Online training course

Session 2

Advanced Grillage Analysis

Session will start on the hour

Session 2

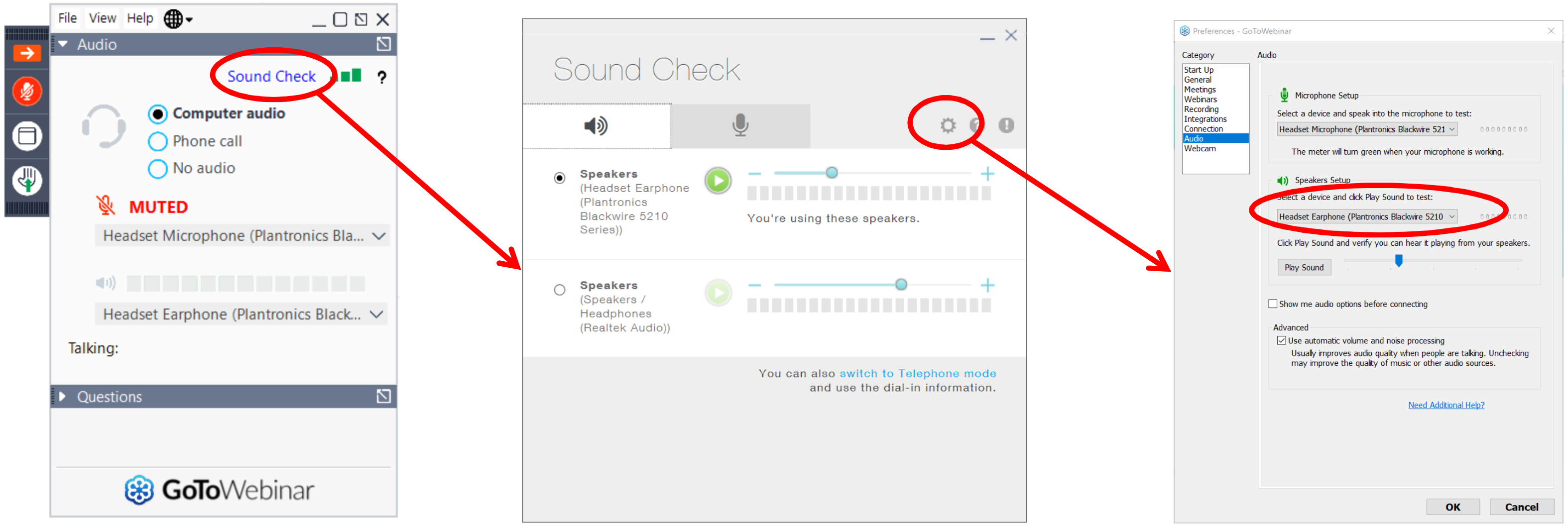
Advanced Grillage Analysis

Presented by:

Julian Moses CEng MIStructE

Audio Settings

- We are now talking
- If you can’t hear us, please click Sound Check, then the Settings cog, then select your speakers



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Audio Settings

- If you still can't hear us, please be aware that a recording of this session will be made available afterwards
- But we're now going to move on with the session for the benefit of the majority of trainees who have working audio

Schedule

- ~~12th October — **Introduction to Grillage Analysis**~~
- 19th October — **Advanced Grillage Analysis**

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Training Format

- 2 hour session
  - Presentation on advanced LUSAS grillage features
  - Demonstration of LUSAS on beam & slab grillage
  - **Type questions into the Questions or Chat box**
  - Session will be recorded
- Homework
  - Worked Example for you to complete (see handouts)
  - You will need the latest version loaded (20.0)
  - Support available via email (onlinetraining@lusas.com)
  - Quiz to test your understanding

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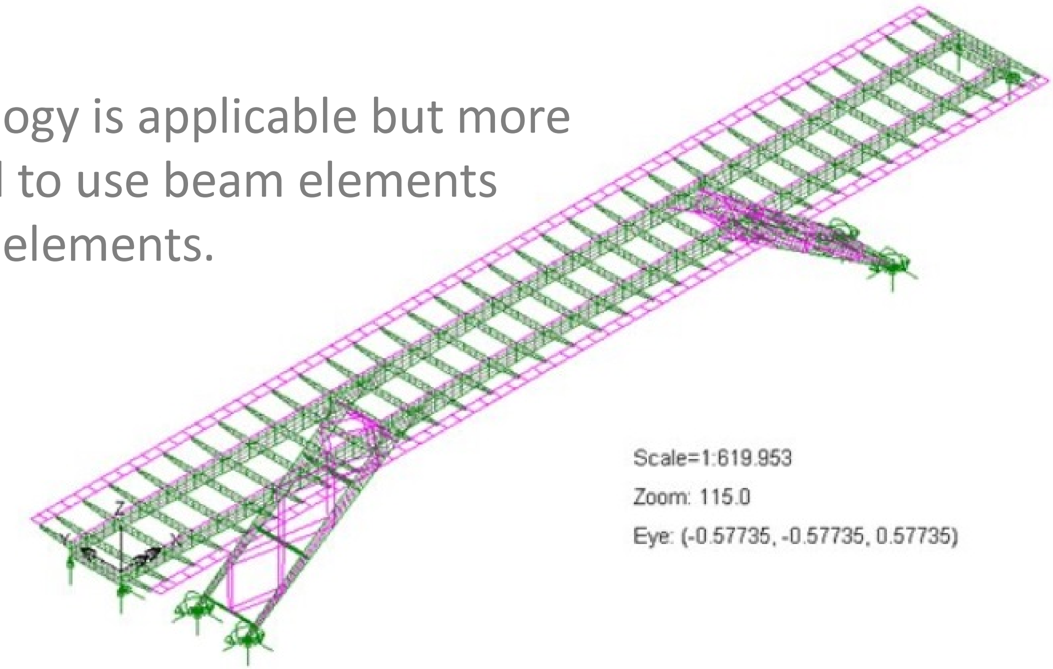
Training Format

- Installation/Licenses
  - You don't need LUSAS installed or a license to watch this session
  - You do need it installed with a license to do the homework!
  - If you don't already have one, please contact your local LUSAS expert and ask them to contact their LUSAS Account Manager

