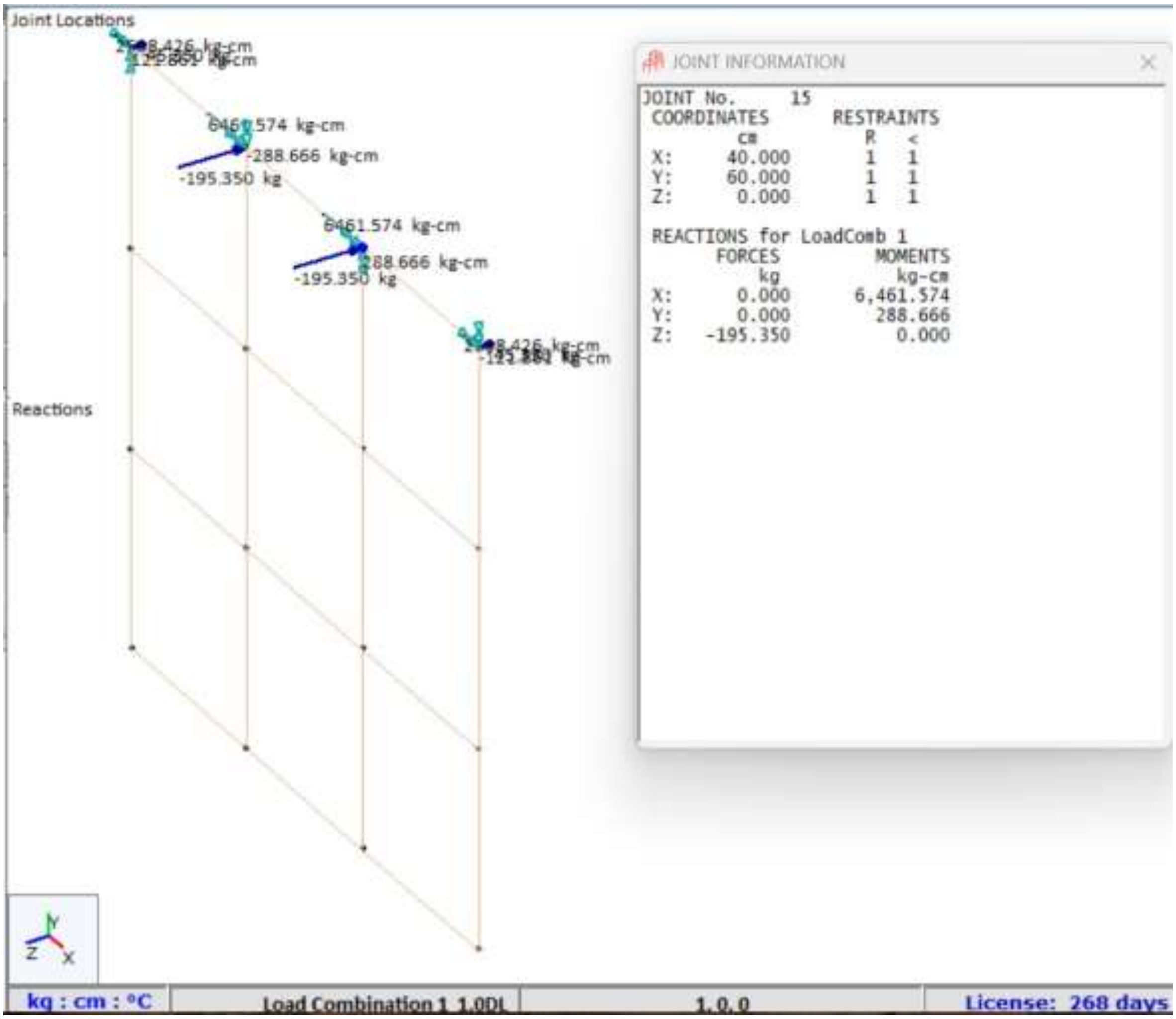
SHELLS FJ TEST II 03/31/2024

G L O B A L D I S P L A C E M E N T S

Load Combination 1 of 3 1.0DL

Joint	Disp X cm	Disp Y cm	Disp Z cm	Rot X rad	Rot Y rad	Rot Z rad
1	0	0	1.61249177	-0.04258825	-0.00249589	0
2	0	0	1.64785604	-0.04240713	-0.00104683	0
3	0	0	1.64785604	-0.04240713	0.00104683	0
4	0	0	1.61249177	-0.04258825	0.00249589	0
5	0	0	0.80935772	-0.03772170	-0.00317823	0
6	0	0	0.85128004	-0.03724760	-0.00100752	0
7	0	0	0.85128004	-0.03724760	0.00100752	0
8	0	0	0.80935772	-0.03772170	0.00317823	0
9	0	0	0.21601005	-0.02160876	-0.00257140	0
10	0	0	0.23943215	-0.02393475	2.2293E-04	0
11	0	0	0.23943215	-0.02393475	-2.2293E-04	0
12	0	0	0.21601005	-0.02160876	0.00257140	0
13	0	0	0	0	0	0
14	0	0	0	0	0	0
15	0	0	0	0	0	0
16	0	0	0	0	0	0



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SHELLS FJ TEST II 03/31/2024

R E A C T I O N S A N D A P P L I E D F O R C E S

Load Combination 1 of 3 1.0DL

Joint	Force X	Force Y	Force Z	Mom X	Mom Y	Mom Z
	kg	kg	kg	kg-cm	kg-cm	kg-cm
13	0	0	45.350	2538.426	121.861	0
14	0	0	-195.350	6461.574	-288.666	0
15	0	0	-195.350	6461.574	288.666	0
16	0	0	45.350	2538.426	-121.861	0
TOTAL	0	0	-300.000	18000.000	0	0

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SHELLS FJ TEST II 03/31/2024

Load Combinations
1 1.0DL
2 1.0LL
3 1.0EX

S H E L L S I N T E R N A L F O R C E S

MEMB	Lcmb	Joint	F1 kg	F2 kg	F3 kg	M1 kg-cm	M2 kg-cm	M3 kg-cm
1	1	1	0	0	50.000	0	0	0
		2	0	0	53.221	38.413	85.256	0
		6	0	0	-50.000	1046.843	68.250	0
		5	0	0	-53.221	979.168	-89.082	0

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SHELLS FJ TEST II 03/31/2024

Load Combinations
1 1.0DL
2 1.0LL
3 1.0EX

S H E L L S I N T E R N A L S T R E S S E S

MEMB	Lcmb	Joint	S11 kg/cm/cm	S22 kg/cm/cm	S12 kg/cm/cm	M11 kg-cm/cm	M22 kg-cm/cm	M12 kg-cm/cm
1	1	1	0	0	0	2.532	-49.077	-3.528
		2	0	0	0	1.734	-52.269	-0.579
		6	0	0	0	9.597	-50.303	-1.776
		5	0	0	0	10.395	-47.111	-4.725
		1G	0	0	0	4.025	-49.336	-3.158
		2G	0	0	0	3.565	-51.179	-1.455
		6G	0	0	0	8.104	-50.044	-2.147
		5G	0	0	0	8.565	-48.201	-3.849
		CENTER	0	0	0	6.065	-49.690	-2.652

C VERIFICATION EXAMPLES

Twelve different verification examples of the different static and dynamic capabilities of the software, in relation to some static and dynamic structural analysis books.

1. Continuous Beam with statics loads.
2. Plane frame with statics loads.
3. Space frame with static loads.
4. AISC Manual Fifteenth Edition. Chapter C. Second Order Effects. Analysis Benchmark Problem
5. SAP2000 Software Verification, Example 1-021
6. Space truss with dynamic loads, Modal Superposition.
7. Space frame with dynamic loads, Modal Superposition.
8. Plane frame with dynamic loads, Step Integration
9. Plane frame with dynamic loads, Steady State.
10. Square Plate with uniform surface load.
11. Cantilever I-Beam in Torsion.
12. The Scordelis-Lo Barrel Vault.

Examples 5, 6, 7, 8 and 9 also deliver calculations of the natural frequencies requested (or Eigenvalues) for the analyzed structures.

The following are books of reference used in the above examples.

1) Henri P. Gavin, The Three-Moment Equation for Continuous-Beam Analysis, CEE 201L. Uncertainty, Design, and Optimization, Department of Civil and Environmental Engineering, Duke University, Spring 2009.

2) Weaver William Jr. and M. Gere James, Matrix Analysis of Framed Structures, D. Van Nostrand Company, 1980.

3) Fleming John F., Computer Analysis of Structural Systems, McGraw Hill International Editions, Computer Science Series, 1989.

4) Paz Mario, Leigh William, Structural Dynamics, Theory and Computation Fifth Edition, 2004 Springer Science+Buisness Media, Inc.

5) Paz Mario, Matrix Structural Analysis & Dynamics, Theory and Computation, Computers and Structures, Inc. 2009, Berkeley, California.

6) AISC Manual of Steel Construction. Fifteenth Edition.

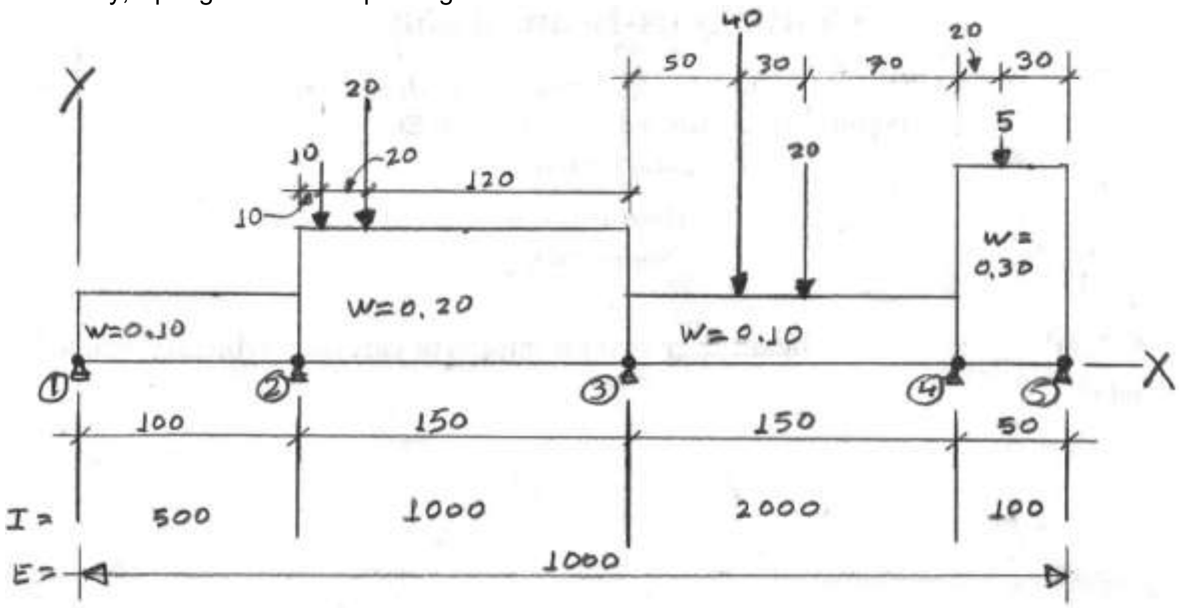
7) CSi SAP2000 Software Verification Rev. 0. Examples

8) Kaushalkumar Kansa, Development of Membrane, Plate and Flat Shell Elements in Java, Thesis to the Faculty of the Virginia Polytechnic Institute & State University, May, 2004, Blacksburg, Virginia.

9) Young W. Kwon, Hyochoong Bang, The Finite Element Method Using Matlab, Second Edition, Boca Raton, London, New Tork, Washington D.C., 2000 by CRC Press LLC.

C.1 Continuous Beam with statics loads

Reference: Henri P. Gavin, The Three-Moment Equation for Continuous-Beam Analysis, CEE 201L. Uncertainty, Design, and Optimization, Department of Civil and Environmental Engineering, Duke University, Spring 2009. Example Page 12.

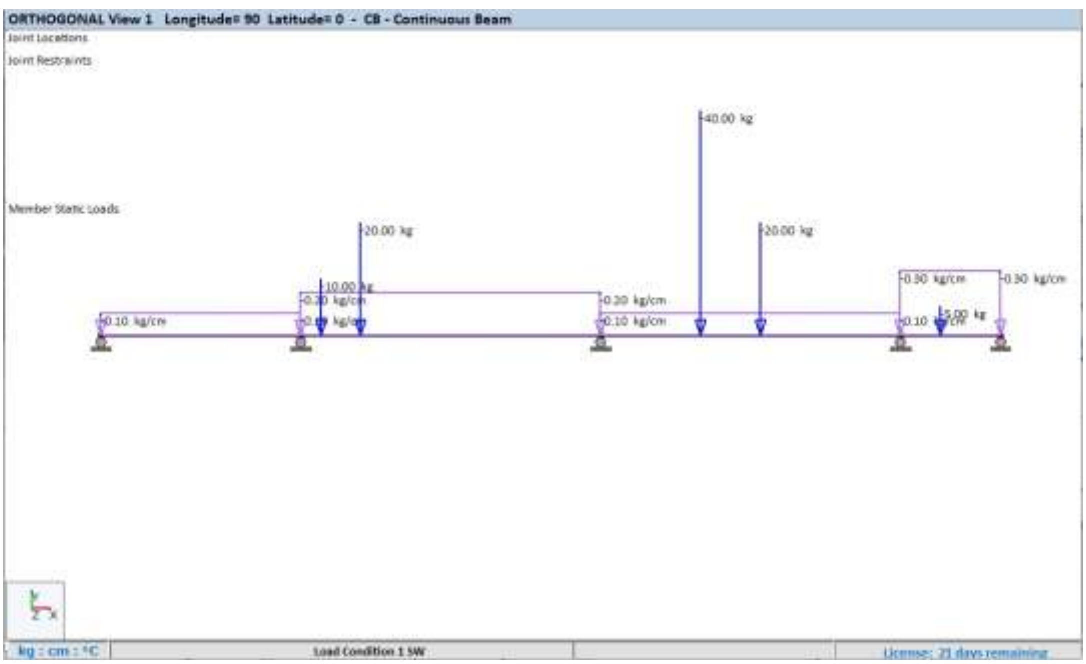


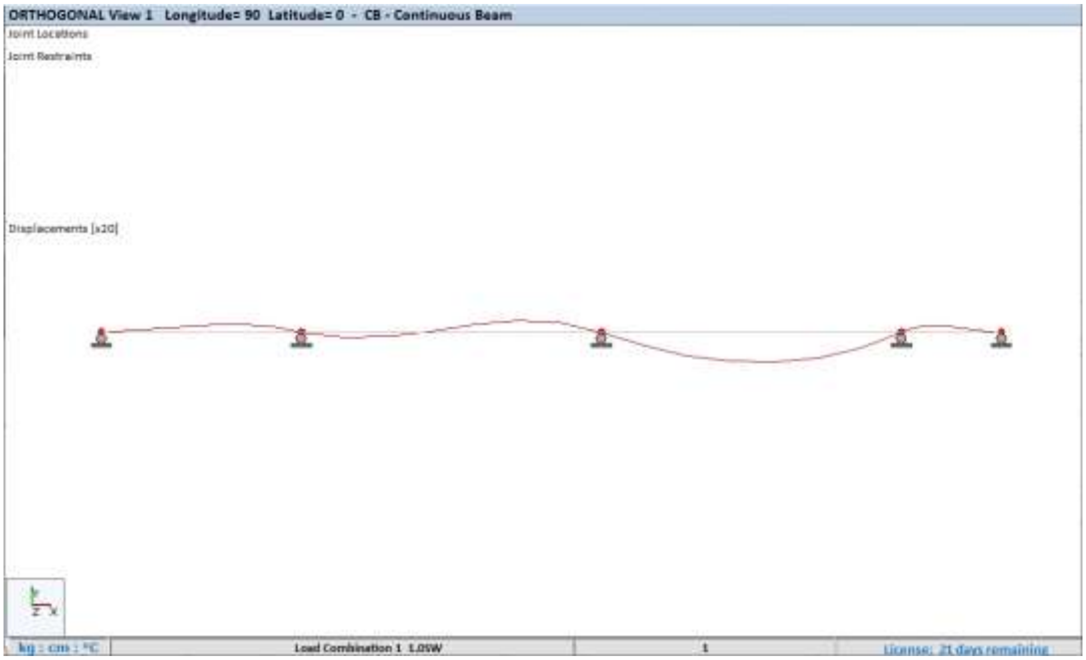
All members:
Area = 100 cm^2
I = As noted
E = As noted

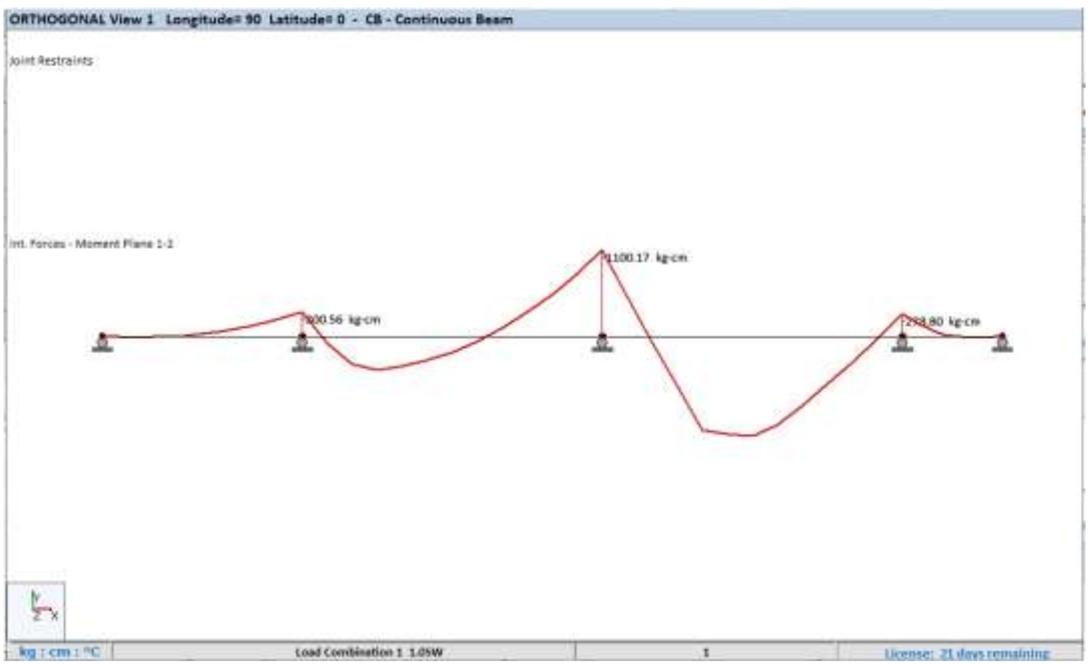
Input data file: :STATIC CB"

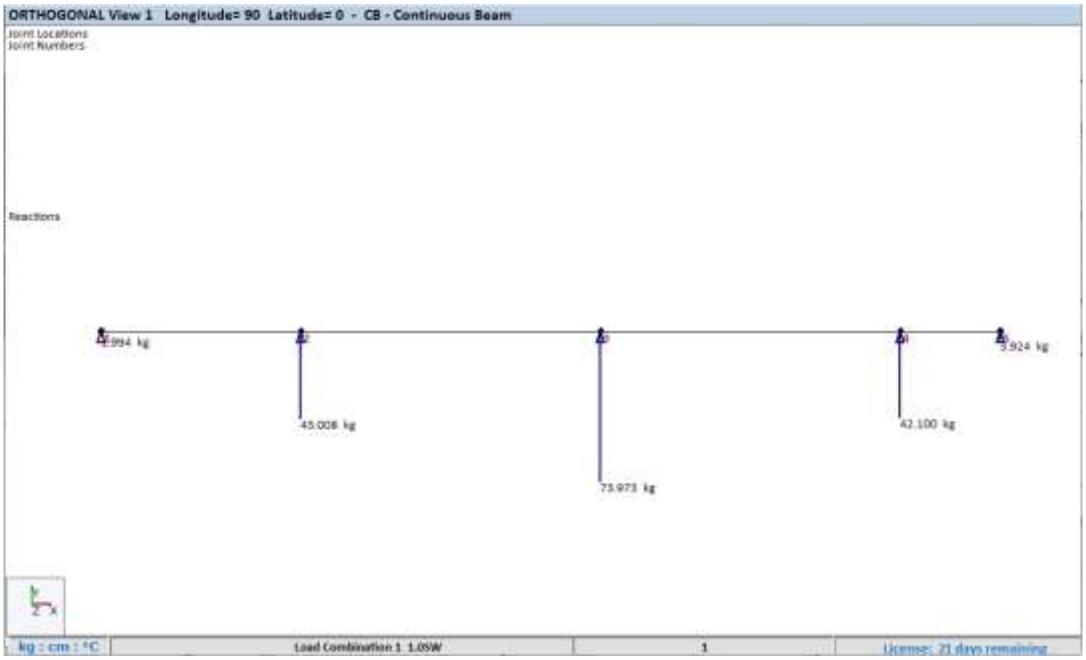
```
STATIC CB TITLE

CONTROL
L=1
C LOAD CONDITION NAMES
  1 SW
C GENERAL PARAMETERS
UF=1  UL=1  UT=1  MT=1 : kg cm ˚C

JOINTS
C LENGTH UNITS USED: cm
    1   X=0                     Y=0                     Z=0
    2   X=100                   Y=0                     Z=0
    3   X=250                   Y=0                     Z=0
    4   X=400                   Y=0                     Z=0
    5   X=450                   Y=0                     Z=0

RESTRAINTS
C (R) DISPLACEMENT IN AXIS, (<) ROTATION ARROUND AXIS.
C 0=FREE   1=RESTRICTED
    1         RY=1  RZ=1  <X=1  <Y=1
    2         RY=1  RZ=1  <X=1  <Y=1
    3         RY=1  RZ=1  <X=1  <Y=1
    4         RY=1  RZ=1  <X=1  <Y=1
    5         RY=1  RZ=1  <X=1  <Y=1
```

```
MEMBERS
NM=4  NSEC=1
C UNITS USED:  kg : cm : ˚C
  1  A=100  I=500,500  E=1000  MT=0 :   1
  2  A=100  I=1000,500  E=1000  MT=0 :   2
  3  A=100  I=2000,500  E=1000  MT=0 :   3
  4  A=100  I=100,500  E=1000  MT=0 :   4
C MEMBERS
     1     1     2  MN=1  P2=2,0
     2     2     3  MN=2  P2=2,0
     3     3     4  MN=3  P2=2,0
     4     4     5  MN=4  P2=2,0

MLOADS
NP=6
C 6 LOAD PATTERNS
C UNITS USED:  kg : cm : ˚C
  1  WL=0,-0.1,0
  2  WL=0,-0.2,0
  3  WL=0,-0.3,0
  4  WL=0,0,0  PL=10,-10,0,30,-20,0
  5  WL=0,0,0  PL=50,-40,0,80,-20,0
  6  WL=0,0,0  PL=20,-5,0
C MEMBER LOADS
C LOAD CONDITION 1 :SW
     1  LP=1                                 L=1
     2  LP=2,4                               L=1
     3  LP=1,5                               L=1
     4  LP=3,6                               L=1

End of File
```




ORTHOGONAL View 1 Longitude= 90 Latitude= 0 - CB - Continuous Beam
Joint Locations
Joint Restraints
Displacements [x20]
kg : cm : °C
Load Combination 1 1.05W
1
License: 21 days remaining


ORTHOGONAL View 1 Longitude= 90 Latitude= 0 - CB - Continuous Beam
Joint Restraints
Int. Forces - Moment Plane 1-2
1100.17 kg-cm
kg : cm : °C
Load Combination 1 1.05W
1
License: 21 days remaining




```
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STATIC CB TITLE

 Load Combinations
    1 1.0SW

 M   L          M E M B E R S      I N T E R N A L      F O R C E S
 E   C
 M   m             Axial  |- P L A N E   1-2 -|
 B   b  Dist.      Force      Shear      Moment
         cm          kg        kg        kg-cm

 1             Joints: 1 to 2   Material: 1   Name:    1
     1   0.000      0          1.994      0
         8.333                 1.161     13.148
        16.667                 0.328     19.351
        19.944                 0         19.888
        25.000                -0.506     18.610
        33.333                -1.339     10.925
        41.667                -2.172     -3.705
        50.000                -3.006    -25.279
        58.333                -3.839    -53.798
        66.667                -4.672    -89.261
        75.000                -5.506   -131.669
        83.333                -6.339   -181.021
        91.667                -7.172   -237.318
       100.000      0         -8.006   -300.559

 2             Joints: 2 to 3   Material: 2   Name:    2
     1   0.000      0         35.003   -300.559
        12.500                22.503     96.349
        25.000                20.003    362.006
        30.000            Point load    459.519
        37.500                -2.497    446.413
        50.000                -4.997    399.571
        62.500                -7.497    321.478
        75.000                -9.997    212.135
```

```
        87.500               -12.497     71.543
       100.000               -14.997   -100.300
       112.500               -17.497   -303.393
       125.000               -19.997   -537.735
       137.500               -22.497   -803.328
       150.000      0        -24.997  -1100.170

 3            Joints: 3 to 4   Material: 3   Name:    3
     1   0.000      0         48.976  -1100.170
        12.500                47.726   -495.786
        25.000                46.476     92.974
        37.500                45.226    666.109
        50.000                 3.976   1223.618
        62.500                 2.726   1265.503
        75.000                 1.476   1291.763
        80.000            Point load   1297.892
        87.500               -19.774   1152.397
       100.000               -21.024    897.407
       112.500               -22.274    626.792
       125.000               -23.524    340.552
       137.500               -24.774     38.686
       150.000      0        -26.024   -278.804

 4            Joints: 4 to 5   Material: 4   Name:    4
     1   0.000      0         16.076   -278.804
         4.167                14.826   -214.425
         8.333                13.576   -155.253
        12.500                12.326   -101.291
        16.667                11.076    -52.536

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STATIC CB TITLE

 M   L          M E M B E R S      I N T E R N A L      F O R C E S
 E   C
 M   m            Axial  |- P L A N E   1-2 -|
 B   b  Dist.     Force      Shear      Moment
          cm        kg        kg        kg-cm
        20.833                 4.826    -13.157
        25.000                 3.576      4.348
        29.167                 2.326     16.644
        33.333                 1.076     23.732
        36.920                 0         25.662
        37.500                -0.174     25.611
        41.667                -1.424     22.283
        45.833                -2.674     13.745
        50.000      0         -3.924      0
```

```
 STRUC Ver. 1.2018   File: e:\STRUC 2020\Manual 2020\CB 2020\STATIC CB.IF3         Page 3
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STATIC CB TITLE

                       T I M E     L O G

              Stiffness and Mass Assembling :   0.001 s

              Equations Solution Phase      :   0.017 s

              Displacements Calculation     :   0.001 s

              Members Internal Forces       :   0.017 s
                                         ---------------
                        TOTAL ANALYSIS TIME:   0.035 s
```
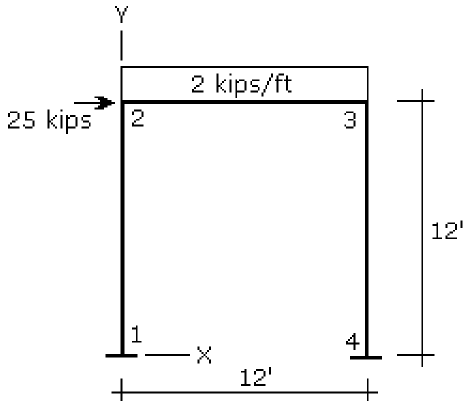

Results table

	Data Type	HP Gavin	STRUC
Maximum	Moment	1303.5500	1297.8920
	Shear	48.9758	48.9760
	Deflection	0.173453	0.161330
Minimum	Moment	-1100.1700	-1100.1700
	Shear	-26.0242	-26.0240
	Deflection	-1.255570	-1.256457
Moments	M1	0.0000	0.0000
	M2	-300.5600	-300.5590
	M3	-1100.2000	-1100.1700
	M4	-278.8000	-278.8040
	M5	0.0000	0.0000
Reactions	R1	1.9944	1.9940
	R2	43.0082	43.0080
	R3	73.9732	73.9730
	R4	42.1003	42.1000
	R5	3.9239	3.9240
Shears	V 1-2	1.9944	1.9940
		-8.0056	-8.0060
	V 2-3	35.0026	35.0030
		-24.9974	-24.9970
	V 3-4	48.9758	48.9760
		-26.0242	-26.0240
	V 4-5	16.0761	16.0760
		-3.9239	-3.9240

Note: The signs of the shears and the moments follow the established in 5.3 "Members internal forces"

C.2 Plane Frame with statics loads

Reference: Fleming John F., Computer Analysis of Structural Systems, McGraw Hill International Editions, Computer Science Series, 1989, Example form Figure 9.43, pp. 362 - 365

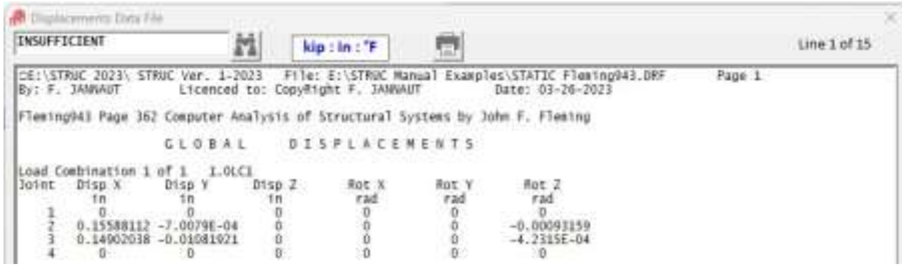


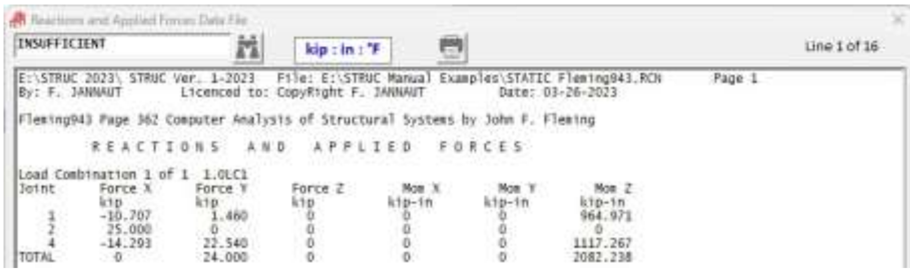
Example from figure 9.43

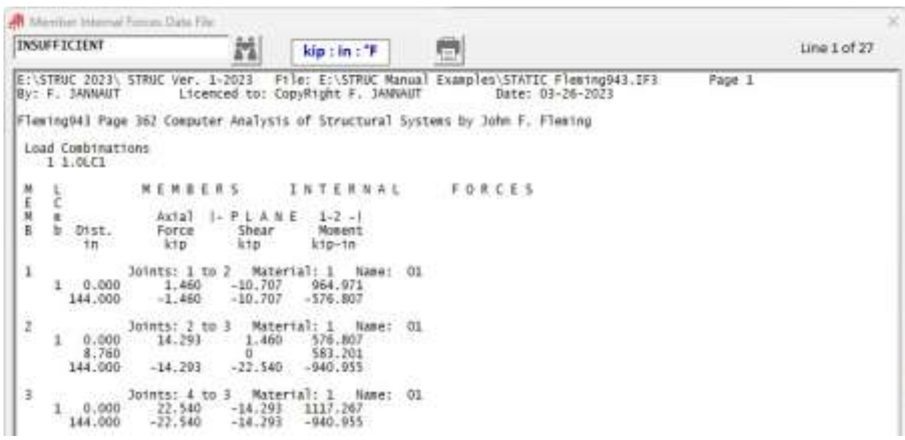
All members:
Area = 10 in^2
I = 1000 in^4
E = 30000 ksi.

Input data file: :STATIC Fleming943"

```
Fleming943 Page 362 Computer Analysis of Structural Systems by John F. Fleming

CONTROL
L=1
UF=6  UL=5  UT=2   :kips, in, Fahrenheit

JOINTS
1   X=0      Y=0      Z=0    S=12  :ft to in
2            Y=12
3   X=12
4            Y=0

RESTRAINTS
1  4  3  RX=1  RY=1  RZ=1  <X=1  <Y=1  <Z=1
2  3     RZ=1  <X=1  <Y=1  :PF

MEMBERS
NM=1
C MATERIALS
1  A=10   I=1000   E=30000   :W=   MT=   FY=
C MEMBERS
1   1   2  MN=1  P2=1,0
2   2   3        P2=2,0
3   4   3        P2=1,0

MLOADS
NP=1
C UNIFORM LOAD
1  WL=0,-2/12   :kips/ft to kips/in
C
2   LP=1  L=1

JLOADS
2   FX=25   L=1
```







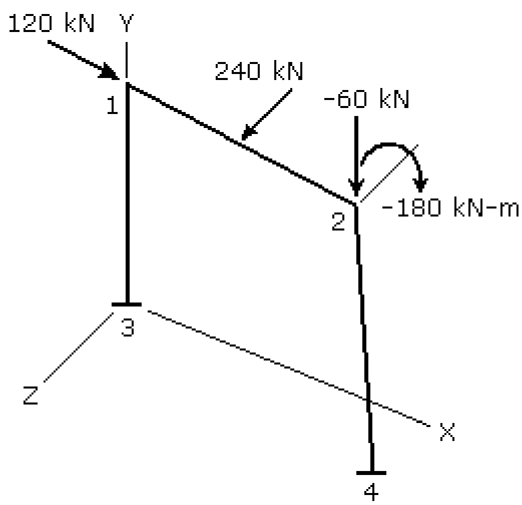
Results table

	Location	Units	FLEMING	STRUC
Displacement	X Joint 2	in	0.15588	0.15588112
	Y Joint 2	in	-0.00070	-0.00070079
Rotation	Z Joint 2	rad	-0.00093	-0.00093159
Shear	J Member 3	kip	14.293	-14.293
	K Member 3	kip	-14.293	-14.293
Moment	J Member 3	kip-in	940.960	-940.955
	K Member 3	kip-in	1117.270	1117.267
Reactions	RX Joint 1	kip	-10.707	-10.707
	RY Joint 1	kip	1.460	1.460
	Mz Joint 1	kip-in	964.970	964.971

Note: The signs of the shears and the moments follow the established in 5.3 "Members internal forces"

C.3 Space Frame with static loads

Reference: Weaver William Jr. and M. Gere James, Matrix Analysis of Framed Structures, D. Van Nostrand Company, 1980, Example form Figure 5-9a, pp. 344 - 357.



Example 1 from Figure 5-9a

All members:
Area = 0.01 m^2
I_2 = 0.001 m^4
I_3 = 0.001 m^4
J = 0.002 m^4
E = 200 E6 kN-m^2
G = 80 E6 kN-m^2

Input data file: “STATIC WWSF1”

```
Space Frame Example 1  William Weaver 1   Dec 20 2010

CONTROL
L=1
UF=4  UL=2  UT=1  :kN, m, C

JOINTS
1   X=0      Y=3      Z=0    S=1
2   X=6
3   X=0      Y=0
4   X=9               Z=3

RESTRAINTS
3 4   RX=1  RY=1  RZ=1  <X=1  <Y=1  <Z=1

MEMBERS
NM=1
C MATERIALS
1  A=0.01   I=1E-3,1E-3   J=2E-3   MT=C  E=200E6   G=80E6
C MEMBERS
1   1   2  MN=1  P2=2,0
2   3   1        P2=1,0
3   2   4        P2=2,0
```

```
MLOADS
NP=1
1  PL=3,0,240
C
1  LP=1  L=1

JLOADS
1   FX=120          L=1
2   FY=-60  MZ=-180
```

Results table

	Location	Units	W. Weaver	STRUC
Displacements Joint 2	X	M	-0.001176	-0.00117605
	Y	M	0.003253	0.00325316
	Z	M	0.005256	0.00525552
Rotations Joint 2	X	Rad	0.001288	0.00128843
	Y	Rad	0.001721	0.00172094
	Z	Rad	-0.000771	-0.00077147
Internal Forces Member 3	V Plane 1-2	kN	9.192	9.192
	M Plane 1-2	kN-m	-32.181	32.181
	Axial	kN	183.623	183.623
	V Plane 1-3	kN	5.967	5.967
	M Plane 1-3	kN-m	46.703	46.703
	Torsion	kN-m	-21.404	-21.404
Reactions Joint 4	X	kN	-105.548	-105.548
	Y	kN	98.509	98.509
	Z	kN	-113.987	-113.987
	Mx	kN-m	-75.898	-75.898
	My	kN-m	-75.808	-75.808
	Mz	kN-m	37.163	37.163

Note: The signs of the shears and the moments follow the established in 5.3 "Members internal forces"

C.4 Analysis Benchmark Problem – AISC Chapter C. Second Order Effects

Reference: AISC Manual Fifteenth Edition. Chapter C. Second Order Effects. Analysis Benchmark Problem. Case 2

Case 2 is a fixed-base cantilevered beam-column subjected to an axial load of 200 kips concurrent with a lateral load at its top of 1 kip. (See AISC 16.1-291, Fig. C-C2.3.)

