MIDAS Training Series

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Title: Bridge Rehabilitation

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Bridge Evaluation Training Series

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- **Session 1:**
  Introduction to Bridge Load Rating

- **Session 2:**
  Bridge Rehabilitation

Content

- Definition of Rehabilitation
- Reasons for Bridge Deterioration
- Reinforced Concrete Bridges
- Steel Bridges
- Modeling Approaches

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All-In-One Solution

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- Steel Plate Girder Bridge
- Precast Girder Bridge
- Push Over Analysis
- Dynamic Analysis
- Concrete Arch Bridge
- Extradosed Bridge
- Culvert
- Slab Bridge
- Moving Load
- Integral Abutment
- Movable Scaffolding Bridge
- Nonlinear Dynamic Analysis
- Steel Arch Bridge
- Truss Bridge
- Cable Stayed Bridge
- PSC Bridge
- Incremental Launching Bridge
- Precast Segmental Bridge
- Steel Box Girder Bridge
- Multi-Cell Box Girder Bridge
- Suspension Bridge
- Long Span Bridge
- Balanced Cantilever Bridge
- Full Staging Bridge

What is Rehabilitation?

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What is Rehabilitation ?

Rehabilitation means to restore, to make suitable, to put back in good condition, to re-establish on a firm, sound basis, to bring back to full use, to reinstate, to renew and to revive.

Rehabilitation concerns mostly the whole bridge structure, including its primary structural members.

Its content also covers many technical and economical problems related to different bridgeworks performed to improve the technical condition and functional features of the structures.

Bridge rehabilitation covers many complex engineering problems as well as economical ones.

Moreover, in the recent few years, many modern rehabilitation methods and non-conventional material solutions to improve the durability of bridge structures have been developed.

Reinforced Concrete Bridges

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Evaluation

The objective of the evaluation process is to prove the functionality and safety of the structure.

- The 1st step is to study the available information of the structure.

- After that, a site visit to confirm the structure typology and its conservation state.

- If the project information is not available, it is necessary to collect the basic site information to prove the current bridge situation.

- For bridges with foundation problems, a geotechnical study will be necessary to identify the possible causes of this damage.

Visual Inspection

The inspection visits constitute the base for the diagnostic and determination of the current state of the structure. It is also useful to confirm the information of the original project and know if any repairs, modifications, etc have been made.
The objective of the site reconnaissance follow these objectives:

- To obtain the bridge geometry and confirm the project data (if available).
- To confirm or recognize the general structural scheme (supports, joints, etc.)
- To determine the general state of the bridge through the identification of the damages and its magnitude.
- To determine the state of the foundation (existence of movements on it or in the rest of the superstructure).

Visual Inspection

- To analyze the existence of shallow defects (stains, efflorescence,…) And/or leaks, also invasions from vegetation.
- To determine the state of the deck’s drainage system.
- To prove the existence of cracking and/or fissures in the bridge elements (estimation of crack widths).
- To detect the presence of carbonation in the structure or corrosion in the reinforcement (estimation of covers and concrete permeability).
- To detect excessive deformations and identify the state of the support devices.

Causes of Deterioration

There are many causes that determine the appearance of damage in concrete bridges. These damages can be generated due to omissions in the Project phase, construction phase or in service, due to accidental actions or lack of maintenance.

During a bridge lifespan, the seismic actions and the extraordinary situations (avenues, impacts, …) can cause damages. Nevertheless, if the structure is revised periodically and necessary repairs are made, no doubt, it would be in better shape to confront the possible situations that could happen.
Here are the most relevant ones:

- Extension of new layers of asphaltic agglomerate on the deck. The permanent load increases, obturation, in some cases, the drainage elements and joints.

- Variation in the traffic conditions.

- Extension of salt used for the ice damages the deck.

- Visual cracks and deformation in the reinforced and pretensioned elements.