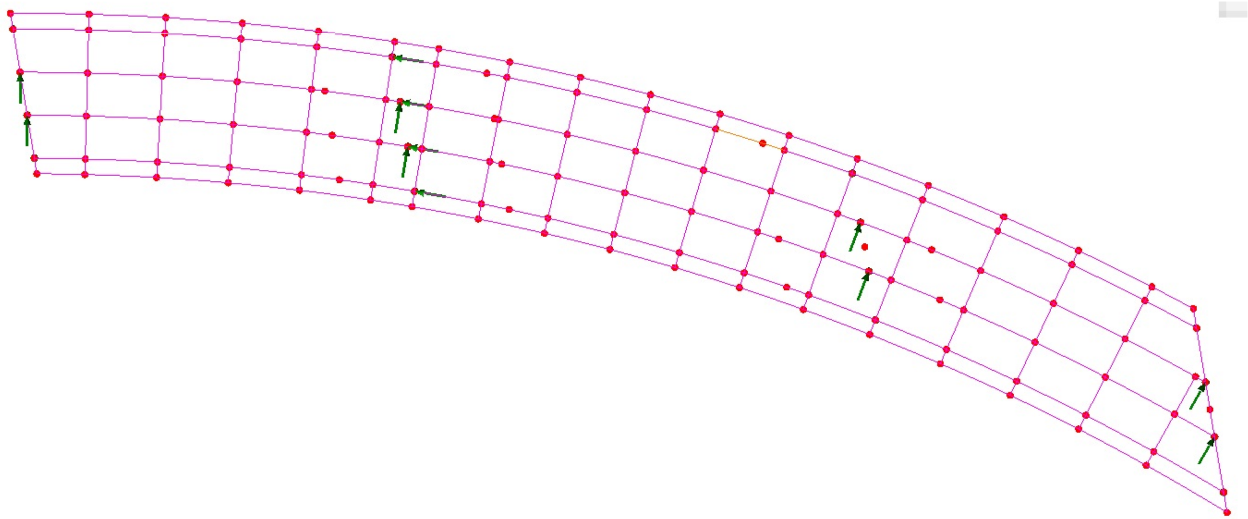
Questions from Session 1

- Can a grillage be used to model complete bridge structure ?
  - Yes the grillage analogy is applicable but more than likely will need to use beam elements rather than grillage elements.



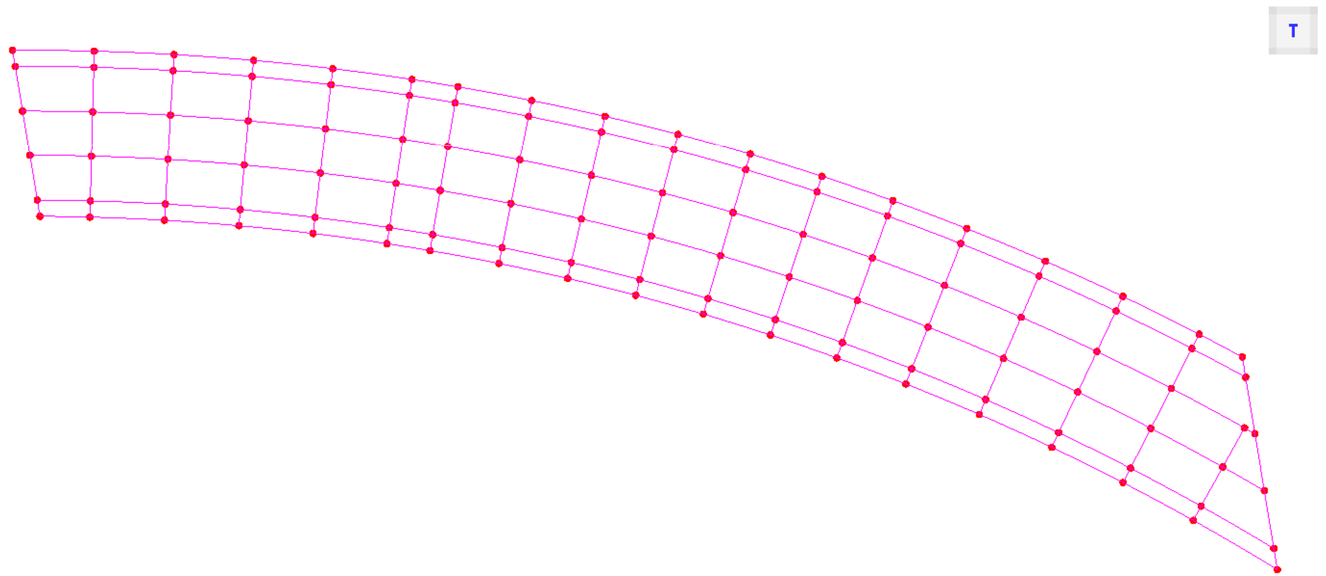
Questions from Session 1

- Grillage wizard will only do certain layouts.
  - More complex layout can be created in modeller or drawn up in CAD



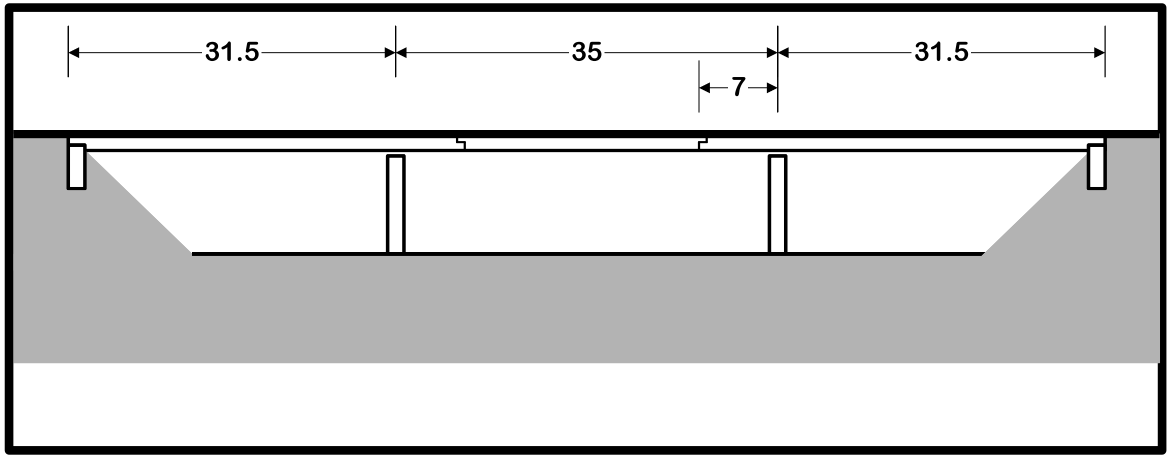
Questions from Session 1

- Use intersection command to create individual grillage lines



Questions from Session 1

- How to use joint elements in a grillage



Grillage modelling

- Overview of last weeks session
- More complex grillage layouts
- Slab and beam section properties
- Stage construction and multiple analysis
- Multi-span composite bridge with bracing example

Structural idealisation

- When analysing a bridge to obtain results of design actions and forces, it is important to realise that what is in fact analysed is not the actual bridge but an idealised mathematical model
  - Stage of design
  - Importance/complexity of the structure
  - What effects are being studied