The column is divided in 5 sections to capture the P-δ effect. Everything else remains the same as presented in Chapter C, Fig. C-C2.3.

All Members:
W14X48 in global X direction
E = 29000 ksi = 4176000 ksf

Input data file: "AISCPDELTA"

```
AISC PD 16.1-291

CONTROL
L=2
C LOAD CONDITION NAMES
  1 VL
  2 HL
C GENERAL PARAMETERS
UF=6  UL=6  UT=2  MT=1  PD=1    :UNITS kip  ft  °F

JOINTS
C LENGTH UNITS USED: ft
    1   X=0                     Y=0                        Z=0
    2   X=0                     Y=5.6                      Z=0
    3   X=0                     Y=11.2                     Z=0
    4   X=0                     Y=16.8                     Z=0
    5   X=0                     Y=22.4                     Z=0
    6   X=0                     Y=28                       Z=0

RESTRAINTS
C (R) DISPLACEMENT IN AXIS, (<) ROTATION ARROUND AXIS.
C 0=FREE   1=RESTRICTED
    1   RX=1  RY=1  RZ=1  <X=1  <Y=1  <Z=1

MEMBERS
NM=1
C UNITS USED: kip : ft : °F
  1  SH=A  T=207  E=4176000  W=0.49006  TC=0.000007222  MT=S  FY=7200,9360 :W14X48
C MEMBERS
     1     1     2  MN=1  P2=1,0
     2     2     3  MN=1  P2=1,0
     3     3     4  MN=1  P2=1,0
     4     4     5  MN=1  P2=1,0
     5     5     6  MN=1  P2=1,0

JLOADS
C UNITS USED: kip : ft : °F
    6                   FY=-200.00                                        L=1 :VL
    6  FX=1.00                                                            L=2 :HL

LOADCOMB
  1  C=1.0000
  2  C=0.0000,1.0000
  3  C=1.0000,1.0000
C LOAD LIST FOR REACTIONS
LR=3

STLDES
C AISC 360-16 DESIGN PROVISIONS
C STEEL DESIGN LOAD COMBINATIONS
LL=3
C STEEL DEFLECTION CONTROL LOAD COMBINATIONS
DP=ASD16

End of File
```

Displacements Data File

INSUFFICIENT kip : ft : °F Line 1 of 43

```
E:\STRUC 2023\ STRUC Ver. 1-2023   File: e:\STRUC 2023\STRUC Manual Examples\AISCPDELTA.DRF   Page 1
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AISC PD 16.1-291

                P - D E L T A   E F F E C T   A C T I V A T E D

Load Condition 1  as Gravity Load

P-DELTA Effect, Displacement Ratio in X Direction 2.878

                  G L O B A L     D I S P L A C E M E N T S

Load Combination 1 of 3   1.0VL
Joint   Disp X      Disp Y      Disp Z       Rot X       Rot Y       Rot Z
          ft          ft          ft          rad         rad         rad
   1      0           0           0           0           0           0
   2      0       -0.00273904     0           0           0           0
   3      0       -0.00547809     0           0           0           0
   4      0       -0.00821713     0           0           0           0
   5      0       -0.01095617     0           0           0           0
   6      0       -0.01369521     0           0           0           0

Load Combination 2 of 3   1.0HL
Joint   Disp X      Disp Y      Disp Z       Rot X       Rot Y       Rot Z
          ft          ft          ft          rad         rad         rad
   1      0           0           0           0           0           0
   2  0.01130894      0           0           0           0       -0.00390576
   3  0.04308176      0           0           0           0       -0.00723921
   4  0.09147724      0           0           0           0       -0.00978613
   5  0.15158593      0           0           0           0       -0.01138283
   6  0.21774566      0           0           0           0       -0.01192672

Load Combination 3 of 3   1.0VL 1.0HL
Joint   Disp X      Disp Y      Disp Z       Rot X       Rot Y       Rot Z
          ft          ft          ft          rad         rad         rad
   1      0           0           0           0           0           0
   2  0.01130894 -0.00273904      0           0           0       -0.00390576
   3  0.04308176 -0.00547809      0           0           0       -0.00723921
   4  0.09147724 -0.00821713      0           0           0       -0.00978613
   5  0.15158593 -0.01095617      0           0           0       -0.01138283
   6  0.21774566 -0.01369521      0           0           0       -0.01192672
```

Reactions and Applied Forces Data File

INSUFFICIENT kip : ft : °F Line 1 of 21

```
E:\STRUC 2023\ STRUC Ver. 1-2023   File: e:\STRUC 2023\STRUC Manual Examples\AISCPDELTA.RCN   Page 1
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AISC PD 16.1-291

                P - D E L T A   E F F E C T   A C T I V A T E D

Load Condition 1  as Gravity Load

P-DELTA Effect, Displacement Ratio in X Direction 2.878

         R E A C T I O N S   A N D   A P P L I E D   F O R C E S

Load Combination 3 of 3  1.0VL 1.0HL
Joint      Force X      Force Y      Force Z       Mom X       Mom Y       Mom Z
             kip          kip          kip         kip-ft      kip-ft      kip-ft
   1       -1.000      200.000         0             0           0         71.549
   6        1.000     -200.000         0             0           0          0
TOTAL         0            0           0             0           0         71.549
```

```
Member Internal Forces Data File
INSUFFICIENT        kip : ft : °F                                    Line 1 of 67

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AISC PD 16.1-291

 Load Combinations
    1 1.0VL
    2 1.0HL
    3 1.0VL 1.0HL

                 P - D E L T A   E F F E C T   A C T I V A T E D

Load Condition 1  as Gravity Load

P-DELTA Effect, Displacement Ratio in X Direction 2.878

 M   L           M E M B E R S     I N T E R N A L     F O R C E S
 E   C
 M   m            Axial  |- P L A N E  1-2 -| |- P L A N E  1-3 -|  Torsion
 B   b  Dist.     Force     Shear     Moment     Shear     Moment     Moment
         ft        kip      kip       kip-ft     kip       kip-ft     kip-ft

 1           Joints: 1 to 2  Material: 1   Name: W14X48
     1  0.000   200.000     0          0          0         0          0

     2  0.000     0        -1.000     71.549      0         0          0
        5.600     0        -1.000     63.687      0         0          0

     3  0.000   200.000    -1.000     71.549      0         0          0
        5.600  -200.000    -1.000     63.687      0         0          0

 2           Joints: 2 to 3  Material: 1   Name: W14X48
     1  0.000   200.000     0          0          0         0          0

     2  0.000     0        -1.000     63.687      0         0          0
        5.600     0        -1.000     51.733      0         0          0

     3  0.000   200.000    -1.000     63.687      0         0          0
        5.600  -200.000    -1.000     51.733      0         0          0

 3           Joints: 3 to 4  Material: 1   Name: W14X48
     1  0.000   200.000     0          0          0         0          0

     2  0.000     0        -1.000     51.733      0         0          0
        5.600     0        -1.000     36.454      0         0          0

     3  0.000   200.000    -1.000     51.733      0         0          0
        5.600  -200.000    -1.000     36.454      0         0          0

 4           Joints: 4 to 5  Material: 1   Name: W14X48
     1  0.000   200.000     0          0          0         0          0

     2  0.000     0        -1.000     36.454      0         0          0
        5.600     0        -1.000     18.832      0         0          0

     3  0.000   200.000    -1.000     36.454      0         0          0
        5.600  -200.000    -1.000     18.832      0         0          0

 5           Joints: 5 to 6  Material: 1   Name: W14X48
     1  0.000   200.000     0          0          0         0          0

     2  0.000     0        -1.000     18.832      0         0          0
        5.600     0        -1.000      0          0         0          0

     3  0.000   200.000    -1.000     18.832      0         0          0
        5.600  -200.000    -1.000      0          0         0          0
```

Results table

Results for Moment at the base and Deflection at its top (joint 6) in X direction

	AISC		STRUC			
Joint	Moment (kip-in)	Deflection (in)	Moment (kip-ft)	Moment (kip-in)	Deflection (ft)	Deflection (in)
1	856.00		71.549	858.59		
6		2.60			0.21774566	2.6129

C.5 Example 1-021 Frame – Bathe and Wilson Eigenvalue Problem

Reference: CSi. SAP2000 Software Verification Rev. 0. Example 1-021

EXAMPLE 1-021

FRAME – BATHE AND WILSON EIGENVALUE PROBLEM

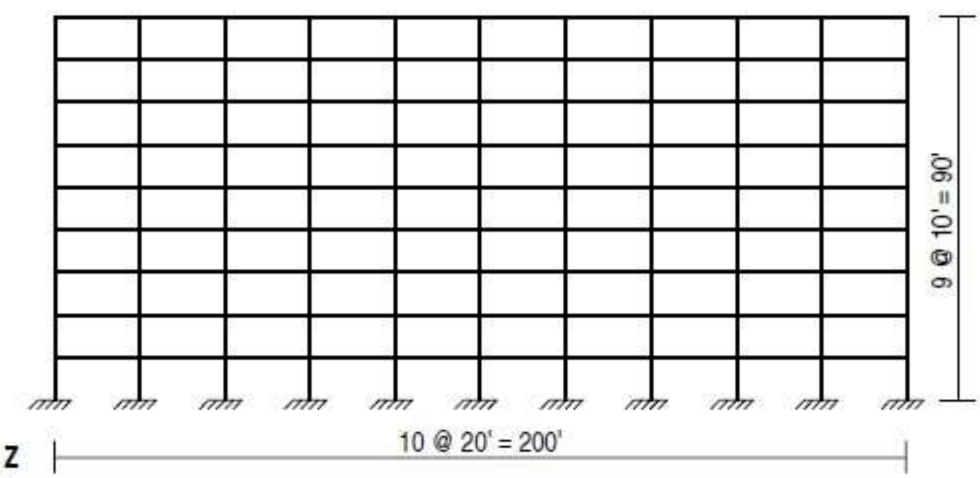
PROBLEM DESCRIPTION

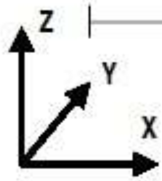
A ten-bay, nine-story, two-dimensional, fixed base frame structure solved in Bathe and Wilson 1972 is analyzed for the first three eigenvalues. The SAP2000 results are compared with independent results presented in Bathe and Wilson 1981 as well as independent results presented in Peterson 1981.

The material and section properties, and the mass per unit length used for all members, shown in the figure below, are consistent with those used in the two above mentioned references.

Important Note: Only bending and axial deformations are considered in the analysis. Shear deformations are ignored by setting the shear area to 0.

GEOMETRY AND PROPERTIES





Material Properties

$E = 432000$ k/ft^2

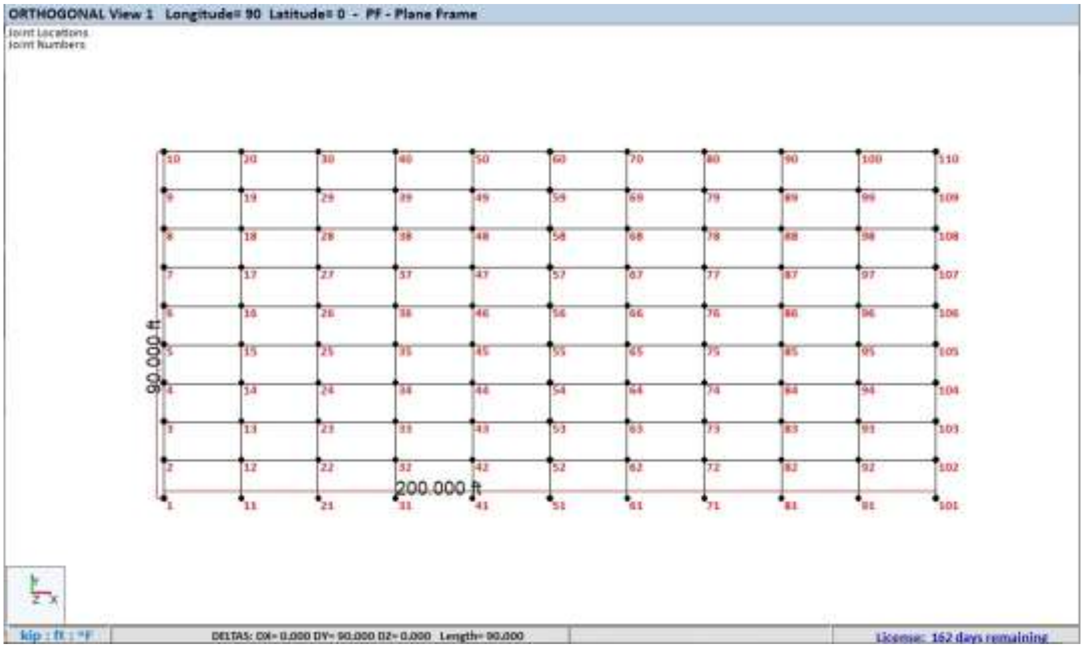
Mass per unit length = 3 k-sec^2/ft^2

Typical Section Properties

$A = 3$ ft^2

$I = 1$ ft^4

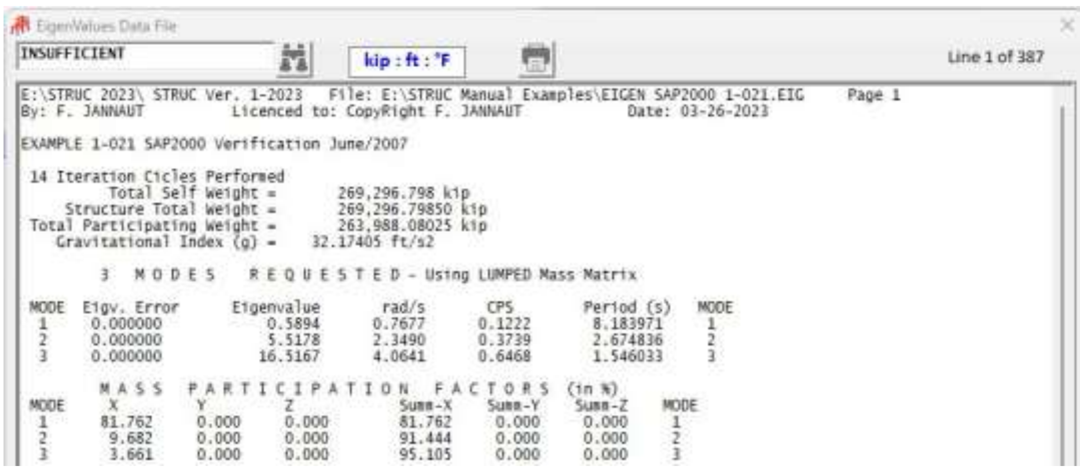
EXAMPLE 1-021 - 1



Input data file: "EIGEN SAP2000 1-021"

```
EXAMPLE 1-021 SAP2000 Verification June/2007

CONTROL
L=1
1  NF
C
UF=6   UL=6  UT=2

JOINTS
  1  X=0   Y=0   Z=0
 10        Y=90
101  X=200 Y=0
110        Y=90      Q=1,10,101,110,1,10

RESTRAINTS
1 110      RX=0  RY=0  RZ=1  <X=1  <Y=1  <Z=0  :PF
1  101 10  RX=1  RY=1  RZ=1  <X=1  <Y=1  <Z=1

MEMBERS
NM=1
C SECCIONS
C SECTION AREA = 3 ft2
C SECTION INERTIA = 1 ft4
C Material Density = 32.17405 kip/ft3 ==> M=(32.17405 kip/ft3 x 3 ft2) / 32.17405 ft/s2 = 3 (kip
s2)/ft2
1  A=3  I=1  E=432000  W=32.17405
C MEMBERS
C COLUMNS
  1   1   2  MN=1 P2=1,0  MG=8,1,1,1
 11  11  12               MG=8,1,1,1
 21  21  22               MG=8,1,1,1
 31  31  32               MG=8,1,1,1
 41  41  42               MG=8,1,1,1
 51  51  52               MG=8,1,1,1
 61  61  62               MG=8,1,1,1
 71  71  72               MG=8,1,1,1
 81  81  82               MG=8,1,1,1
```

```
 91  91  92               MG=8,1,1,1
101 101 102               MG=8,1,1,1
C BEAMS
201   2  12       P2=2,0  MG=9,1,10,10
211   3  13               MG=9,1,10,10
221   4  14               MG=9,1,10,10
231   5  15               MG=9,1,10,10
241   6  16               MG=9,1,10,10
251   7  17               MG=9,1,10,10
261   8  18               MG=9,1,10,10
271   9  19               MG=9,1,10,10
281  10  20               MG=9,1,10,10

MLOADS
WY=-1  L=1

DYNAMIC
DT=1  NR=3  L=1  :NATURAL FREQUENCIES
```



EigenValues Data File

INSUFFICIENT   kip : ft : °F   Line 1 of 387

```
E:\STRUC 2023\ STRUC Ver. 1-2023   File: E:\STRUC Manual Examples\EIGEN SAP2000 1-021.EIG     Page 1
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EXAMPLE 1-021 SAP2000 Verification June/2007

 14 Iteration Cicles Performed
          Total Self Weight =       269,296.798 kip
     Structure Total Weight =       269,296.79850 kip
 Total Participating Weight =       263,988.08025 kip
    Gravitational Index (g) =    32.17405 ft/s2

        3  M O D E S   R E Q U E S T E D - Using LUMPED Mass Matrix

 MODE  Eigv. Error      Eigenvalue      rad/s      CPS       Period (s)   MODE
  1     0.000000          0.5894       0.7677     0.1222      8.183971      1
  2     0.000000          5.5178       2.3490     0.3739      2.674836      2
  3     0.000000         16.5167       4.0641     0.6468      1.546033      3

        M A S S   P A R T I C I P A T I O N   F A C T O R S  (in %)
 MODE     X         Y         Z              Sum-X     Sum-Y     Sum-Z     MODE
  1     81.762    0.000     0.000           81.762     0.000     0.000      1
  2      9.682    0.000     0.000           91.444     0.000     0.000      2
  3      3.661    0.000     0.000           95.105     0.000     0.000      3
```
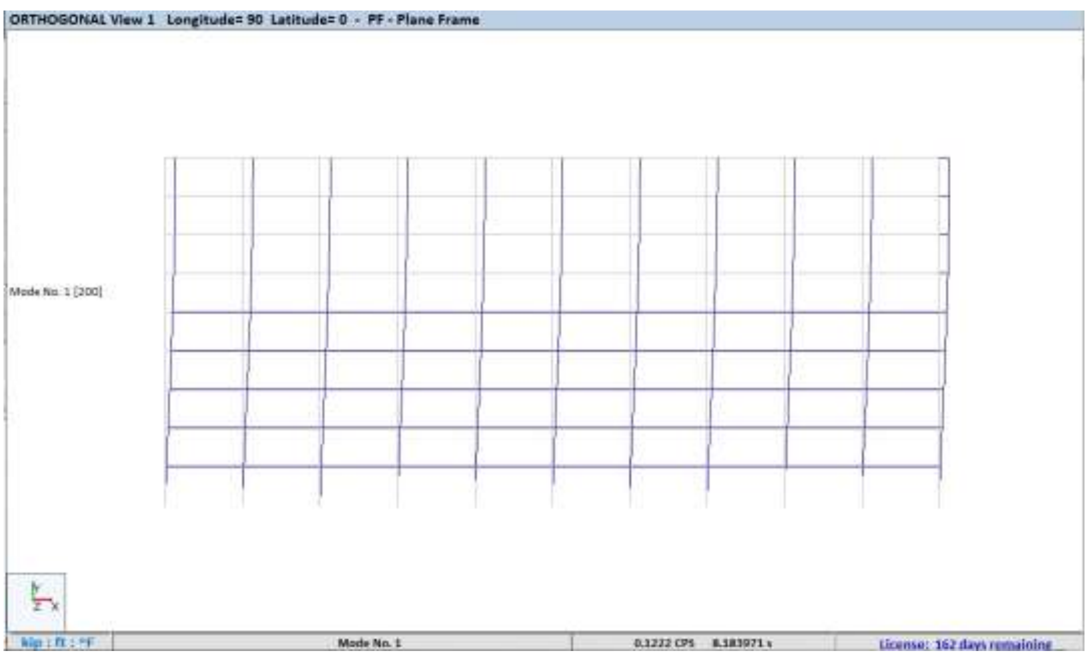
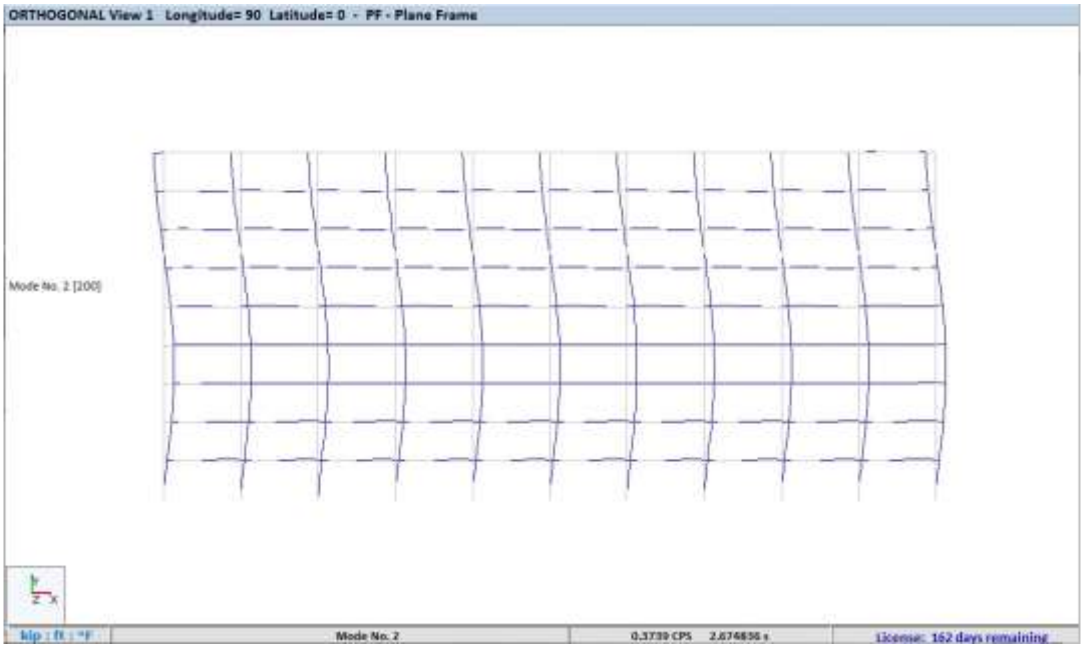
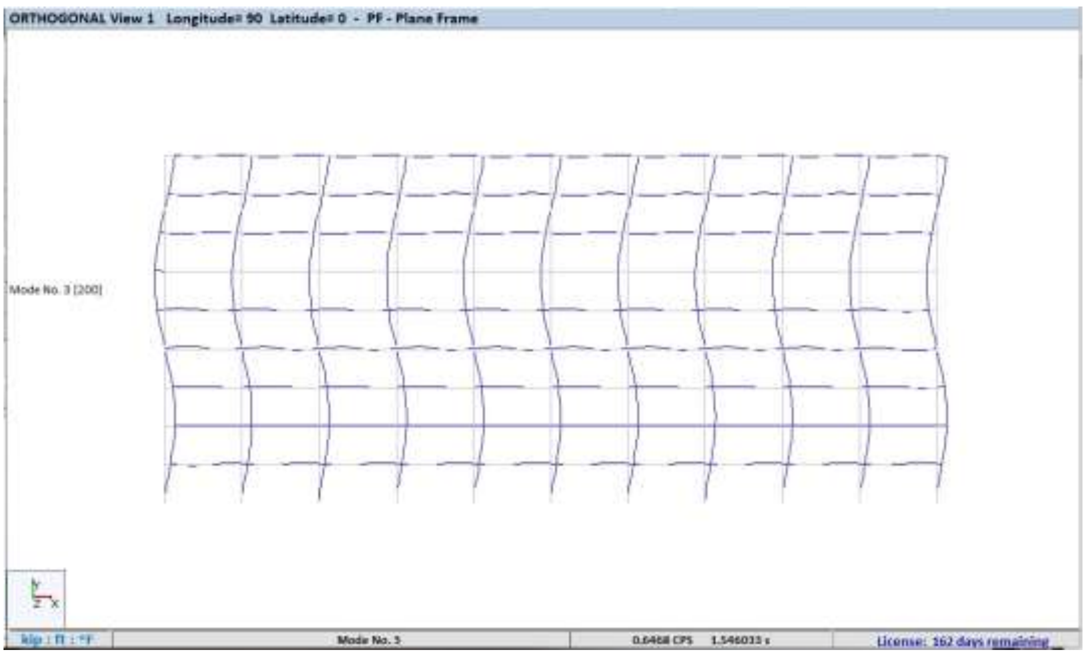







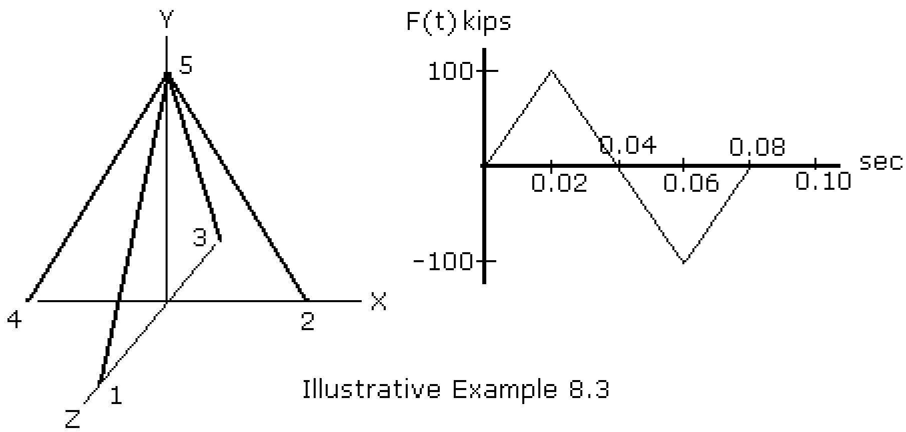
Results table

Results for EIGENVALUES and PERIODS

	SAP2000		STRUC	
Mode	**Eigenvalue**	**Period (s)**	**Eigenvalue**	**Period (s)**
1	0.589541	8.183194	0.5894	8.183971
2	5.52696	2.672617	5.5178	2.674836
3	16.5879	1.542709	16.5167	1.546033

C.6 Space Truss with dynamic loads, Modal Superposition

Reference: Paz Mario, Matrix Structural Analysis & Dynamics, Theory and Computation, Computers and Structures, Inc. 2009, Berkeley, California, Illustrative Example 8.3, pp. 362 - 368.



Illustrative Example 8.3

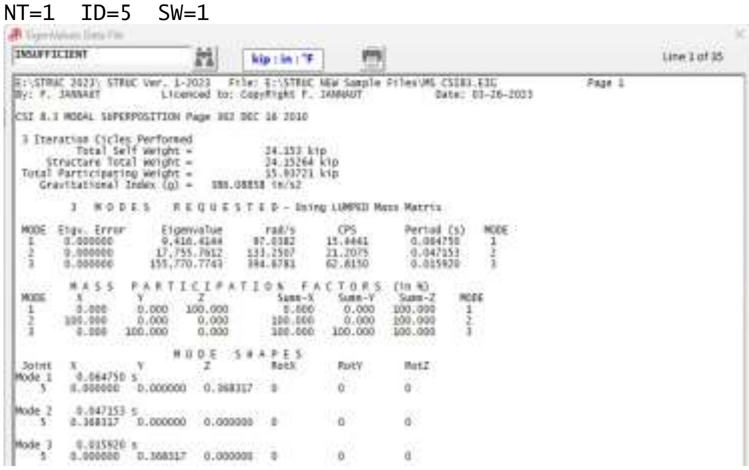
The cross-sectional area for all the members is 10 in^2, mass density *p* = 0.01 (lb/sec^2/in)/in^3 and material modulus of elasticity "E" is 29500 ksi. In addition, the truss carries a concentrated mass *m* = 10 lb.sec^2/in at the top joint. Assume a damping ratio of 0.05 for all modes.

Example taken from the reference. The original excitation force F(t) is applied at a 45° from the X axis in the X-Z plane, therefore it is divided into two vector forces reduced by the cosine of 45 °; one is applied in the direction of the X axis and the other is applied in the direction of the Z axis. The forces are applied simultaneously and to a total analysis time of 0.60 seconds.

Input data file: "MS CSI83"

```
CSI 8.3 MODAL SUPERPOSITION Page 362 DEC 16 2010

CONTROL
L=2
UF=6  UL=5  UT=2  MT=1  :kips inches Fahrenheit and Lumped Mass Matrix

JOINTS
1   X=0      Y=0      Z=4    S=12  :feet to inches
2   X=6               Z=0
3   X=0               Z=-4
4   X=-6              Z=0
5   X=0      Y=12

RESTRAINTS
1 4   RX=1  RY=1  RZ=1  <X=1  <Y=1  <Z=1
5     <X=1  <Y=1  <Z=1

MEMBERS
NM=1
C MATERIALS
C 0.01 (Lbxs2/in)/in3/1000 = 0.00001 (kipsxs2/in)/in3 x 386.0886 in/s2 = 0.003860886 kips/in3
1  A=10   J=0.001  E=29500   W=0.003860886
C MEMBERS
1   1   5  MN=1  P2=2,0  RM2=0,1  RM3=0,1
2   2   5                RM2=0,1  RM3=0,1
3   3   5                RM2=0,1  RM3=0,1
4   4   5                RM2=0,1  RM3=0,1
```

```
MLOADS
WY=-1  L=1

JLOADS
C 10 lbxs2/in/1000 = 0.01 kipsxs2/in x 386.0886 in/s2 = 3.860886 kips
5   FY=-3.860886  L=2

MASS
M=2

DAMP
DR=0.05

DYNAMIC
DT=2  NR=3  L=2  :Modal Superposition using 3 Natural Frequencies
NF=2  TI=0.001  AG=0  PR=1  :Time Step = 0.001 S, Modal Damping Ratio = 0.05
C 100 x cos(45) = 70.710678
1  NP=5  :Applied Horizontal Impulsive Force in X direction up to 0.6 seconds
0,0
0.02,70.710678
0.06,-70.710678
0.08,0
0.6,0
2  NP=5  :Applied Horizontal Impulsive Force in Z direction up to 0.6 seconds
0,0
0.02,70.710678
0.06,-70.710678
0.08,0
0.6,0
5  EX=1    :In X Direction
5  EZ=2    :In Z Direction

PRINT
NT=1  ID=5  SW=1
```



```
INSUFFICIENT          kip : in : °F                                Line 1 of 35
E:\STRUC 2023\ STRUC Ver. 1-2023   File: E:\STRUC NEW Sample Files\MS CSI83.EIG      Page 1
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CSI 8.3 MODAL SUPERPOSITION Page 382 DEC 16 2010

 3 Iteration Cycles Performed
           Total Self Weight =          24.153 kip
       Structure Total Weight =          24.15264 kip
   Total Participating Weight =          15.93721 kip
      Gravitational Index (g) =   386.08858 in/s2

        3  M O D E S   R E Q U E S T E D - Using LUMPED Mass Matrix

 MODE  Eigv. Error     Eigenvalue      rad/s       CPS       Period (s)   MODE
  1     0.000000       9,416.4144     97.0382     15.4441     0.064750     1
  2     0.000000      17,755.7612    133.2507     21.2075     0.047153     2
  3     0.000000     155,770.7743    394.6781     62.8150     0.015920     3

        M A S S   P A R T I C I P A T I O N   F A C T O R S  (in %)
 MODE     X        Y        Z            Sum-X    Sum-Y    Sum-Z    MODE
  1      0.000    0.000   100.000        0.000    0.000   100.000    1
  2    100.000    0.000     0.000      100.000    0.000   100.000    2
  3      0.000  100.000     0.000      100.000  100.000   100.000    3

                      M O D E   S H A P E S
 Joint    X          Y          Z         RotX      RotY      RotZ
Mode 1   0.064750 s
   5    0.000000   0.000000   0.368317    0         0         0

Mode 2   0.047153 s
   5    0.368317   0.000000   0.000000    0         0         0

Mode 3   0.015920 s
   5    0.000000   0.368317   0.000000    0         0         0
```
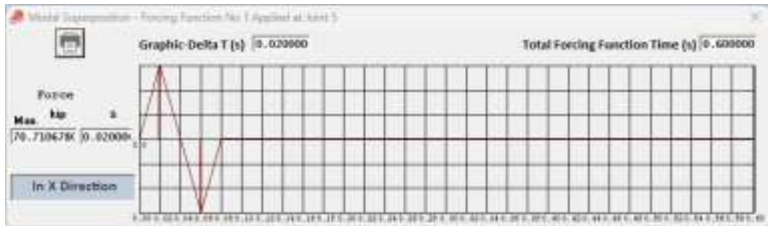
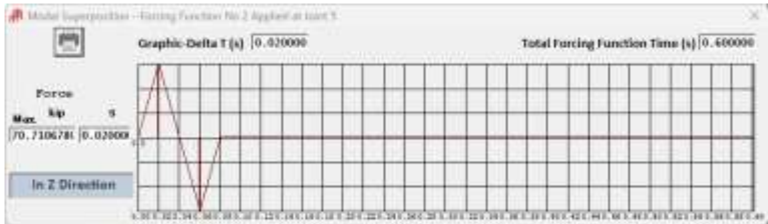
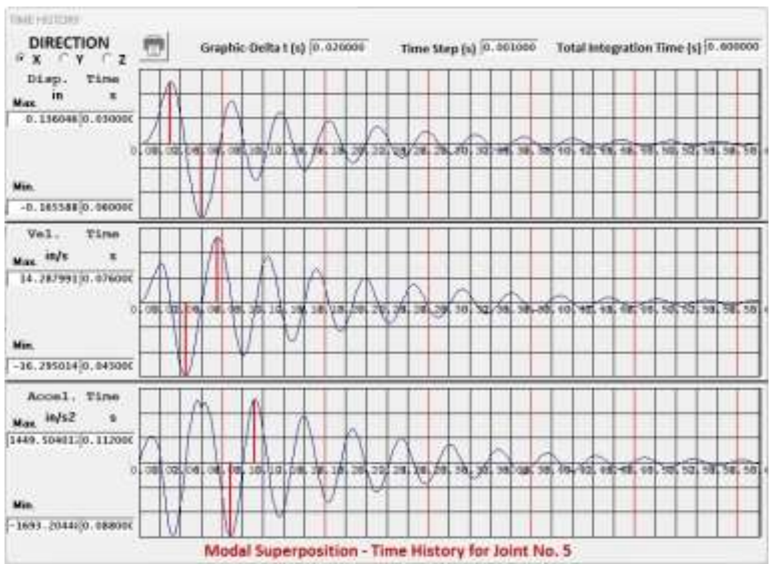
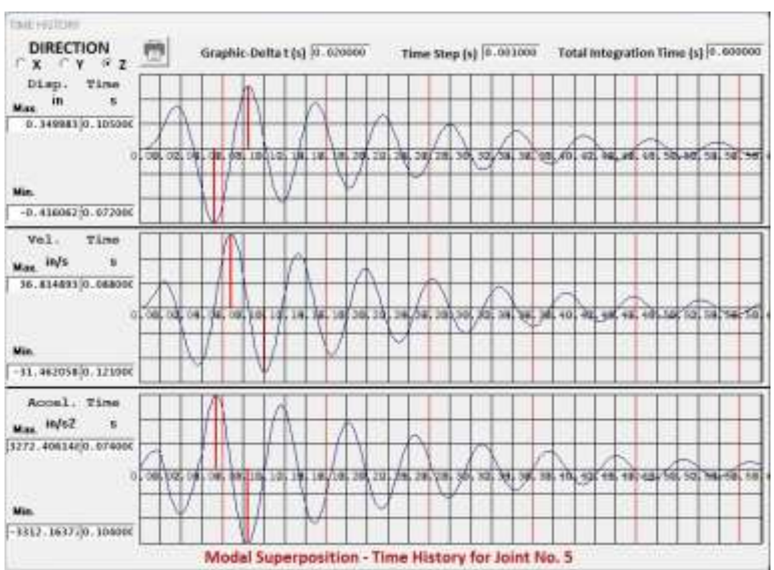


Graphic-Delta T (s) 0.020000
Total Forcing Function Time (s) 0.600000
Force
Max. kip s
70.710678 0.02000
In X Direction