Steel Bridges

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Visual Inspection

The main objectives for the visual inspection of a Steel bridge are shown below:

- To determine the general state of the bridge through the identification of the damages and its magnitude.
- To detect deterioration due to corrosion, loss of material, etc.
- To determine the state of the foundation.
- To allow decision making with respect to the safety of the structure immediately.
- In many bridges, the elements are connected through bolts, for witch is necessary to evaluate their state, and if they are acting correctly.

Causes of Deterioration

Corrosion of the structure is the main damage and the most frequent in Steel structures. Since bridges are usually outdoors, the risk of corrosion increases and should be compensated with an adequate maintenance program.
Corrosion.

The major problems are found in joints, hidden places, where the humidity and lack of cleanliness accelerates corrosion.

Protection against corrosion starts in the project phase, in which correct protection and evacuation of water should be fixated.

Other possible action to be taken into consideration is the loads produced other than service, such as the accumulation of dead loads.

Reasons for Bridge Deterioration

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Reasons for Bridge Deterioration

The reasons leading to deterioration of the existing bridge stock (which have been in service 20-30 years or more).

- Increase in traffic flows and weight of vehicles, especially their axle loads, compared to the period when the bridges have been designed and constructed.
- Harmful influence of environmental pollution, especially atmospheric ones, on the performance of structural materials.
- Common use of de-icing agents in countries of moderate climate.
- Low quality structural materials as well as bridge equipment elements, such as expansion joints, waterproofing membranes, etc.
- Limited maintenance program or insufficient standard of maintenance.
- Structural and material solutions particularly sensitive to damage produced by both traffic loads and environmental factors.

Modeling Approaches

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Modeling Approaches

Bridges come in a wide range of structural arrangements such as trusses, PSC composite girders, steel girders composite with Reinforced Concrete (RC) decks and so on.

Assessments usually start with a linear elastic analysis to evaluate the load-carrying capacity of the structure. Often FE software is involved early on, when it is typically not known if nonlinear analysis will be required later.

However, software which has nonlinear capabilities should be selected at the outset, enabling analysis models to be modified and developed, rather than re-created from scratch, as the assessment progresses from stage to stage.

For bridges where lateral soil pressures are a consideration, such as integral bridges, clearly, the treatment of the soil-structure interaction is fundamental to the structural behavior and special attention must be afforded.

Useful Functions In midas Civil

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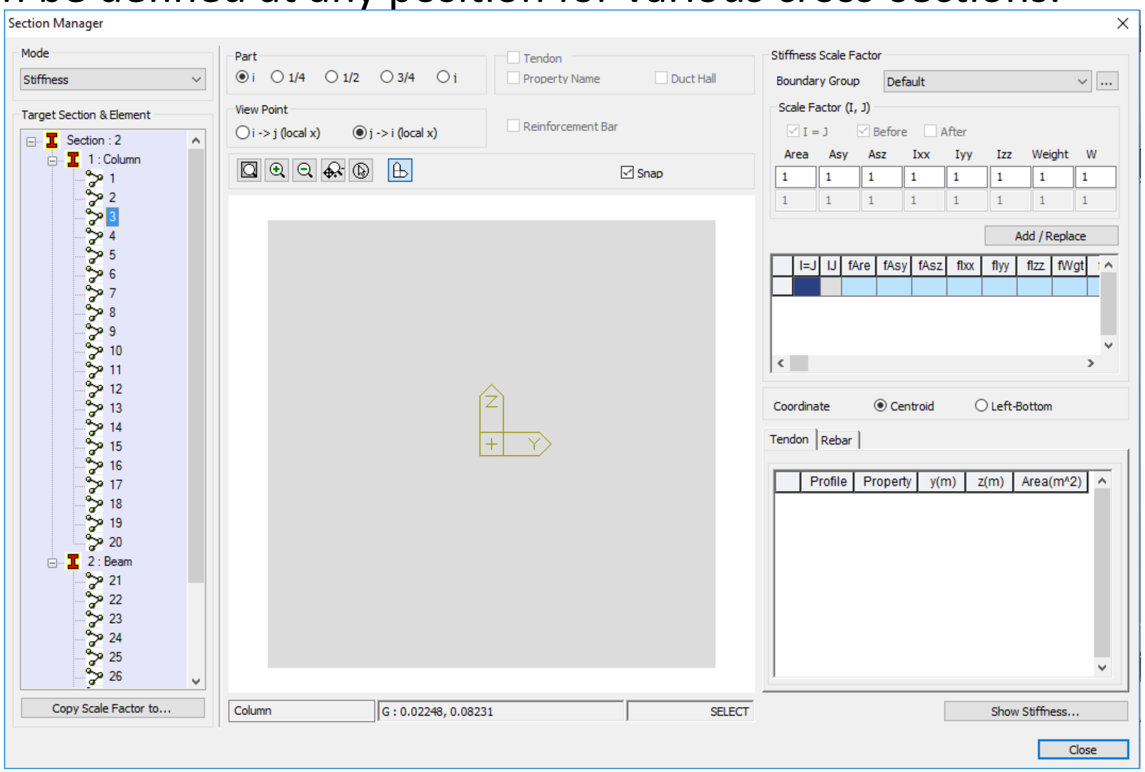
How to reduce the section capacity to model a cracked section app oxi