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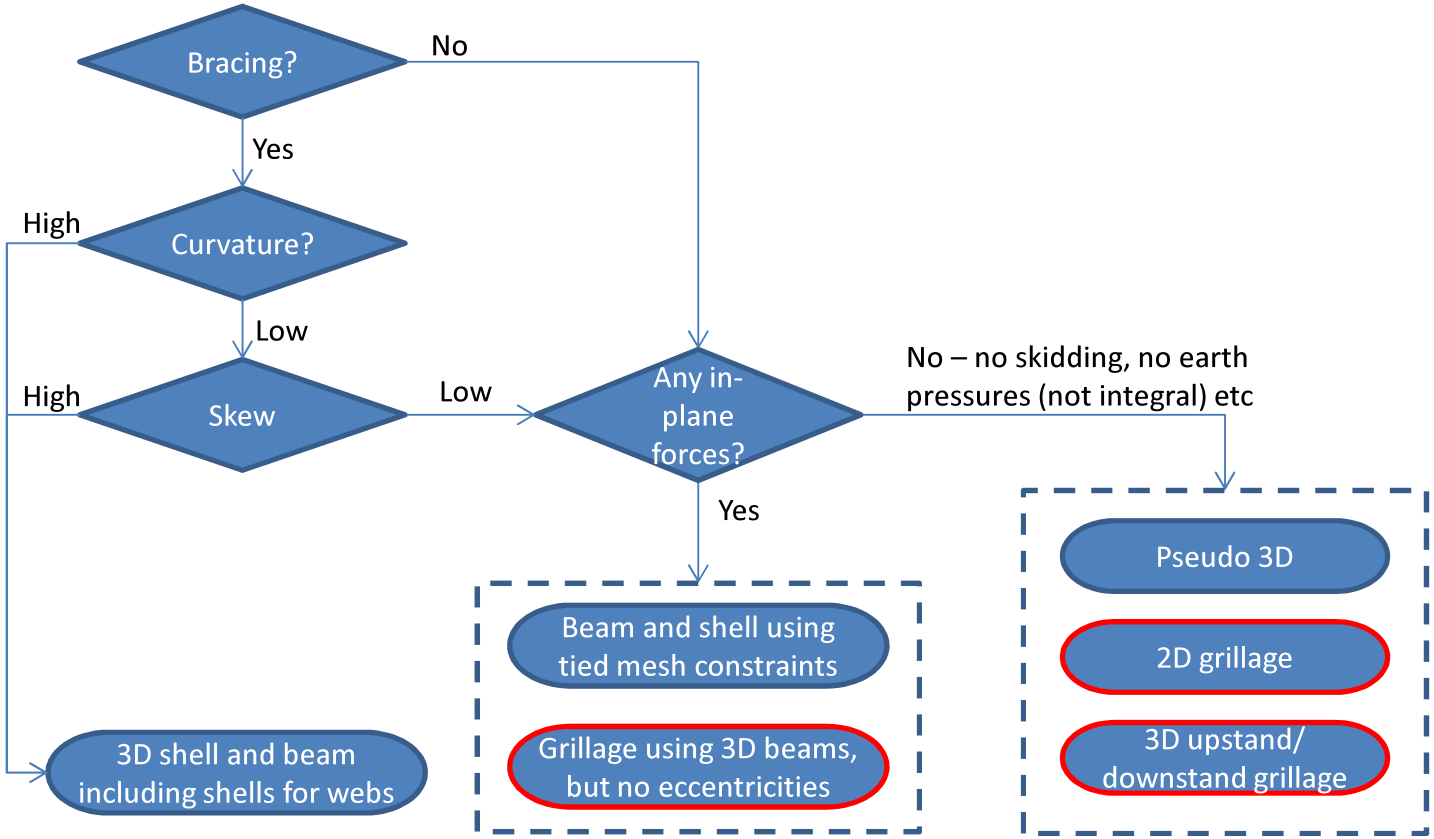
Structural idealisation

THE INTERNATIONAL ASSOCIATION FOR THE ENGINEERING ANALYSIS COMMUNITY

"There is a strong tendency for new users of FE to focus on the generation of an accurate geometric model ...
Powerful and alluring graphics ... and facilities to import geometry from 3D CAD packages reinforce this tendency.
The purpose of a finite element analysis is to ***model the behaviour of a structure under a system of loads****, not its geometry."*

How to model with Finite Elements, Chapter 2

When is a grillage model OK?



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Structural idealisation


A CHRISTMAS APPEAL! NEW YORK'S NEEDIEST CASES, SECTION 2

The New York Times.

LATE CITY EDITION

PRESIDENT PROCLAIMS A NATIONAL EMERGENCY; AUTO PRICES ROLLED BACK; RAIL STRIKE ENDS; ALLIES GIVE UP HAMHUNG; WU REJECTS TRUCE

Recent Auto Rises Canceled By First Price-Freeze Edict

Paris and London Void Pacts In Arming Bonn, Soviet Says

U. S. Urges Defense Parley By All American Republics

Everything should be made as simple as possible, but not simpler

Albert Einstein

Creating a grillage model

- Features: a grid of short lines
  - generally along beam centrelines
  - Ideally orthogonal, skews <20° OK
  - Similar spacing longitudinal and transverse
- Grid spacing assumed
  - is equivalent to making an assumption about spreading elastic peaks over a width in an FE model
  - should be determined by rules from Hambly
  - may not improve accuracy if the spacing is reduced

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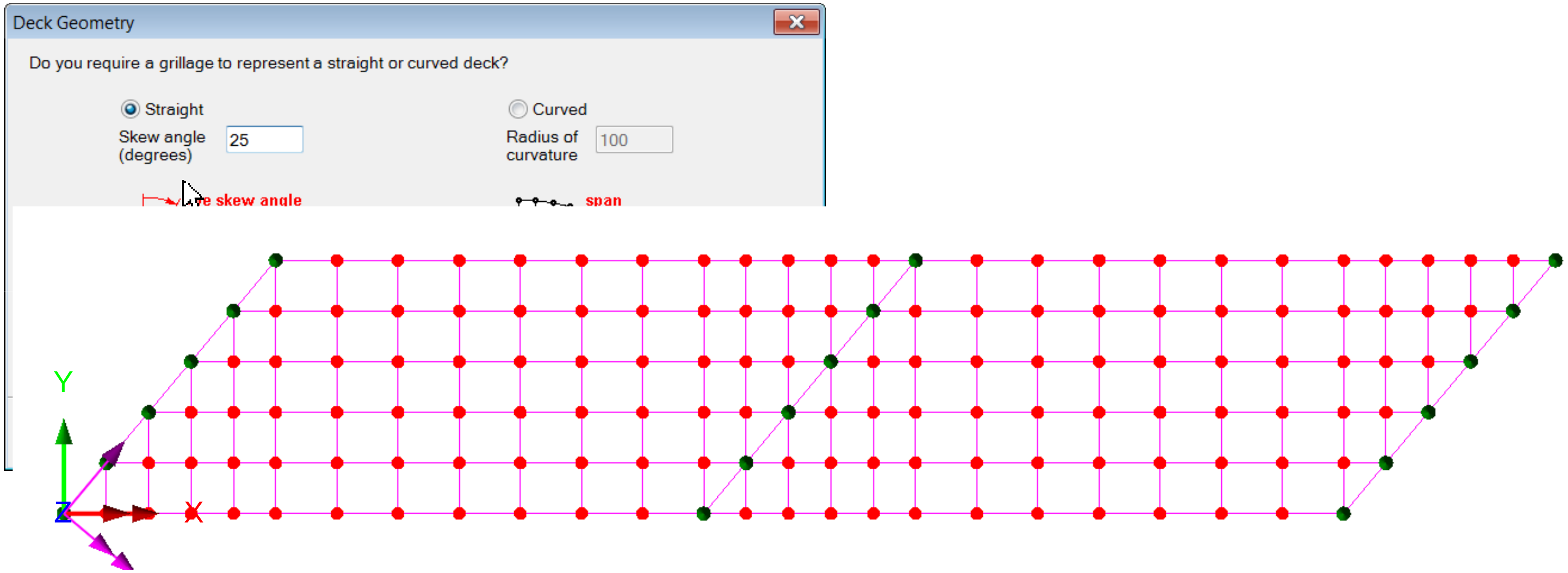
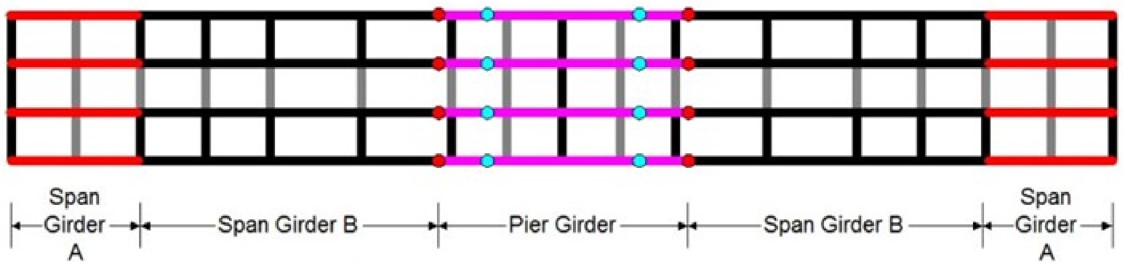
Grillage analogy