Graphic-Delta T (s) 0.020000
Total Forcing Function Time (s) 0.600000
Force
Max. kip s
70.710678 0.02000
In Z Direction


DIRECTION
X Y Z
Graphic-Delta t (s) 0.020000
Time Step (s) 0.001000
Total Integration Time (s) 0.600000
Disp. Time
Max. in s
0.136046 0.03000
Min.
-0.165588 0.06000
Vel. Time
Max. in/s s
14.287991 0.07600
Min.
-16.295014 0.04500
Accel. Time
Max. in/s2 s
1449.50401 0.11200
Min.
-1693.2044 0.08800
Modal Superposition - Time History for Joint No. 5


DIRECTION
X Y Z
Graphic-Delta t (s) 0.020000
Time Step (s) 0.001000
Total Integration Time (s) 0.600000
Disp. Time
Max. in s
0.349983 0.10500
Min.
-0.416062 0.07200
Vel. Time
Max. in/s s
36.814893 0.08800
Min.
-31.462058 0.12100
Accel. Time
Max. in/s2 s
3272.40614 0.07400
Min.
-3312.1637 0.10400
Modal Superposition - Time History for Joint No. 5

```
E:\STRUC 2023\ STRUC Ver. 1-2023   File: E:\STRUC NEW Sample Files\MS CSI83.MOD          Page 3
By: F. JANNAUT        Licenced to: CopyRight F. JANNAUT          Date: 03-25-2023

CSI 8.3 MODAL SUPERPOSITION Page 362 DEC 16 2010

     R E S P O N S E   B Y   M O D A L   S U P E R P O S I T I O N   M E T H O D
                   Z   E X C I T A T I O N   F O R C E (S)

  JOINT   DIR    TIME        DISPLACEMENT          VELOCITY        ACCELERATION
   No.             s           [in-rad]           [in-rad]/s       [in-rad]/s2
    5      X    0.027000      0.12788798          4.75286525     -1,220.624526
           Y    0.027000      0.00000000          0.00000000          0.000000
           Z    0.027000      0.17864250         11.85205255       -683.725776

    5      X    0.028000      0.13200591          3.45940304     -1,362.156533
           Y    0.028000      0.00000000          0.00000000          0.000000
           Z    0.028000      0.19012128         11.07446895       -869.919664

    5      X    0.029000      0.13476385          2.03717878     -1,477.824954
           Y    0.029000      0.00000000          0.00000000          0.000000
           Z    0.029000      0.20073097         10.11552896     -1,046.169985

    5      X    0.030000      0.13604625          0.51294491     -1,565.934997
           Y    0.030000      0.00000000          0.00000000          0.000000
           Z    0.030000      0.21029544          8.98596297     -1,210.922439

    5      X    0.031000      0.13576512         -1.08510361     -1,625.299659
           Y    0.031000      0.00000000          0.00000000          0.000000
           Z    0.031000      0.21865008          7.69799542     -1,362.745396

    5      X    0.032000      0.13386114         -2.72784507     -1,655.253907
           Y    0.032000      0.00000000          0.00000000          0.000000
           Z    0.032000      0.22564315          6.26521588     -1,500.342118

    5      X    0.033000      0.13030437         -4.38575606     -1,655.659487
           Y    0.033000      0.00000000          0.00000000          0.000000
           Z    0.033000      0.23113716          4.70243865     -1,622.561594

    5      X    0.034000      0.12509438         -6.02943682     -1,626.900382
           Y    0.034000      0.00000000          0.00000000          0.000000
           Z    0.034000      0.23500998          3.02555222     -1,728.407917

    5      X    0.035000      0.11825984         -7.63012736     -1,569.869140
           Y    0.035000      0.00000000          0.00000000          0.000000
           Z    0.035000      0.23715583          1.25136008     -1,817.048107

    5      X    0.036000      0.10985768         -9.16020553     -1,485.944417
           Y    0.036000      0.00000000          0.00000000          0.000000
           Z    0.036000      0.23748611         -0.60258541     -1,887.818335

    5      X    0.037000      0.09997166        -10.59365841     -1,376.960270
           Y    0.037000      0.00000000          0.00000000          0.000000
           Z    0.037000      0.23593011         -2.51815461     -1,940.228513

    5      X    0.038000      0.08871059        -11.90651916     -1,245.167819
           Y    0.038000      0.00000000          0.00000000          0.000000
           Z    0.038000      0.23243544         -4.47681596     -1,973.965196

    5      X    0.039000      0.07620603        -13.07726205     -1,093.190088
           Y    0.039000      0.00000000          0.00000000          0.000000
           Z    0.039000      0.22696836         -6.45981334     -1,988.892819

    5      X    0.040000      0.06260972        -14.08714923       -923.970880
           Y    0.040000      0.00000000          0.00000000          0.000000
           Z    0.040000      0.21951397         -8.44834391     -1,985.053244
```

Results from EIGENVALUES

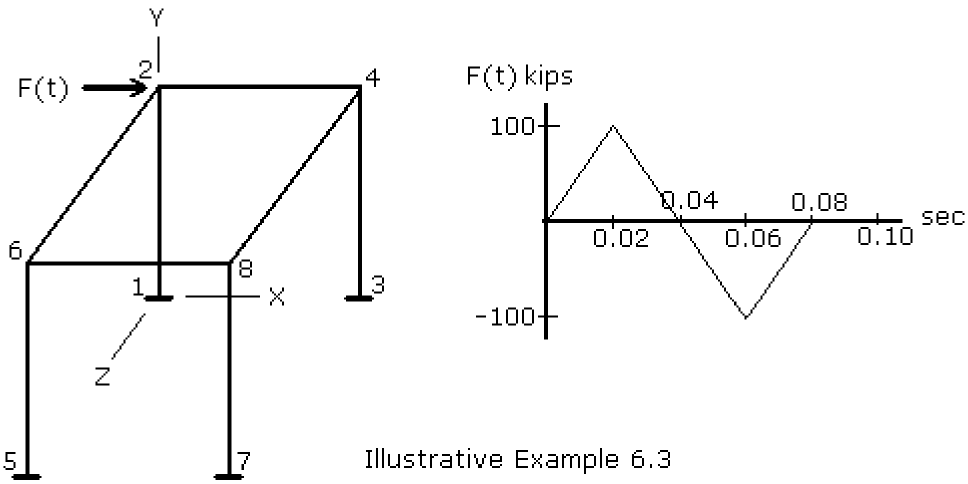
	CSI / SAP2000	STRUC
Mode	**Period (s)**	**Period (s)**
1	0.064700	0.064750
2	0.047100	0.047153
3	0.015900	0.015920

Some Results from TIME HISTORY

	CSI / SAP2000		**STRUC**	
	t (s)	**Disp. (in)**	**t (s)**	**Disp. (in)**
Direction X	0.031	+0.131	0.030	+0.13604625
	0.061	-0.168	0.060	-0.16558833
	0.089	+0.090	0.089	+0.09502728
Direction Z	0.036	+0.234	0.036	+0.23748611
	0.071	-0.421	0.072	-0.41606180
	0.106	+0.346	0.105	+0.34998338
	CSI Values taken from book Fig. 8.7			

C.7 Space Frame with dynamic loads, Modal Superposition

Reference: Paz Mario, Matrix Structural Analysis & Dynamics, Theory and Computation, Computers and Structures, Inc. 2009, Berkeley, California, Illustrative Example 6.3, pp. 288 - 295



Illustrative Example 6.3

Material modulus of elasticity "E" is 29500 ksi.
Poisson's ratio = 0.3
Modal damping ratio = 0
Columns: W24x146
Girders: W14x82
The frame has concentrated masses of *m* = 0.001 (kip sec^2/in) at each of the four top joints.

Example taken from the reference. The original excitation force F(t) is applied in the direction of the X axis in joint number 2. The force is applied to a total analysis time of 0.10 second.

Input data file: "MS CSI63"

```
CSI 6.3 MODAL SUPERPOSITION Page 288 DEC 15 2010

CONTROL
L=2
UF=6  UL=5  UT=2  MT=1  :kips inches Fahrenheit and Lumped Mass Matrix

JOINTS
1   X=0      Y=0      Z=0
2            Y=180
3   X=114    Y=0
4            Y=180
5   X=0      Y=0      Z=240
6            Y=180
7   X=114    Y=0
8            Y=180

RESTRAINTS
1 7 2   RX=1  RY=1  RZ=1  <X=1  <Y=1  <Z=1

MEMBERS
NM=2
```

```
C MATERIALS
1  SH=A   T=105   E=29500   G=11346.15  MT=S  :W24X146
2  SH=A   T=192   E=29500   G=11346.15  MT=S  :W14X82
C MEMBERS
1   1   2  MN=1  P2=3,0
2   3   4
3   5   6
4   7   8
C
5   2   6  MN=2  P2=2,0
6   4   8
7   2   4
8   6   8

JLOADS
C 1 lbXs2/in / 1000 = kipsXs2/in x 386.0886 in/s2 = 0.3860886 kips
2 8 2  FY=-0.3860886  L=1  :Joints 2, 4, 6 and 8

MASS
1  M=1

DYNAMIC
DT=2  NR=6  L=2   :Modal Superposition using 6 Natural Frequencies
NF=1  TI=0.002  AG=0  PR=1  :Time Step = 0.002 s, Modal Damping Ratio = 0
1  NP=6  :Applied Horizontal Impulsive Force in X direction up to 0.1 seconds
0,0
0.02,1
0.04,0
0.06,-1
0.08,0
0.1,0
C
2  EX=1   :In X Direction

PRINT
NT=1  ID=2  SW=1
```

Results tables

Results from EIGENVALUES

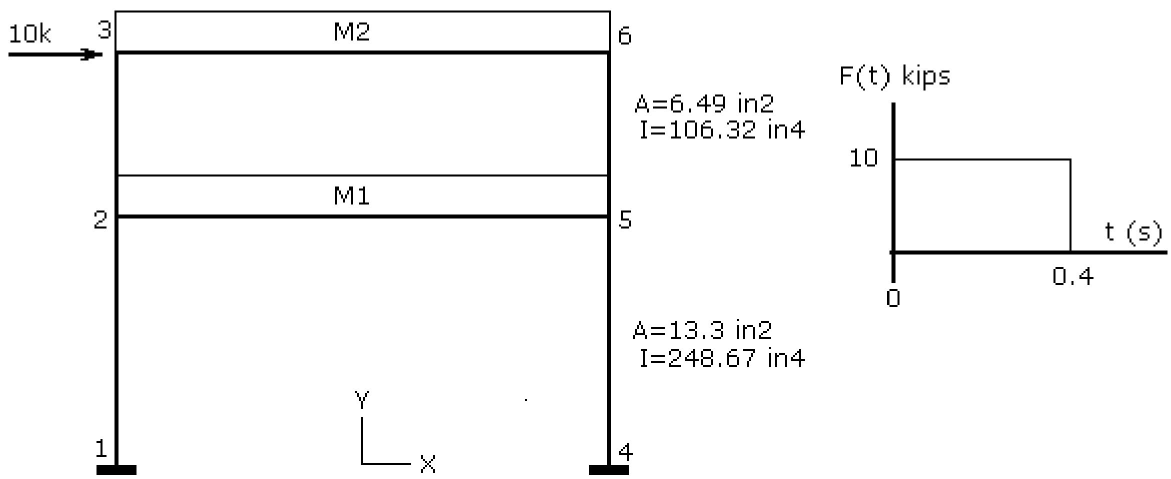
	CSI / SAP2000	**STRUC**
Mode	**Period (s)**	**Period (s)**
1	0.044572	0.047214
2	0.040749	0.042859
3	0.020409	0.020527
4	0.018242	0.018412
5	0.002565	0.002570
6	0.002563	0.002568

Some Results from TIME HISTORY

	CSI / SAP2000	**STRUC**
Time (s)	**Y Displacement Joint 2 (in)**	**X Displacement Joint 2 (in)**
0.028	+0.0347	+0.03804295
0.054	-0.0380	-0.04400796
0.094	+0.0110	+0.01104567
	CSI Values taken from book Fig. 6.13	

C.8 Plane Frame with dynamic loads, Step Integration

Reference: Paz Mario, Leigh William, Structural Dynamics, Theory and Computation Fifth Edition, 2004 Springer Science+Buisness Media, Inc., Illustrative Example 16.2, pp. 505 - 506



Illustrative Example 16.2

Two story shear building.
E = 30000 ksi
M1 = 0.136 kip sec^2/in
M2 = 0.066 kip sec^2/in
Suddenly applied force of 10 Kip at the level of the second floor and for 0.4 seconds.

Input data file: "SI PAZ162N"

```
PAZ 2004 Example 16.2 OCT-12-2010  Units Kips-in

CONTROL
L=1
UF=6  UL=5  UT=2  :kips inches Fahrenheit

JOINTS
C  COORDINATES IN in
 1  X=-180  Y=0     Z=0
 2          Y=180
 3          Y=300
 4  X=180   Y=0
 5          Y=180
 6          Y=300

RESTRAINTS
1 6    RZ=1  <X=1  <Y=1  :PF
1 4 3  RX=1  RY=1  RZ=1  <X=1  <Y=1  <Z=1

MEMBERS
NM=3
C
1 A=13.3  I=248.67  J=0.000  MT=C  E=30000
2 A=6.49  I=106.32  J=0.000  MT=C  E=30000
3 A=1E6   I=1E6     J=0.000  MT=C  E=30000
C COLUMNS
 1  1 2  P2=1,0  MN=1
```

```
 2  2 3          MN=2
 3  4 5          MN=1
 4  5 6          MN=2
C BEAMS
 5  2 5  P2=2,0  MN=3
 6  3 6

JLOADS
2   FY=0.136*386.0886  L=1
3   FY=0.066*386.0886

MASS
1  M=1

C DAMP
C DR=0.05

DYNAMIC
DT=3  NR=2   L=1   :STEP INTEGRATION
NF=1  TI=0.02  PR=1
1  NP=3
0,10
0.4,10
1,0
C
3  EX=1

PRINT
NT=1  ID=2,3  SW=1
```

Results chart

	Joint	T (s)	Disp. (X) (in)	Vel. (X) (in/s)	Accel. (X) (in/s^2)
PAZ	2	0.02	0.00080	0.1189	8.8750
	3	0.02	0.02860	2.7781	132.850
STRUC	2	0.02	0.00080	0.1198	11.9796
	3	0.02	0.02861	2.7765	126.1314

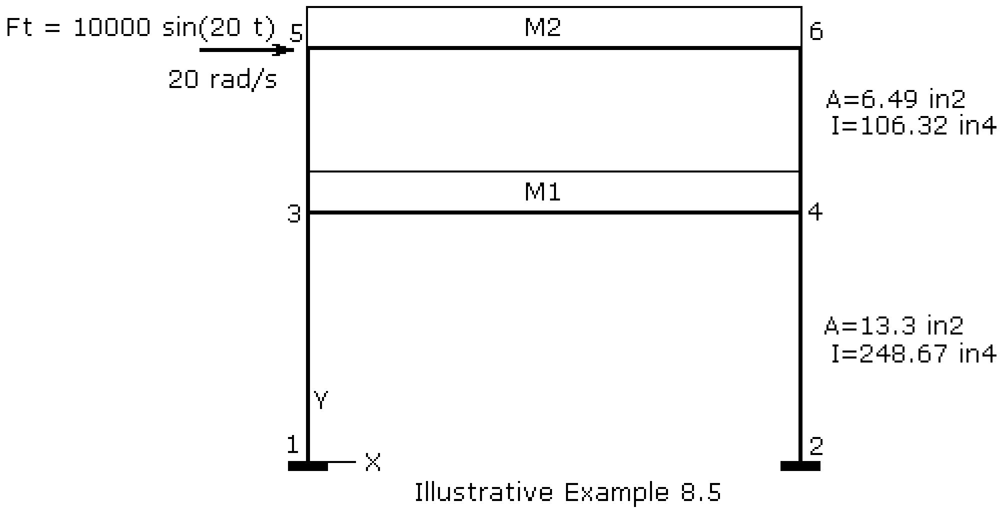
Step Integration after a first cycle of 0.02 seconds.

	Joint	Disp. (X) (in)	Vel. (X) (in/s)	Accel. (X) (in/s^2)
PAZ	2	0.692	5.875	89.763
	3	1.087	7.273	147.611
STRUC	2	0.700	5.700	80.532
	3	1.076	6.907	151.515

Step Integration, Maximum Response

C.9 Plane Frame with dynamic loads, Steady State

Reference: Paz Mario, Leigh William, Structural Dynamics, Theory and Computation Fifth Edition, 2004 Springer Science+Buisness Media, Inc., Illustrative Example 8.5, pp. 247 - 251



Two story shear building.
E = 30 E6 psi
M1 = 136 lb sec^2/in
M2 = 66 lb sec^2/in
Damping Mass Factor = 0.00
Damping Stiffness Factor = 0.01
Determine the Steady State response when subjected to the force F(t) = 10000 sin (20 t) applied at joint 5 in “X” direction.
[10000 lb and 20 rad/s].

Input data file: “SS PAZ85N”

```
PAZ Problem 8.5 NEW EDITION lb-in Julio-13-2009

CONTROL
L=1
UF=5  UL=5  UT=2  :lb, in, Fahrenheit

JOINTS
1  X=0  Y=0  Z=0   S=12  :ft to in
3       Y=15
5       Y=25
2  X=30 Y=0
4       Y=15
6       Y=25

RESTRAINTS
1 6   RZ=1  <X=1  <Y=1    :PF
1 2   RX=1  RY=1  RZ=1  <X=1  <Y=1  <Z=1

MEMBERS
NM=3
1  A=100000  I=1000000,1000000  J=0.01  E=3E7  MT=S :Beams
2  A=13.3  I=248.67,53.4  J=0.01   MT=S  E=3E7     :Columns W10x45
3  A=6.49  I=106.32,11.4  J=0.01   MT=S  E=3E7     :Columns W10x22
C BEAMS
```

```
1  3 4  MN=1  P2=2,0
2  5 6
C COLUMNS
3  1 3  MN=2  P2=1,0
4  3 5  MN=3
5  2 4  MN=2
6  4 6  MN=3

JLOADS
3  4   FY=68*386.0886   L=1  :136 lb.s2/in / 2 = 68 lb.s2/in
5  6   FY=33*386.0886        : 66 lb.s2/in / 2 = 33 lb.s2/in

MASS
1  M=1

DAMP
DC=0,0.01

DYNAMIC
DT=4  NR=2  L=1  :STEADY STATE
C FS SIN(WR t) = 10000 SIN(20 rad/s . t) with 20 rad/s = 3.18309886 cps
FS=10000 WR=3.18309886  TI=0.01  TT=1  PR=1
5  EX=1

C End of File
```

Results chart

Without Damping Applied

Paz, bellow chart computed from page 248 as:

Joint 5: Disp. in X = -0.129255 sin(20t) (in) {20 rad/s} (Exact solution)

Disp. X (in)	Joint	t = 0.00 (s)	t = 0.10 (s)	t = 0.20 (s)	t = 0.30 (s)	t = 0.40 (s)	t = 0.50 (s)
PAZ	**5**	0.000000	-0.117531	0.097821	-0.036116	0.127879	-0.070317
STRUC	**5**	0.000000	-0.117367	0.097684	-0.036065	0.127701	-0.070219

With Damping Applied

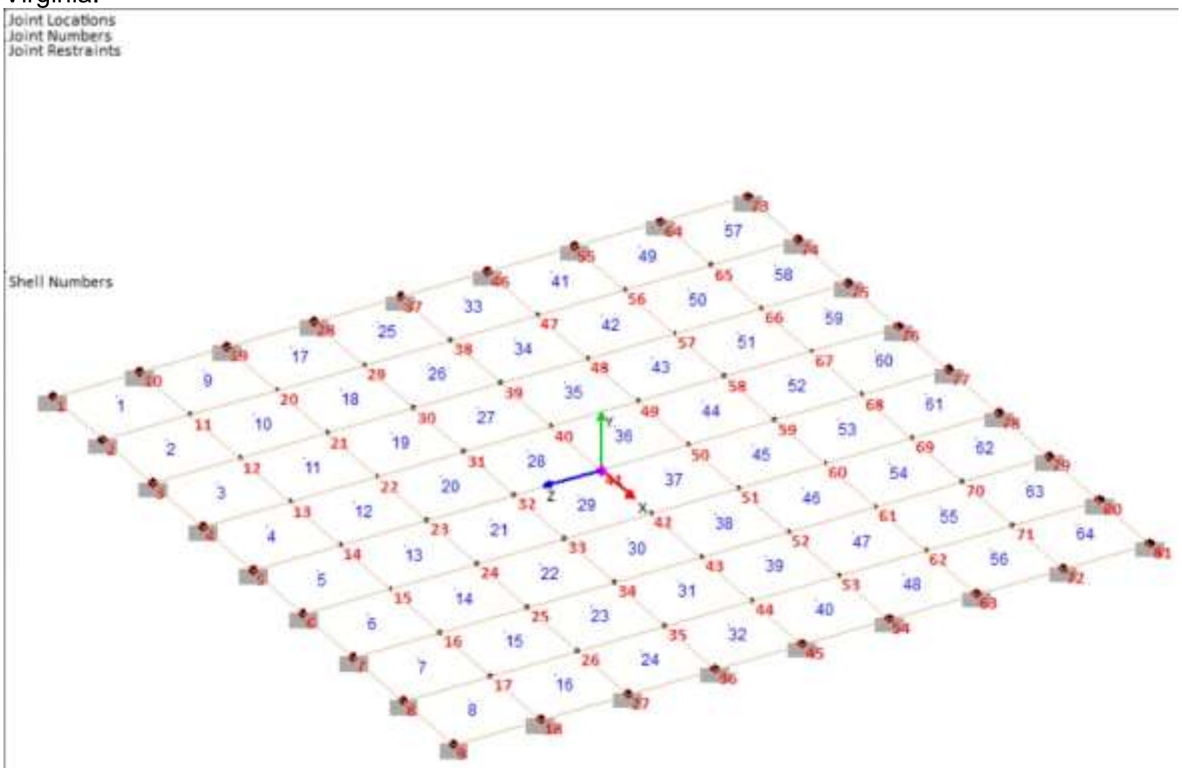
Paz, bellow chart computed from page 251 as:

Joint 5: Disp. in X = 0.1516 sin(20t + 3.571) (in) {20 rad/s}

Disp. X (in)	Joint	t = 0.00 (s)	t = 0.10 (s)	t = 0.20 (s)	t = 0.30 (s)	t = 0.40 (s)	t = 0.50 (s)
PAZ	**5**	-0.063116	-0.099069	0.145570	-0.022088	-0.127186	0.127945
STRUC	**5**	-0.063177	-0.098942	0.145526	-0.022178	-0.127067	0.127935

C.10 Square Plate with uniform surface load

Reference: Kaushalkumar Kansa, Development of Membrane, Plate and Flat Shell Elements in Java, Thesis to the Faculty of the Virginia Polytechnic Institute & State University, May, 2004, Blacksburg, Virginia.



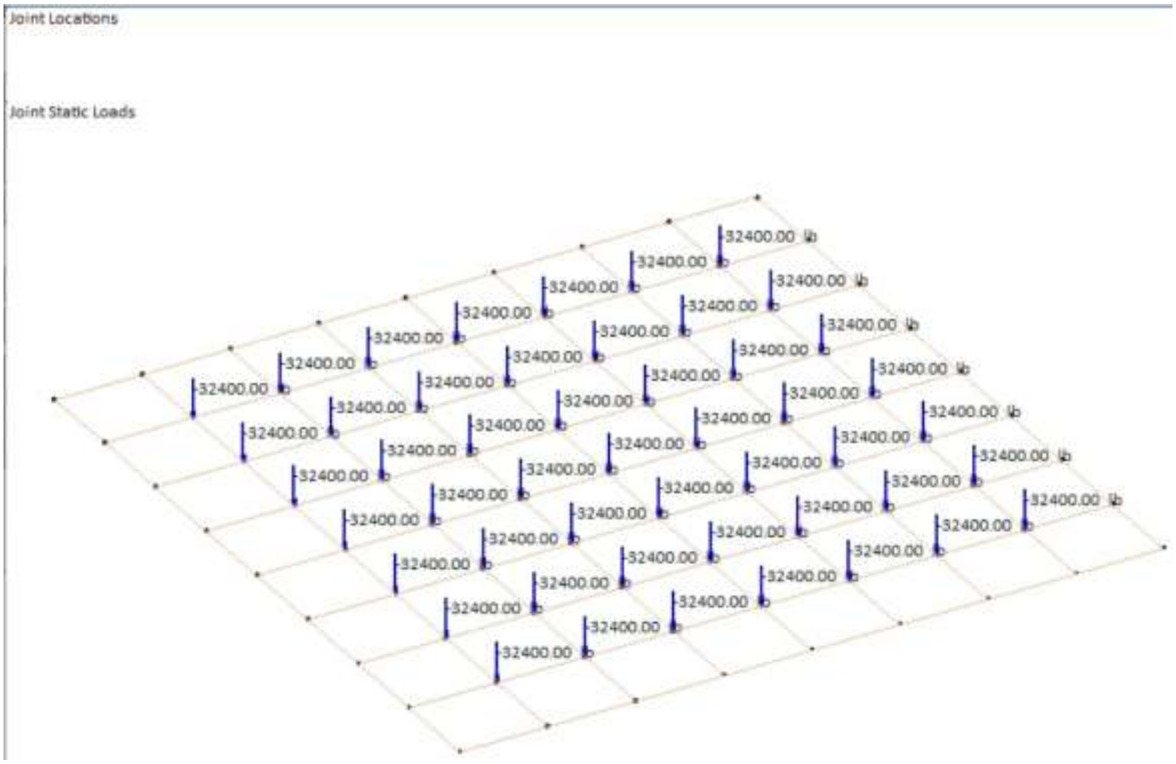
Square plate of size 12 ft x 12 ft (144 in x 144 in) and has a thickness of 6 in. A uniform surface load of 0.10 kips/sq. in. (100 psi) is applied to the plate. All the edges of the plate are fixed. The finite element model is generated using 64 four node quadrilateral plate bending elements.

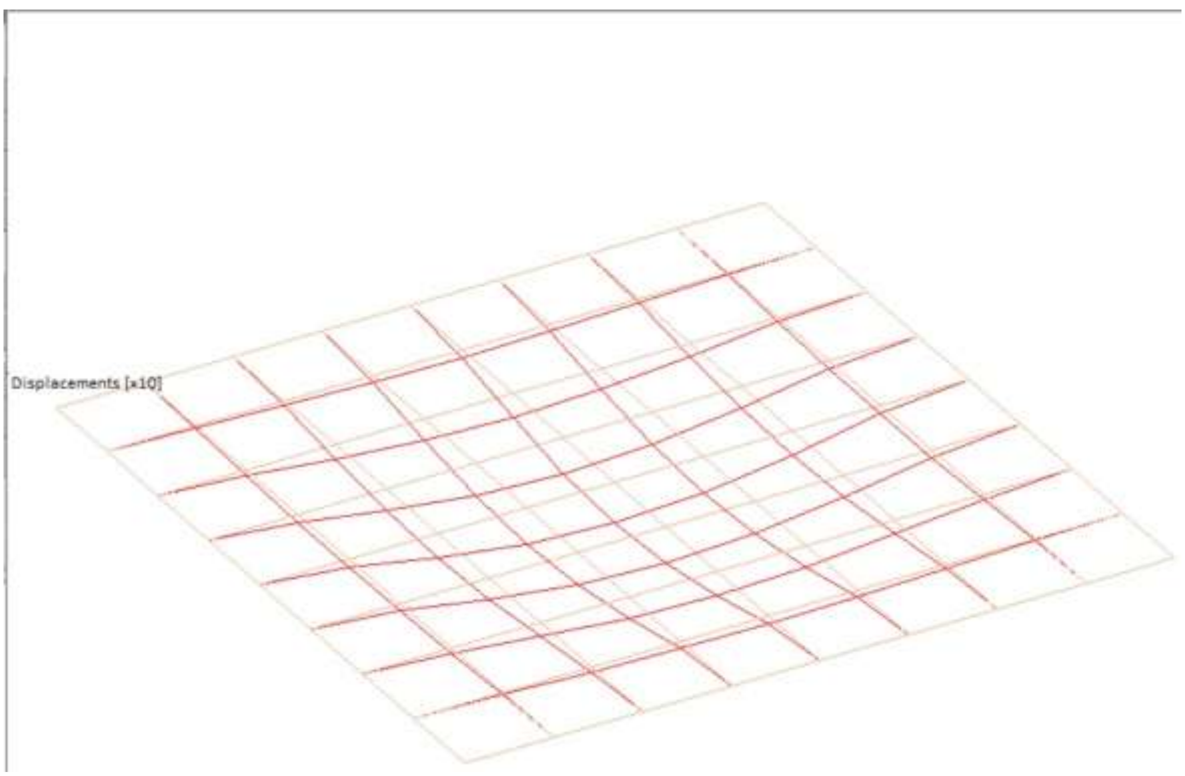
E = 3.6E6 psi
Poisson Ratio = 0.20
Thickness = 6 in

Input data file: "STATIC JAVA Test Example 10"

```
SQUARE PLATE JAVA EXAMPLE 10 01/03/2024

CONTROL
L=1
C LOAD CONDITION NAMES
  1 DL
C GENERAL PARAMETERS
UF=5  UL=5  UT=2  MT=1  :UNITS  lb   ft  ˚F

JOINTS
C LENGTH UNITS USED:  in
    1   X=-72                 Y=0             Z=72
    9   X=72                                  Z=72
   73   X=-72                                 Z=-72
   81   X=72                                  Z=-72   Q=1,9,73,81,1,9
```

```
RESTRAINTS
C (R) DISPLACEMENT IN AXIS, (<) ROTATION ARROUND AXIS.
C 0=FREE   1=RESTRICTED
    1  9     RX=1   RY=1   RZ=1   <X=1   <Y=1   <Z=1
   10 64 9   RX=1   RY=1   RZ=1   <X=1   <Y=1   <Z=1
   18 72 9   RX=1   RY=1   RZ=1   <X=1   <Y=1   <Z=1
   73 81     RX=1   RY=1   RZ=1   <X=1   <Y=1   <Z=1

SHELLS
NM=1
C UNITS USED:  lb  :  in : ˚F
C E = 3.6E6 psi = 4.32E8 lb/ft2
C Poisson's ratio = 0.3
C Thickness = 6 in
C Type 0 = Bending, Shear & Membrane
C Shell Name = 6
  1  E=3.6E6  P=0.2  T=6  ST=0  :6.00
C SHELLS
  1  SJ=10,11,2,1   SM=1   SG=8,8

JLOADS
C UNITS  lb
C FY 0.10 KIPS/SQ in = 100 lb X 18 in X 18 in = 32400 lb PER JOINT
  11  17    FY=-32400   L=1
  20  26    FY=-32400   L=1
  29  35    FY=-32400   L=1
  38  44    FY=-32400   L=1
  47  53    FY=-32400   L=1
  56  62    FY=-32400   L=1
  65  71    FY=-32400   L=1

End of File
```


Joint Locations
Joint Static Loads
-32400.00 lb


Displacements [x10]

```
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            G L O B A L   D I S P L A C E M E N T S   S U M M A R Y

Load Combination 1 of 1   1.0DL
    Direction   Value  Unit   Joint
    Min  X      0.000000 in      1
    Max  X      0.000000 in      1

    Min  Y     -0.820972 in     41
    Max  Y      0.000000 in      1

    Min  Z      0.000000 in      1
    Max  Z      0.000000 in      1

    Min <X     -0.017130 rad    23
    Max <X      0.017130 rad    59

    Min <Y      0.000000 rad     1
    Max <Y      0.000000 rad     1

    Min <Z     -0.017130 rad    39
    Max <Z      0.017130 rad    43
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SQUARE PLATE JAVA EXAMPLE 10 01/03/2024

             M I N I M U M   A N D   M A X I M U M   E N V E L O P E

    Direction   Value  Unit   Joint Load Comb Name
    Min  X      0.000000 in      1       1    1.0DL
    Max  X      0.000000 in      1       1    1.0DL

    Min  Y     -0.820972 in     41       1    1.0DL
    Max  Y      0.000000 in      1       1    1.0DL

    Min  Z      0.000000 in      1       1    1.0DL
    Max  Z      0.000000 in      1       1    1.0DL

    Min <X     -0.017130 rad    23       1    1.0DL
    Max <X      0.017130 rad    59       1    1.0DL

    Min <Y      0.000000 rad     1       1    1.0DL
    Max <Y      0.000000 rad     1       1    1.0DL

    Min <Z     -0.017130 rad    39       1    1.0DL
    Max <Z      0.017130 rad    43       1    1.0DL
```

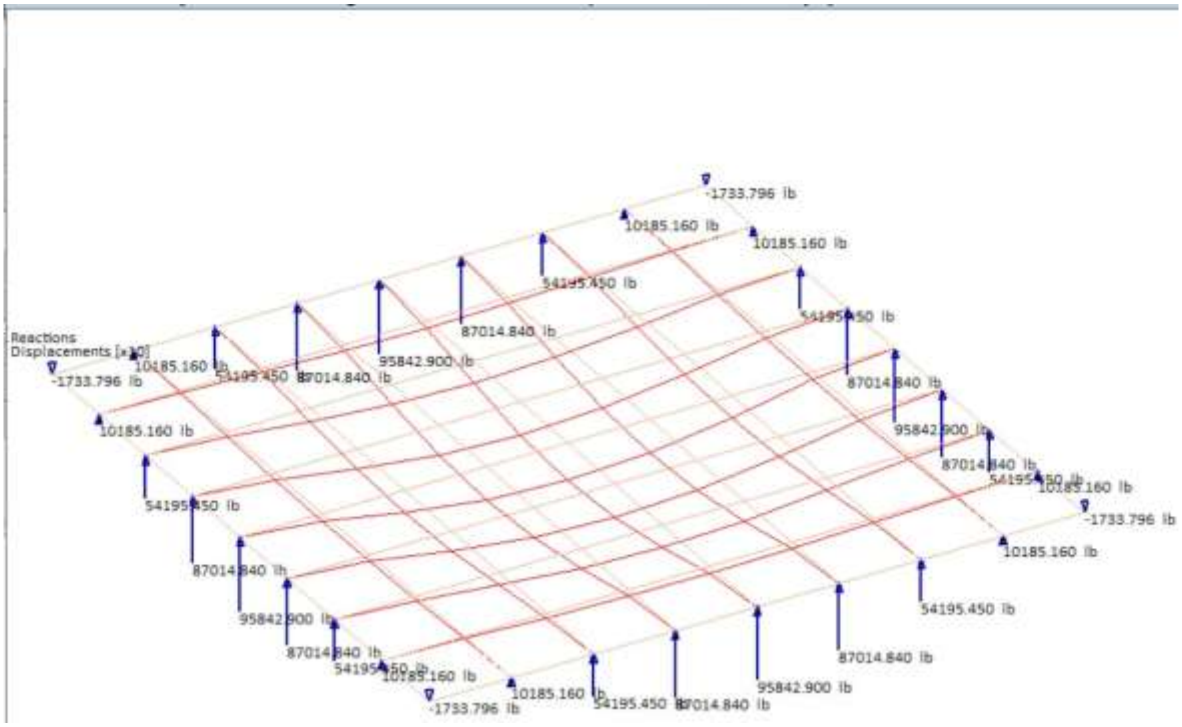

□C:\STRUC 2024\ STRUC Ver. 1-2023 File: C:\SHELLS\STATIC JAVA Test Example 10.RSM Page 3
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SQUARE PLATE JAVA EXAMPLE 10 01/03/2024

G L O B A L R E A C T I O N S S U M M A R Y

M I N I M U M A N D M A X I M U M E N V E L O P E

Direction	Value	Unit	Joint	Load Comb	Name
Min X	0	lb	1	1	1.0DL
Max X	0	lb	1	1	1.0DL
Min Y	-1733.796	lb	9	1	1.0DL
Max Y	95842.898	lb	5	1	1.0DL
Min Z	0	lb	1	1	1.0DL
Max Z	0	lb	1	1	1.0DL
Min MX	-1.86845E+06	lb-in	77	1	1.0DL
Max MX	1.86845E+06	lb-in	5	1	1.0DL
Min MY	0	lb-in	1	1	1.0DL
Max MY	0	lb-in	1	1	1.0DL
Min MZ	-1.86845E+06	lb-in	45	1	1.0DL
Max MZ	1.86845E+06	lb-in	37	1	1.0DL

```
C:\STRUC 2024\ STRUC Ver. 1-2023   File: C:\SHELLS\STATIC JAVA Test Example 10.SFS          Page 1
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SQUARE PLATE JAVA EXAMPLE 10 01/03/2024

 Load Combinations
    1 1.0DL

 S H E L L S   I N T E R N A L   F O R C E S   S U M M A R Y

    M I N I M U M   A N D   M A X I M U M   E N V E L O P E

                Force     Units     Shell  Joint   LC  Name
     F1 Min.       0      lb           1     10     1  1.0DL
     F1 Max.       0      lb           1     10     1  1.0DL

     F2 Min.       0      lb           1     10     1  1.0DL
     F2 Max.       0      lb           1     10     1  1.0DL

     F3 Min.  -47921.449 lb           33     37     1  1.0DL
     F3 Max.   47921.449 lb           33     47     1  1.0DL

     M1 Min. -958564.704 lb-in        61     78     1  1.0DL
     M1 Max.  958564.704 lb-in         4      4     1  1.0DL

     M2 Min. -958564.704 lb-in        40     54     1  1.0DL
     M2 Max.  958564.704 lb-in        25     28     1  1.0DL

     M3 Min.       0      lb-in        1     10     1  1.0DL
     M3 Max.       0      lb-in        1     10     1  1.0DL
```