Calculate the transformed section properties reflecting tendon and reinforcement. Input of reinforcement for the PSC / Composite Steel-I / Composite Steel-Box Sections becomes more user-friendly.

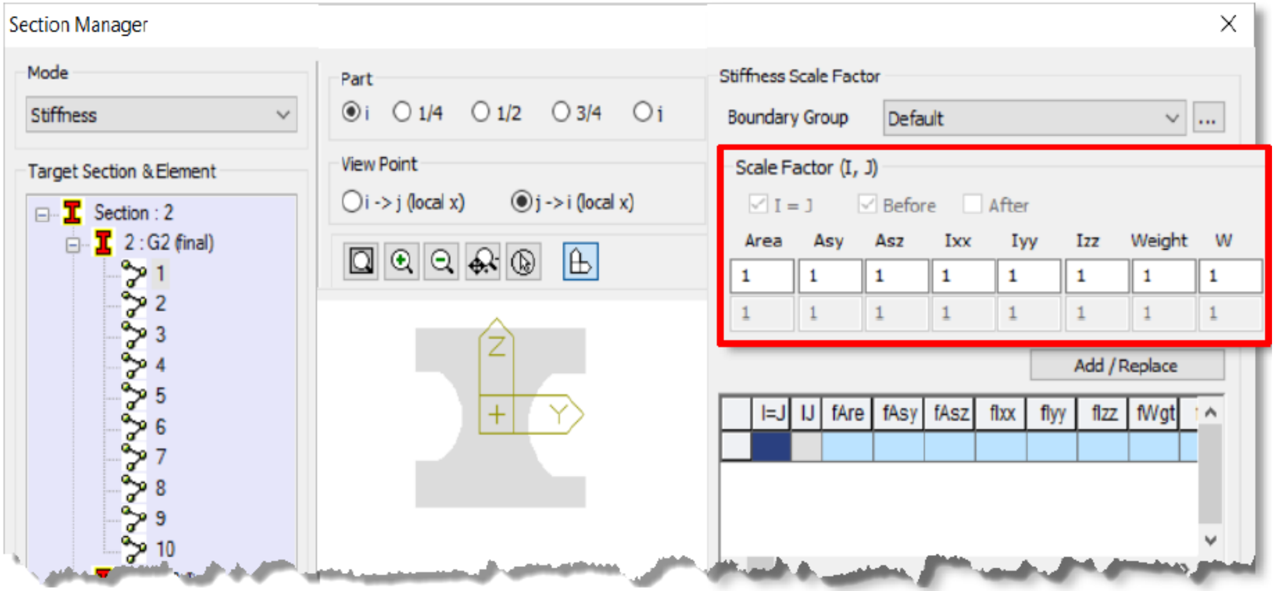
Stress points can be defined at any position for various cross-sections.