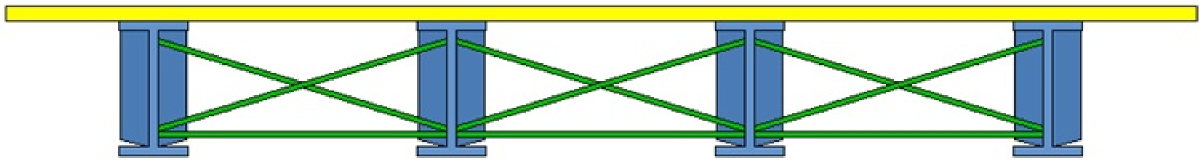
Multi-span composite bridge with bracing demo

- Creating the geometry for the grillage model

Summary data



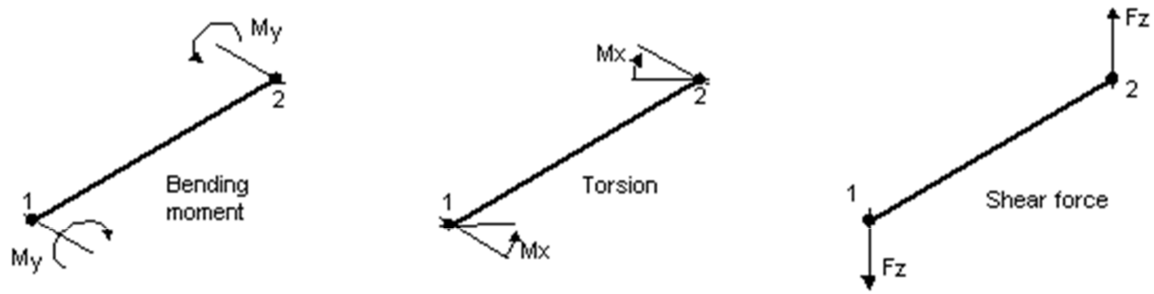
Plan on proposed grillage model



Indicative Cross Section

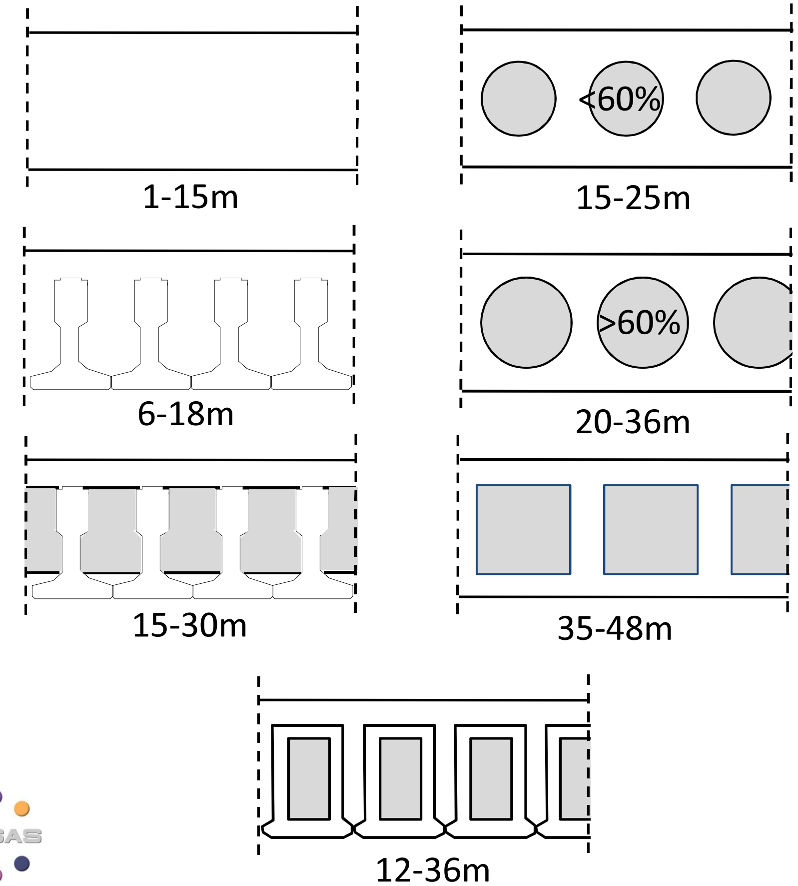
Grillage analogy

- Grillage elements (2D) have 3DOF



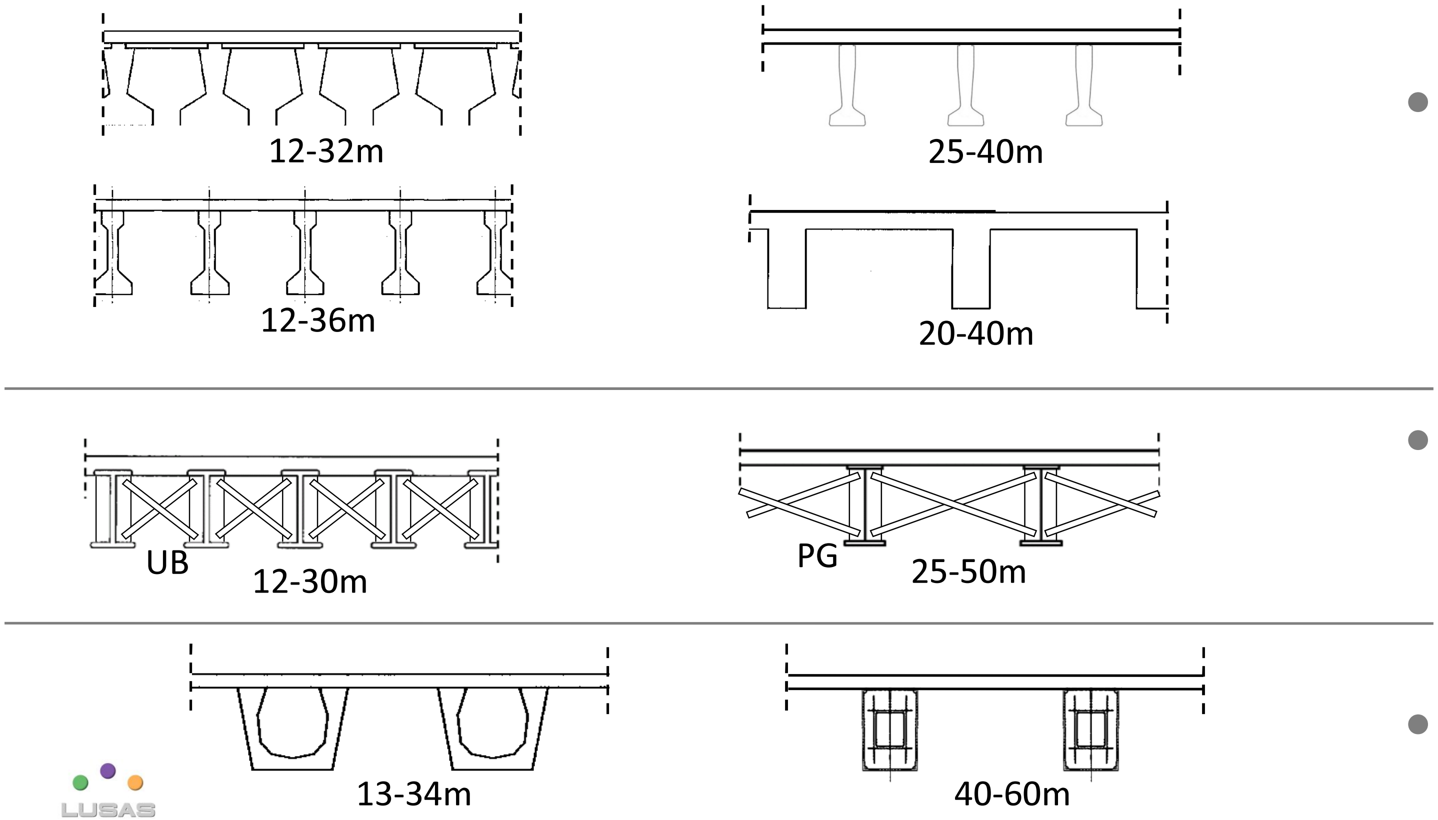
  - They do not carry axial load