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SQUARE PLATE JAVA EXAMPLE 10 01/03/2024

 Load Combinations
    1 1.0DL

 S H E L L S   I N T E R N A L   S T R E S S E S   S U M M A R Y

      M I N I M U M   A N D   M A X I M U M   E N V E L O P E

              S T R E S S E S   A T   J O I N T S

                 Stress      Units      Shell  Joint   LC  Name
    S11 Min.       0        lb/in/in       1     10     1  1.0DL
    S11 Max.       0        lb/in/in       1     10     1  1.0DL

    S22 Min.       0        lb/in/in       1     10     1  1.0DL
    S22 Max.       0        lb/in/in       1     10     1  1.0DL

    S12 Min.       0        lb/in/in       1     10     1  1.0DL
    S12 Max.       0        lb/in/in       1     10     1  1.0DL

    M11 Min.   -63631.657 lb/in/in        33     37     1  1.0DL
    M11 Max.    44396.415 lb/in/in        36     41     1  1.0DL

    M22 Min.   -63631.657 lb/in/in        60     77     1  1.0DL
    M22 Max.    44396.415 lb/in/in        36     41     1  1.0DL

    M12 Min.   -18523.089 lb/in/in        15     17     1  1.0DL
    M12 Max.    18523.089 lb/in/in        10     11     1  1.0DL
```

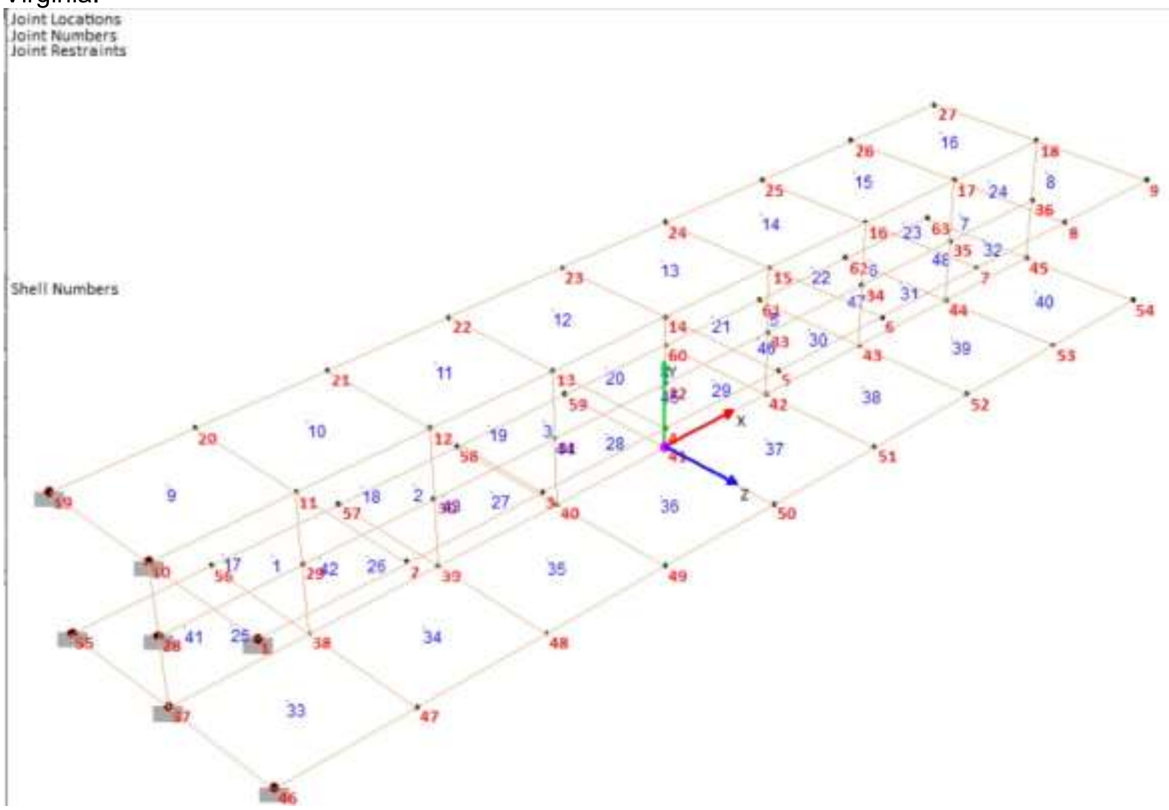
Results chart

Results for Deflection at Joint 41 in Y direction.

	Thesis	STRUC
Joint	Deflection (in)	Deflection (in)
41	-0.84005	-0.820972

C.11 Cantilever I-Beam in Torsion

Reference: Kaushalkumar Kansa, Development of Membrane, Plate and Flat Shell Elements in Java, Thesis to the Faculty of the Virginia Polytechnic Institute & State University, May, 2004, Blacksburg, Virginia.



Cantilever I-Beam in torsion by applying point loads of 1600 lbs each in two opposite directions at the top and bottom flanges of the beam.

E = 1E7 psi
Poisson Ratio = 0.30
Thickness = 0.25 in

Input data file: "STATIC JAVA Test Example 17"

```
CANTILEVER I BEAM JAVA EXAMPLE 17 02/12/2024

CONTROL
L=1
C LOAD CONDITION NAMES
  1 DL
C GENERAL PARAMETERS
UF=5  UL=5  UT=2  MT=1  :UNITS  lb   in  °F

JOINTS
C LENGTH UNITS USED:  in
    1   X=-20     Y=5     Z=5
    9   X=20
   19   X=-20             Z=-5
   27   X=20                        Q=1,9,19,27,1,9
   28   X=-20     Y=2.5   Z=0
```

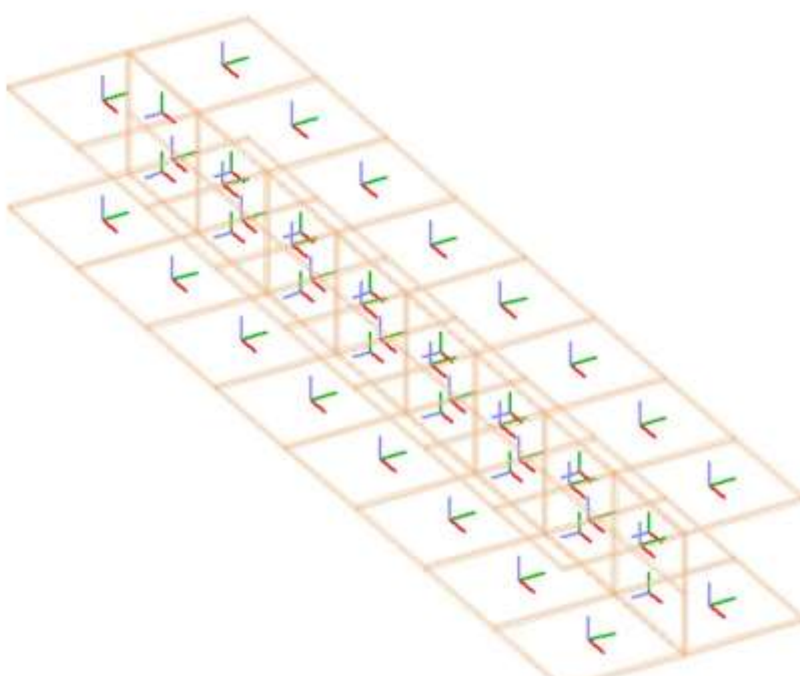
```
   36   X=20
   37   X=-20     Y=0     Z=0
   45   X=20                       Q=28,36,37,45,1,9
   46   X=-20             Z=5
   54   X=20                       G=46,54,1
   55   X=-20             Z=-5
   63   X=20                       G=55,63,1

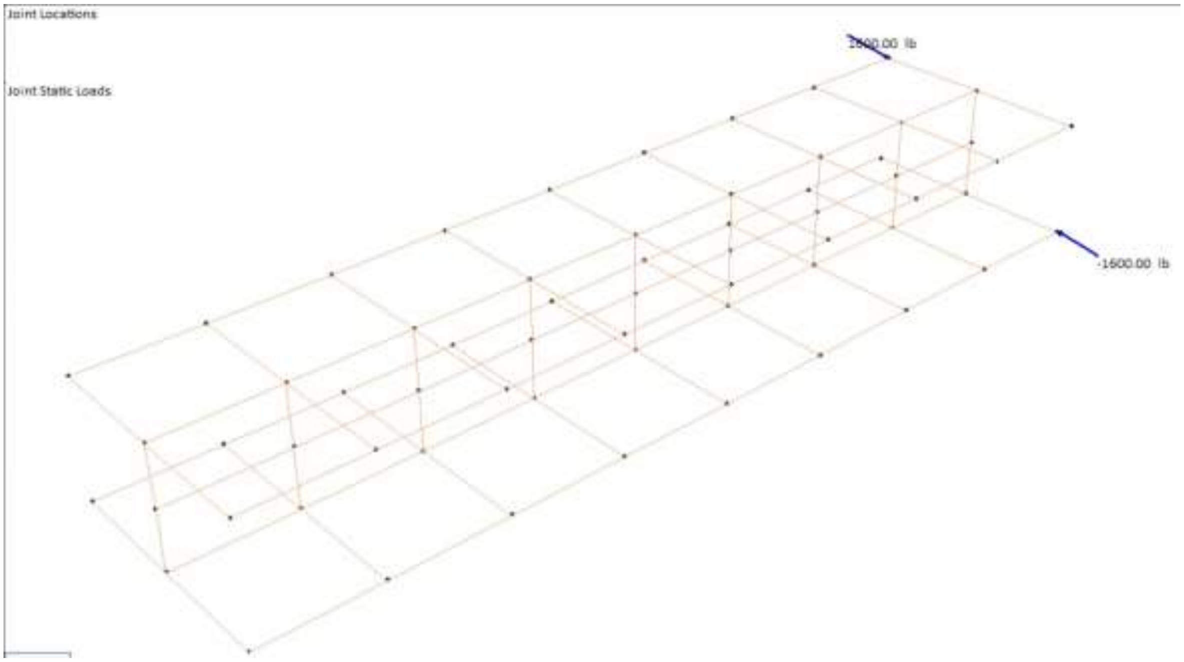
RESTRAINTS
C (R) DISPLACEMENT IN AXIS, (<) ROTATION ARROUND AXIS.
C 0=FREE   1=RESTRICTED
    1  19  9    RX=1   RY=1   RZ=1   <X=1   <Y=1   <Z=1
   28           RX=1   RY=1   RZ=1   <X=1   <Y=1   <Z=1
   37  55  9    RX=1   RY=1   RZ=1   <X=1   <Y=1   <Z=1

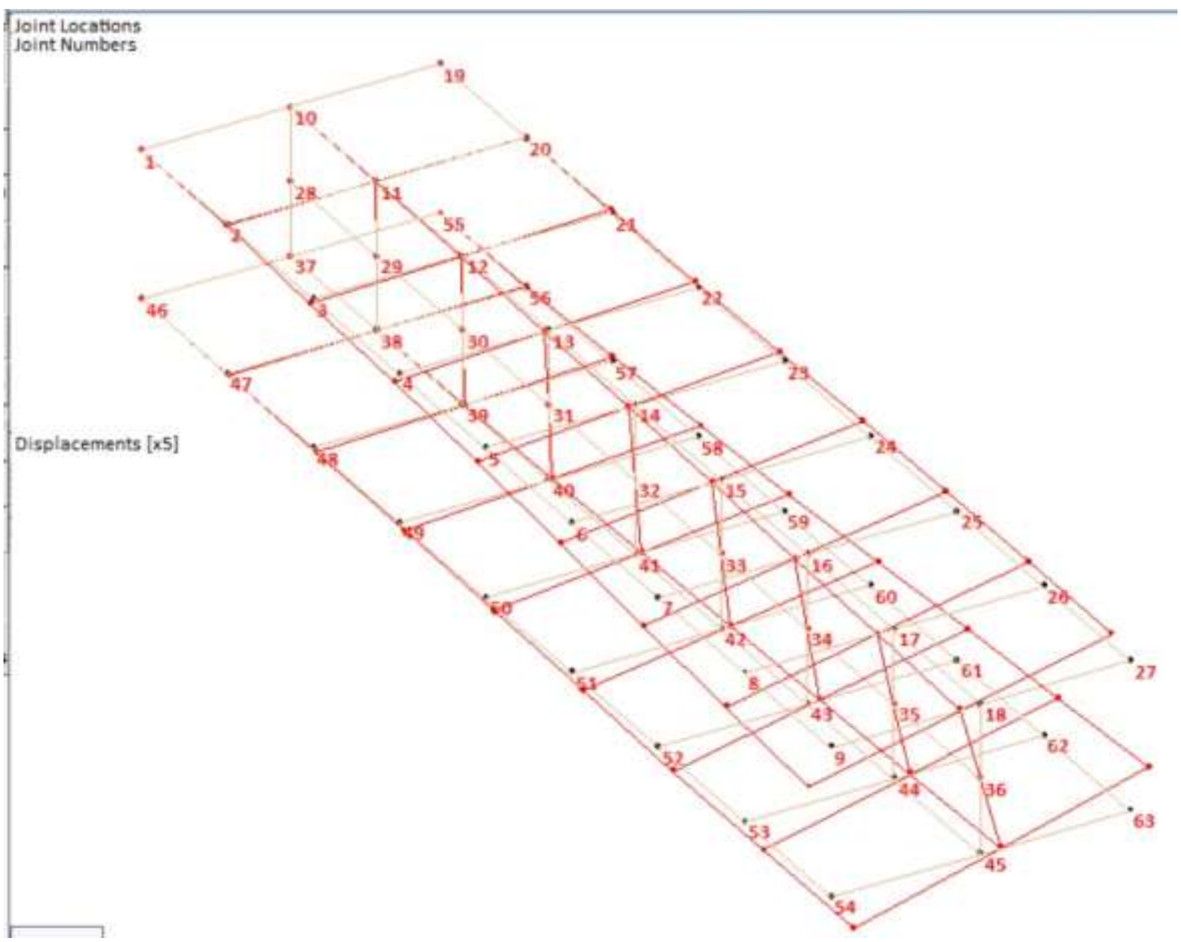
SHELLS
NM=1
C UNITS USED:  lb  :  in : °F
C E = 1E7 psi
C Poisson's ratio = 0.3
C Thickness = 0.25 in
C Type 0 = Bending, Shear & Membrane
C Shell Name = 0.25
  1  E=1E7  P=0.3  T=0.25  ST=0  :1.0
C SHELLS
  1  SJ=1,2,11,10    SM=1   SG=8,2
 17  SJ=28,29,11,10  SM=1   SG=8,1
 25  SJ=37,38,29,28  SM=1   SG=8,1
 33  SJ=46,47,38,37  SM=1   SG=8,1
 41  SJ=37,38,56,55  SM=1   SG=8,1

JLOADS
C UNITS  lb
C FZ 1.6 KIPS = 1600 lb PER JOINT AS A TORSION
  27    FZ=1600    L=1
  54    FZ=-1600   L=1

End of File
```




Joint Locations
Joint Static Loads
-1600.00 lb


Joint Locations
Joint Numbers
Displacements [x5]

```
□C:\STRUC 2024\ STRUC Ver. 1-2023   File: C:\Example 17\STATIC JAVA Test Example 17.DSM        Page 1
By: F. JANNAUT        Licenced to: CopyRight F. JANNAUT          Date: 07-01-2024

CANTILEVER I BEAM JAVA EXAMPLE 17 02/12/2024

            G L O B A L   D I S P L A C E M E N T S   S U M M A R Y

Load Combination 1 of 1   1.0DL
    Direction   Value  Unit   Joint
    Min  X    -0.024312 in       9
    Max  X     0.024947 in      54

    Min  Y    -0.236902 in      54
    Max  Y     0.236902 in      27

    Min  Z    -0.137445 in      54
    Max  Z     0.137445 in      27

    Min <X     0.000000 rad      1
    Max <X     0.057729 rad     36

    Min <Y    -0.005023 rad     18
    Max <Y     0.005023 rad     45

    Min <Z    -0.008507 rad     51
    Max <Z     0.008507 rad     24
□C:\STRUC 2024\ STRUC Ver. 1-2023   File: C:\Example 17\STATIC JAVA Test Example 17.DSM        Page 2
By: F. JANNAUT        Licenced to: CopyRight F. JANNAUT          Date: 07-01-2024

CANTILEVER I BEAM JAVA EXAMPLE 17 02/12/2024

             M I N I M U M   A N D   M A X I M U M   E N V E L O P E

    Direction   Value  Unit   Joint Load Comb Name
    Min  X    -0.024312 in       9        1    1.0DL
    Max  X     0.024947 in      54        1    1.0DL

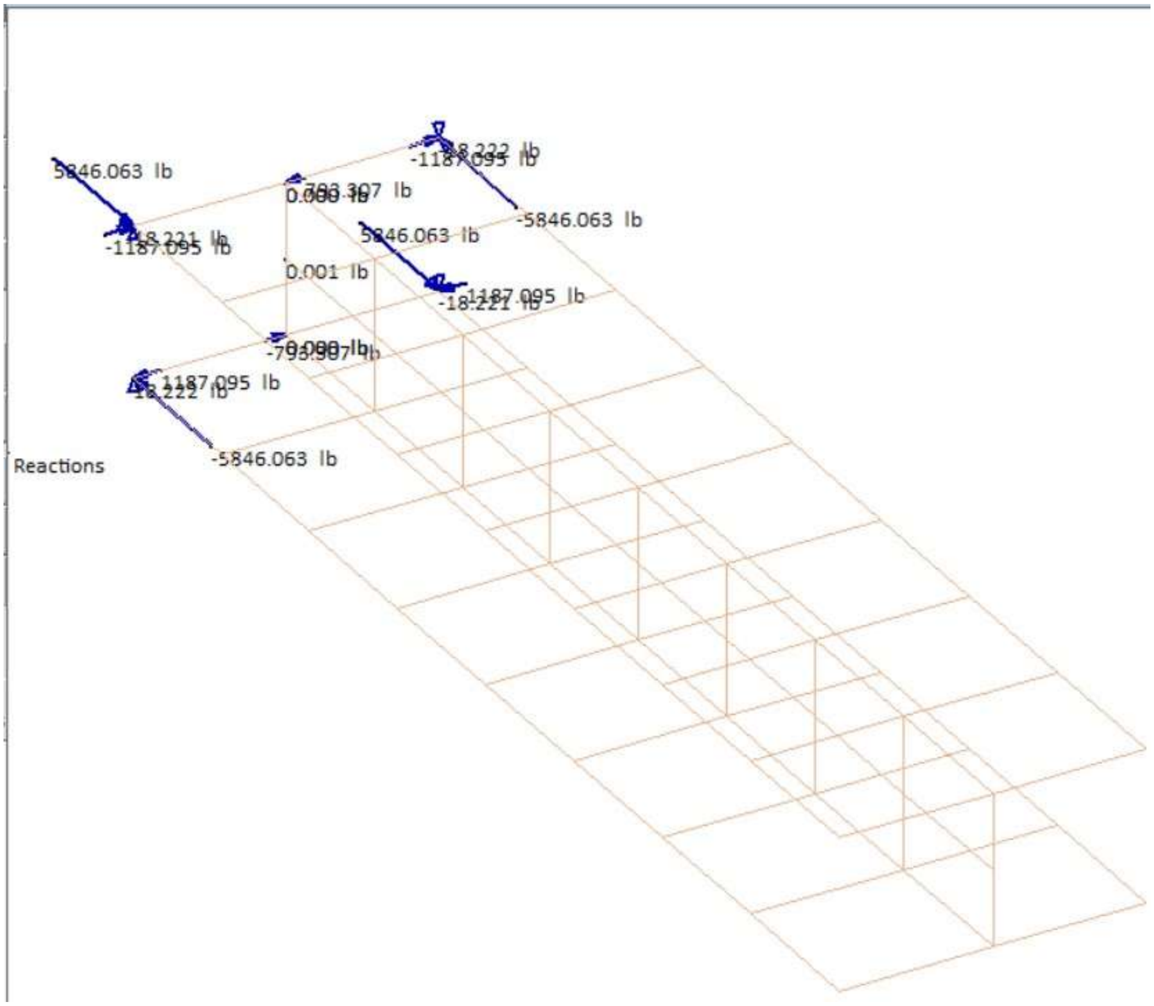
    Min  Y    -0.236902 in      54        1    1.0DL
    Max  Y     0.236902 in      27        1    1.0DL

    Min  Z    -0.137445 in      54        1    1.0DL
    Max  Z     0.137445 in      27        1    1.0DL

    Min <X     0.000000 rad      1        1    1.0DL
    Max <X     0.057729 rad     36        1    1.0DL

    Min <Y    -0.005023 rad     18        1    1.0DL
    Max <Y     0.005023 rad     45        1    1.0DL

    Min <Z    -0.008507 rad     51        1    1.0DL
    Max <Z     0.008507 rad     24        1    1.0DL
```



C:\STRUC 2024\ STRUC Ver. 1-2023 File: C:\SHELLS\STATIC JAVA Test Example 17.RSM Page 2
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CANTILEVER I BEAM JAVA EXAMPLE 17 02/12/2024

G L O B A L R E A C T I O N S S U M M A R Y

M I N I M U M A N D M A X I M U M E N V E L O P E

Direction	Value	Unit	Joint	Load Comb	Name
Min X	-5846.063	lb	19	1	1.0DL
Max X	5846.063	lb	55	1	1.0DL
Min Y	-18.222	lb	19	1	1.0DL
Max Y	18.222	lb	46	1	1.0DL
Min Z	-1187.095	lb	1	1	1.0DL
Max Z	1187.095	lb	55	1	1.0DL
Min MX	0	lb-in	2	1	1.0DL
Max MX	62.848	lb-in	37	1	1.0DL
Min MY	-7.484	lb-in	37	1	1.0DL
Max MY	7.484	lb-in	10	1	1.0DL
Min MZ	-30.649	lb-in	19	1	1.0DL
Max MZ	30.649	lb-in	46	1	1.0DL

```
C:\STRUC 2024\ STRUC Ver. 1-2023   File: C:\Example 17\STATIC JAVA Test Example 17.SFS        Page 1
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CANTILEVER I BEAM JAVA EXAMPLE 17 02/12/2024

 Load Combinations
    1 1.0DL

 S H E L L S   I N T E R N A L   F O R C E S   S U M M A R Y

    M I N I M U M   A N D   M A X I M U M   E N V E L O P E


                Force   Units    Shell  Joint   LC  Name
     F1 Min.  -5846.063 lb          9     19     1  1.0DL
     F1 Max.   5846.063 lb         41     55     1  1.0DL

     F2 Min.  -1600.000 lb         16     27     1  1.0DL
     F2 Max.   1600.000 lb         40     54     1  1.0DL

     F3 Min.   -120.182 lb         32     45     1  1.0DL
     F3 Max.    120.182 lb         32     35     1  1.0DL

     M1 Min.   -189.232 lb-in      32     44     1  1.0DL
     M1 Max.     81.346 lb-in      48     45     1  1.0DL

     M2 Min.   -164.259 lb-in      31     35     1  1.0DL
     M2 Max.    164.259 lb-in      23     35     1  1.0DL

     M3 Min.     -3.850 lb-in       8     18     1  1.0DL
     M3 Max.      3.850 lb-in      40     45     1  1.0DL
```

```
C:\STRUC 2024\ STRUC Ver. 1-2023   File: C:\Example 17\STATIC JAVA Test Example 17.SSS        Page 1
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CANTILEVER I BEAM JAVA EXAMPLE 17 02/12/2024

 Load Combinations
    1 1.0DL

 S H E L L S   I N T E R N A L   S T R E S S E S   S U M M A R Y

     M I N I M U M   A N D   M A X I M U M   E N V E L O P E

            S T R E S S E S   A T   J O I N T S

                Stress      Units     Shell  Joint   LC  Name
    S11 Min.  -3123.757 lb/in/in       41     55     1  1.0DL
    S11 Max.   3123.757 lb/in/in        9     19     1  1.0DL

    S22 Min.   -937.127 lb/in/in       41     55     1  1.0DL
    S22 Max.    937.127 lb/in/in        9     19     1  1.0DL

    S12 Min.   -795.669 lb/in/in        1      1     1  1.0DL
    S12 Max.    795.669 lb/in/in       41     55     1  1.0DL

    M11 Min.    -12.110 lb/in/in       32     36     1  1.0DL
    M11 Max.     12.110 lb/in/in       24     36     1  1.0DL

    M22 Min.    -40.367 lb/in/in       32     36     1  1.0DL
    M22 Max.     40.367 lb/in/in       24     36     1  1.0DL

    M12 Min.    -21.759 lb/in/in       32     36     1  1.0DL
    M12 Max.     -0.967 lb/in/in       17     28     1  1.0DL
```

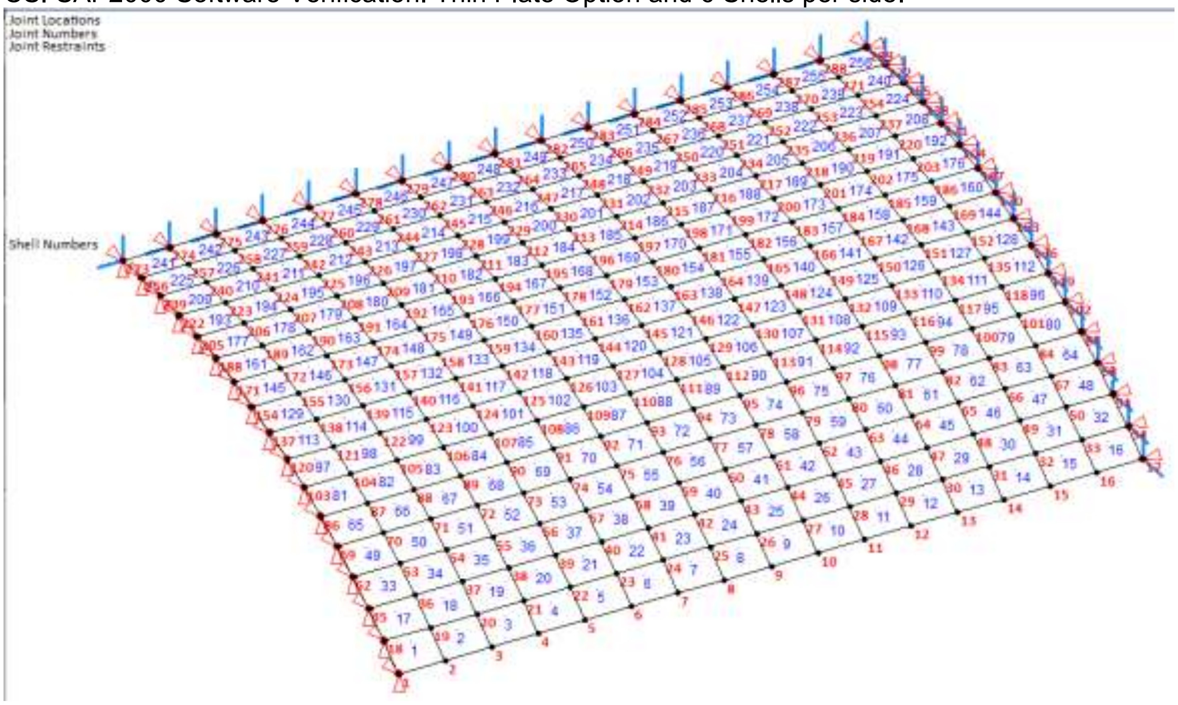
Results chart

Results for Deflection at Joint 9 in X direction.

	Thesis	**STRUC**
Joint	**Deflection (in)**	**Deflection (in)**
9	-0.025120	-0.024312

C.12 The Scordelis-Lo Barrel Vault

Reference: CSI Software Verification, EXAMPLE 2-006 Shell-Scordelis-Lo Roof with Static Loads" by CSI SAP2000 Software Verification. Thin Plate Option and 6 Shells per side.



The Scordelis-Lo barrel vault is a classical test problem for shell structures (MacNeal and Harder, 1985, Scordelis and Lo, 1964). The structure is a barrel vault with a radius of 25 ft, subtended angle of 80 degrees, length of 50 ft, and thickness of 3 in, subject to a self-weight of 90 lb/ft^2. Because of symmetry, a quarter of the structure is modeled in STRUC using 16x16 element mesh. Results are also presented using 4x4 element mesh, and 8x8 element mesh to show the asymptotic analysis of this problem.

E = 4.32E8 psf
Poisson Ratio = 0.0
Thickness = 0.25 ft (3 in)

Input data file: "STATIC SCORDELIS_LO 16 PER SIDE"

```
SCORDELIS-LO 16 PER SIDE TEST 02/28/2025

CONTROL
L=1
C LOAD CONDITION NAMES
  1  SW
C GENERAL PARAMETERS
UF=5  UL=6  UT=2  MT=1   :UNITS  lb   ft  °F

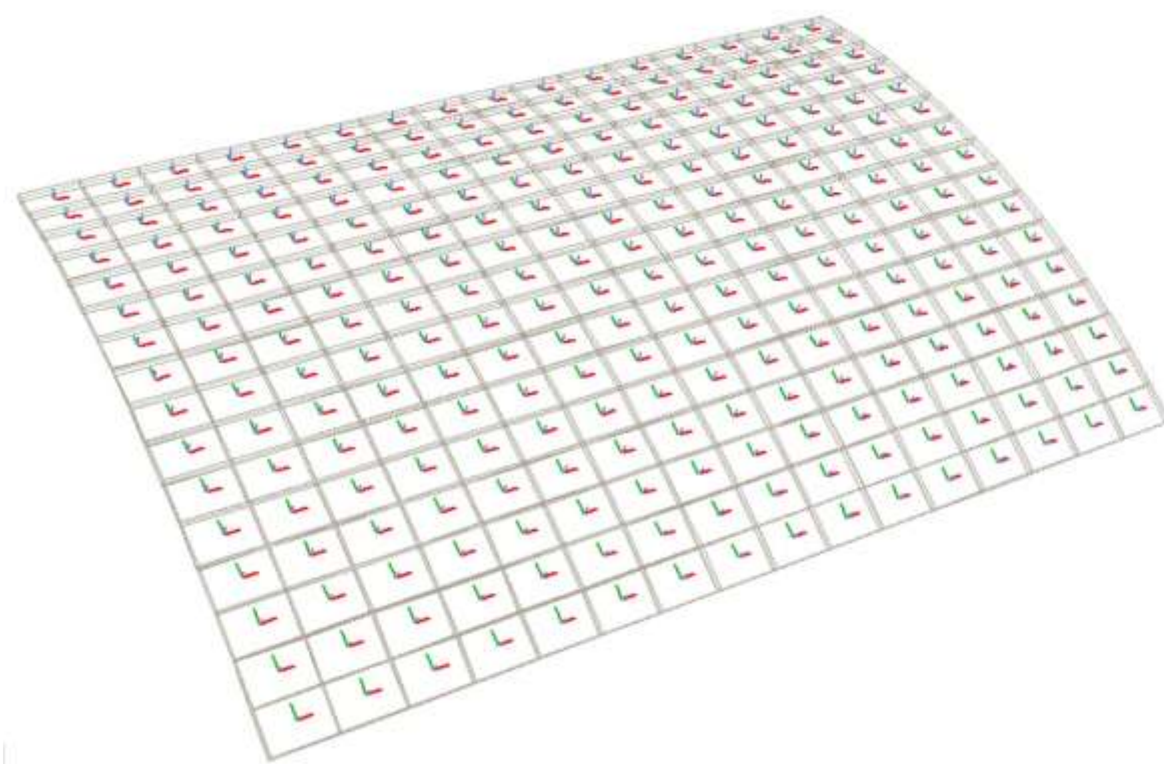
JOINTS
C
 290   X=0    Y=0    Z=0
 291                 Z=25
    1   X=16.06969024  Y=19.151111078  Z=25  C=290,291,1,16,17,2.5
   17                                  Z=0   G=1,17,1   F=1,17,273,1,17
```

```
RESTRAINTS
    1  256  17   RX=1  RY=1  RZ=0  <X=0  <Y=0  <Z=0
  273            RX=1  RY=1  RZ=0  <X=0  <Y=1  <Z=1
  274   288      RX=1  RY=0  RZ=0  <X=0  <Y=1  <Z=1
   17   272 17   RX=0  RY=0  RZ=1  <X=1  <Y=1  <Z=0
  289            RX=1  RY=0  RZ=1  <X=1  <Y=1  <Z=1

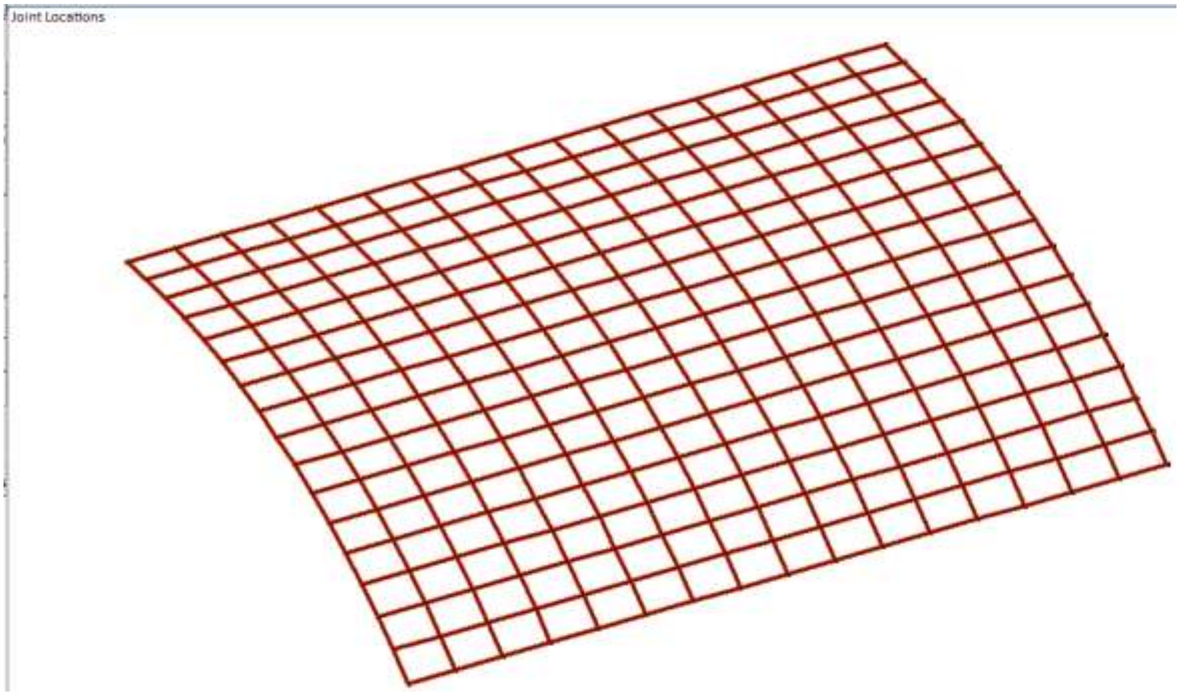
SHELLS
NM=1
C
 1  E=4.32E8  P=0  T=0.25  ST=0  W=360  TC=0.00001
C
   1  SJ=1,2,19,18  SM=1  SG=16,16

SHLOADS
C UNITS  lb
C Self Weight = Shell W Density (360 lb/ft3) X Thickness (0.25 ft) = 90 lb/ft2
NP=0  WY=-1  L=1