Section Stiffness Scale Factor

To model a section as cracked and to arbitrarily reduce its load carrying capacity, its stiffness could be reduced, by applying Stiffness reduction factors.
Select the section whose capacity has to be modified from the 'Section Manager' window and input the appropriate reduction factors.

As boxed out in the image, suitable modification factor could be applied for changing the cross sectional area, shear area, torsion moment of inertia or weight for any section at desired location and in desired direction.



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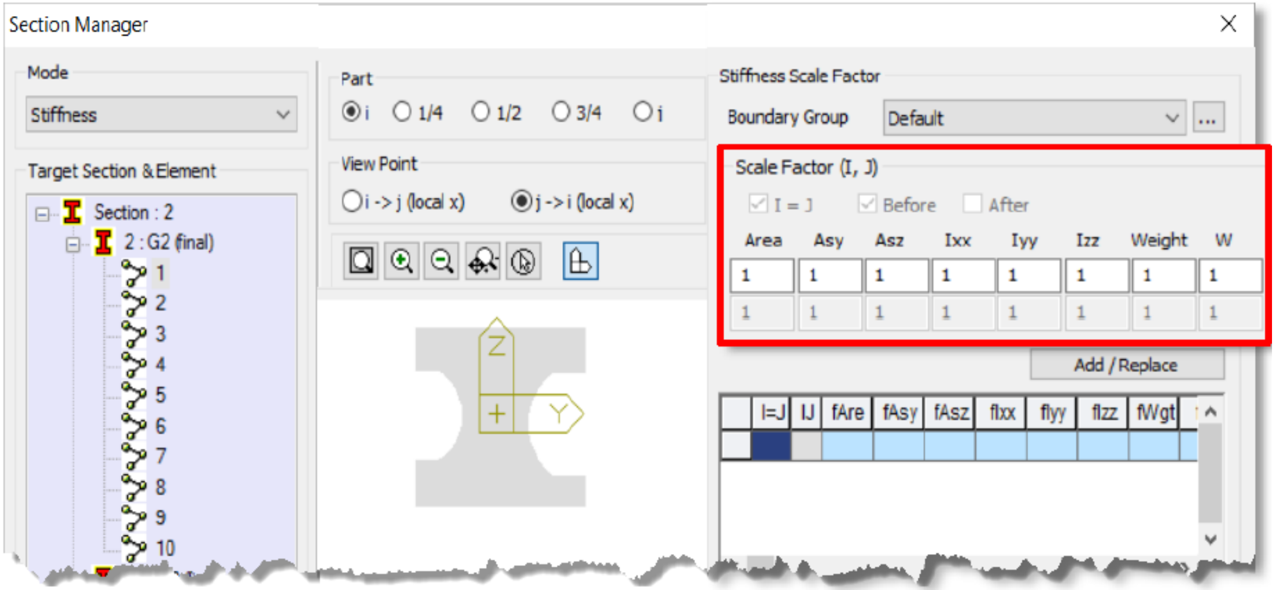
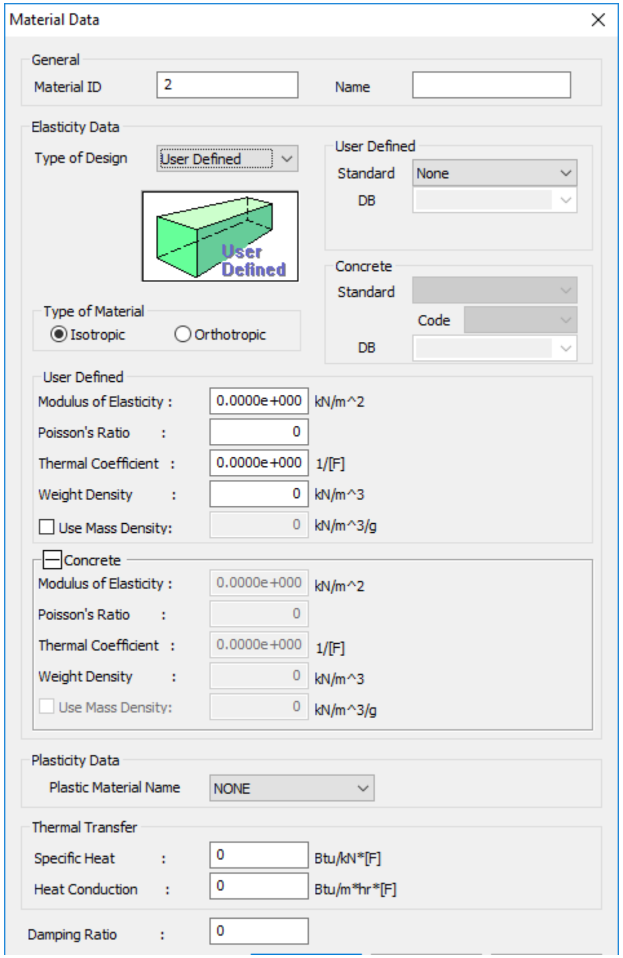
Section Stiffness Scale Factor