  - Grillages are for out-of-plane loads only i.e. vertical loads on bridge decks
  - Usually 1 element on each side of a grillage bay.   But can use more e.g. 2

Flat slab deck types



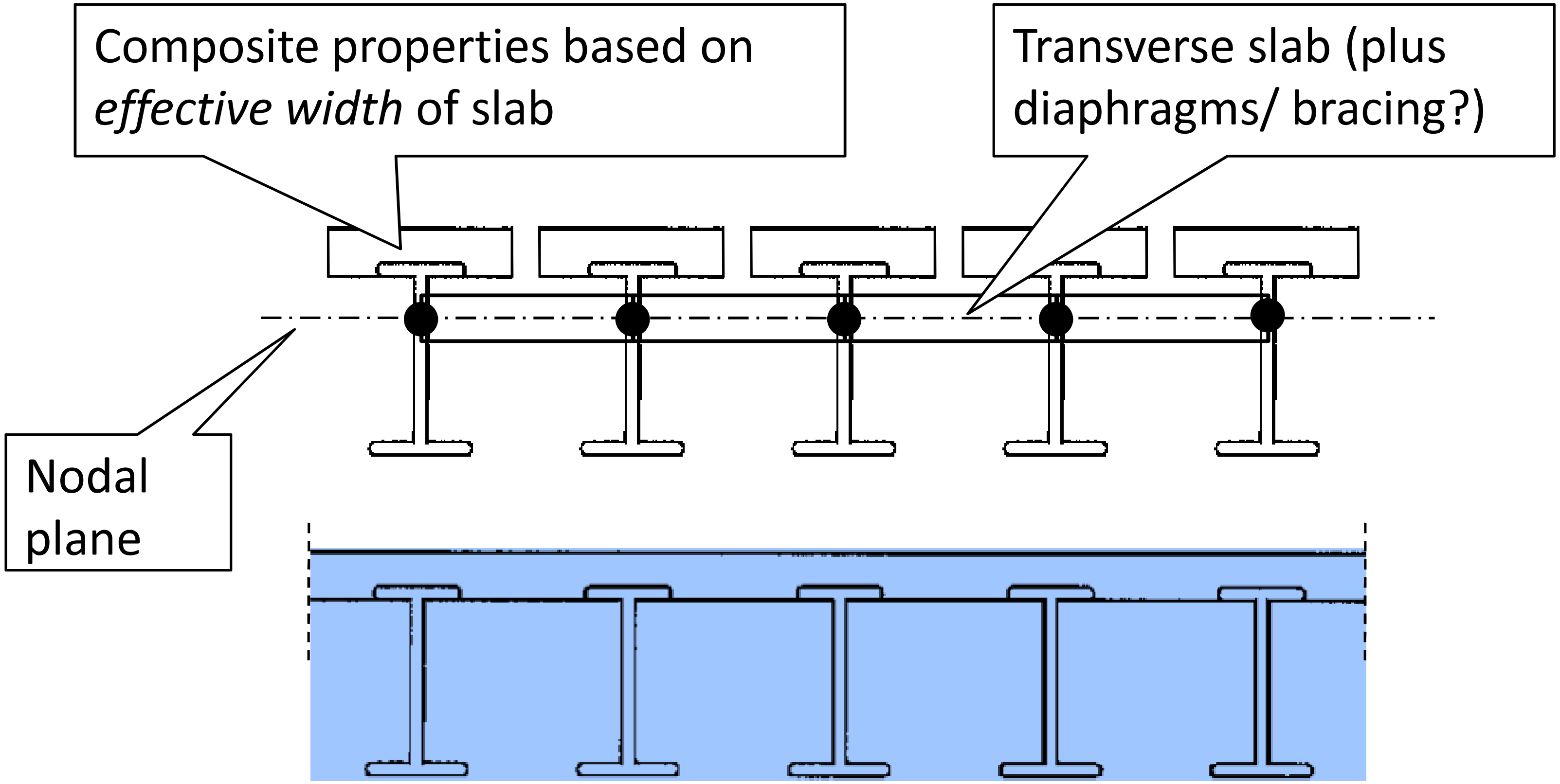
- Isotropic slabs
  - Solid
  - Voids <60% depth
- Orthotropic slabs
  - Beam & infill
  - Voids > 60% depth
- Multicellular
  - M-beams
  - Post-tensioned
- Shear key/ box beam