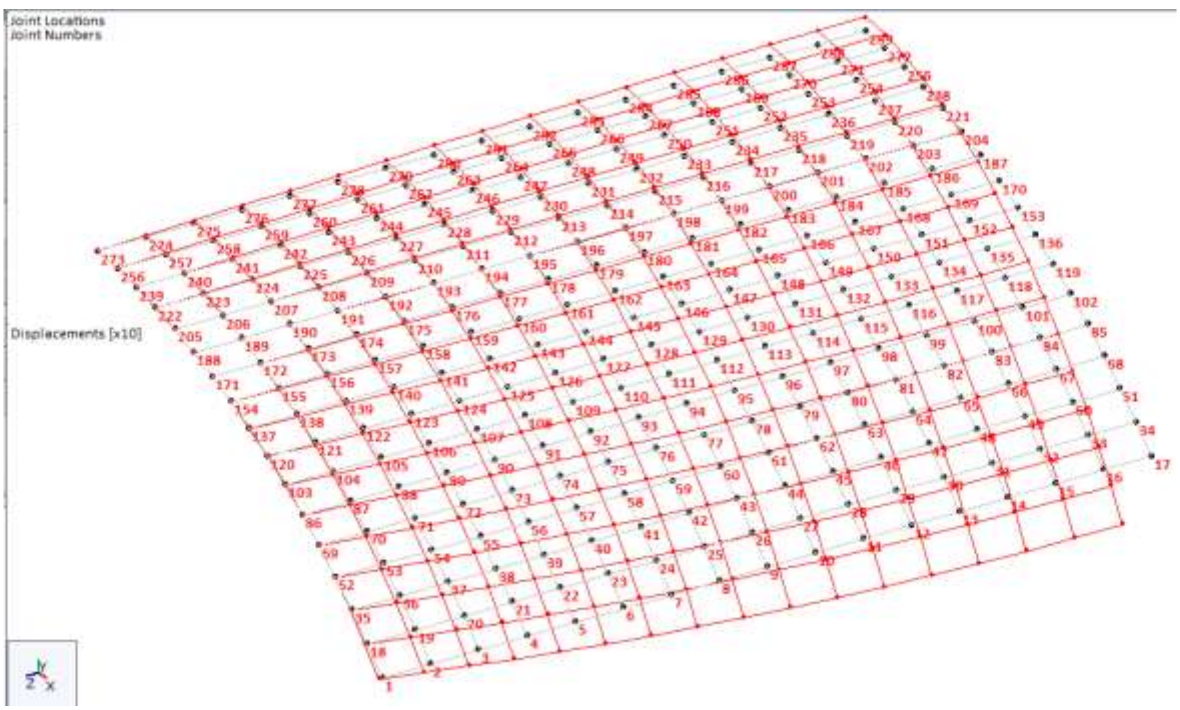
C End of File
```



Local axes 1, 2 and 3 orientations



Self weight applied



Joint numbers and Global Displacements

```
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SCORDELIS-LO 16 PER SIDE TEST 02/28/2025

                    G L O B A L     D I S P L A C E M E N T S

Load Combination 1 of 1   1.0SW
Joint    Disp X       Disp Y       Disp Z       Rot X        Rot Y        Rot Z
           ft           ft           ft          rad          rad          rad
    1       0            0        0.01246170 -0.01851325  0.01485846 -2.8051E-04
    2  -0.01825498 -0.03386192  0.01237356 -0.01799236  0.01444039 -0.00342090
    3  -0.03584379 -0.06668692  0.01212030 -0.01732577  0.01390540 -0.00725975
    4  -0.05266843 -0.09819610  0.01172505 -0.01651426  0.01325410 -0.01020790
    5  -0.06852422 -0.12802187  0.01120933 -0.01551614  0.01245302 -0.01358622
    6  -0.08335883 -0.15601236  0.01059058 -0.01448682  0.01162690 -0.01621995
    7  -0.09705492 -0.18195163  0.00988267 -0.01332876  0.01069746 -0.01905826
    8  -0.10959670 -0.20576055  0.00909725 -0.01215474  0.00975521 -0.02129507
    9  -0.12089571 -0.22727907  0.00824457 -0.01089362  0.00874306 -0.02358923
   10  -0.13095662 -0.24646994  0.00733396 -0.00962225  0.00772267 -0.02538454
   11  -0.13970908 -0.26321015  0.00637403 -0.00829333  0.00665610 -0.02714075
   12  -0.14716957 -0.27749005  0.00537280 -0.00695712  0.00558368 -0.02846595
   13  -0.15327995 -0.28921339  0.00433782 -0.00558432  0.00448189 -0.02969057
   14  -0.15806409 -0.29839014  0.00327626 -0.00420649  0.00337606 -0.03052639
   15  -0.16147292 -0.30494496  0.00219501 -0.00280825  0.00225386 -0.03122535
   16  -0.16353615 -0.30890410  0.00110074 -0.00140741  0.00112956 -0.03155840
   17  -0.16421209 -0.31020992      0            0            0        -0.03173773
```

```
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SCORDELIS-LO 16 PER SIDE TEST 02/28/2025

             G L O B A L    D I S P L A C E M E N T S    S U M M A R Y

Load Combination 1 of 1   1.0SW
    Direction    Value  Unit   Joint
    Min  X     -0.164212 ft      17
    Max  X      0.000000 ft       1

    Min  Y     -0.310210 ft      17
    Max  Y      0.046921 ft     289

    Min  Z     -0.002818 ft     120
    Max  Z      0.012462 ft       1

    Min <X     -0.018513 rad      1
    Max <X      0.002908 rad    275

    Min <Y      0.000000 rad     17
    Max <Y      0.022931 rad     18

    Min <Z     -0.031897 rad     68
    Max <Z      0.000000 rad    273
```

```
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SCORDELIS-LO 16 PER SIDE TEST 02/28/2025

              M I N I M U M   A N D   M A X I M U M   E N V E L O P E

    Direction    Value  Unit   Joint Load Comb Name
    Min  X     -0.164212 ft      17        1     1.0SW
    Max  X      0.000000 ft       1        1     1.0SW

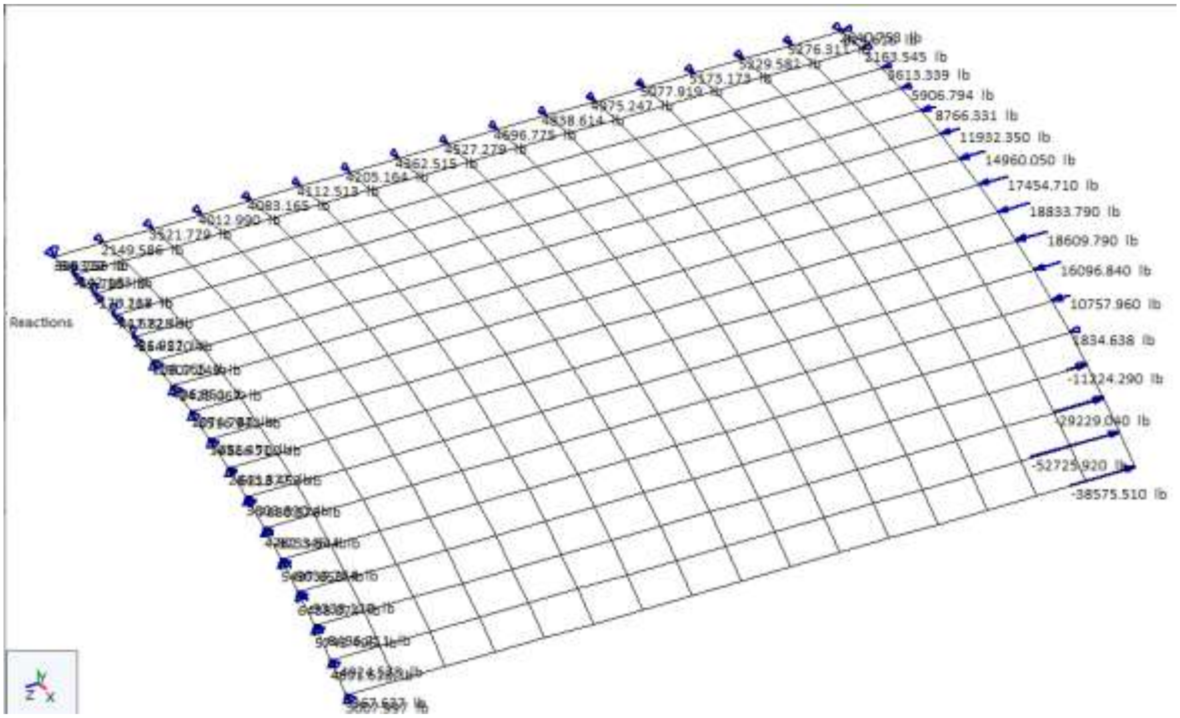
    Min  Y     -0.310210 ft      17        1     1.0SW
    Max  Y      0.046921 ft     289        1     1.0SW

    Min  Z     -0.002818 ft     120        1     1.0SW
    Max  Z      0.012462 ft       1        1     1.0SW

    Min <X     -0.018513 rad      1        1     1.0SW
    Max <X      0.002908 rad    275        1     1.0SW

    Min <Y      0.000000 rad     17        1     1.0SW
    Max <Y      0.022931 rad     18        1     1.0SW

    Min <Z     -0.031897 rad     68        1     1.0SW
    Max <Z      0.000000 rad    273        1     1.0SW
```



Global Reactions (Forces only)

```
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SCORDELIS-LO 16 PER SIDE TEST 02/28/2025

                G L O B A L   R E A C T I O N S   S U M M A R Y


             M I N I M U M   A N D   M A X I M U M   E N V E L O P E

    Direction    Value     Unit      Joint Load Comb Name
    Min  X     -9624.265   lb          69       1     1.0SW
    Max  X      5238.392   lb         288       1     1.0SW

    Min  Y      -153.009   lb         239       1     1.0SW
    Max  Y      6419.401   lb          52       1     1.0SW

    Min  Z    -53271.594   lb          34       1     1.0SW
    Max  Z     19190.022   lb         153       1     1.0SW

    Min MX      -101.401   lb-ft      272       1     1.0SW
    Max MX       531.575   lb-ft       34       1     1.0SW

    Min MY      -411.022   lb-ft       34       1     1.0SW
    Max MY         6.720   lb-ft      238       1     1.0SW

    Min MZ         0       lb-ft        1       1     1.0SW
    Max MZ      3256.473   lb-ft      288       1     1.0SW
```

```
E:\STRUC 2025\ STRUC Ver. 3-2025   File: ALIBRATION FILES\STATIC SCORDELIS-LO 16 PER SIDE.SFS Page 1
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SCORDELIS-LO 16 PER SIDE TEST 02/28/2025

 Load Combinations
    1 1.0SW

 S H E L L S   I N T E R N A L   F O R C E S   S U M M A R Y

    M I N I M U M   A N D   M A X I M U M   E N V E L O P E

                Force    Units     Shell  Joint   LC  Name
     F1 Min. -38970.962 lb           16     16     1  1.0SW
     F1 Max.  39096.130 lb           16     17     1  1.0SW

     F2 Min.  -6660.084 lb           50     71     1  1.0SW
     F2 Max.   6488.849 lb           50     53     1  1.0SW

     F3 Min.  -1816.726 lb            1     19     1  1.0SW
     F3 Max.   1816.726 lb            1      1     1  1.0SW

     M1 Min.  -1637.629 lb-ft       256    289     1  1.0SW
     M1 Max.   1624.140 lb-ft       256    272     1  1.0SW

     M2 Min.  -1532.048 lb-ft         2     20     1  1.0SW
     M2 Max.   1522.396 lb-ft        18     19     1  1.0SW

     M3 Min.      0     lb-ft        13     14     1  1.0SW
     M3 Max.      2.739 lb-ft        17     19     1  1.0SW
```

```
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SCORDELIS-LO 16 PER SIDE TEST 02/28/2025

 Load Combinations
    1 1.0SW

 S H E L L S   I N T E R N A L   S T R E S S E S   S U M M A R Y

     M I N I M U M   A N D   M A X I M U M   E N V E L O P E

            S T R E S S E S   A T   J O I N T S

               Stress     Units     Shell  Joint   LC  Name
    S11 Min. -17695.514 lb/ft/ft     128    153     1  1.0SW
    S11 Max.  76083.328 lb/ft/ft      16     17     1  1.0SW

    S22 Min.  -3357.222 lb/ft/ft     256    272     1  1.0SW
    S22 Max.      0     lb/ft/ft       1     18     1  1.0SW

    S12 Min. -10974.807 lb/ft/ft      34     54     1  1.0SW
    S12 Max.   9875.453 lb/ft/ft      16     16     1  1.0SW

    M11 Min.   -649.668 lb-ft/ft      16     17     1  1.0SW
    M11 Max.     99.791 lb-ft/ft     256    289     1  1.0SW

    M22 Min.    -50.151 lb-ft/ft      32     34     1  1.0SW
    M22 Max.   2091.423 lb-ft/ft     256    272     1  1.0SW

    M12 Min.  -1374.184 lb-ft/ft      18     36     1  1.0SW
    M12 Max.      0     lb-ft/ft     256    289     1  1.0SW
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Results chart

Results for Maximum Deflection in Y direction. Reference: "CSI Software Verification, EXAMPLE 2-006 Shell-Scordelis-Lo Roof with Static Loads" by CSI SAP2000 Software Verification. Thin Plate Option and 6 Shells per side.

	SAP2000 6X6	**STRUC 4X4**	**STRUC 8X8**	**STRUC 16X16**
Direction (Y)	**Deflection (ft)**	**Deflection (ft)**	**Deflection (ft)**	**Deflection (ft)**
Vertical	-0.3068	-0.301485	-0.306915	-0.310210

D APPENDIXES

D.1 AISC15.BIN File of American Shapes

D.1.1 Cross Reference for: W, M, S, HP, WT, MT, ST, C, MC, L, 2L, HSS, PIPE Types

Number	Type	Name	Number	Type	Name	Number	Type	Name	Number	Type	Name	Number	Type	Name
1	W	W44X335	67	W	W30X391	133	W	W21X83	199	W	W14X109	265	W	W8X35
2	W	W44X290	68	W	W30X357	134	W	W21X73	200	W	W14X99	266	W	W8X31
3	W	W44X262	69	W	W30X326	135	W	W21X68	201	W	W14X90	267	W	W8X28
4	W	W44X230	70	W	W30X292	136	W	W21X62	202	W	W14X82	268	W	W8X24
5	W	W40X655	71	W	W30X261	137	W	W21X55	203	W	W14X74	269	W	W8X21
6	W	W40X593	72	W	W30X235	138	W	W21X48	204	W	W14X68	270	W	W8X18
7	W	W40X503	73	W	W30X211	139	W	W21X57	205	W	W14X61	271	W	W8X15
8	W	W40X431	74	W	W30X191	140	W	W21X50	206	W	W14X53	272	W	W8X13
9	W	W40X397	75	W	W30X173	141	W	W21X44	207	W	W14X48	273	W	W8X10
10	W	W40X372	76	W	W30X148	142	W	W18X311	208	W	W14X43	274	W	W6X25
11	W	W40X362	77	W	W30X132	143	W	W18X283	209	W	W14X38	275	W	W6X20
12	W	W40X324	78	W	W30X124	144	W	W18X258	210	W	W14X34	276	W	W6X15
13	W	W40X297	79	W	W30X116	145	W	W18X234	211	W	W14X30	277	W	W6X16
14	W	W40X277	80	W	W30X108	146	W	W18X211	212	W	W14X26	278	W	W6X12
15	W	W40X249	81	W	W30X99	147	W	W18X192	213	W	W14X22	279	W	W6X9
16	W	W40X215	82	W	W30X90	148	W	W18X175	214	W	W12X336	280	W	W6X8.5
17	W	W40X199	83	W	W27X539	149	W	W18X158	215	W	W12X305	281	W	W5X19
18	W	W40X392	84	W	W27X368	150	W	W18X143	216	W	W12X279	282	W	W5X16
19	W	W40X331	85	W	W27X336	151	W	W18X130	217	W	W12X252	283	W	W4X13
20	W	W40X327	86	W	W27X307	152	W	W18X119	218	W	W12X230	284	M	M12.5X12.4
21	W	W40X294	87	W	W27X281	153	W	W18X106	219	W	W12X210	285	M	M12.5X11.6
22	W	W40X278	88	W	W27X258	154	W	W18X97	220	W	W12X190	286	M	M12X11.8
23	W	W40X264	89	W	W27X235	155	W	W18X86	221	W	W12X170	287	M	M12X10.8
24	W	W40X235	90	W	W27X217	156	W	W18X76	222	W	W12X152	288	M	M12X10
25	W	W40X211	91	W	W27X194	157	W	W18X71	223	W	W12X136	289	M	M10X9
26	W	W40X183	92	W	W27X178	158	W	W18X65	224	W	W12X120	290	M	M10X8
27	W	W40X167	93	W	W27X161	159	W	W18X60	225	W	W12X106	291	M	M10X7.5
28	W	W40X149	94	W	W27X146	160	W	W18X55	226	W	W12X96	292	M	M8X6.5
29	W	W36X925	95	W	W27X129	161	W	W18X50	227	W	W12X87	293	M	M8X6.2
30	W	W36X853	96	W	W27X114	162	W	W18X46	228	W	W12X79	294	M	M6X4.4
31	W	W36X802	97	W	W27X102	163	W	W18X40	229	W	W12X72	295	M	M6X3.7
32	W	W36X723	98	W	W27X94	164	W	W18X35	230	W	W12X65	296	M	M5X18.9
33	W	W36X652	99	W	W27X84	165	W	W16X100	231	W	W12X58	297	M	M4X6
34	W	W36X529	100	W	W24X370	166	W	W16X89	232	W	W12X53	298	M	M4X4.08
35	W	W36X487	101	W	W24X335	167	W	W16X77	233	W	W12X50	299	M	M4X3.45
36	W	W36X441	102	W	W24X306	168	W	W16X67	234	W	W12X45	300	M	M4X3.2
37	W	W36X395	103	W	W24X279	169	W	W16X57	235	W	W12X40	301	M	M3X2.9
38	W	W36X361	104	W	W24X250	170	W	W16X50	236	W	W12X35	302	S	S24X121
39	W	W36X330	105	W	W24X229	171	W	W16X45	237	W	W12X30	303	S	S24X106
40	W	W36X302	106	W	W24X207	172	W	W16X40	238	W	W12X26	304	S	S24X100
41	W	W36X282	107	W	W24X192	173	W	W16X36	239	W	W12X22	305	S	S24X90
42	W	W36X262	108	W	W24X176	174	W	W16X31	240	W	W12X19	306	S	S24X80
43	W	W36X247	109	W	W24X162	175	W	W16X26	241	W	W12X16	307	S	S20X96
44	W	W36X231	110	W	W24X146	176	W	W14X873	242	W	W12X14	308	S	S20X86
45	W	W36X256	111	W	W24X131	177	W	W14X808	243	W	W10X112	309	S	S20X75
46	W	W36X232	112	W	W24X117	178	W	W14X730	244	W	W10X100	310	S	S20X66
47	W	W36X210	113	W	W24X104	179	W	W14X665	245	W	W10X88	311	S	S18X70
48	W	W36X194	114	W	W24X103	180	W	W14X605	246	W	W10X77	312	S	S18X54.7
49	W	W36X182	115	W	W24X94	181	W	W14X550	247	W	W10X68	313	S	S15X50
50	W	W36X170	116	W	W24X84	182	W	W14X500	248	W	W10X60	314	S	S15X42.9
51	W	W36X160	117	W	W24X76	183	W	W14X455	249	W	W10X54	315	S	S12X50
52	W	W36X150	118	W	W24X68	184	W	W14X426	250	W	W10X49	316	S	S12X40.8
53	W	W36X135	119	W	W24X62	185	W	W14X398	251	W	W10X45	317	S	S12X35
54	W	W33X387	120	W	W24X55	186	W	W14X370	252	W	W10X39	318	S	S12X31.8
55	W	W33X354	121	W	W21X275	187	W	W14X342	253	W	W10X33	319	S	S10X35
56	W	W33X318	122	W	W21X248	188	W	W14X311	254	W	W10X30	320	S	S10X25.4
57	W	W33X291	123	W	W21X223	189	W	W14X283	255	W	W10X26	321	S	S8X23
58	W	W33X263	124	W	W21X201	190	W	W14X257	256	W	W10X22	322	S	S8X18.4
59	W	W33X241	125	W	W21X182	191	W	W14X233	257	W	W10X19	323	S	S6X17.25
60	W	W33X221	126	W	W21X166	192	W	W14X211	258	W	W10X17	324	S	S6X12.5
61	W	W33X201	127	W	W21X147	193	W	W14X193	259	W	W10X15	325	S	S5X10
62	W	W33X169	128	W	W21X132	194	W	W14X176	260	W	W10X12	326	S	S4X9.5
63	W	W33X152	129	W	W21X122	195	W	W14X159	261	W	W8X67	327	S	S4X7.7
64	W	W33X141	130	W	W21X111	196	W	W14X145	262	W	W8X58	328	S	S3X7.5
65	W	W33X130	131	W	W21X101	197	W	W14X132	263	W	W8X48	329	S	S3X5.7
66	W	W33X118	132	W	W21X93	198	W	W14X120	264	W	W8X40	330	HP	HP18X204

Number	Type	Name	Number	Type	Name	Number	Type	Name	Number	Type	Name	Number	Type	Name
331	HP	HP18X181	397	WT	WT18X116	463	WT	WT12X58.5	529	WT	WT7X365	595	WT	WT5X50
332	HP	HP18X157	398	WT	WT18X105	464	WT	WT12X52	530	WT	WT7X332.5	596	WT	WT5X44
333	HP	HP18X135	399	WT	WT18X97	465	WT	WT12X51.5	531	WT	WT7X302.5	597	WT	WT5X38.5
334	HP	HP16X183	400	WT	WT18X91	466	WT	WT12X47	532	WT	WT7X275	598	WT	WT5X34
335	HP	HP16X162	401	WT	WT18X85	467	WT	WT12X42	533	WT	WT7X250	599	WT	WT5X30
336	HP	HP16X141	402	WT	WT18X80	468	WT	WT12X38	534	WT	WT7X227.5	600	WT	WT5X27
337	HP	HP16X121	403	WT	WT18X75	469	WT	WT12X34	535	WT	WT7X213	601	WT	WT5X24.5
338	HP	HP16X101	404	WT	WT18X67.5	470	WT	WT12X31	536	WT	WT7X199	602	WT	WT5X22.5
339	HP	HP16X88	405	WT	WT16.5X193.5	471	WT	WT12X27.5	537	WT	WT7X185	603	WT	WT5X19.5
340	HP	HP14X117	406	WT	WT16.5X177	472	WT	WT10.5X137.5	538	WT	WT7X171	604	WT	WT5X16.5
341	HP	HP14X102	407	WT	WT16.5X159	473	WT	WT10.5X124	539	WT	WT7X155.5	605	WT	WT5X15
342	HP	HP14X89	408	WT	WT16.5X145.5	474	WT	WT10.5X111.5	540	WT	WT7X141.5	606	WT	WT5X13
343	HP	HP14X73	409	WT	WT16.5X131.5	475	WT	WT10.5X100.5	541	WT	WT7X128.5	607	WT	WT5X11
344	HP	HP12X89	410	WT	WT16.5X120.5	476	WT	WT10.5X91	542	WT	WT7X116.5	608	WT	WT5X9.5
345	HP	HP12X84	411	WT	WT16.5X110.5	477	WT	WT10.5X83	543	WT	WT7X105.5	609	WT	WT5X8.5
346	HP	HP12X74	412	WT	WT16.5X100.5	478	WT	WT10.5X73.5	544	WT	WT7X96.5	610	WT	WT5X7.5
347	HP	HP12X63	413	WT	WT16.5X84.5	479	WT	WT10.5X66	545	WT	WT7X88	611	WT	WT5X6
348	HP	HP12X53	414	WT	WT16.5X76	480	WT	WT10.5X61	546	WT	WT7X79.5	612	WT	WT4X33.5
349	HP	HP10X57	415	WT	WT16.5X70.5	481	WT	WT10.5X55.5	547	WT	WT7X72.5	613	WT	WT4X29
350	HP	HP10X42	416	WT	WT16.5X65	482	WT	WT10.5X50.5	548	WT	WT7X66	614	WT	WT4X24
351	HP	HP8X36	417	WT	WT16.5X59	483	WT	WT10.5X46.5	549	WT	WT7X60	615	WT	WT4X20
352	WT	WT22X167.5	418	WT	WT15X195.5	484	WT	WT10.5X41.5	550	WT	WT7X54.5	616	WT	WT4X17.5
353	WT	WT22X145	419	WT	WT15X178.5	485	WT	WT10.5X36.5	551	WT	WT7X49.5	617	WT	WT4X15.5
354	WT	WT22X131	420	WT	WT15X163	486	WT	WT10.5X34	552	WT	WT7X45	618	WT	WT4X14
355	WT	WT22X115	421	WT	WT15X146	487	WT	WT10.5X31	553	WT	WT7X41	619	WT	WT4X12
356	WT	WT20X327.5	422	WT	WT15X130.5	488	WT	WT10.5X27.5	554	WT	WT7X37	620	WT	WT4X10.5
357	WT	WT20X296.5	423	WT	WT15X117.5	489	WT	WT10.5X24	555	WT	WT7X34	621	WT	WT4X9
358	WT	WT20X251.5	424	WT	WT15X105.5	490	WT	WT10.5X28.5	556	WT	WT7X30.5	622	WT	WT4X7.5
359	WT	WT20X215.5	425	WT	WT15X95.5	491	WT	WT10.5X25	557	WT	WT7X26.5	623	WT	WT4X6.5
360	WT	WT20X198.5	426	WT	WT15X86.5	492	WT	WT10.5X22	558	WT	WT7X24	624	WT	WT4X5
361	WT	WT20X186	427	WT	WT15X74	493	WT	WT9X155.5	559	WT	WT7X21.5	625	WT	WT3X12.5
362	WT	WT20X181	428	WT	WT15X66	494	WT	WT9X141.5	560	WT	WT7X19	626	WT	WT3X10
363	WT	WT20X162	429	WT	WT15X62	495	WT	WT9X129	561	WT	WT7X17	627	WT	WT3X7.5
364	WT	WT20X148.5	430	WT	WT15X58	496	WT	WT9X117	562	WT	WT7X15	628	WT	WT3X8
365	WT	WT20X138.5	431	WT	WT15X54	497	WT	WT9X105.5	563	WT	WT7X13	629	WT	WT3X6
366	WT	WT20X124.5	432	WT	WT15X49.5	498	WT	WT9X96	564	WT	WT7X11	630	WT	WT3X4.5
367	WT	WT20X107.5	433	WT	WT15X45	499	WT	WT9X87.5	565	WT	WT6X168	631	WT	WT3X4.25
368	WT	WT20X99.5	434	WT	WT13.5X269.5	500	WT	WT9X79	566	WT	WT6X152.5	632	WT	WT2.5X9.5
369	WT	WT20X196	435	WT	WT13.5X184	501	WT	WT9X71.5	567	WT	WT6X139.5	633	WT	WT2.5X8
370	WT	WT20X165.5	436	WT	WT13.5X168	502	WT	WT9X65	568	WT	WT6X126	634	WT	WT2X6.5
371	WT	WT20X163.5	437	WT	WT13.5X153.5	503	WT	WT9X59.5	569	WT	WT6X115	635	MT	MT6.25X6.2
372	WT	WT20X147	438	WT	WT13.5X140.5	504	WT	WT9X53	570	WT	WT6X105	636	MT	MT6.25X5.8
373	WT	WT20X139	439	WT	WT13.5X129	505	WT	WT9X48.5	571	WT	WT6X95	637	MT	MT6X5.9
374	WT	WT20X132	440	WT	WT13.5X117.5	506	WT	WT9X43	572	WT	WT6X85	638	MT	MT6X5.4
375	WT	WT20X117.5	441	WT	WT13.5X108.5	507	WT	WT9X38	573	WT	WT6X76	639	MT	MT6X5
376	WT	WT20X105.5	442	WT	WT13.5X97	508	WT	WT9X35.5	574	WT	WT6X68	640	MT	MT5X4.5
377	WT	WT20X91.5	443	WT	WT13.5X89	509	WT	WT9X32.5	575	WT	WT6X60	641	MT	MT5X4
378	WT	WT20X83.5	444	WT	WT13.5X80.5	510	WT	WT9X30	576	WT	WT6X53	642	MT	MT5X3.75
379	WT	WT20X74.5	445	WT	WT13.5X73	511	WT	WT9X27.5	577	WT	WT6X48	643	MT	MT4X3.25
380	WT	WT18X462.5	446	WT	WT13.5X64.5	512	WT	WT9X25	578	WT	WT6X43.5	644	MT	MT4X3.1
381	WT	WT18X426.5	447	WT	WT13.5X57	513	WT	WT9X23	579	WT	WT6X39.5	645	MT	MT3X2.2
382	WT	WT18X401	448	WT	WT13.5X51	514	WT	WT9X20	580	WT	WT6X36	646	MT	MT3X1.85
383	WT	WT18X361.5	449	WT	WT13.5X47	515	WT	WT9X17.5	581	WT	WT6X32.5	647	MT	MT2.5X9.45
384	WT	WT18X326	450	WT	WT13.5X42	516	WT	WT8X50	582	WT	WT6X29	648	MT	MT2X3
385	WT	WT18X264.5	451	WT	WT12X185	517	WT	WT8X44.5	583	WT	WT6X26.5	649	ST	ST12X60.5
386	WT	WT18X243.5	452	WT	WT12X167.5	518	WT	WT8X38.5	584	WT	WT6X25	650	ST	ST12X53
387	WT	WT18X220.5	453	WT	WT12X153	519	WT	WT8X33.5	585	WT	WT6X22.5	651	ST	ST12X50
388	WT	WT18X197.5	454	WT	WT12X139.5	520	WT	WT8X28.5	586	WT	WT6X20	652	ST	ST12X45
389	WT	WT18X180.5	455	WT	WT12X125	521	WT	WT8X25	587	WT	WT6X17.5	653	ST	ST12X40
390	WT	WT18X165	456	WT	WT12X114.5	522	WT	WT8X22.5	588	WT	WT6X15	654	ST	ST10X48
391	WT	WT18X151	457	WT	WT12X103.5	523	WT	WT8X20	589	WT	WT6X13	655	ST	ST10X43
392	WT	WT18X141	458	WT	WT12X96	524	WT	WT8X18	590	WT	WT6X11	656	ST	ST10X37.5
393	WT	WT18X131	459	WT	WT12X88	525	WT	WT8X15.5	591	WT	WT6X9.5	657	ST	ST10X33
394	WT	WT18X123.5	460	WT	WT12X81	526	WT	WT8X13	592	WT	WT6X8	658	ST	ST9X35
395	WT	WT18X115.5	461	WT	WT12X73	527	WT	WT7X436.5	593	WT	WT6X7	659	ST	ST9X27.35
396	WT	WT18X128	462	WT	WT12X65.5	528	WT	WT7X404	594	WT	WT5X56	660	ST	ST7.5X25

Number	Type	Name	Number	Type	Name	Number	Type	Name	Number	Type	Name	Number	Type	Name
661	ST	ST7.5X21.45	727	MC	MC10X25	793	L	L6X6X5/16	859	L	L3X2-1/2X1/2	925	2L	2L8X8X3/4
662	ST	ST6X25	728	MC	MC10X22	794	L	L6X4X7/8	860	L	L3X2-1/2X7/16	926	2L	2L8X8X3/4X3/8
663	ST	ST6X20.4	729	MC	MC10X8.4	795	L	L6X4X3/4	861	L	L3X2-1/2X3/8	927	2L	2L8X8X3/4X3/4
664	ST	ST6X17.5	730	MC	MC10X6.5	796	L	L6X4X5/8	862	L	L3X2-1/2X5/16	928	2L	2L8X8X5/8
665	ST	ST6X15.9	731	MC	MC9X25.4	797	L	L6X4X9/16	863	L	L3X2-1/2X1/4	929	2L	2L8X8X5/8X3/8
666	ST	ST5X17.5	732	MC	MC9X23.9	798	L	L6X4X1/2	864	L	L3X2-1/2X3/16	930	2L	2L8X8X5/8X3/4
667	ST	ST5X12.7	733	MC	MC8X22.8	799	L	L6X4X7/16	865	L	L3X2X1/2	931	2L	2L8X8X9/16
668	ST	ST4X11.5	734	MC	MC8X21.4	800	L	L6X4X3/8	866	L	L3X2X3/8	932	2L	2L8X8X9/16X3/8
669	ST	ST4X9.2	735	MC	MC8X20	801	L	L6X4X5/16	867	L	L3X2X5/16	933	2L	2L8X8X9/16X3/4
670	ST	ST3X8.6	736	MC	MC8X18.7	802	L	L6X3-1/2X1/2	868	L	L3X2X1/4	934	2L	2L8X8X1/2
671	ST	ST3X6.25	737	MC	MC8X8.5	803	L	L6X3-1/2X3/8	869	L	L3X2X3/16	935	2L	2L8X8X1/2X3/8
672	ST	ST2.5X5	738	MC	MC7X22.7	804	L	L6X3-1/2X5/16	870	L	L2-1/2X2-1/2X1/2	936	2L	2L8X8X1/2X3/4
673	ST	ST2X4.75	739	MC	MC7X19.1	805	L	L5X5X7/8	871	L	L2-1/2X2-1/2X3/8	937	2L	2L6X6X1
674	ST	ST2X3.85	740	MC	MC6X18	806	L	L5X5X3/4	872	L	L2-1/2X2-1/2X5/16	938	2L	2L6X6X1X3/8
675	ST	ST1.5X3.75	741	MC	MC6X15.3	807	L	L5X5X5/8	873	L	L2-1/2X2-1/2X1/4	939	2L	2L6X6X1X3/4
676	ST	ST1.5X2.85	742	MC	MC6X16.3	808	L	L5X5X1/2	874	L	L2-1/2X2-1/2X3/16	940	2L	2L6X6X7/8
677	C	C15X50	743	MC	MC6X15.1	809	L	L5X5X7/16	875	L	L2-1/2X2X3/8	941	2L	2L6X6X7/8X3/8
678	C	C15X40	744	MC	MC6X12	810	L	L5X5X3/8	876	L	L2-1/2X2X5/16	942	2L	2L6X6X7/8X3/4
679	C	C15X33.9	745	MC	MC6X7	811	L	L5X5X5/16	877	L	L2-1/2X2X1/4	943	2L	2L6X6X3/4
680	C	C12X30	746	MC	MC6X6.5	812	L	L5X3-1/2X3/4	878	L	L2-1/2X2X3/16	944	2L	2L6X6X3/4X3/8
681	C	C12X25	747	MC	MC4X13.8	813	L	L5X3-1/2X5/8	879	L	L2-1/2X1-1/2X1/4	945	2L	2L6X6X3/4X3/4
682	C	C12X20.7	748	MC	MC3X7.1	814	L	L5X3-1/2X1/2	880	L	L2-1/2X1-1/2X3/16	946	2L	2L6X6X5/8
683	C	C10X30	749	L	L12X12X1-3/8	815	L	L5X3-1/2X3/8	881	L	L2X2X3/8	947	2L	2L6X6X5/8X3/8
684	C	C10X25	750	L	L12X12X1-1/4	816	L	L5X3-1/2X5/16	882	L	L2X2X5/16	948	2L	2L6X6X5/8X3/4
685	C	C10X20	751	L	L12X12X1-1/8	817	L	L5X3-1/2X1/4	883	L	L2X2X1/4	949	2L	2L6X6X9/16
686	C	C10X15.3	752	L	L12X12X1	818	L	L5X3X1/2	884	L	L2X2X3/16	950	2L	2L6X6X9/16X3/8
687	C	C9X20	753	L	L10X10X1-3/8	819	L	L5X3X7/16	885	L	L2X2X1/8	951	2L	2L6X6X9/16X3/4
688	C	C9X15	754	L	L10X10X1-1/4	820	L	L5X3X3/8	886	2L	2L12X12X1-3/8	952	2L	2L6X6X1/2
689	C	C9X13.4	755	L	L10X10X1-1/8	821	L	L5X3X5/16	887	2L	2L12X12X1-3/8X3/4	953	2L	2L6X6X1/2X3/8
690	C	C8X18.75	756	L	L10X10X1	822	L	L5X3X1/4	888	2L	2L12X12X1-3/8X1-1/2	954	2L	2L6X6X1/2X3/4
691	C	C8X13.75	757	L	L10X10X7/8	823	L	L4X4X3/4	889	2L	2L12X12X1-1/4	955	2L	2L6X6X7/16
692	C	C8X11.5	758	L	L10X10X3/4	824	L	L4X4X5/8	890	2L	2L12X12X1-1/4X3/4	956	2L	2L6X6X7/16X3/8
693	C	C7X14.75	759	L	L8X8X1-1/8	825	L	L4X4X1/2	891	2L	2L12X12X1-1/4X1-1/2	957	2L	2L6X6X7/16X3/4
694	C	C7X12.25	760	L	L8X8X1	826	L	L4X4X7/16	892	2L	2L12X12X1-1/8	958	2L	2L6X6X3/8
695	C	C7X9.8	761	L	L8X8X7/8	827	L	L4X4X3/8	893	2L	2L12X12X1-1/8X3/4	959	2L	2L6X6X3/8X3/8
696	C	C6X13	762	L	L8X8X3/4	828	L	L4X4X5/16	894	2L	2L12X12X1-1/8X1-1/2	960	2L	2L6X6X3/8X3/4
697	C	C6X10.5	763	L	L8X8X5/8	829	L	L4X4X1/4	895	2L	2L12X12X1	961	2L	2L6X6X5/16
698	C	C6X8.2	764	L	L8X8X9/16	830	L	L4X3-1/2X1/2	896	2L	2L12X12X1X3/4	962	2L	2L6X6X5/16X3/8
699	C	C5X9	765	L	L8X8X1/2	831	L	L4X3-1/2X3/8	897	2L	2L12X12X1X1-1/2	963	2L	2L6X6X5/16X3/4
700	C	C5X6.7	766	L	L8X6X1	832	L	L4X3-1/2X5/16	898	2L	2L10X10X1-3/8	964	2L	2L5X5X7/8
701	C	C4X7.25	767	L	L8X6X7/8	833	L	L4X3-1/2X1/4	899	2L	2L10X10X1-3/8X3/4	965	2L	2L5X5X7/8X3/8
702	C	C4X6.25	768	L	L8X6X3/4	834	L	L4X3X5/8	900	2L	2L10X10X1-3/8X1-1/2	966	2L	2L5X5X7/8X3/4
703	C	C4X5.4	769	L	L8X6X5/8	835	L	L4X3X1/2	901	2L	2L10X10X1-1/4	967	2L	2L5X5X3/4
704	C	C4X4.5	770	L	L8X6X9/16	836	L	L4X3X3/8	902	2L	2L10X10X1-1/4X3/4	968	2L	2L5X5X3/4X3/8
705	C	C3X6	771	L	L8X6X1/2	837	L	L4X3X5/16	903	2L	2L10X10X1-1/4X1-1/2	969	2L	2L5X5X3/4X3/4
706	C	C3X5	772	L	L8X6X7/16	838	L	L4X3X1/4	904	2L	2L10X10X1-1/8	970	2L	2L5X5X5/8
707	C	C3X4.1	773	L	L8X4X1	839	L	L3-1/2X3-1/2X1/2	905	2L	2L10X10X1-1/8X3/4	971	2L	2L5X5X5/8X3/8
708	C	C3X3.5	774	L	L8X4X7/8	840	L	L3-1/2X3-1/2X7/16	906	2L	2L10X10X1-1/8X1-1/2	972	2L	2L5X5X5/8X3/4
709	MC	MC18X58	775	L	L8X4X3/4	841	L	L3-1/2X3-1/2X3/8	907	2L	2L10X10X1	973	2L	2L5X5X1/2
710	MC	MC18X51.9	776	L	L8X4X5/8	842	L	L3-1/2X3-1/2X5/16	908	2L	2L10X10X1X3/4	974	2L	2L5X5X1/2X3/8
711	MC	MC18X45.8	777	L	L8X4X9/16	843	L	L3-1/2X3-1/2X1/4	909	2L	2L10X10X1X1-1/2	975	2L	2L5X5X1/2X3/4
712	MC	MC18X42.7	778	L	L8X4X1/2	844	L	L3-1/2X3X1/2	910	2L	2L10X10X7/8	976	2L	2L5X5X7/16
713	MC	MC13X50	779	L	L8X4X7/16	845	L	L3-1/2X3X7/16	911	2L	2L10X10X7/8X3/4	977	2L	2L5X5X7/16X3/8
714	MC	MC13X40	780	L	L7X4X3/4	846	L	L3-1/2X3X3/8	912	2L	2L10X10X7/8X1-1/2	978	2L	2L5X5X7/16X3/4
715	MC	MC13X35	781	L	L7X4X5/8	847	L	L3-1/2X3X5/16	913	2L	2L10X10X3/4	979	2L	2L5X5X3/8
716	MC	MC13X31.8	782	L	L7X4X1/2	848	L	L3-1/2X3X1/4	914	2L	2L10X10X3/4X3/4	980	2L	2L5X5X3/8X3/8
717	MC	MC12X50	783	L	L7X4X7/16	849	L	L3-1/2X2-1/2X1/2	915	2L	2L10X10X3/4X1-1/2	981	2L	2L5X5X3/8X3/4
718	MC	MC12X45	784	L	L7X4X3/8	850	L	L3-1/2X2-1/2X3/8	916	2L	2L8X8X1-1/8	982	2L	2L5X5X5/16
719	MC	MC12X40	785	L	L6X6X1	851	L	L3-1/2X2-1/2X5/16	917	2L	2L8X8X1-1/8X3/8	983	2L	2L5X5X5/16X3/8
720	MC	MC12X35	786	L	L6X6X7/8	852	L	L3-1/2X2-1/2X1/4	918	2L	2L8X8X1-1/8X3/4	984	2L	2L5X5X5/16X3/4
721	MC	MC12X31	787	L	L6X6X3/4	853	L	L3X3X1/2	919	2L	2L8X8X1	985	2L	2L4X4X3/4
722	MC	MC12X14.3	788	L	L6X6X5/8	854	L	L3X3X7/16	920	2L	2L8X8X1X3/8	986	2L	2L4X4X3/4X3/8
723	MC	MC12X10.6	789	L	L6X6X9/16	855	L	L3X3X3/8	921	2L	2L8X8X1X3/4	987	2L	2L4X4X3/4X3/4
724	MC	MC10X41.1	790	L	L6X6X1/2	856	L	L3X3X5/16	922	2L	2L8X8X7/8	988	2L	2L4X4X5/8
725	MC	MC10X33.6	791	L	L6X6X7/16	857	L	L3X3X1/4	923	2L	2L8X8X7/8X3/8	989	2L	2L4X4X5/8X3/8
726	MC	MC10X28.5	792	L	L6X6X3/8	858	L	L3X3X3/16	924	2L	2L8X8X7/8X3/4	990	2L	2L4X4X5/8X3/4