For example, say to reduce the stiffness of the section on cracking, the moment of inertia about local y direction could be reduced by a factor. This factor could be assigned to particular boundary groups as well in case construction stage or boundary change assignments needs to be performed. The scale factors for I and J end are kept same by default. However, these can be different in case of a tapered section.



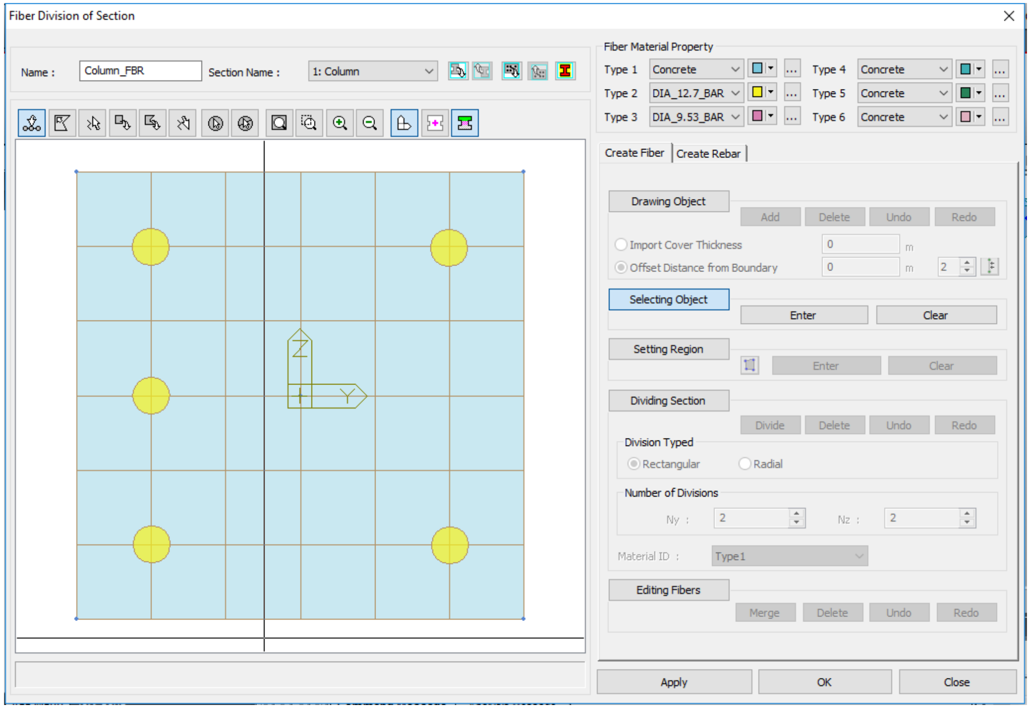
Material

Enter the isotropic and orthotropic material properties. The user should enter the orthotropic material in User Defined Material.