Beam & slab deck options



- Single web beams (no bracing)
- Single web beams with bracing
- Box beams

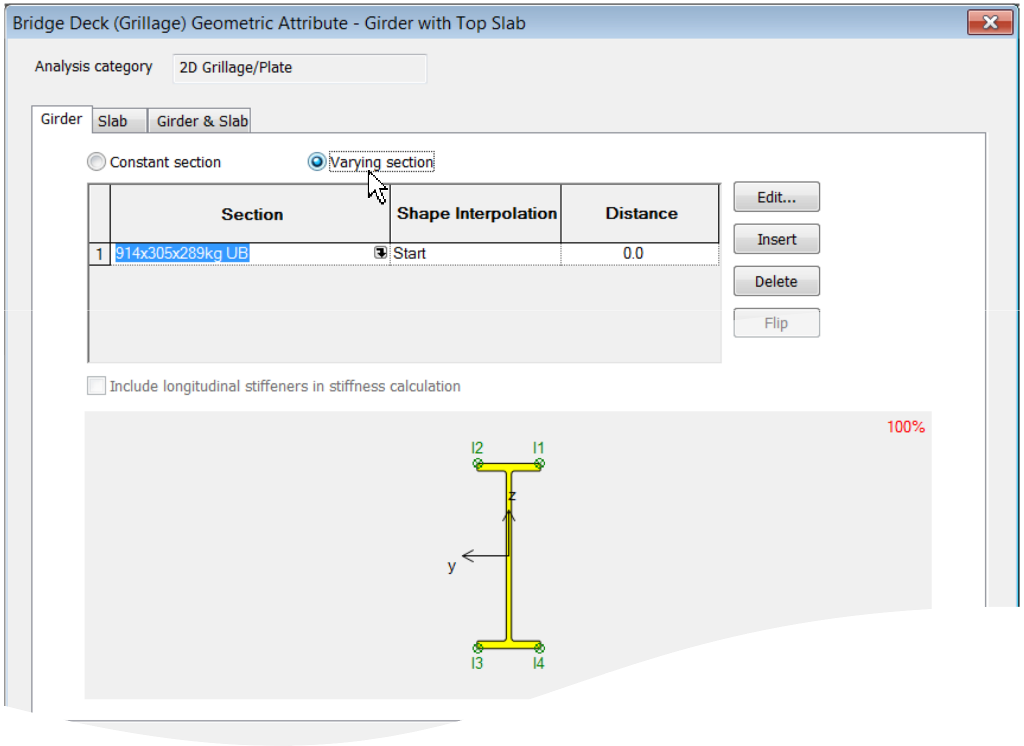
Beam & slab deck options



Section properties calculated about neutral axis

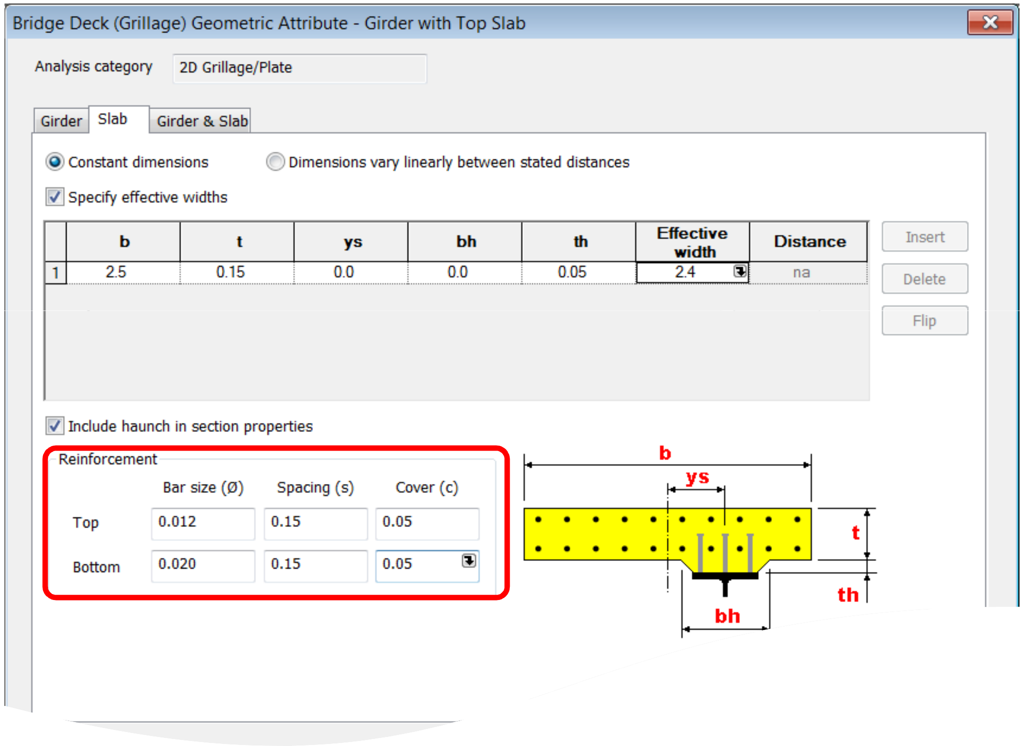
Grillage sections – girder with top slab

- Steel/ plate girder
- Precast
- Rectangular (diaphragm)
- Arbitrary (custom)
- Prismatic or varying



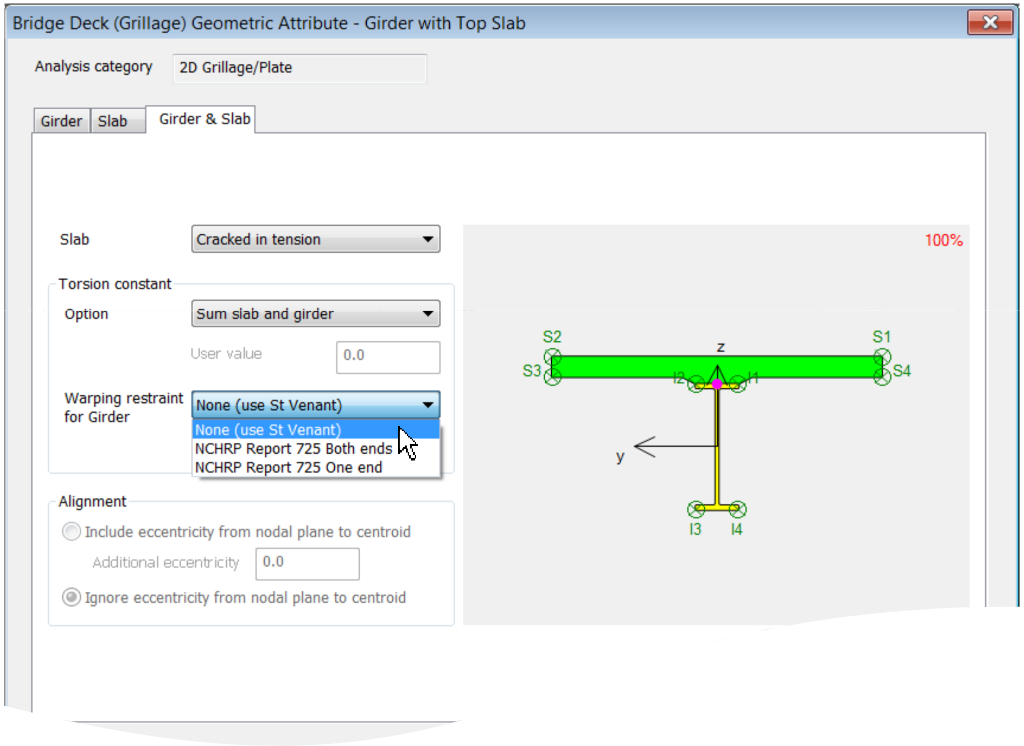
Grillage sections – girder with top slab