Number	Type	Name	Number	Type	Name	Number	Type	Name	Number	Type	Name	Number	Type	Name
991	2L	2L4X4X1/2	1057	2L	2L2X2X5/16	1123	2L	2L7X4X3/8LLBB	1189	2L	2L5X3X1/4LLBB	1255	2L	2L3X2-1/2X5/16LLBB
992	2L	2L4X4X1/2X3/8	1058	2L	2L2X2X5/16X3/8	1124	2L	2L7X4X3/8X3/8LLBB	1190	2L	2L5X3X1/4X3/8LLBB	1256	2L	2L3X2-1/2X5/16X3/8LLBB
993	2L	2L4X4X1/2X3/4	1059	2L	2L2X2X5/16X3/4	1125	2L	2L7X4X3/8X3/4LLBB	1191	2L	2L5X3X1/4X3/4LLBB	1257	2L	2L3X2-1/2X5/16X3/4LLBB
994	2L	2L4X4X7/16	1060	2L	2L2X2X1/4	1126	2L	2L6X4X7/8LLBB	1192	2L	2L4X3-1/2X1/2LLBB	1258	2L	2L3X2-1/2X1/4LLBB
995	2L	2L4X4X7/16X3/8	1061	2L	2L2X2X1/4X3/8	1127	2L	2L6X4X7/8X3/8LLBB	1193	2L	2L4X3-1/2X1/2X3/8LLBB	1259	2L	2L3X2-1/2X1/4X3/8LLBB
996	2L	2L4X4X7/16X3/4	1062	2L	2L2X2X1/4X3/4	1128	2L	2L6X4X7/8X3/4LLBB	1194	2L	2L4X3-1/2X1/2X3/4LLBB	1260	2L	2L3X2-1/2X1/4X3/4LLBB
997	2L	2L4X4X3/8	1063	2L	2L2X2X3/16	1129	2L	2L6X4X3/4LLBB	1195	2L	2L4X3-1/2X3/8LLBB	1261	2L	2L3X2-1/2X3/16LLBB
998	2L	2L4X4X3/8X3/8	1064	2L	2L2X2X3/16X3/8	1130	2L	2L6X4X3/4X3/8LLBB	1196	2L	2L4X3-1/2X3/8X3/8LLBB	1262	2L	2L3X2-1/2X3/16X3/8LLBB
999	2L	2L4X4X3/8X3/4	1065	2L	2L2X2X3/16X3/4	1131	2L	2L6X4X3/4X3/4LLBB	1197	2L	2L4X3-1/2X3/8X3/4LLBB	1263	2L	2L3X2-1/2X3/16X3/4LLBB
1000	2L	2L4X4X5/16	1066	2L	2L2X2X1/8	1132	2L	2L6X4X5/8LLBB	1198	2L	2L4X3-1/2X5/16LLBB	1264	2L	2L3X2X1/2LLBB
1001	2L	2L4X4X5/16X3/8	1067	2L	2L2X2X1/8X3/8	1133	2L	2L6X4X5/8X3/8LLBB	1199	2L	2L4X3-1/2X5/16X3/8LLBB	1265	2L	2L3X2X1/2X3/8LLBB
1002	2L	2L4X4X5/16X3/4	1068	2L	2L2X2X1/8X3/4	1134	2L	2L6X4X5/8X3/4LLBB	1200	2L	2L4X3-1/2X5/16X3/4LLBB	1266	2L	2L3X2X1/2X3/4LLBB
1003	2L	2L4X4X1/4	1069	2L	2L8X8X1LLBB	1135	2L	2L6X4X9/16LLBB	1201	2L	2L4X3-1/2X1/4LLBB	1267	2L	2L3X2X3/8LLBB
1004	2L	2L4X4X1/4X3/8	1070	2L	2L8X8X1X3/8LLBB	1136	2L	2L6X4X9/16X3/8LLBB	1202	2L	2L4X3-1/2X1/4X3/8LLBB	1268	2L	2L3X2X3/8X3/8LLBB
1005	2L	2L4X4X1/4X3/4	1071	2L	2L8X8X1X3/4LLBB	1137	2L	2L6X4X9/16X3/4LLBB	1203	2L	2L4X3-1/2X1/4X3/4LLBB	1269	2L	2L3X2X3/8X3/4LLBB
1006	2L	2L3-1/2X3-1/2X1/2	1072	2L	2L8X8X7/8LLBB	1138	2L	2L6X4X1/2LLBB	1204	2L	2L4X3X5/8LLBB	1270	2L	2L3X2X5/16LLBB
1007	2L	2L3-1/2X3-1/2X1/2X3/8	1073	2L	2L8X8X7/8X3/8LLBB	1139	2L	2L6X4X1/2X3/8LLBB	1205	2L	2L4X3X5/8X3/8LLBB	1271	2L	2L3X2X5/16X3/8LLBB
1008	2L	2L3-1/2X3-1/2X1/2X3/4	1074	2L	2L8X8X7/8X3/4LLBB	1140	2L	2L6X4X1/2X3/4LLBB	1206	2L	2L4X3X5/8X3/4LLBB	1272	2L	2L3X2X5/16X3/4LLBB
1009	2L	2L3-1/2X3-1/2X7/16	1075	2L	2L8X8X3/4LLBB	1141	2L	2L6X4X7/16LLBB	1207	2L	2L4X3X1/2LLBB	1273	2L	2L3X2X1/4LLBB
1010	2L	2L3-1/2X3-1/2X7/16X3/8	1076	2L	2L8X8X3/4X3/8LLBB	1142	2L	2L6X4X7/16X3/8LLBB	1208	2L	2L4X3X1/2X3/8LLBB	1274	2L	2L3X2X1/4X3/8LLBB
1011	2L	2L3-1/2X3-1/2X7/16X3/4	1077	2L	2L8X8X3/4X3/4LLBB	1143	2L	2L6X4X7/16X3/4LLBB	1209	2L	2L4X3X1/2X3/4LLBB	1275	2L	2L3X2X1/4X3/4LLBB
1012	2L	2L3-1/2X3-1/2X3/8	1078	2L	2L8X8X5/8LLBB	1144	2L	2L6X4X3/8LLBB	1210	2L	2L4X3X3/8LLBB	1276	2L	2L3X2X3/16LLBB
1013	2L	2L3-1/2X3-1/2X3/8X3/8	1079	2L	2L8X8X5/8X3/8LLBB	1145	2L	2L6X4X3/8X3/8LLBB	1211	2L	2L4X3X3/8X3/8LLBB	1277	2L	2L3X2X3/16X3/8LLBB
1014	2L	2L3-1/2X3-1/2X3/8X3/4	1080	2L	2L8X8X5/8X3/4LLBB	1146	2L	2L6X4X3/8X3/4LLBB	1212	2L	2L4X3X3/8X3/4LLBB	1278	2L	2L3X2X3/16X3/4LLBB
1015	2L	2L3-1/2X3-1/2X5/16	1081	2L	2L8X8X9/16LLBB	1147	2L	2L6X4X5/16LLBB	1213	2L	2L4X3X5/16LLBB	1279	2L	2L2-1/2X2X3/8LLBB
1016	2L	2L3-1/2X3-1/2X5/16X3/8	1082	2L	2L8X8X9/16X3/8LLBB	1148	2L	2L6X4X5/16X3/8LLBB	1214	2L	2L4X3X5/16X3/8LLBB	1280	2L	2L2-1/2X2X3/8X3/8LLBB
1017	2L	2L3-1/2X3-1/2X5/16X3/4	1083	2L	2L8X8X9/16X3/4LLBB	1149	2L	2L6X4X5/16X3/4LLBB	1215	2L	2L4X3X5/16X3/4LLBB	1281	2L	2L2-1/2X2X3/8X3/4LLBB
1018	2L	2L3-1/2X3-1/2X1/4	1084	2L	2L8X8X1/2LLBB	1150	2L	2L6X3-1/2X1/2LLBB	1216	2L	2L4X3X1/4LLBB	1282	2L	2L2-1/2X2X5/16LLBB
1019	2L	2L3-1/2X3-1/2X1/4X3/8	1085	2L	2L8X8X1/2X3/8LLBB	1151	2L	2L6X3-1/2X1/2X3/8LLBB	1217	2L	2L4X3X1/4X3/8LLBB	1283	2L	2L2-1/2X2X5/16X3/8LLBB
1020	2L	2L3-1/2X3-1/2X1/4X3/4	1086	2L	2L8X8X1/2X3/4LLBB	1152	2L	2L6X3-1/2X1/2X3/4LLBB	1218	2L	2L4X3X1/4X3/4LLBB	1284	2L	2L2-1/2X2X5/16X3/4LLBB
1021	2L	2L3X3X1/2	1087	2L	2L8X6X7/16LLBB	1153	2L	2L6X3-1/2X3/8LLBB	1219	2L	2L3-1/2X3X1/2LLBB	1285	2L	2L2-1/2X2X1/4LLBB
1022	2L	2L3X3X1/2X3/8	1088	2L	2L8X6X7/16X3/8LLBB	1154	2L	2L6X3-1/2X3/8X3/8LLBB	1220	2L	2L3-1/2X3X1/2X3/8LLBB	1286	2L	2L2-1/2X2X1/4X3/8LLBB
1023	2L	2L3X3X1/2X3/4	1089	2L	2L8X6X7/16X3/4LLBB	1155	2L	2L6X3-1/2X3/8X3/4LLBB	1221	2L	2L3-1/2X3X1/2X3/4LLBB	1287	2L	2L2-1/2X2X1/4X3/4LLBB
1024	2L	2L3X3X7/16	1090	2L	2L8X4X1LLBB	1156	2L	2L6X3-1/2X5/16LLBB	1222	2L	2L3-1/2X3X7/16LLBB	1288	2L	2L2-1/2X2X3/16LLBB
1025	2L	2L3X3X7/16X3/8	1091	2L	2L8X4X1X3/8LLBB	1157	2L	2L6X3-1/2X5/16X3/8LLBB	1223	2L	2L3-1/2X3X7/16X3/8LLBB	1289	2L	2L2-1/2X2X3/16X3/8LLBB
1026	2L	2L3X3X7/16X3/4	1092	2L	2L8X4X1X3/4LLBB	1158	2L	2L6X3-1/2X5/16X3/4LLBB	1224	2L	2L3-1/2X3X7/16X3/4LLBB	1290	2L	2L2-1/2X2X3/16X3/4LLBB
1027	2L	2L3X3X3/8	1093	2L	2L8X4X7/8LLBB	1159	2L	2L5X3-1/2X3/4LLBB	1225	2L	2L3-1/2X3X3/8LLBB	1291	2L	2L2-1/2X1-1/2X1/4LLBB
1028	2L	2L3X3X3/8X3/8	1094	2L	2L8X4X7/8X3/8LLBB	1160	2L	2L5X3-1/2X3/4X3/8LLBB	1226	2L	2L3-1/2X3X3/8X3/8LLBB	1292	2L	2L2-1/2X1-1/2X1/4X3/8LLBB
1029	2L	2L3X3X3/8X3/4	1095	2L	2L8X4X7/8X3/4LLBB	1161	2L	2L5X3-1/2X3/4X3/4LLBB	1227	2L	2L3-1/2X3X3/8X3/4LLBB	1293	2L	2L2-1/2X1-1/2X1/4X3/4LLBB
1030	2L	2L3X3X5/16	1096	2L	2L8X4X3/4LLBB	1162	2L	2L5X3-1/2X5/8LLBB	1228	2L	2L3-1/2X3X5/16LLBB	1294	2L	2L2-1/2X1-1/2X3/16LLBB
1031	2L	2L3X3X5/16X3/8	1097	2L	2L8X4X3/4X3/8LLBB	1163	2L	2L5X3-1/2X5/8X3/8LLBB	1229	2L	2L3-1/2X3X5/16X3/8LLBB	1295	2L	2L2-1/2X1-1/2X3/16X3/8LLBB
1032	2L	2L3X3X5/16X3/4	1098	2L	2L8X4X3/4X3/4LLBB	1164	2L	2L5X3-1/2X5/8X3/4LLBB	1230	2L	2L3-1/2X3X5/16X3/4LLBB	1296	2L	2L2-1/2X1-1/2X3/16X3/4LLBB
1033	2L	2L3X3X1/4	1099	2L	2L8X4X5/8LLBB	1165	2L	2L5X3-1/2X1/2LLBB	1231	2L	2L3-1/2X3X1/4LLBB	1297	2L	2L8X6X1SLBB
1034	2L	2L3X3X1/4X3/8	1100	2L	2L8X4X5/8X3/8LLBB	1166	2L	2L5X3-1/2X1/2X3/8LLBB	1232	2L	2L3-1/2X3X1/4X3/8LLBB	1298	2L	2L8X6X1X3/8SLBB
1035	2L	2L3X3X1/4X3/4	1101	2L	2L8X4X5/8X3/4LLBB	1167	2L	2L5X3-1/2X1/2X3/4LLBB	1233	2L	2L3-1/2X3X1/4X3/4LLBB	1299	2L	2L8X6X1X3/4SLBB
1036	2L	2L3X3X3/16	1102	2L	2L8X4X9/16LLBB	1168	2L	2L5X3-1/2X3/8LLBB	1234	2L	2L3-1/2X2-1/2X1/2LLBB	1300	2L	2L8X6X7/8SLBB
1037	2L	2L3X3X3/16X3/8	1103	2L	2L8X4X9/16X3/8LLBB	1169	2L	2L5X3-1/2X3/8X3/8LLBB	1235	2L	2L3-1/2X2-1/2X1/2X3/8LLBB	1301	2L	2L8X6X7/8X3/8SLBB
1038	2L	2L3X3X3/16X3/4	1104	2L	2L8X4X9/16X3/4LLBB	1170	2L	2L5X3-1/2X3/8X3/4LLBB	1236	2L	2L3-1/2X2-1/2X1/2X3/4LLBB	1302	2L	2L8X6X7/8X3/4SLBB
1039	2L	2L2-1/2X2-1/2X1/2	1105	2L	2L8X4X1/2LLBB	1171	2L	2L5X3-1/2X5/16LLBB	1237	2L	2L3-1/2X2-1/2X3/8LLBB	1303	2L	2L8X6X3/4SLBB
1040	2L	2L2-1/2X2-1/2X1/2X3/8	1106	2L	2L8X4X1/2X3/8LLBB	1172	2L	2L5X3-1/2X5/16X3/8LLBB	1238	2L	2L3-1/2X2-1/2X3/8X3/8LLBB	1304	2L	2L8X6X3/4X3/8SLBB
1041	2L	2L2-1/2X2-1/2X1/2X3/4	1107	2L	2L8X4X1/2X3/4LLBB	1173	2L	2L5X3-1/2X5/16X3/4LLBB	1239	2L	2L3-1/2X2-1/2X3/8X3/4LLBB	1305	2L	2L8X6X3/4X3/4SLBB
1042	2L	2L2-1/2X2-1/2X3/8	1108	2L	2L8X4X7/16LLBB	1174	2L	2L5X3-1/2X1/4LLBB	1240	2L	2L3-1/2X2-1/2X5/16LLBB	1306	2L	2L8X6X5/8SLBB
1043	2L	2L2-1/2X2-1/2X3/8X3/8	1109	2L	2L8X4X7/16X3/8LLBB	1175	2L	2L5X3-1/2X1/4X3/8LLBB	1241	2L	2L3-1/2X2-1/2X5/16X3/8LLBB	1307	2L	2L8X6X5/8X3/8SLBB
1044	2L	2L2-1/2X2-1/2X3/8X3/4	1110	2L	2L8X4X7/16X3/4LLBB	1176	2L	2L5X3-1/2X1/4X3/4LLBB	1242	2L	2L3-1/2X2-1/2X5/16X3/4LLBB	1308	2L	2L8X6X5/8X3/4SLBB
1045	2L	2L2-1/2X2-1/2X5/16	1111	2L	2L7X4X3/4LLBB	1177	2L	2L5X3X1/2LLBB	1243	2L	2L3-1/2X2-1/2X1/4LLBB	1309	2L	2L8X6X9/16SLBB
1046	2L	2L2-1/2X2-1/2X5/16X3/8	1112	2L	2L7X4X3/4X3/8LLBB	1178	2L	2L5X3X1/2X3/8LLBB	1244	2L	2L3-1/2X2-1/2X1/4X3/8LLBB	1310	2L	2L8X6X9/16X3/8SLBB
1047	2L	2L2-1/2X2-1/2X5/16X3/4	1113	2L	2L7X4X3/4X3/4LLBB	1179	2L	2L5X3X1/2X3/4LLBB	1245	2L	2L3-1/2X2-1/2X1/4X3/4LLBB	1311	2L	2L8X6X9/16X3/4SLBB
1048	2L	2L2-1/2X2-1/2X1/4	1114	2L	2L7X4X5/8LLBB	1180	2L	2L5X3X7/16LLBB	1246	2L	2L3X2-1/2X1/2LLBB	1312	2L	2L8X6X1/2SLBB
1049	2L	2L2-1/2X2-1/2X1/4X3/8	1115	2L	2L7X4X5/8X3/8LLBB	1181	2L	2L5X3X7/16X3/8LLBB	1247	2L	2L3X2-1/2X1/2X3/8LLBB	1313	2L	2L8X6X1/2X3/8SLBB
1050	2L	2L2-1/2X2-1/2X1/4X3/4	1116	2L	2L7X4X5/8X3/4LLBB	1182	2L	2L5X3X7/16X3/4LLBB	1248	2L	2L3X2-1/2X1/2X3/4LLBB	1314	2L	2L8X6X1/2X3/4SLBB
1051	2L	2L2-1/2X2-1/2X3/16	1117	2L	2L7X4X1/2LLBB	1183	2L	2L5X3X3/8LLBB	1249	2L	2L3X2-1/2X7/16LLBB	1315	2L	2L8X6X7/16SLBB
1052	2L	2L2-1/2X2-1/2X3/16X3/8	1118	2L	2L7X4X1/2X3/8LLBB	1184	2L	2L5X3X3/8X3/8LLBB	1250	2L	2L3X2-1/2X7/16X3/8LLBB	1316	2L	2L8X6X7/16X3/8SLBB
1053	2L	2L2-1/2X2-1/2X3/16X3/4	1119	2L	2L7X4X1/2X3/4LLBB	1185	2L	2L5X3X3/8X3/4LLBB	1251	2L	2L3X2-1/2X7/16X3/4LLBB	1317	2L	2L8X6X7/16X3/4SLBB
1054	2L	2L2X2X3/8	1120	2L	2L7X4X7/16LLBB	1186	2L	2L5X3X5/16LLBB	1252	2L	2L3X2-1/2X3/8LLBB	1318	2L	2L8X4X1SLBB
1055	2L	2L2X2X3/8X3/8	1121	2L	2L7X4X7/16X3/8LLBB	1187	2L	2L5X3X5/16X3/8LLBB	1253	2L	2L3X2-1/2X3/8X3/8LLBB	1319	2L	2L8X4X1X3/8SLBB
1056	2L	2L2X2X3/8X3/4	1122	2L	2L7X4X7/16X3/4LLBB	1188	2L	2L5X3X5/16X3/4LLBB	1254	2L	2L3X2-1/2X3/8X3/4LLBB	1320	2L	2L8X4X1X3/4SLBB

Number	Type	Name
1321	2L	2L8X4X7/8SLBB
1322	2L	2L8X4X7/8X3/8SLBB
1323	2L	2L8X4X7/8X3/4SLBB
1324	2L	2L8X4X3/4SLBB
1325	2L	2L8X4X3/4X3/8SLBB
1326	2L	2L8X4X3/4X3/4SLBB
1327	2L	2L8X4X5/8SLBB
1328	2L	2L8X4X5/8X3/8SLBB
1329	2L	2L8X4X5/8X3/4SLBB
1330	2L	2L8X4X9/16SLBB
1331	2L	2L8X4X9/16X3/8SLBB
1332	2L	2L8X4X9/16X3/4SLBB
1333	2L	2L8X4X1/2SLBB
1334	2L	2L8X4X1/2X3/8SLBB
1335	2L	2L8X4X1/2X3/4SLBB
1336	2L	2L8X4X7/16SLBB
1337	2L	2L8X4X7/16X3/8SLBB
1338	2L	2L8X4X7/16X3/4SLBB
1339	2L	2L7X4X3/4SLBB
1340	2L	2L7X4X3/4X3/8SLBB
1341	2L	2L7X4X3/4X3/4SLBB
1342	2L	2L7X4X5/8SLBB
1343	2L	2L7X4X5/8X3/8SLBB
1344	2L	2L7X4X5/8X3/4SLBB
1345	2L	2L7X4X1/2SLBB
1346	2L	2L7X4X1/2X3/8SLBB
1347	2L	2L7X4X1/2X3/4SLBB
1348	2L	2L7X4X7/16SLBB
1349	2L	2L7X4X7/16X3/8SLBB
1350	2L	2L7X4X7/16X3/4SLBB
1351	2L	2L7X4X3/8SLBB
1352	2L	2L7X4X3/8X3/8SLBB
1353	2L	2L7X4X3/8X3/4SLBB
1354	2L	2L6X4X7/8SLBB
1355	2L	2L6X4X7/8X3/8SLBB
1356	2L	2L6X4X7/8X3/4SLBB
1357	2L	2L6X4X3/4SLBB
1358	2L	2L6X4X3/4X3/8SLBB
1359	2L	2L6X4X3/4X3/4SLBB
1360	2L	2L6X4X5/8SLBB
1361	2L	2L6X4X5/8X3/8SLBB
1362	2L	2L6X4X5/8X3/4SLBB
1363	2L	2L6X4X9/16SLBB
1364	2L	2L6X4X9/16X3/8SLBB
1365	2L	2L6X4X9/16X3/4SLBB
1366	2L	2L6X4X1/2SLBB
1367	2L	2L6X4X1/2X3/8SLBB
1368	2L	2L6X4X1/2X3/4SLBB
1369	2L	2L6X4X7/16SLBB
1370	2L	2L6X4X7/16X3/8SLBB
1371	2L	2L6X4X7/16X3/4SLBB
1372	2L	2L6X4X3/8SLBB
1373	2L	2L6X4X3/8X3/8SLBB
1374	2L	2L6X4X3/8X3/4SLBB
1375	2L	2L6X4X5/16SLBB
1376	2L	2L6X4X5/16X3/8SLBB
1377	2L	2L6X4X5/16X3/4SLBB
1378	2L	2L6X3-1/2X1/2SLBB
1379	2L	2L6X3-1/2X1/2X3/8SLBB
1380	2L	2L6X3-1/2X1/2X3/4SLBB
1381	2L	2L6X3-1/2X3/8SLBB
1382	2L	2L6X3-1/2X3/8X3/8SLBB
1383	2L	2L6X3-1/2X3/8X3/4SLBB
1384	2L	2L6X3-1/2X5/16SLBB
1385	2L	2L6X3-1/2X5/16X3/8SLBB
1386	2L	2L6X3-1/2X5/16X3/4SLBB

Number	Type	Name
1387	2L	2L5X3-1/2X3/4SLBB
1388	2L	2L5X3-1/2X3/4X3/8SLBB
1389	2L	2L5X3-1/2X3/4X3/4SLBB
1390	2L	2L5X3-1/2X5/8SLBB
1391	2L	2L5X3-1/2X5/8X3/8SLBB
1392	2L	2L5X3-1/2X5/8X3/4SLBB
1393	2L	2L5X3-1/2X1/2SLBB
1394	2L	2L5X3-1/2X1/2X3/8SLBB
1395	2L	2L5X3-1/2X1/2X3/4SLBB
1396	2L	2L5X3-1/2X3/8SLBB
1397	2L	2L5X3-1/2X3/8X3/8SLBB
1398	2L	2L5X3-1/2X3/8X3/4SLBB
1399	2L	2L5X3-1/2X5/16SLBB
1400	2L	2L5X3-1/2X5/16X3/8SLBB
1401	2L	2L5X3-1/2X5/16X3/4SLBB
1402	2L	2L5X3-1/2X1/4SLBB
1403	2L	2L5X3-1/2X1/4X3/8SLBB
1404	2L	2L5X3-1/2X1/4X3/4SLBB
1405	2L	2L5X3X1/2SLBB
1406	2L	2L5X3X1/2X3/8SLBB
1407	2L	2L5X3X1/2X3/4SLBB
1408	2L	2L5X3X7/16SLBB
1409	2L	2L5X3X7/16X3/8SLBB
1410	2L	2L5X3X7/16X3/4SLBB
1411	2L	2L5X3X3/8SLBB
1412	2L	2L5X3X3/8X3/8SLBB
1413	2L	2L5X3X3/8X3/4SLBB
1414	2L	2L5X3X5/16SLBB
1415	2L	2L5X3X5/16X3/8SLBB
1416	2L	2L5X3X5/16X3/4SLBB
1417	2L	2L5X3X1/4SLBB
1418	2L	2L5X3X1/4X3/8SLBB
1419	2L	2L5X3X1/4X3/4SLBB
1420	2L	2L4X3-1/2X1/2SLBB
1421	2L	2L4X3-1/2X1/2X3/8SLBB
1422	2L	2L4X3-1/2X1/2X3/4SLBB
1423	2L	2L4X3-1/2X3/8SLBB
1424	2L	2L4X3-1/2X3/8X3/8SLBB
1425	2L	2L4X3-1/2X3/8X3/4SLBB
1426	2L	2L4X3-1/2X5/16SLBB
1427	2L	2L4X3-1/2X5/16X3/8SLBB
1428	2L	2L4X3-1/2X5/16X3/4SLBB
1429	2L	2L4X3-1/2X1/4SLBB
1430	2L	2L4X3-1/2X1/4X3/8SLBB
1431	2L	2L4X3-1/2X1/4X3/4SLBB
1432	2L	2L4X3X5/8SLBB
1433	2L	2L4X3X5/8X3/8SLBB
1434	2L	2L4X3X5/8X3/4SLBB
1435	2L	2L4X3X1/2SLBB
1436	2L	2L4X3X1/2X3/8SLBB
1437	2L	2L4X3X1/2X3/4SLBB
1438	2L	2L4X3X3/8SLBB
1439	2L	2L4X3X3/8X3/8SLBB
1440	2L	2L4X3X3/8X3/4SLBB
1441	2L	2L4X3X5/16SLBB
1442	2L	2L4X3X5/16X3/8SLBB
1443	2L	2L4X3X5/16X3/4SLBB
1444	2L	2L4X3X1/4SLBB
1445	2L	2L4X3X1/4X3/8SLBB
1446	2L	2L4X3X1/4X3/4SLBB
1447	2L	2L3-1/2X3X1/2SLBB
1448	2L	2L3-1/2X3X1/2X3/8SLBB
1449	2L	2L3-1/2X3X1/2X3/4SLBB
1450	2L	2L3-1/2X3X7/16SLBB
1451	2L	2L3-1/2X3X7/16X3/8SLBB
1452	2L	2L3-1/2X3X7/16X3/4SLBB

Number	Type	Name
1453	2L	2L3-1/2X3X3/8SLBB
1454	2L	2L3-1/2X3X3/8X3/8SLBB
1455	2L	2L3-1/2X3X3/8X3/4SLBB
1456	2L	2L3-1/2X3X5/16SLBB
1457	2L	2L3-1/2X3X5/16X3/8SLBB
1458	2L	2L3-1/2X3X5/16X3/4SLBB
1459	2L	2L3-1/2X3X1/4SLBB
1460	2L	2L3-1/2X3X1/4X3/8SLBB
1461	2L	2L3-1/2X3X1/4X3/4SLBB
1462	2L	2L3-1/2X2-1/2X1/2SLBB
1463	2L	2L3-1/2X2-1/2X1/2X3/8SLBB
1464	2L	2L3-1/2X2-1/2X1/2X3/4SLBB
1465	2L	2L3-1/2X2-1/2X3/8SLBB
1466	2L	2L3-1/2X2-1/2X3/8X3/8SLBB
1467	2L	2L3-1/2X2-1/2X3/8X3/4SLBB
1468	2L	2L3-1/2X2-1/2X5/16SLBB
1469	2L	2L3-1/2X2-1/2X5/16X3/8SLBB
1470	2L	2L3-1/2X2-1/2X5/16X3/4SLBB
1471	2L	2L3-1/2X2-1/2X1/4SLBB
1472	2L	2L3-1/2X2-1/2X1/4X3/8SLBB
1473	2L	2L3-1/2X2-1/2X1/4X3/4SLBB
1474	2L	2L3X2-1/2X1/2SLBB
1475	2L	2L3X2-1/2X1/2X3/8SLBB
1476	2L	2L3X2-1/2X1/2X3/4SLBB
1477	2L	2L3X2-1/2X7/16SLBB
1478	2L	2L3X2-1/2X7/16X3/8SLBB
1479	2L	2L3X2-1/2X7/16X3/4SLBB
1480	2L	2L3X2-1/2X3/8SLBB
1481	2L	2L3X2-1/2X3/8X3/8SLBB
1482	2L	2L3X2-1/2X3/8X3/4SLBB
1483	2L	2L3X2-1/2X5/16SLBB
1484	2L	2L3X2-1/2X5/16X3/8SLBB
1485	2L	2L3X2-1/2X5/16X3/4SLBB
1486	2L	2L3X2-1/2X1/4SLBB
1487	2L	2L3X2-1/2X1/4X3/8SLBB
1488	2L	2L3X2-1/2X1/4X3/4SLBB
1489	2L	2L3X2-1/2X3/16SLBB
1490	2L	2L3X2-1/2X3/16X3/8SLBB
1491	2L	2L3X2-1/2X3/16X3/4SLBB
1492	2L	2L3X2X1/2SLBB
1493	2L	2L3X2X1/2X3/8SLBB
1494	2L	2L3X2X1/2X3/4SLBB
1495	2L	2L3X2X3/8SLBB
1496	2L	2L3X2X3/8X3/8SLBB
1497	2L	2L3X2X3/8X3/4SLBB
1498	2L	2L3X2X5/16SLBB
1499	2L	2L3X2X5/16X3/8SLBB
1500	2L	2L3X2X5/16X3/4SLBB
1501	2L	2L3X2X1/4SLBB
1502	2L	2L3X2X1/4X3/8SLBB
1503	2L	2L3X2X1/4X3/4SLBB
1504	2L	2L3X2X3/16SLBB
1505	2L	2L3X2X3/16X3/8SLBB
1506	2L	2L3X2X3/16X3/4SLBB
1507	2L	2L2-1/2X2X3/8SLBB
1508	2L	2L2-1/2X2X3/8X3/8SLBB
1509	2L	2L2-1/2X2X3/8X3/4SLBB
1510	2L	2L2-1/2X2X5/16SLBB
1511	2L	2L2-1/2X2X5/16X3/8SLBB
1512	2L	2L2-1/2X2X5/16X3/4SLBB
1513	2L	2L2-1/2X2X1/4SLBB
1514	2L	2L2-1/2X2X1/4X3/8SLBB
1515	2L	2L2-1/2X2X1/4X3/4SLBB
1516	2L	2L2-1/2X2X3/16SLBB
1517	2L	2L2-1/2X2X3/16X3/8SLBB
1518	2L	2L2-1/2X2X3/16X3/4SLBB