Fiber Division of Section

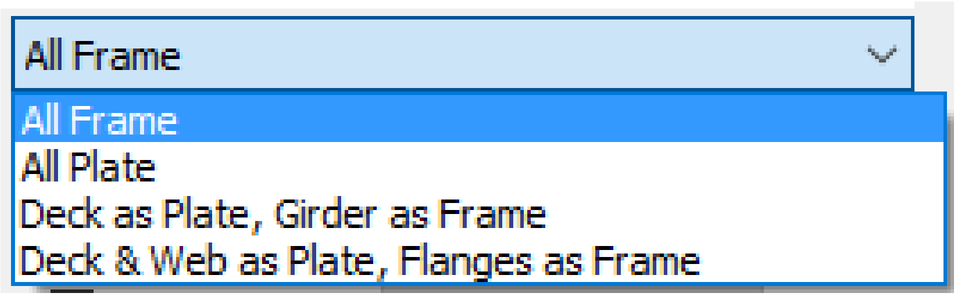
In order to carry out a nonlinear analysis using fiber elements, beam cross-sections are appropriately divided into fiber cells. Such fiber cells are assigned various nonlinear material properties representing stress-strain hysteresis models for concrete, steel, etc. For a reinforced concrete structure, cover concrete, core concrete, reinforcing steel, etc. can be assigned to the sections.



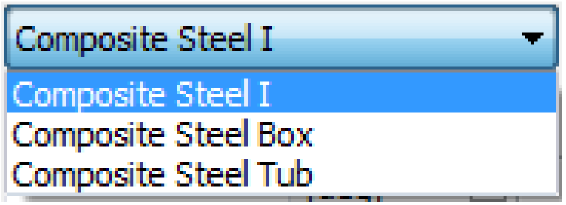
Using different types of elements

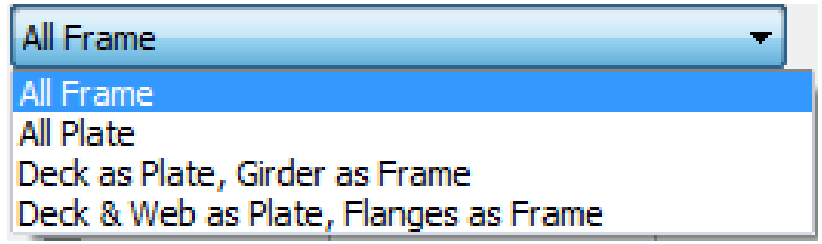
With the wizards that were recently implemented in the program, you can use different elements to simulate the current state of a bridge. Different types of modeling are available:

-All Frame
-All Plate
-Deck as Plate, Girder as Frame
-Deck & Web as Plate, Flanges as Frame