- Width may vary
- Effective widths
- Include rebar for slabs cracked in tension



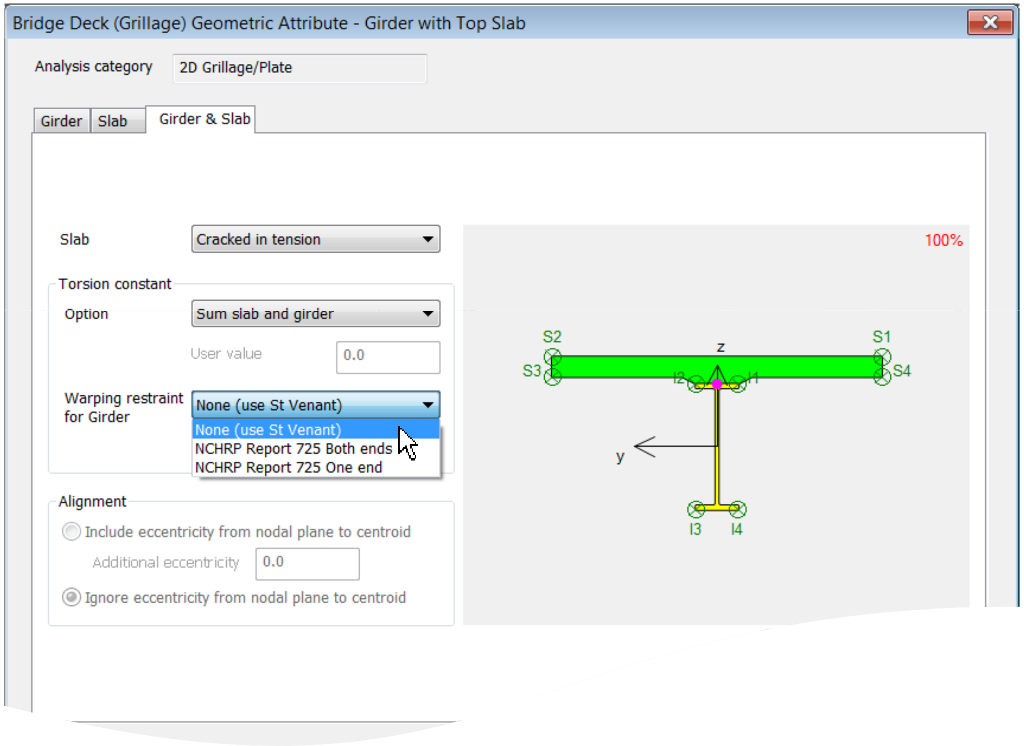
Grillage sections – girder with top slab

- Treatment of slab
- Torsional constant
- Warping restraint



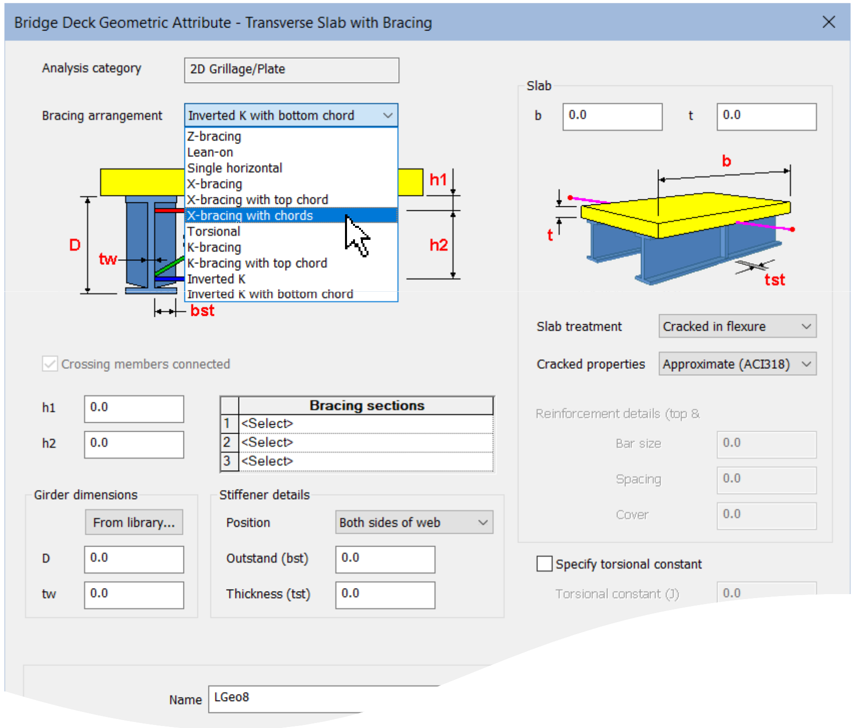
Grillage sections – girder with top slab