Number	Type	Name
1519	2L	2L2-1/2X1-1/2X1/4SLBB
1520	2L	2L2-1/2X1-1/2X1/4X3/8SLBB
1521	2L	2L2-1/2X1-1/2X1/4X3/4SLBB
1522	2L	2L2-1/2X1-1/2X3/16SLBB
1523	2L	2L2-1/2X1-1/2X3/16X3/8SLBB
1524	2L	2L2-1/2X1-1/2X3/16X3/4SLBB
1525	HSS	HSS24X12X3/4
1526	HSS	HSS24X12X5/8
1527	HSS	HSS24X12X1/2
1528	HSS	HSS22X22X7/8
1529	HSS	HSS22X22X3/4
1530	HSS	HSS20X20X7/8
1531	HSS	HSS20X20X3/4
1532	HSS	HSS20X20X5/8
1533	HSS	HSS20X20X1/2
1534	HSS	HSS20X12X3/4
1535	HSS	HSS20X12X5/8
1536	HSS	HSS20X12X1/2
1537	HSS	HSS20X12X3/8
1538	HSS	HSS20X12X5/16
1539	HSS	HSS20X8X5/8
1540	HSS	HSS20X8X1/2
1541	HSS	HSS20X8X3/8
1542	HSS	HSS20X8X5/16
1543	HSS	HSS20X4X1/2
1544	HSS	HSS20X4X3/8
1545	HSS	HSS20X4X5/16
1546	HSS	HSS20X4X1/4
1547	HSS	HSS18X18X7/8
1548	HSS	HSS18X18X3/4
1549	HSS	HSS18X18X5/8
1550	HSS	HSS18X18X1/2
1551	HSS	HSS18X6X5/8
1552	HSS	HSS18X6X1/2
1553	HSS	HSS18X6X3/8
1554	HSS	HSS18X6X5/16
1555	HSS	HSS18X6X1/4
1556	HSS	HSS16X16X7/8
1557	HSS	HSS16X16X3/4
1558	HSS	HSS16X16X5/8
1559	HSS	HSS16X16X1/2
1560	HSS	HSS16X16X3/8
1561	HSS	HSS16X16X5/16
1562	HSS	HSS16X12X3/4
1563	HSS	HSS16X12X5/8
1564	HSS	HSS16X12X1/2
1565	HSS	HSS16X12X3/8
1566	HSS	HSS16X12X5/16
1567	HSS	HSS16X8X5/8
1568	HSS	HSS16X8X1/2
1569	HSS	HSS16X8X3/8
1570	HSS	HSS16X8X5/16
1571	HSS	HSS16X8X1/4
1572	HSS	HSS16X4X5/8
1573	HSS	HSS16X4X1/2
1574	HSS	HSS16X4X3/8
1575	HSS	HSS16X4X5/16
1576	HSS	HSS16X4X1/4
1577	HSS	HSS16X4X3/16
1578	HSS	HSS14X14X7/8
1579	HSS	HSS14X14X3/4
1580	HSS	HSS14X14X5/8
1581	HSS	HSS14X14X1/2
1582	HSS	HSS14X14X3/8
1583	HSS	HSS14X14X5/16
1584	HSS	HSS14X10X5/8

Number	Type	Name
1585	HSS	HSS14X10X1/2
1586	HSS	HSS14X10X3/8
1587	HSS	HSS14X10X5/16
1588	HSS	HSS14X10X1/4
1589	HSS	HSS14X6X5/8
1590	HSS	HSS14X6X1/2
1591	HSS	HSS14X6X3/8
1592	HSS	HSS14X6X5/16
1593	HSS	HSS14X6X1/4
1594	HSS	HSS14X6X3/16
1595	HSS	HSS14X4X5/8
1596	HSS	HSS14X4X1/2
1597	HSS	HSS14X4X3/8
1598	HSS	HSS14X4X5/16
1599	HSS	HSS14X4X1/4
1600	HSS	HSS14X4X3/16
1601	HSS	HSS12X12X3/4
1602	HSS	HSS12X12X5/8
1603	HSS	HSS12X12X1/2
1604	HSS	HSS12X12X3/8
1605	HSS	HSS12X12X5/16
1606	HSS	HSS12X12X1/4
1607	HSS	HSS12X12X3/16
1608	HSS	HSS12X10X1/2
1609	HSS	HSS12X10X3/8
1610	HSS	HSS12X10X5/16
1611	HSS	HSS12X10X1/4
1612	HSS	HSS12X8X5/8
1613	HSS	HSS12X8X1/2
1614	HSS	HSS12X8X3/8
1615	HSS	HSS12X8X5/16
1616	HSS	HSS12X8X1/4
1617	HSS	HSS12X8X3/16
1618	HSS	HSS12X6X5/8
1619	HSS	HSS12X6X1/2
1620	HSS	HSS12X6X3/8
1621	HSS	HSS12X6X5/16
1622	HSS	HSS12X6X1/4
1623	HSS	HSS12X6X3/16
1624	HSS	HSS12X4X5/8
1625	HSS	HSS12X4X1/2
1626	HSS	HSS12X4X3/8
1627	HSS	HSS12X4X5/16
1628	HSS	HSS12X4X1/4
1629	HSS	HSS12X4X3/16
1630	HSS	HSS12X3-1/2X3/8
1631	HSS	HSS12X3-1/2X5/16
1632	HSS	HSS12X3X5/16
1633	HSS	HSS12X3X1/4
1634	HSS	HSS12X3X3/16
1635	HSS	HSS12X2X5/16
1636	HSS	HSS12X2X1/4
1637	HSS	HSS12X2X3/16
1638	HSS	HSS10X10X3/4
1639	HSS	HSS10X10X5/8
1640	HSS	HSS10X10X1/2
1641	HSS	HSS10X10X3/8
1642	HSS	HSS10X10X5/16
1643	HSS	HSS10X10X1/4
1644	HSS	HSS10X10X3/16
1645	HSS	HSS10X8X5/8
1646	HSS	HSS10X8X1/2
1647	HSS	HSS10X8X3/8
1648	HSS	HSS10X8X5/16
1649	HSS	HSS10X8X1/4
1650	HSS	HSS10X8X3/16

Number	Type	Name
1651	HSS	HSS10X6X5/8
1652	HSS	HSS10X6X1/2
1653	HSS	HSS10X6X3/8
1654	HSS	HSS10X6X5/16
1655	HSS	HSS10X6X1/4
1656	HSS	HSS10X6X3/16
1657	HSS	HSS10X5X3/8
1658	HSS	HSS10X5X5/16
1659	HSS	HSS10X5X1/4
1660	HSS	HSS10X5X3/16
1661	HSS	HSS10X4X5/8
1662	HSS	HSS10X4X1/2
1663	HSS	HSS10X4X3/8
1664	HSS	HSS10X4X5/16
1665	HSS	HSS10X4X1/4
1666	HSS	HSS10X4X3/16
1667	HSS	HSS10X4X1/8
1668	HSS	HSS10X3-1/2X1/2
1669	HSS	HSS10X3-1/2X3/8
1670	HSS	HSS10X3-1/2X5/16
1671	HSS	HSS10X3-1/2X1/4
1672	HSS	HSS10X3-1/2X3/16
1673	HSS	HSS10X3-1/2X1/8
1674	HSS	HSS10X3X3/8
1675	HSS	HSS10X3X5/16
1676	HSS	HSS10X3X1/4
1677	HSS	HSS10X3X3/16
1678	HSS	HSS10X3X1/8
1679	HSS	HSS10X2X3/8
1680	HSS	HSS10X2X5/16
1681	HSS	HSS10X2X1/4
1682	HSS	HSS10X2X3/16
1683	HSS	HSS10X2X1/8
1684	HSS	HSS9X9X5/8
1685	HSS	HSS9X9X1/2
1686	HSS	HSS9X9X3/8
1687	HSS	HSS9X9X5/16
1688	HSS	HSS9X9X1/4
1689	HSS	HSS9X9X3/16
1690	HSS	HSS9X9X1/8
1691	HSS	HSS9X7X5/8
1692	HSS	HSS9X7X1/2
1693	HSS	HSS9X7X3/8
1694	HSS	HSS9X7X5/16
1695	HSS	HSS9X7X1/4
1696	HSS	HSS9X7X3/16
1697	HSS	HSS9X5X5/8
1698	HSS	HSS9X5X1/2
1699	HSS	HSS9X5X3/8
1700	HSS	HSS9X5X5/16
1701	HSS	HSS9X5X1/4
1702	HSS	HSS9X5X3/16
1703	HSS	HSS9X3X1/2
1704	HSS	HSS9X3X3/8
1705	HSS	HSS9X3X5/16
1706	HSS	HSS9X3X1/4
1707	HSS	HSS9X3X3/16
1708	HSS	HSS8X8X5/8
1709	HSS	HSS8X8X1/2
1710	HSS	HSS8X8X3/8
1711	HSS	HSS8X8X5/16
1712	HSS	HSS8X8X1/4
1713	HSS	HSS8X8X3/16
1714	HSS	HSS8X8X1/8
1715	HSS	HSS8X6X5/8
1716	HSS	HSS8X6X1/2
1717	HSS	HSS8X6X3/8
1718	HSS	HSS8X6X5/16
1719	HSS	HSS8X6X1/4
1720	HSS	HSS8X6X3/16
1721	HSS	HSS8X4X5/8
1722	HSS	HSS8X4X1/2
1723	HSS	HSS8X4X3/8
1724	HSS	HSS8X4X5/16
1725	HSS	HSS8X4X1/4
1726	HSS	HSS8X4X3/16
1727	HSS	HSS8X4X1/8
1728	HSS	HSS8X3X1/2
1729	HSS	HSS8X3X3/8
1730	HSS	HSS8X3X5/16
1731	HSS	HSS8X3X1/4
1732	HSS	HSS8X3X3/16
1733	HSS	HSS8X3X1/8
1734	HSS	HSS8X2X3/8
1735	HSS	HSS8X2X5/16
1736	HSS	HSS8X2X1/4
1737	HSS	HSS8X2X3/16
1738	HSS	HSS8X2X1/8
1739	HSS	HSS7X7X5/8
1740	HSS	HSS7X7X1/2
1741	HSS	HSS7X7X3/8
1742	HSS	HSS7X7X5/16
1743	HSS	HSS7X7X1/4
1744	HSS	HSS7X7X3/16
1745	HSS	HSS7X7X1/8
1746	HSS	HSS7X5X1/2
1747	HSS	HSS7X5X3/8
1748	HSS	HSS7X5X5/16
1749	HSS	HSS7X5X1/4
1750	HSS	HSS7X5X3/16
1751	HSS	HSS7X5X1/8
1752	HSS	HSS7X4X1/2
1753	HSS	HSS7X4X3/8
1754	HSS	HSS7X4X5/16
1755	HSS	HSS7X4X1/4
1756	HSS	HSS7X4X3/16
1757	HSS	HSS7X4X1/8
1758	HSS	HSS7X3X1/2
1759	HSS	HSS7X3X3/8
1760	HSS	HSS7X3X5/16
1761	HSS	HSS7X3X1/4
1762	HSS	HSS7X3X3/16
1763	HSS	HSS7X3X1/8
1764	HSS	HSS7X2X1/4
1765	HSS	HSS7X2X3/16
1766	HSS	HSS7X2X1/8
1767	HSS	HSS6X6X5/8
1768	HSS	HSS6X6X1/2
1769	HSS	HSS6X6X3/8
1770	HSS	HSS6X6X5/16
1771	HSS	HSS6X6X1/4
1772	HSS	HSS6X6X3/16
1773	HSS	HSS6X6X1/8
1774	HSS	HSS6X5X1/2
1775	HSS	HSS6X5X3/8
1776	HSS	HSS6X5X5/16
1777	HSS	HSS6X5X1/4
1778	HSS	HSS6X5X3/16
1779	HSS	HSS6X5X1/8
1780	HSS	HSS6X4X1/2
1781	HSS	HSS6X4X3/8
1782	HSS	HSS6X4X5/16
1783	HSS	HSS6X4X1/4
1784	HSS	HSS6X4X3/16
1785	HSS	HSS6X4X1/8
1786	HSS	HSS6X3X1/2
1787	HSS	HSS6X3X3/8
1788	HSS	HSS6X3X5/16
1789	HSS	HSS6X3X1/4
1790	HSS	HSS6X3X3/16
1791	HSS	HSS6X3X1/8
1792	HSS	HSS6X2X3/8
1793	HSS	HSS6X2X5/16
1794	HSS	HSS6X2X1/4
1795	HSS	HSS6X2X3/16
1796	HSS	HSS6X2X1/8
1797	HSS	HSS5-1/2X5-1/2X3/8
1798	HSS	HSS5-1/2X5-1/2X5/16
1799	HSS	HSS5-1/2X5-1/2X1/4
1800	HSS	HSS5-1/2X5-1/2X3/16
1801	HSS	HSS5-1/2X5-1/2X1/8
1802	HSS	HSS5X5X1/2
1803	HSS	HSS5X5X3/8
1804	HSS	HSS5X5X5/16
1805	HSS	HSS5X5X1/4
1806	HSS	HSS5X5X3/16
1807	HSS	HSS5X5X1/8
1808	HSS	HSS5X4X1/2
1809	HSS	HSS5X4X3/8
1810	HSS	HSS5X4X5/16
1811	HSS	HSS5X4X1/4
1812	HSS	HSS5X4X3/16
1813	HSS	HSS5X4X1/8
1814	HSS	HSS5X3X1/2
1815	HSS	HSS5X3X3/8
1816	HSS	HSS5X3X5/16
1817	HSS	HSS5X3X1/4
1818	HSS	HSS5X3X3/16
1819	HSS	HSS5X3X1/8
1820	HSS	HSS5X2-1/2X1/4
1821	HSS	HSS5X2-1/2X3/16
1822	HSS	HSS5X2-1/2X1/8
1823	HSS	HSS5X2X3/8
1824	HSS	HSS5X2X5/16
1825	HSS	HSS5X2X1/4
1826	HSS	HSS5X2X3/16
1827	HSS	HSS5X2X1/8
1828	HSS	HSS4-1/2X4-1/2X1/2
1829	HSS	HSS4-1/2X4-1/2X3/8
1830	HSS	HSS4-1/2X4-1/2X5/16
1831	HSS	HSS4-1/2X4-1/2X1/4
1832	HSS	HSS4-1/2X4-1/2X3/16
1833	HSS	HSS4-1/2X4-1/2X1/8
1834	HSS	HSS4X4X1/2
1835	HSS	HSS4X4X3/8
1836	HSS	HSS4X4X5/16
1837	HSS	HSS4X4X1/4
1838	HSS	HSS4X4X3/16
1839	HSS	HSS4X4X1/8
1840	HSS	HSS4X3X3/8
1841	HSS	HSS4X3X5/16
1842	HSS	HSS4X3X1/4
1843	HSS	HSS4X3X3/16
1844	HSS	HSS4X3X1/8
1845	HSS	HSS4X2-1/2X3/8
1846	HSS	HSS4X2-1/2X5/16
1847	HSS	HSS4X2-1/2X1/4
1848	HSS	HSS4X2-1/2X3/16
1849	HSS	HSS4X2-1/2X1/8
1850	HSS	HSS4X2X3/8
1851	HSS	HSS4X2X5/16
1852	HSS	HSS4X2X1/4
1853	HSS	HSS4X2X3/16
1854	HSS	HSS4X2X1/8
1855	HSS	HSS3-1/2X3-1/2X3/8
1856	HSS	HSS3-1/2X3-1/2X5/16
1857	HSS	HSS3-1/2X3-1/2X1/4
1858	HSS	HSS3-1/2X3-1/2X3/16
1859	HSS	HSS3-1/2X3-1/2X1/8
1860	HSS	HSS3-1/2X2-1/2X3/8
1861	HSS	HSS3-1/2X2-1/2X5/16
1862	HSS	HSS3-1/2X2-1/2X1/4
1863	HSS	HSS3-1/2X2-1/2X3/16
1864	HSS	HSS3-1/2X2-1/2X1/8
1865	HSS	HSS3-1/2X2X1/4
1866	HSS	HSS3-1/2X2X3/16
1867	HSS	HSS3-1/2X2X1/8
1868	HSS	HSS3-1/2X1-1/2X1/4
1869	HSS	HSS3-1/2X1-1/2X3/16
1870	HSS	HSS3-1/2X1-1/2X1/8
1871	HSS	HSS3X3X3/8
1872	HSS	HSS3X3X5/16
1873	HSS	HSS3X3X1/4
1874	HSS	HSS3X3X3/16
1875	HSS	HSS3X3X1/8
1876	HSS	HSS3X2-1/2X5/16
1877	HSS	HSS3X2-1/2X1/4
1878	HSS	HSS3X2-1/2X3/16
1879	HSS	HSS3X2-1/2X1/8
1880	HSS	HSS3X2X5/16
1881	HSS	HSS3X2X1/4
1882	HSS	HSS3X2X3/16
1883	HSS	HSS3X2X1/8
1884	HSS	HSS3X1-1/2X1/4
1885	HSS	HSS3X1-1/2X3/16
1886	HSS	HSS3X1-1/2X1/8
1887	HSS	HSS3X1X3/16
1888	HSS	HSS3X1X1/8
1889	HSS	HSS2-1/2X2-1/2X5/16
1890	HSS	HSS2-1/2X2-1/2X1/4
1891	HSS	HSS2-1/2X2-1/2X3/16
1892	HSS	HSS2-1/2X2-1/2X1/8
1893	HSS	HSS2-1/2X2X1/4
1894	HSS	HSS2-1/2X2X3/16
1895	HSS	HSS2-1/2X2X1/8
1896	HSS	HSS2-1/2X1-1/2X1/4
1897	HSS	HSS2-1/2X1-1/2X3/16
1898	HSS	HSS2-1/2X1-1/2X1/8
1899	HSS	HSS2-1/2X1X3/16
1900	HSS	HSS2-1/2X1X1/8
1901	HSS	HSS2-1/4X2-1/4X1/4
1902	HSS	HSS2-1/4X2-1/4X3/16
1903	HSS	HSS2-1/4X2-1/4X1/8
1904	HSS	HSS2-1/4X2X3/16
1905	HSS	HSS2-1/4X2X1/8
1906	HSS	HSS2X2X1/4
1907	HSS	HSS2X2X3/16
1908	HSS	HSS2X2X1/8
1909	HSS	HSS2X1-1/2X3/16
1910	HSS	HSS2X1-1/2X1/8
1911	HSS	HSS2X1X3/16
1912	HSS	HSS2X1X1/8
1913	HSS	HSS20.000X0.500
1914	HSS	HSS20.000X0.375
1915	HSS	HSS18.000X0.500
1916	HSS	HSS18.000X0.375
1917	HSS	HSS16.000X0.625
1918	HSS	HSS16.000X0.500
1919	HSS	HSS16.000X0.438
1920	HSS	HSS16.000X0.375
1921	HSS	HSS16.000X0.312
1922	HSS	HSS16.000X0.250
1923	HSS	HSS14.000X0.625
1924	HSS	HSS14.000X0.500
1925	HSS	HSS14.000X0.375
1926	HSS	HSS14.000X0.312
1927	HSS	HSS14.000X0.250
1928	HSS	HSS12.750X0.500
1929	HSS	HSS12.750X0.375
1930	HSS	HSS12.750X0.250
1931	HSS	HSS10.750X0.500
1932	HSS	HSS10.750X0.375
1933	HSS	HSS10.750X0.250
1934	HSS	HSS10.000X0.625
1935	HSS	HSS10.000X0.500
1936	HSS	HSS10.000X0.375
1937	HSS	HSS10.000X0.312
1938	HSS	HSS10.000X0.250
1939	HSS	HSS10.000X0.188
1940	HSS	HSS9.625X0.500
1941	HSS	HSS9.625X0.375
1942	HSS	HSS9.625X0.312
1943	HSS	HSS9.625X0.250
1944	HSS	HSS9.625X0.188
1945	HSS	HSS8.625X0.625
1946	HSS	HSS8.625X0.500
1947	HSS	HSS8.625X0.375
1948	HSS	HSS8.625X0.322
1949	HSS	HSS8.625X0.250
1950	HSS	HSS8.625X0.188
1951	HSS	HSS7.625X0.375
1952	HSS	HSS7.625X0.328
1953	HSS	HSS7.500X0.500
1954	HSS	HSS7.500X0.375
1955	HSS	HSS7.500X0.312
1956	HSS	HSS7.500X0.250
1957	HSS	HSS7.500X0.188
1958	HSS	HSS7.000X0.500
1959	HSS	HSS7.000X0.375
1960	HSS	HSS7.000X0.312
1961	HSS	HSS7.000X0.250
1962	HSS	HSS7.000X0.188
1963	HSS	HSS7.000X0.125
1964	HSS	HSS6.875X0.500
1965	HSS	HSS6.875X0.375
1966	HSS	HSS6.875X0.312
1967	HSS	HSS6.875X0.250
1968	HSS	HSS6.875X0.188
1969	HSS	HSS6.625X0.500
1970	HSS	HSS6.625X0.432
1971	HSS	HSS6.625X0.375
1972	HSS	HSS6.625X0.312
1973	HSS	HSS6.625X0.280
1974	HSS	HSS6.625X0.250
1975	HSS	HSS6.625X0.188
1976	HSS	HSS6.625X0.125
1977	HSS	HSS6.000X0.500
1978	HSS	HSS6.000X0.375
1979	HSS	HSS6.000X0.312
1980	HSS	HSS6.000X0.280

Number	Type	Name
1981	HSS	HSS6.000X0.250
1982	HSS	HSS6.000X0.188
1983	HSS	HSS6.000X0.125
1984	HSS	HSS5.563X0.500
1985	HSS	HSS5.563X0.375
1986	HSS	HSS5.563X0.258
1987	HSS	HSS5.563X0.188
1988	HSS	HSS5.563X0.134
1989	HSS	HSS5.500X0.500
1990	HSS	HSS5.500X0.375
1991	HSS	HSS5.500X0.258
1992	HSS	HSS5.000X0.500
1993	HSS	HSS5.000X0.375
1994	HSS	HSS5.000X0.312
1995	HSS	HSS5.000X0.258
1996	HSS	HSS5.000X0.250
1997	HSS	HSS5.000X0.188
1998	HSS	HSS5.000X0.125
1999	HSS	HSS4.500X0.375
2000	HSS	HSS4.500X0.337
2001	HSS	HSS4.500X0.237
2002	HSS	HSS4.500X0.188
2003	HSS	HSS4.500X0.125
2004	HSS	HSS4.000X0.313
2005	HSS	HSS4.000X0.250
2006	HSS	HSS4.000X0.237
2007	HSS	HSS4.000X0.226
2008	HSS	HSS4.000X0.220
2009	HSS	HSS4.000X0.188
2010	HSS	HSS4.000X0.125
2011	HSS	HSS3.500X0.313
2012	HSS	HSS3.500X0.300
2013	HSS	HSS3.500X0.250
2014	HSS	HSS3.500X0.216
2015	HSS	HSS3.500X0.203
2016	HSS	HSS3.500X0.188
2017	HSS	HSS3.500X0.125
2018	HSS	HSS3.000X0.250
2019	HSS	HSS3.000X0.216
2020	HSS	HSS3.000X0.203
2021	HSS	HSS3.000X0.188
2022	HSS	HSS3.000X0.152
2023	HSS	HSS3.000X0.134
2024	HSS	HSS3.000X0.125
2025	HSS	HSS2.875X0.250
2026	HSS	HSS2.875X0.203
2027	HSS	HSS2.875X0.188
2028	HSS	HSS2.875X0.125
2029	HSS	HSS2.500X0.250
2030	HSS	HSS2.500X0.188
2031	HSS	HSS2.500X0.125
2032	HSS	HSS2.375X0.250
2033	HSS	HSS2.375X0.218
2034	HSS	HSS2.375X0.188
2035	HSS	HSS2.375X0.154
2036	HSS	HSS2.375X0.125
2037	HSS	HSS1.900X0.188
2038	HSS	HSS1.900X0.145
2039	HSS	HSS1.900X0.120
2040	HSS	HSS1.660X0.140
2041	PIPE	Pipe26STD
2042	PIPE	Pipe24STD
2043	PIPE	Pipe20STD
2044	PIPE	Pipe18STD
2045	PIPE	Pipe16STD
2046	PIPE	Pipe14STD
2047	PIPE	Pipe12STD
2048	PIPE	Pipe10STD
2049	PIPE	Pipe8STD
2050	PIPE	Pipe6STD
2051	PIPE	Pipe5STD
2052	PIPE	Pipe4STD
2053	PIPE	Pipe3-1/2STD
2054	PIPE	Pipe3STD
2055	PIPE	Pipe2-1/2STD
2056	PIPE	Pipe2STD
2057	PIPE	Pipe1-1/2STD
2058	PIPE	Pipe1-1/4STD
2059	PIPE	Pipe1STD
2060	PIPE	Pipe3/4STD
2061	PIPE	Pipe1/2STD
2062	PIPE	Pipe26XS
2063	PIPE	Pipe24XS
2064	PIPE	Pipe20XS
2065	PIPE	Pipe18XS
2066	PIPE	Pipe16XS
2067	PIPE	Pipe14XS
2068	PIPE	Pipe12XS
2069	PIPE	Pipe10XS
2070	PIPE	Pipe8XS
2071	PIPE	Pipe6XS
2072	PIPE	Pipe5XS
2073	PIPE	Pipe4XS
2074	PIPE	Pipe3-1/2XS
2075	PIPE	Pipe3XS
2076	PIPE	Pipe2-1/2XS
2077	PIPE	Pipe2XS
2078	PIPE	Pipe1-1/2XS
2079	PIPE	Pipe1-1/4XS
2080	PIPE	Pipe1XS
2081	PIPE	Pipe3/4XS
2082	PIPE	Pipe1/2XS
2083	PIPE	Pipe12XXS
2084	PIPE	Pipe10XXS
2085	PIPE	Pipe8XXS
2086	PIPE	Pipe6XXS
2087	PIPE	Pipe5XXS
2088	PIPE	Pipe4XXS
2089	PIPE	Pipe3XXS
2090	PIPE	Pipe2-1/2XXS
2091	PIPE	Pipe2XXS

D.2 EURO.BIN File of European Shapes

D.2.1 Cross Reference for: IPN, IPE, HD, HE, HL, HP, T, UPN, UPE, UAP, U, L, RHS, SHS, CSH Types

Number	Type	Name	Number	Type	Name	Number	Type	Name	Number	Type	Name	Number	Type	Name
1	IPN	IPN 600	67	IPE	IPEA 300	133	HD	HD 400X551	199	HE	HE 600X399	265	HE	HE 180 C
2	IPN	IPN 550	68	IPE	IPER 270	134	HD	HD 400X509	200	HE	HE 600X337	266	HE	HE 180 B
3	IPN	IPN 500	69	IPE	IPEO 270	135	HD	HD 400X463	201	HE	HE 600 M	267	HE	HE 180 A
4	IPN	IPN 450	70	IPE	IPE 270	136	HD	HD 400X421	202	HE	HE 600 B	268	HE	HE 180 AA
5	IPN	IPN 400	71	IPE	IPEA 270	137	HD	HD 400X382	203	HE	HE 600 A	269	HE	HE 160 M
6	IPN	IPN 380	72	IPE	IPER 240	138	HD	HD 400X347	204	HE	HE 600 AA	270	HE	HE 160 C
7	IPN	IPN 360	73	IPE	IPEO 240	139	HD	HD 400X314	205	HE	HE 550 M	271	HE	HE 160 B
8	IPN	IPN 340	74	IPE	IPE 240	140	HD	HD 400X287	206	HE	HE 550 B	272	HE	HE 160 A
9	IPN	IPN 320	75	IPE	IPEA 240	141	HD	HD 400X262	207	HE	HE 550 A	273	HE	HE 160 AA
10	IPN	IPN 300	76	IPE	IPEAA 240	142	HD	HD 400X237	208	HE	HE 550 AA	274	HE	HE 140 M
11	IPN	IPN 280	77	IPE	IPER 220	143	HD	HD 400X216	209	HE	HE 500 M	275	HE	HE 140 C
12	IPN	IPN 260	78	IPE	IPEO 220	144	HD	HD 400X187	210	HE	HE 500 B	276	HE	HE 140 B
13	IPN	IPN 240	79	IPE	IPE 220	145	HD	HD 360X196	211	HE	HE 500 A	277	HE	HE 140 A
14	IPN	IPN 220	80	IPE	IPEA 220	146	HD	HD 360X179	212	HE	HE 500 AA	278	HE	HE 140 AA
15	IPN	IPN 200	81	IPE	IPEAA 220	147	HD	HD 360X162	213	HE	HE 450 M	279	HE	HE 120 M
16	IPN	IPN 180	82	IPE	IPEAAA 220	148	HD	HD 360X147	214	HE	HE 450 B	280	HE	HE 120 C
17	IPN	IPN 160	83	IPE	IPEAAAA 220	149	HD	HD 360X134	215	HE	HE 450 A	281	HE	HE 120 B
18	IPN	IPN 140	84	IPE	IPER 200	150	HD	HD 320X300	216	HE	HE 450 AA	282	HE	HE 120 A
19	IPN	IPN 120	85	IPE	IPEO 200	151	HD	HD 320X245	217	HE	HE 400 M	283	HE	HE 120 AA
20	IPN	IPN 100	86	IPE	IPE 200	152	HD	HD 320X198	218	HE	HE 400 B	284	HE	HE 100 M
21	IPN	IPN 80	87	IPE	IPEA 200	153	HD	HD 320X158	219	HE	HE 400 A	285	HE	HE 100 C
22	IPE	IPE 750X222	88	IPE	IPEAA 200	154	HD	HD 320X127	220	HE	HE 400 AA	286	HE	HE 100 B
23	IPE	IPE 750X210	89	IPE	IPEAAA 200	155	HD	HD 320X97.6	221	HE	HE 360 M	287	HE	HE 100 A
24	IPE	IPE 750X196	90	IPE	IPEAAAA 200	156	HD	HD 320X74.2	222	HE	HE 360 B	288	HE	HE 100 AA
25	IPE	IPE 750X185	91	IPE	IPER 180	157	HD	HD 260X172	223	HE	HE 360 A	289	HL	HL 1100 D Z
26	IPE	IPE 750X173	92	IPE	IPEO 180	158	HD	HD 260X142	224	HE	HE 360 AA	290	HL	HL 1100 C Z
27	IPE	IPE 750X161	93	IPE	IPE 180	159	HD	HD 260X114	225	HE	HE 340 M	291	HL	HL 1100 B Z
28	IPE	IPE 750X147	94	IPE	IPEA 180	160	HD	HD 260X93	226	HE	HE 340 B	292	HL	HL 1100 A Z
29	IPE	IPE 750X137	95	IPE	IPEAA 180	161	HD	HD 260X68.2	227	HE	HE 340 A	293	HL	HL 1100X607
30	IPE	IPE 750X134	96	IPE	IPEAAA 180	162	HD	HD 260X54.1	228	HE	HE 340 AA	294	HL	HL 1100X584
31	IPE	IPEV 600	97	IPE	IPEAAAA 180	163	HE	HE 1000X584	229	HE	HE 320 M	295	HL	HL 1100 R
32	IPE	IPER 600	98	IPE	IPER 160	164	HE	HE 1000X579	230	HE	HE 320 C	296	HL	HL 1100 M
33	IPE	IPEO 600	99	IPE	IPE 160	165	HE	HE 1000X494	231	HE	HE 320 B	297	HL	HL 1100 B
34	IPE	IPE 600	100	IPE	IPEA 160	166	HE	HE 1000X488	232	HE	HE 320 A	298	HL	HL 1100 A
35	IPE	IPEA 600	101	IPE	IPEAA 160	167	HE	HE 1000X438	233	HE	HE 320 AA	299	HL	HL 1000X976
36	IPE	IPEV 550	102	IPE	IPEAAA 160	168	HE	HE 1000X415	234	HE	HE 300 M	300	HL	HL 1000X883
37	IPE	IPER 550	103	IPE	IPEAAAA 160	169	HE	HE 1000X409	235	HE	HE 300 C	301	HL	HL 1000X748
38	IPE	IPEO 550	104	IPE	IPER 140	170	HE	HE 1000X393	236	HE	HE 300 B	302	HL	HL 1000X642
39	IPE	IPE 550	105	IPE	IPE 140	171	HE	HE 1000 M	237	HE	HE 300 A	303	HL	HL 1000X591
40	IPE	IPEA 550	106	IPE	IPEA 140	172	HE	HE 1000 B	238	HE	HE 300 AA	304	HL	HL 1000X554
41	IPE	IPEV 500	107	IPE	IPEAA 140	173	HE	HE 1000 A	239	HE	HE 280 M	305	HL	HL 1000X539
42	IPE	IPER 500	108	IPE	IPEAAA 140	174	HE	HE 1000 AA	240	HE	HE 280 C	306	HL	HL 1000X483
43	IPE	IPEO 500	109	IPE	IPEAAAA 140	175	HE	HE 900X466	241	HE	HE 280 B	307	HL	HL 1000X443
44	IPE	IPE 500	110	IPE	IPE 120	176	HE	HE 900X391	242	HE	HE 280 A	308	HL	HL 1000 M
45	IPE	IPEA 500	111	IPE	IPEA 120	177	HE	HE 900 M	243	HE	HE 280 AA	309	HL	HL 1000 B
46	IPE	IPEV 450	112	IPE	IPEAA 120	178	HE	HE 900 B	244	HE	HE 260 M	310	HL	HL 1000 A
47	IPE	IPER 450	113	IPE	IPEAAA 120	179	HE	HE 900 A	245	HE	HE 260 C	311	HL	HL 1000 AA
48	IPE	IPEO 450	114	IPE	IPEAAAA 120	180	HE	HE 900 AA	246	HE	HE 260 B	312	HL	HL 920X1377
49	IPE	IPE 450	115	IPE	IPE 100	181	HE	HE 800X444	247	HE	HE 260 A	313	HL	HL 920X1269
50	IPE	IPEA 450	116	IPE	IPEA 100	182	HE	HE 800X373	248	HE	HE 260 AA	314	HL	HL 920X1194
51	IPE	IPEV 400	117	IPE	IPEAA 100	183	HE	HE 800 M	249	HE	HE 240 M	315	HL	HL 920X1077
52	IPE	IPER 400	118	IPE	IPEAAA 100	184	HE	HE 800 B	250	HE	HE 240 C	316	HL	HL 920X970
53	IPE	IPEO 400	119	IPE	IPEAAAA 100	185	HE	HE 800 A	251	HE	HE 240 B	317	HL	HL 920X967
54	IPE	IPE 400	120	IPE	IPE 80	186	HE	HE 800 AA	252	HE	HE 240 A	318	HL	HL 920X784
55	IPE	IPEA 400	121	IPE	IPEA 80	187	HE	HE 700X418	253	HE	HE 240 AA	319	HL	HL 920X653
56	IPE	IPER 360	122	IPE	IPEAA 80	188	HE	HE 700X352	254	HE	HE 220 M	320	HL	HL 920X585
57	IPE	IPEO 360	123	IPE	IPEAAA 80	189	HE	HE 700 M	255	HE	HE 220 C	321	HL	HL 920X534
58	IPE	IPE 360	124	IPE	IPEAAAA 80	190	HE	HE 700 B	256	HE	HE 220 B	322	HL	HL 920X488
59	IPE	IPEA 360	125	HD	HD 400X1086	191	HE	HE 700 A	257	HE	HE 220 A	323	HL	HL 920X446
60	IPE	IPER 330	126	HD	HD 400X990	192	HE	HE 700 AA	258	HE	HE 220 AA	324	HL	HL 920X417
61	IPE	IPEO 330	127	HD	HD 400X900	193	HE	HE 650X407	259	HE	HE 200 M	325	HL	HL 920X387
62	IPE	IPE 330	128	HD	HD 400X818	194	HE	HE 650X343	260	HE	HE 200 C	326	HL	HL 920X365
63	IPE	IPEA 330	129	HD	HD 400X744	195	HE	HE 650 M	261	HE	HE 200 B	327	HL	HL 920X342
64	IPE	IPER 300	130	HD	HD 400X677	196	HE	HE 650 B	262	HE	HE 200 A	328	HP	HP 400X231
65	IPE	IPEO 300	131	HD	HD 400X634	197	HE	HE 650 A	263	HE	HE 200 AA	329	HP	HP 400X213
66	IPE	IPE 300	132	HD	HD 400X592	198	HE	HE 650 AA	264	HE	HE 180 M	330	HP	HP 400X194