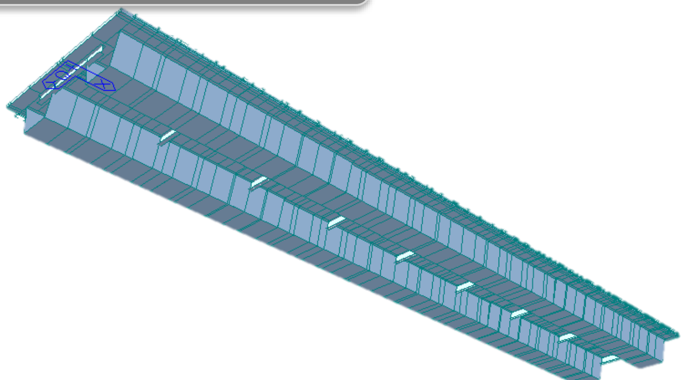


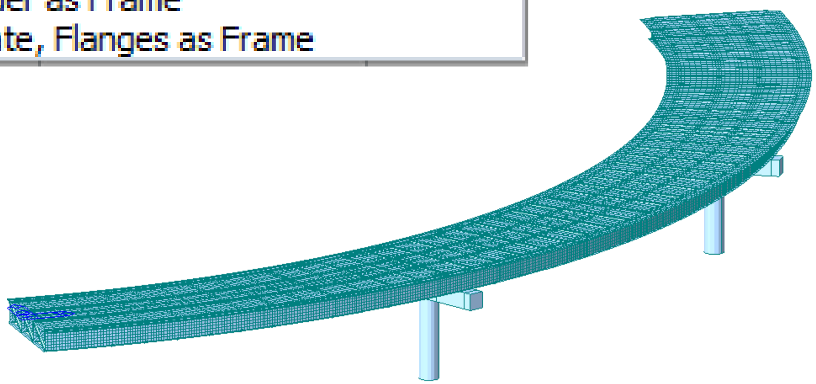
Using different types of elements

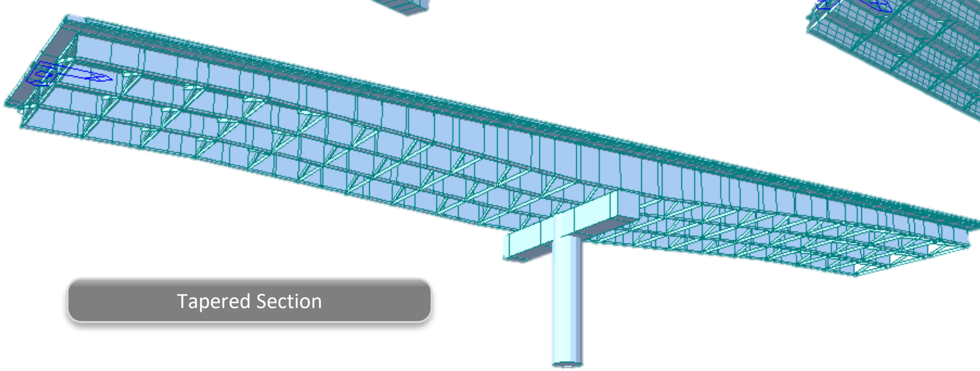




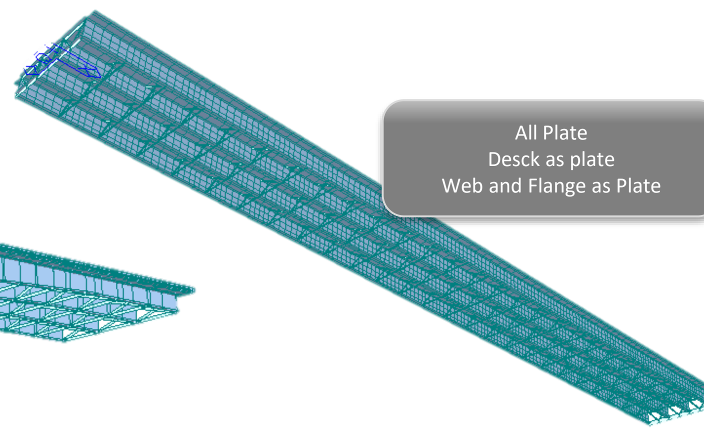
Model of a Steel Composite Tub







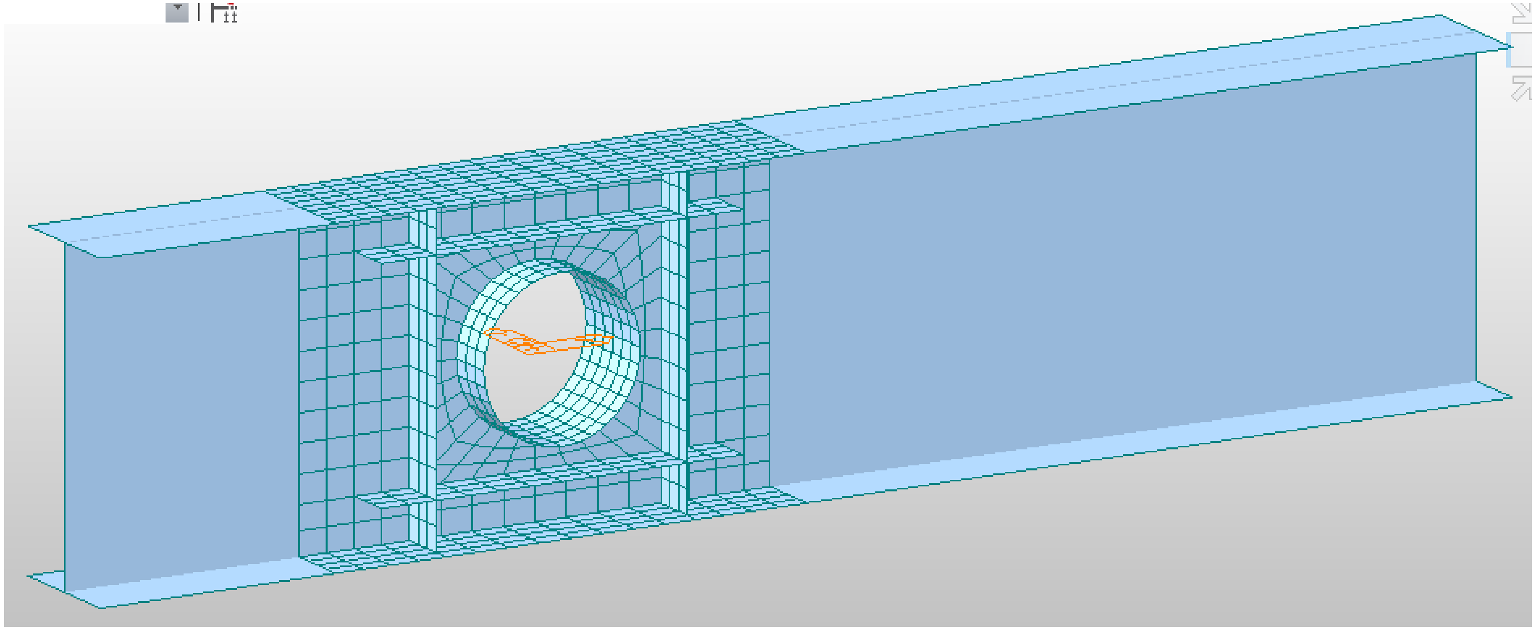
Tapered Section



All Plate
Desck as plate
Web and Flange as Plate

Element Detail Analysis

Detail modeling using plate elements to study the stress distribution around the vicinity of the opening.