Number	Type	Name	Number	Type	Name	Number	Type	Name	Number	Type	Name	Number	Type	Name
331	HP	HP 400X176	397	T	THE 320 M	463	L	L 250X250X28	529	L	L 90X90X8	595	L	L 150X75X11
332	HP	HP 400X158	398	T	THE 320 B	464	L	L 250X250X27	530	L	L 90X90X7	596	L	L 150X75X10
333	HP	HP 400X140	399	T	THE 300 M	465	L	L 250X250X26	531	L	L 90X90X6	597	L	L 150X75X9
334	HP	HP 400X122	400	T	THE 300 B	466	L	L 250X250X25	532	L	L 80X80X10	598	L	L 140X90X14
335	HP	HP 360X180	401	T	THE 300 A	467	L	L 250X250X24	533	L	L 80X80X8	599	L	L 140X90X12
336	HP	HP 360X174	402	T	THE 280 M	468	L	L 250X250X23	534	L	L 80X80X7	600	L	L 140X90X10
337	HP	HP 360X152	403	T	THE 280 A	469	L	L 250X250X22	535	L	L 80X80X6	601	L	L 140X90X8
338	HP	HP 360X133	404	T	THE 260 M	470	L	L 250X250X21	536	L	L 80X80X5	602	L	L 130X90X14
339	HP	HP 360X109	405	T	THE 260 B	471	L	L 250X250X20	537	L	L 75X75X10	603	L	L 130X90X12
340	HP	HP 360X84	406	T	THE 240 M	472	L	L 200X200X26	538	L	L 75X75X8	604	L	L 130X90X10
341	HP	HP 320X184	407	T	THE 220 M	473	L	L 200X200X25	539	L	L 75X75X7	605	L	L 125X75X12
342	HP	HP 320X147	408	T	THP 400X194	474	L	L 200X200X24	540	L	L 75X75X6	606	L	L 125X75X10
343	HP	HP 320X117	409	T	THP 400X176	475	L	L 200X200X23	541	L	L 75X75X5	607	L	L 125X75X9
344	HP	HP 320X103	410	T	THP 400X158	476	L	L 200X200X22	542	L	L 75X75X4	608	L	L 125X75X8
345	HP	HP 320X88	411	T	THP 400X140	477	L	L 200X200X21	543	L	L 70X70X10	609	L	L 120X80X12
346	HP	HP 305X223	412	T	THP 400X122	478	L	L 200X200X20	544	L	L 70X70X9	610	L	L 120X80X10
347	HP	HP 305X186	413	T	THP 360X152	479	L	L 200X200X19	545	L	L 70X70X8	611	L	L 120X80X8
348	HP	HP 305X180	414	T	THP 360X133	480	L	L 200X200X18	546	L	L 70X70X7	612	L	L 110X70X12
349	HP	HP 305X149	415	T	THP 360X109	481	L	L 200X200X17	547	L	L 70X70X6	613	L	L 110X70X10
350	HP	HP 305X126	416	UPN	UPN 400	482	L	L 200X200X16	548	L	L 65X65X8	614	L	L 100X75X12
351	HP	HP 305X110	417	UPN	UPN 380	483	L	L 200X200X15	549	L	L 65X65X7	615	L	L 100X75X10
352	HP	HP 305X95	418	UPN	UPN 350	484	L	L 180X180X20	550	L	L 65X65X6	616	L	L 100X75X8
353	HP	HP 305X88	419	UPN	UPN 320	485	L	L 180X180X19	551	L	L 60X60X10	617	L	L 100X65X12
354	HP	HP 305X79	420	UPN	UPN 300	486	L	L 180X180X18	552	L	L 60X60X8	618	L	L 100X65X10
355	HP	HP 260X87	421	UPN	UPN 280	487	L	L 180X180X17	553	L	L 60X60X6	619	L	L 100X65X9
356	HP	HP 260X75	422	UPN	UPN 260	488	L	L 180X180X16	554	L	L 60X60X5	620	L	L 100X65X8
357	HP	HP 220X57	423	UPN	UPN 240	489	L	L 180X180X15	555	L	L 55X55X6	621	L	L 100X65X7
358	HP	HP 200X53	424	UPN	UPN 220	490	L	L 180X180X14	556	L	L 55X55X5	622	L	L 80X60X8
359	HP	HP 200X43	425	UPN	UPN 200	491	L	L 180X180X13	557	L	L 50X50X8	623	L	L 80X60X7
360	T	T 80	426	UPN	UPN 180	492	L	L 160X160X17	558	L	L 50X50X7	624	L	L 80X60X6
361	T	T 70	427	UPN	UPN 160	493	L	L 160X160X16	559	L	L 50X50X6	625	L	L 75X50X8
362	T	T 60	428	UPN	UPN 140	494	L	L 160X160X15	560	L	L 50X50X5	626	L	L 75X50X6
363	T	T 50	429	UPN	UPN 120	495	L	L 160X160X14	561	L	L 50X50X4	627	L	L 65X50X8
364	T	T 40	430	UPN	UPN 100	496	L	L 150X150X20	562	L	L 50X50X3	628	L	L 65X50X6
365	T	T 35	431	UPN	UPN 80	497	L	L 150X150X18	563	L	L 45X45X6	629	L	L 65X50X5
366	T	T 30	432	UPN	UPN 65	498	L	L 150X150X16	564	L	L 45X45X5	630	L	L 60X30X6
367	T	TIPEO 600	433	UPN	UPN 50	499	L	L 150X150X15	565	L	L 45X45X4.5	631	L	L 60X30X5
368	T	TIPE 600	434	UPE	UPE 400	500	L	L 150X150X14	566	L	L 45X45X4	632	L	L 60X30X4
369	T	TIPEO 550	435	UPE	UPE 360	501	L	L 150X150X13	567	L	L 45X45X3	633	L	L 40X25X4
370	T	TIPE 550	436	UPE	UPE 330	502	L	L 150X150X12	568	L	L 40X40X6	634	RHS	RHS 500X300X20
371	T	TIPEO 500	437	UPE	UPE 300	503	L	L 150X150X10	569	L	L 40X40X5	635	RHS	RHS 500X300X16
372	T	TIPE 500	438	UPE	UPE 270	504	L	L 130X130X16	570	L	L 40X40X4	636	RHS	RHS 500X300X12.5
373	T	TIPEO 450	439	UPE	UPE 240	505	L	L 130X130X14	571	L	L 40X40X3	637	RHS	RHS 500X300X12
374	T	TIPE 450	440	UPE	UPE 220	506	L	L 130X130X13	572	L	L 35X35X4	638	RHS	RHS 500X300X10
375	T	TIPEO 400	441	UPE	UPE 200	507	L	L 130X130X12	573	L	L 30X30X5	639	RHS	RHS 500X300X8
376	T	TIPE 400	442	UPE	UPE 180	508	L	L 130X130X10	574	L	L 30X30X4	640	RHS	RHS 450X250X16
377	T	THE 650 M	443	UPE	UPE 160	509	L	L 120X120X16	575	L	L 30X30X3	641	RHS	RHS 450X250X12.5
378	T	THE 650 B	444	UPE	UPE 140	510	L	L 120X120X15	576	L	L 25X25X5	642	RHS	RHS 450X250X12
379	T	THE 650 A	445	UPE	UPE 120	511	L	L 120X120X13	577	L	L 25X25X4	643	RHS	RHS 450X250X10
380	T	THE 600 M	446	UPE	UPE 100	512	L	L 120X120X12	578	L	L 25X25X3	644	RHS	RHS 400X200X16
381	T	THE 600 B	447	UPE	UPE 80	513	L	L 120X120X11	579	L	L 20X20X3	645	RHS	RHS 400X200X12.5
382	T	THE 600 A	448	UAP	UAP 300	514	L	L 120X120X10	580	L	L 200X150X18	646	RHS	RHS 400X200X12
383	T	THE 550 M	449	UAP	UAP 250	515	L	L 120X120X8	581	L	L 200X150X15	647	RHS	RHS 400X200X10
384	T	THE 550 B	450	UAP	UAP 220	516	L	L 110X110X12	582	L	L 200X150X12	648	RHS	RHS 400X200X8
385	T	THE 550 A	451	UAP	UAP 200	517	L	L 110X110X10	583	L	L 200X100X15	649	RHS	RHS 400X200X6.3
386	T	THE 500 M	452	UAP	UAP 175	518	L	L 110X110X8	584	L	L 200X100X14	650	RHS	RHS 400X200X6
387	T	THE 500 B	453	UAP	UAP 150	519	L	L 100X100X15	585	L	L 200X100X12	651	RHS	RHS 350X250X16
388	T	THE 500 A	454	UAP	UAP 130	520	L	L 100X100X12	586	L	L 200X100X10	652	RHS	RHS 350X250X12.5
389	T	THE 450 M	455	UAP	UAP 100	521	L	L 100X100X10	587	L	L 150X100X14	653	RHS	RHS 350X250X12
390	T	THE 450 B	456	UAP	UAP 80	522	L	L 100X100X8	588	L	L 150X100X12	654	RHS	RHS 350X250X10
391	T	THE 400 M	457	U	U 65X42X5.5	523	L	L 100X100X7	589	L	L 150X100X10	655	RHS	RHS 350X250X8
392	T	THE 400 B	458	U	U 60X30X6	524	L	L 100X100X6	590	L	L 150X90X15	656	RHS	RHS 350X250X6.3
393	T	THE 360 M	459	U	U 50X25X5	525	L	L 90X90X12	591	L	L 150X90X12	657	RHS	RHS 350X250X6
394	T	THE 360 B	460	U	U 40X20X5	526	L	L 90X90X11	592	L	L 150X90X11	658	RHS	RHS 300X200X16
395	T	THE 340 M	461	U	U 40X20X4	527	L	L 90X90X10	593	L	L 150X90X10	659	RHS	RHS 300X200X12.5
396	T	THE 340 B	462	L	L 250X250X35	528	L	L 90X90X9	594	L	L 150X75X12	660	RHS	RHS 300X200X12

Number	Type	Name	Number	Type	Name	Number	Type	Name	Number	Type	Name	Number	Type	Name
661	RHS	RHS 300X200X10	727	RHS	RHS 120X80X8	793	RHS	RHS 50X30X2.5	859	SHS	SHS 350X19	925	SHS	SHS 150X10
662	RHS	RHS 300X200X8	728	RHS	RHS 120X80X6.3	794	RHS	RHS 50X25X3	860	SHS	SHS 350X16	926	SHS	SHS 150X8
663	RHS	RHS 300X200X6.3	729	RHS	RHS 120X80X6	795	RHS	RHS 50X25X2.5	861	SHS	SHS 350X12.5	927	SHS	SHS 150X6.3
664	RHS	RHS 300X200X6	730	RHS	RHS 120X80X5	796	SHS	SHS 800X50	862	SHS	SHS 350X12	928	SHS	SHS 150X6
665	RHS	RHS 300X200X5	731	RHS	RHS 120X80X4	797	SHS	SHS 800X45	863	SHS	SHS 350X10	929	SHS	SHS 150X5
666	RHS	RHS 260X180X16	732	RHS	RHS 120X80X3.6	798	SHS	SHS 800X40	864	SHS	SHS 350X8	930	SHS	SHS 150X4
667	RHS	RHS 260X180X12.5	733	RHS	RHS 120X60X10	799	SHS	SHS 800X36	865	SHS	SHS 300X16	931	SHS	SHS 140X12.5
668	RHS	RHS 260X180X12	734	RHS	RHS 120X60X8	800	SHS	SHS 800X32	866	SHS	SHS 300X12.5	932	SHS	SHS 140X12
669	RHS	RHS 260X180X10	735	RHS	RHS 120X60X6.3	801	SHS	SHS 800X28	867	SHS	SHS 300X12	933	SHS	SHS 140X10
670	RHS	RHS 260X180X8	736	RHS	RHS 120X60X6	802	SHS	SHS 800X25	868	SHS	SHS 300X10	934	SHS	SHS 140X8
671	RHS	RHS 260X180X6.3	737	RHS	RHS 120X60X5	803	SHS	SHS 750X50	869	SHS	SHS 300X8	935	SHS	SHS 140X6.3
672	RHS	RHS 260X180X6	738	RHS	RHS 120X60X4	804	SHS	SHS 750X45	870	SHS	SHS 300X6.3	936	SHS	SHS 140X6
673	RHS	RHS 250X150X16	739	RHS	RHS 120X60X3.6	805	SHS	SHS 750X40	871	SHS	SHS 300X6	937	SHS	SHS 140X5
674	RHS	RHS 250X150X12.5	740	RHS	RHS 100X60X8	806	SHS	SHS 750X36	872	SHS	SHS 260X16	938	SHS	SHS 140X4
675	RHS	RHS 250X150X12	741	RHS	RHS 100X60X6.3	807	SHS	SHS 750X32	873	SHS	SHS 260X12.5	939	SHS	SHS 120X12.5
676	RHS	RHS 250X150X10	742	RHS	RHS 100X60X6	808	SHS	SHS 750X28	874	SHS	SHS 260X12	940	SHS	SHS 120X12
677	RHS	RHS 250X150X8	743	RHS	RHS 100X60X5	809	SHS	SHS 750X25	875	SHS	SHS 260X10	941	SHS	SHS 120X10
678	RHS	RHS 250X150X6.3	744	RHS	RHS 100X60X4	810	SHS	SHS 700X50	876	SHS	SHS 260X8	942	SHS	SHS 120X8
679	RHS	RHS 250X150X6	745	RHS	RHS 100X60X3.6	811	SHS	SHS 700X45	877	SHS	SHS 260X6.3	943	SHS	SHS 120X6.3
680	RHS	RHS 250X150X5	746	RHS	RHS 100X60X3.2	812	SHS	SHS 700X40	878	SHS	SHS 260X6	944	SHS	SHS 120X6
681	RHS	RHS 200X120X12.5	747	RHS	RHS 100X60X3	813	SHS	SHS 700X36	879	SHS	SHS 250X16	945	SHS	SHS 120X5
682	RHS	RHS 200X120X12	748	RHS	RHS 100X50X8	814	SHS	SHS 700X32	880	SHS	SHS 250X12.5	946	SHS	SHS 120X4
683	RHS	RHS 200X120X10	749	RHS	RHS 100X50X6.3	815	SHS	SHS 700X28	881	SHS	SHS 250X12	947	SHS	SHS 100X12.5
684	RHS	RHS 200X120X8	750	RHS	RHS 100X50X6	816	SHS	SHS 700X25	882	SHS	SHS 250X10	948	SHS	SHS 100X12
685	RHS	RHS 200X120X6.3	751	RHS	RHS 100X50X5	817	SHS	SHS 650X50	883	SHS	SHS 250X18	949	SHS	SHS 100X10
686	RHS	RHS 200X120X6	752	RHS	RHS 100X50X4	818	SHS	SHS 650X45	884	SHS	SHS 250X6.3	950	SHS	SHS 100X8
687	RHS	RHS 200X100X16	753	RHS	RHS 100X50X3.6	819	SHS	SHS 650X40	885	SHS	SHS 250X6	951	SHS	SHS 100X6.3
688	RHS	RHS 200X100X12.5	754	RHS	RHS 100X50X3.2	820	SHS	SHS 650X36	886	SHS	SHS 250X5	952	SHS	SHS 100X6
689	RHS	RHS 200X100X12	755	RHS	RHS 100X50X3	821	SHS	SHS 650X32	887	SHS	SHS 220X16	953	SHS	SHS 100X5
690	RHS	RHS 200X100X10	756	RHS	RHS 90X50X8	822	SHS	SHS 650X28	888	SHS	SHS 220X12.5	954	SHS	SHS 100X4
691	RHS	RHS 200X100X8	757	RHS	RHS 90X50X6.3	823	SHS	SHS 650X25	889	SHS	SHS 220X12	955	SHS	SHS 100X3
692	RHS	RHS 200X100X6.3	758	RHS	RHS 90X50X6	824	SHS	SHS 600X50	890	SHS	SHS 220X10	956	SHS	SHS 90X8
693	RHS	RHS 200X100X6	759	RHS	RHS 90X50X5	825	SHS	SHS 600X45	891	SHS	SHS 220X8	957	SHS	SHS 90X6.3
694	RHS	RHS 200X100X5	760	RHS	RHS 90X50X4	826	SHS	SHS 600X40	892	SHS	SHS 220X6.3	958	SHS	SHS 90X6
695	RHS	RHS 200X100X4	761	RHS	RHS 90X50X3.6	827	SHS	SHS 600X36	893	SHS	SHS 220X	959	SHS	SHS 90X5
696	RHS	RHS 180X100X12.5	762	RHS	RHS 90X50X3.2	828	SHS	SHS 600X32	894	SHS	SHS 220X5	960	SHS	SHS 90X4
697	RHS	RHS 180X100X12	763	RHS	RHS 90X50X3	829	SHS	SHS 600X28	895	SHS	SHS 200X16	961	SHS	SHS 90X3.6
698	RHS	RHS 180X100X10	764	RHS	RHS 76.2X50.8X8	830	SHS	SHS 600X25	896	SHS	SHS 200X12.5	962	SHS	SHS 90X3
699	RHS	RHS 180X100X8	765	RHS	RHS 76.2X50.8X6.3	831	SHS	SHS 550X40	897	SHS	SHS 200X12	963	SHS	SHS 80X8
700	RHS	RHS 180X100X6.3	766	RHS	RHS 76.2X50.8X6	832	SHS	SHS 550X36	898	SHS	SHS 200X10	964	SHS	SHS 80X6.3
701	RHS	RHS 180X100X6	767	RHS	RHS 76.2X50.8X5	833	SHS	SHS 550X32	899	SHS	SHS 200X8	965	SHS	SHS 80X6
702	RHS	RHS 180X100X5	768	RHS	RHS 76.2X50.8X4	834	SHS	SHS 550X28	900	SHS	SHS 200X6.3	966	SHS	SHS 80X5
703	RHS	RHS 180X100X4	769	RHS	RHS 76.2X50.8X3.6	835	SHS	SHS 550X25	901	SHS	SHS 200X6	967	SHS	SHS 80X4
704	RHS	RHS 160X80X12.5	770	RHS	RHS 76.2X50.8X3.2	836	SHS	SHS 550X22	902	SHS	SHS 200X5	968	SHS	SHS 80X3.6
705	RHS	RHS 160X80X12	771	RHS	RHS 76.2X50.8X3	837	SHS	SHS 500X36	903	SHS	SHS 200X4	969	SHS	SHS 80X3
706	RHS	RHS 160X80X10	772	RHS	RHS 80X40X8	838	SHS	SHS 500X32	904	SHS	SHS 180X16	970	SHS	SHS 70X6.3
707	RHS	RHS 160X80X8	773	RHS	RHS 80X40X6.3	839	SHS	SHS 500X28	905	SHS	SHS 180X12.5	971	SHS	SHS 70X6
708	RHS	RHS 160X80X6.3	774	RHS	RHS 80X40X6	840	SHS	SHS 500X25	906	SHS	SHS 180X12	972	SHS	SHS 70X5
709	RHS	RHS 160X80X6	775	RHS	RHS 80X40X5	841	SHS	SHS 500X22	907	SHS	SHS 180X10	973	SHS	SHS 70X4
710	RHS	RHS 160X80X5	776	RHS	RHS 80X40X4	842	SHS	SHS 500X19	908	SHS	SHS 180X8	974	SHS	SHS 70X3.6
711	RHS	RHS 160X80X4	777	RHS	RHS 80X40X3.6	843	SHS	SHS 500X16	909	SHS	SHS 180X6.3	975	SHS	SHS 70X3
712	RHS	RHS 150X100X12.5	778	RHS	RHS 80X40X3.2	844	SHS	SHS 500X12	910	SHS	SHS 180X6	976	SHS	SHS 70X2.5
713	RHS	RHS 150X100X12	779	RHS	RHS 80X40X3	845	SHS	SHS 450X32	911	SHS	SHS 180X5	977	SHS	SHS 60X6.3
714	RHS	RHS 150X100X10	780	RHS	RHS 60X40X6.3	846	SHS	SHS 450X28	912	SHS	SHS 180X4	978	SHS	SHS 60X6
715	RHS	RHS 150X100X8	781	RHS	RHS 60X40X6	847	SHS	SHS 450X25	913	SHS	SHS 160X16	979	SHS	SHS 60X5
716	RHS	RHS 150X100X6.3	782	RHS	RHS 60X40X5	848	SHS	SHS 450X22	914	SHS	SHS 160X12.5	980	SHS	SHS 60X4
717	RHS	RHS 150X100X6	783	RHS	RHS 60X40X4	849	SHS	SHS 450X19	915	SHS	SHS 160X12	981	SHS	SHS 60X3
718	RHS	RHS 150X100X5	784	RHS	RHS 60X40X3.6	850	SHS	SHS 450X16	916	SHS	SHS 160X10	982	SHS	SHS 60X2.5
719	RHS	RHS 150X100X4	785	RHS	RHS 60X40X3.2	851	SHS	SHS 450X12	917	SHS	SHS 160X8	983	SHS	SHS 60X2
720	RHS	RHS 140X80X10	786	RHS	RHS 60X40X3	852	SHS	SHS 400X25	918	SHS	SHS 160X6.3	984	SHS	SHS 50X5
721	RHS	RHS 140X80X8	787	RHS	RHS 60X40X2.5	853	SHS	SHS 400X22	919	SHS	SHS 160X6	985	SHS	SHS 50X4
722	RHS	RHS 140X80X6.3	788	RHS	RHS 50X30X5	854	SHS	SHS 400X12.5	920	SHS	SHS 160X5	986	SHS	SHS 50X3
723	RHS	RHS 140X80X6	789	RHS	RHS 50X30X4	855	SHS	SHS 400X12	921	SHS	SHS 160X4	987	SHS	SHS 50X2.5
724	RHS	RHS 140X80X5	790	RHS	RHS 50X30X3.6	856	SHS	SHS 400X10	922	SHS	SHS 150X16	988	SHS	SHS 50X2
725	RHS	RHS 140X80X4	791	RHS	RHS 50X30X3.2	857	SHS	SHS 350X25	923	SHS	SHS 150X12.5	989	SHS	SHS 40X4
726	RHS	RHS 120X80X10	792	RHS	RHS 50X30X3	858	SHS	SHS 350X22	924	SHS	SHS 150X12	990	SHS	SHS 40X3

Number	Type	Name
991	SHS	SHS 40X2.5
992	SHS	SHS 40X2
993	SHS	SHS 30X3
994	SHS	SHS 30X2.5
995	SHS	SHS 30X2
996	SHS	SHS 25X3
997	SHS	SHS 25X2.5
998	SHS	SHS 25X2
999	SHS	SHS 20X2.5
1000	SHS	SHS 20X2.5
1001	CHS	CHS 2134X22.2
1002	CHS	CHS 2134X20.6
1003	CHS	CHS 2134X19.1
1004	CHS	CHS 2134X17.5
1005	CHS	CHS 2134X15.9
1006	CHS	CHS 2134X14.3
1007	CHS	CHS 2134X12.7
1008	CHS	CHS 2134X11.9
1009	CHS	CHS 2020X22.2
1010	CHS	CHS 2020X20.6
1011	CHS	CHS 2020X19.1
1012	CHS	CHS 2020X17.5
1013	CHS	CHS 2020X15.9
1014	CHS	CHS 2020X14.3
1015	CHS	CHS 2020X12.7
1016	CHS	CHS 2020X11.9
1017	CHS	CHS 1829X22.2
1018	CHS	CHS 1829X20.6
1019	CHS	CHS 1829X19.1
1020	CHS	CHS 1829X17.5
1021	CHS	CHS 1829X15.9
1022	CHS	CHS 1829X14.3
1023	CHS	CHS 1829X12.7
1024	CHS	CHS 1829X11.9
1025	CHS	CHS 1676X22.2
1026	CHS	CHS 1676X20.6
1027	CHS	CHS 1676X19.1
1028	CHS	CHS 1676X17.5
1029	CHS	CHS 1676X15.9
1030	CHS	CHS 1676X14.3
1031	CHS	CHS 1676X12.7
1032	CHS	CHS 1676X11.9
1033	CHS	CHS 1626X22.2
1034	CHS	CHS 1626X20.6
1035	CHS	CHS 1626X19.1
1036	CHS	CHS 1626X17.5
1037	CHS	CHS 1626X15.9
1038	CHS	CHS 1626X14.3
1039	CHS	CHS 1626X12.7
1040	CHS	CHS 1626X11.9
1041	CHS	CHS 1524X22.2
1042	CHS	CHS 1524X20.6
1043	CHS	CHS 1524X19.1
1044	CHS	CHS 1524X17.5
1045	CHS	CHS 1524X15.9
1046	CHS	CHS 1524X14.3
1047	CHS	CHS 1524X12.7
1048	CHS	CHS 1524X11.9
1049	CHS	CHS 1473X22.2
1050	CHS	CHS 1473X20.6
1051	CHS	CHS 1473X19.1
1052	CHS	CHS 1473X17.5
1053	CHS	CHS 1473X15.9
1054	CHS	CHS 1473X14.3
1055	CHS	CHS 1473X12.7
1056	CHS	CHS 1473X11.9

Number	Type	Name
1057	CHS	CHS 1422X22.2
1058	CHS	CHS 1422X20.6
1059	CHS	CHS 1422X19.1
1060	CHS	CHS 1422X17.5
1061	CHS	CHS 1422X15.9
1062	CHS	CHS 1422X14.3
1063	CHS	CHS 1422X12.7
1064	CHS	CHS 1422X11.9
1065	CHS	CHS 1372X22.2
1066	CHS	CHS 1372X20.6
1067	CHS	CHS 1372X19.1
1068	CHS	CHS 1372X17.5
1069	CHS	CHS 1372X15.9
1070	CHS	CHS 1372X14.3
1071	CHS	CHS 1372X12.7
1072	CHS	CHS 1372X11.9
1073	CHS	CHS 1372X11.1
1074	CHS	CHS 1372X10.3
1075	CHS	CHS 1372X9.5
1076	CHS	CHS 1321X22.2
1077	CHS	CHS 1321X20.6
1078	CHS	CHS 1321X19.1
1079	CHS	CHS 1321X17.5
1080	CHS	CHS 1321X15.9
1081	CHS	CHS 1321X14.3
1082	CHS	CHS 1321X12.7
1083	CHS	CHS 1321X11.9
1084	CHS	CHS 1321X11.1
1085	CHS	CHS 1321X10.3
1086	CHS	CHS 1321X9.5
1087	CHS	CHS 1270X22.2
1088	CHS	CHS 1270X20.6
1089	CHS	CHS 1270X19.1
1090	CHS	CHS 1270X17.5
1091	CHS	CHS 1270X15.9
1092	CHS	CHS 1270X14.3
1093	CHS	CHS 1270X12.7
1094	CHS	CHS 1270X11.9
1095	CHS	CHS 1270X11.1
1096	CHS	CHS 1270X10.3
1097	CHS	CHS 1270X9.5
1098	CHS	CHS 1219X25
1099	CHS	CHS 1219X22.2
1100	CHS	CHS 1219X20.6
1101	CHS	CHS 1219X20
1102	CHS	CHS 1219X19.1
1103	CHS	CHS 1219X17.5
1104	CHS	CHS 1219X16
1105	CHS	CHS 1219X15.9
1106	CHS	CHS 1219X14.3
1107	CHS	CHS 1219X12.7
1108	CHS	CHS 1219X12.5
1109	CHS	CHS 1219X12
1110	CHS	CHS 1219X11.9
1111	CHS	CHS 1219X11.1
1112	CHS	CHS 1219X10.3
1113	CHS	CHS 1219X10
1114	CHS	CHS 1219X9.5
1115	CHS	CHS 1168X25
1116	CHS	CHS 1168X22.2
1117	CHS	CHS 1168X20.6
1118	CHS	CHS 1168X20
1119	CHS	CHS 1168X19.1
1120	CHS	CHS 1168X17.5
1121	CHS	CHS 1168X16
1122	CHS	CHS 1168X15.9

Number	Type	Name
1123	CHS	CHS 1168X14.3
1124	CHS	CHS 1168X12.7
1125	CHS	CHS 1168X12.5
1126	CHS	CHS 1168X12
1127	CHS	CHS 1168X11.9
1128	CHS	CHS 1168X11.1
1129	CHS	CHS 1168X10.3
1130	CHS	CHS 1168X10
1131	CHS	CHS 1168X9.5
1132	CHS	CHS 1118X22.2
1133	CHS	CHS 1118X20.6
1134	CHS	CHS 1118X19.1
1135	CHS	CHS 1118X17.5
1136	CHS	CHS 1118X15.9
1137	CHS	CHS 1118X14.3
1138	CHS	CHS 1118X12.7
1139	CHS	CHS 1118X11.9
1140	CHS	CHS 1118X11.1
1141	CHS	CHS 1118X10.3
1142	CHS	CHS 1118X9.5
1143	CHS	CHS 1067X30
1144	CHS	CHS 1067X28.6
1145	CHS	CHS 1067X27
1146	CHS	CHS 1067X25.4
1147	CHS	CHS 1067X25
1148	CHS	CHS 1067X23.8
1149	CHS	CHS 1067X22.2
1150	CHS	CHS 1067X20.6
1151	CHS	CHS 1067X20
1152	CHS	CHS 1067X19.1
1153	CHS	CHS 1067X17.5
1154	CHS	CHS 1067X16
1155	CHS	CHS 1067X15.9
1156	CHS	CHS 1067X14.3
1157	CHS	CHS 1067X12.7
1158	CHS	CHS 1067X12.5
1159	CHS	CHS 1067X12
1160	CHS	CHS 1067X11.9
1161	CHS	CHS 1067X11.1
1162	CHS	CHS 1067X10.3
1163	CHS	CHS 1067X10
1164	CHS	CHS 1067X9.5
1165	CHS	CHS 1016X30
1166	CHS	CHS 1016X28.6
1167	CHS	CHS 1016X27
1168	CHS	CHS 1016X25.4
1169	CHS	CHS 1016X25
1170	CHS	CHS 1016X23.8
1171	CHS	CHS 1016X22.2
1172	CHS	CHS 1016X20.6
1173	CHS	CHS 1016X20
1174	CHS	CHS 1016X19.1
1175	CHS	CHS 1016X17.5
1176	CHS	CHS 1016X16
1177	CHS	CHS 1016X15.9
1178	CHS	CHS 1016X14.3
1179	CHS	CHS 1016X12.7
1180	CHS	CHS 1016X12.5
1181	CHS	CHS 1016X12
1182	CHS	CHS 1016X11.9
1183	CHS	CHS 1016X11.1
1184	CHS	CHS 1016X10.3
1185	CHS	CHS 1016X10
1186	CHS	CHS 1016X9.5
1187	CHS	CHS 1016X8.7
1188	CHS	CHS 1016X8

Number	Type	Name
1189	CHS	CHS 1016X7.9
1190	CHS	CHS 965X28.6
1191	CHS	CHS 965X27
1192	CHS	CHS 965X25.4
1193	CHS	CHS 965X23.8
1194	CHS	CHS 965X22.2
1195	CHS	CHS 965X20.6
1196	CHS	CHS 965X19.1
1197	CHS	CHS 965X17.5
1198	CHS	CHS 965X15.9
1199	CHS	CHS 965X14.3
1200	CHS	CHS 965X12.7
1201	CHS	CHS 965X11.9
1202	CHS	CHS 965X11.1
1203	CHS	CHS 965X10.3
1204	CHS	CHS 965X9.5
1205	CHS	CHS 965X8.7
1206	CHS	CHS 965X7.9
1207	CHS	CHS 914X30
1208	CHS	CHS 914X28.6
1209	CHS	CHS 914X27
1210	CHS	CHS 914X25.4
1211	CHS	CHS 914X25
1212	CHS	CHS 914X23.8
1213	CHS	CHS 914X22.2
1214	CHS	CHS 914X20.6
1215	CHS	CHS 914X20
1216	CHS	CHS 914X19.1
1217	CHS	CHS 914X17.5
1218	CHS	CHS 914X16
1219	CHS	CHS 914X15.9
1220	CHS	CHS 914X14.3
1221	CHS	CHS 914X12.7
1222	CHS	CHS 914X12.5
1223	CHS	CHS 914X12
1224	CHS	CHS 914X11.9
1225	CHS	CHS 914X11.1
1226	CHS	CHS 914X10.3
1227	CHS	CHS 914X10
1228	CHS	CHS 914X9.5
1229	CHS	CHS 914X8.7
1230	CHS	CHS 914X8
1231	CHS	CHS 914X7.9
1232	CHS	CHS 864X28.6
1233	CHS	CHS 864X27
1234	CHS	CHS 864X25.4
1235	CHS	CHS 864X23.8
1236	CHS	CHS 864X22.2
1237	CHS	CHS 864X20.6
1238	CHS	CHS 864X19.1
1239	CHS	CHS 864X17.5
1240	CHS	CHS 864X15.9
1241	CHS	CHS 864X14.3
1242	CHS	CHS 864X12.7
1243	CHS	CHS 864X11.9
1244	CHS	CHS 864X11.1
1245	CHS	CHS 864X10.3
1246	CHS	CHS 864X9.5
1247	CHS	CHS 864X8.7
1248	CHS	CHS 864X7.9
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1250	CHS	CHS 813X28.6
1251	CHS	CHS 813X27
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1253	CHS	CHS 813X25
1254	CHS	CHS 813X23.8

Number	Type	Name
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1258	CHS	CHS 813X19.1
1259	CHS	CHS 813X17.5
1260	CHS	CHS 813X16
1261	CHS	CHS 813X15.9
1262	CHS	CHS 813X14.3
1263	CHS	CHS 813X12.7
1264	CHS	CHS 813X12.5
1265	CHS	CHS 813X12
1266	CHS	CHS 813X11.9
1267	CHS	CHS 813X11.1
1268	CHS	CHS 813X10.3
1269	CHS	CHS 813X10
1270	CHS	CHS 813X9.5
1271	CHS	CHS 813X8.7
1272	CHS	CHS 813X8
1273	CHS	CHS 813X7.9
1274	CHS	CHS 762X30
1275	CHS	CHS 762X28.6
1276	CHS	CHS 762X27
1277	CHS	CHS 762X25.4
1278	CHS	CHS 762X25
1279	CHS	CHS 762X23.8
1280	CHS	CHS 762X22.2
1281	CHS	CHS 762X20.6
1282	CHS	CHS 762X20
1283	CHS	CHS 762X19.1
1284	CHS	CHS 762X17.5
1285	CHS	CHS 762X16
1286	CHS	CHS 762X15.9
1287	CHS	CHS 762X14.3
1288	CHS	CHS 762X12.7
1289	CHS	CHS 762X12.5
1290	CHS	CHS 762X12
1291	CHS	CHS 762X11.9
1292	CHS	CHS 762X11.1
1293	CHS	CHS 762X10.3
1294	CHS	CHS 762X10
1295	CHS	CHS 762X9.5
1296	CHS	CHS 762X8.7
1297	CHS	CHS 762X8
1298	CHS	CHS 762X7.9
1299	CHS	CHS 762X6.4
1300	CHS	CHS 762X6.3
1301	CHS	CHS 762X6
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1310	CHS	CHS 711X19.1
1311	CHS	CHS 711X17.5
1312	CHS	CHS 711X16
1313	CHS	CHS 711X15.9
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1315	CHS	CHS 711X12.7
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1320	CHS	CHS 711X10.3

Number	Type	Name
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1325	CHS	CHS 711X7.9
1326	CHS	CHS 711X6.4
1327	CHS	CHS 711X6.3
1328	CHS	CHS 711X6
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1331	CHS	CHS 660X22.2
1332	CHS	CHS 660X20.6
1333	CHS	CHS 660X19.1
1334	CHS	CHS 660X17.5
1335	CHS	CHS 660X15.9
1336	CHS	CHS 660X14.3
1337	CHS	CHS 660X12.7
1338	CHS	CHS 660X11.9
1339	CHS	CHS 660X11.1
1340	CHS	CHS 660X10.3
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1342	CHS	CHS 660X8.7
1343	CHS	CHS 660X7.9
1344	CHS	CHS 660X6.4
1345	CHS	CHS 610X30
1346	CHS	CHS 610X25
1347	CHS	CHS 610X23.8
1348	CHS	CHS 610X22.2
1349	CHS	CHS 610X20.6
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1351	CHS	CHS 610X19.1
1352	CHS	CHS 610X17.5
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1366	CHS	CHS 610X7.9
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1383	CHS	CHS 559X6.4
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1550	CHS	CHS 26.9X2
1551	CHS	CHS 21.3X3
1552	CHS	CHS 21.3X2.5
1553	CHS	CHS 21.3X2

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Version 2

LINEAR FINITE ELEMENT
STATIC, SEISMIC AND DYNAMIC ANALYSYS
SOFTWARE
FOR 3D STRUCTURES

STRUCTURAL STEEL VERIFICATION
CODE: AISC ASD-89 or AISC 360-10/16

REINFORCED CONCRETE DESIGN
CODE: ACI 318-19

For Windows®

February 2026