Using Plastic Materials

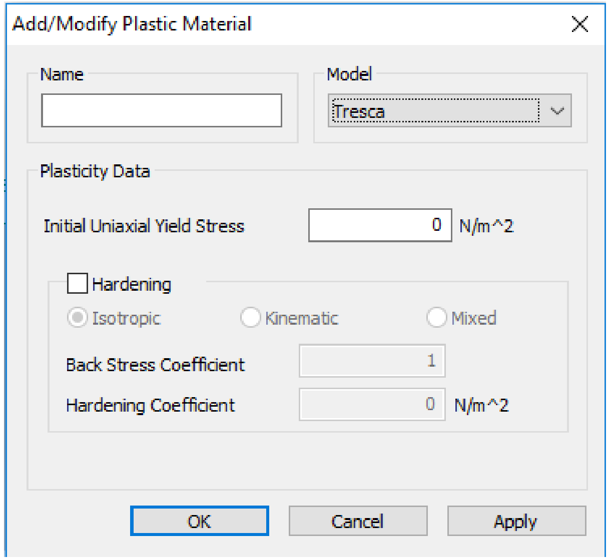
Plastic Material Models

Tresca & Von Mises

Appropriate for ductile metals, which exhibit Plastic Incompressibility

Mohr-Coulomb, Drucker-Prager

Appropriate for brittle materials such as concrete, rock and soils, which exhibit the behavior of volumetric plastic straining



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Thank you