- Treatment of slab
- Torsional constant
- Warping restraint



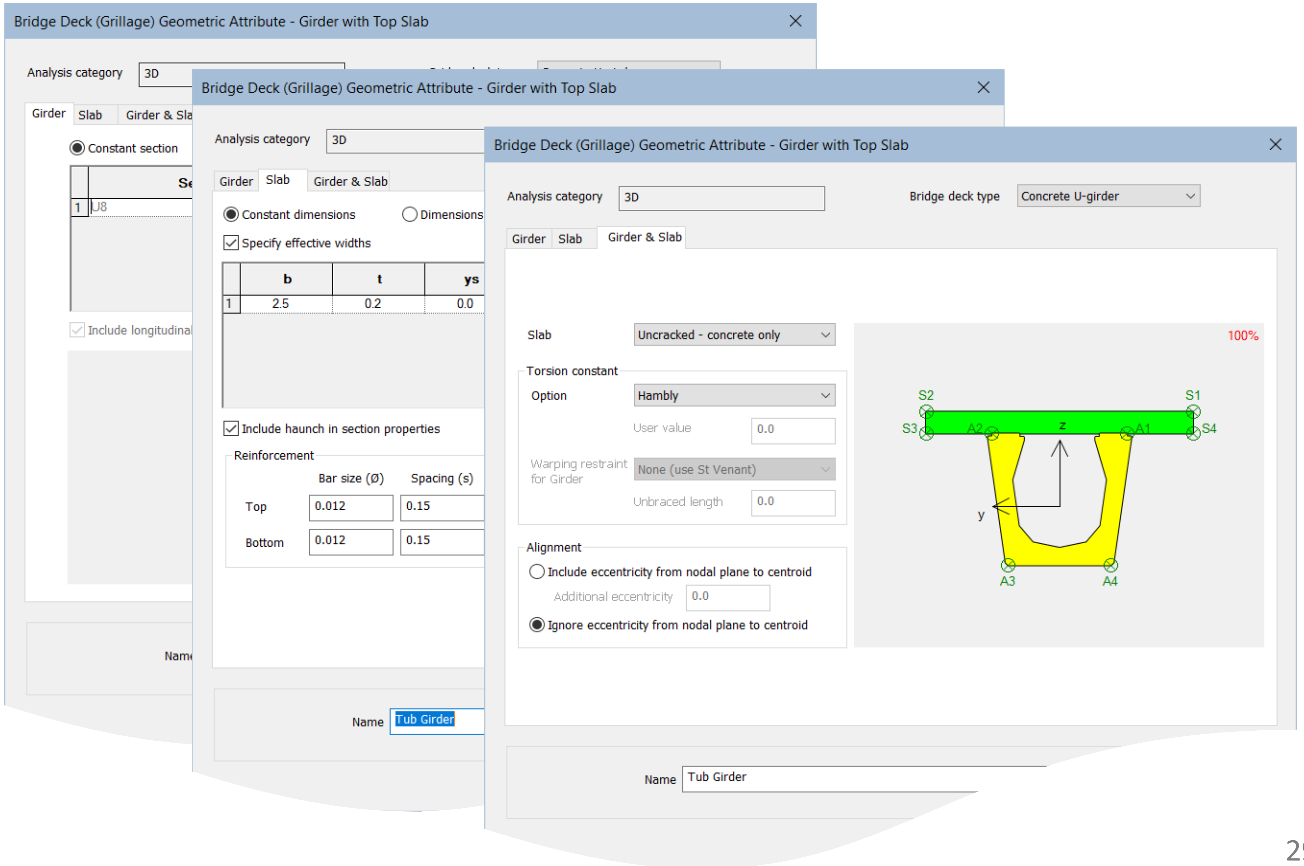
Grillage sections – cross-bracing

- Treatment of slab
- Torsional constant
- Warping restraint
- Allows simple inclusion of cross-bracing into section calculation



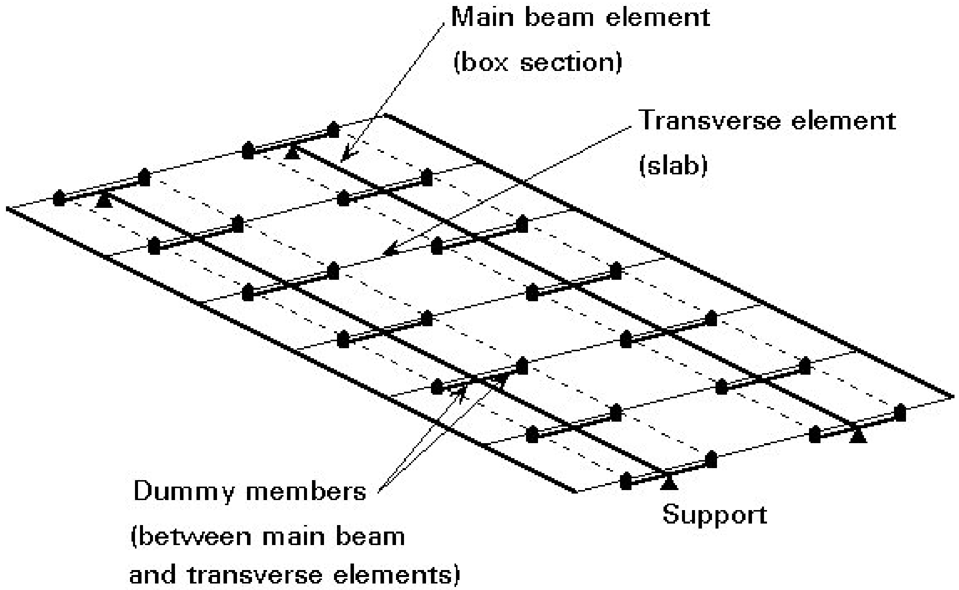
Grillage sections – Tub girder with top slab

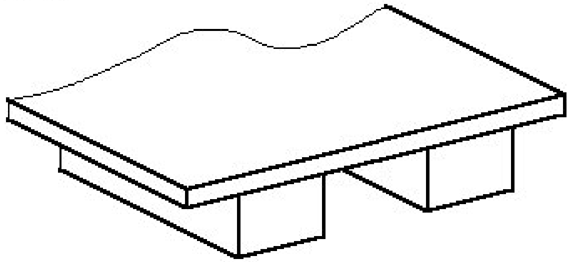
- Coming V21



Beam & slab grillages

- Box beams





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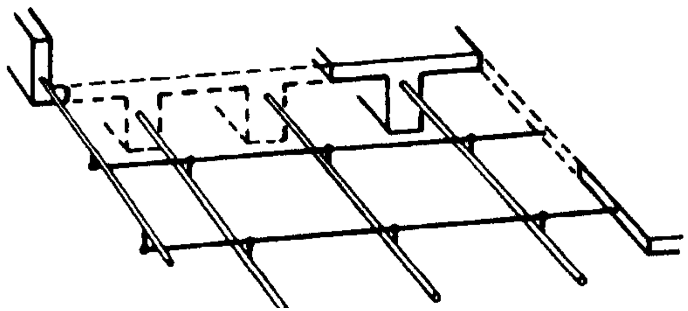
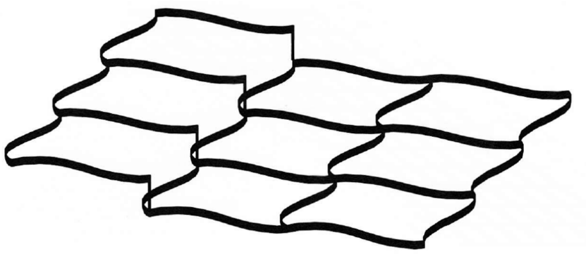
Beam & slab grillages

- Torsionless grillages
  - Appropriate for beams of low torsional stiffness e.g. Steel I-girders
  - Simplifies input and output
  - Lower bound theory, so OK
- Downstand grillages
  - Questionable

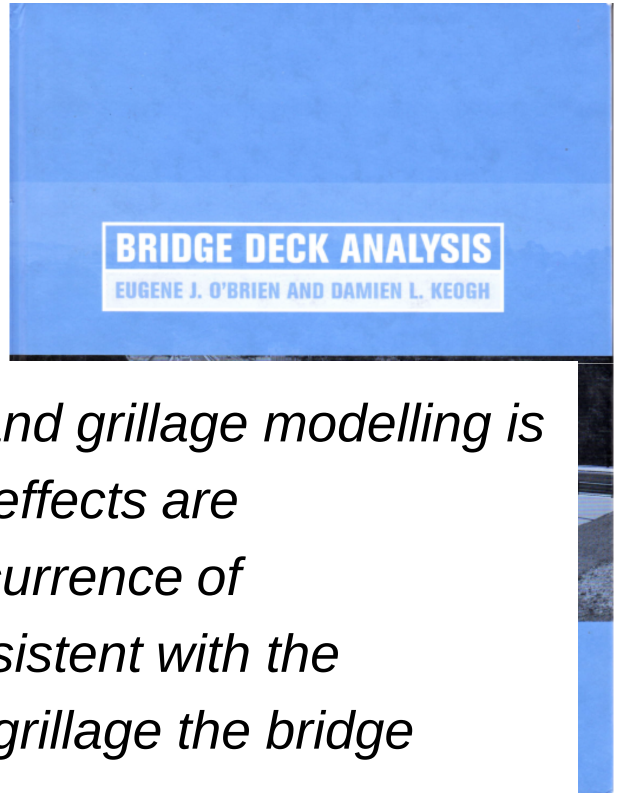


Downstand grillage

Beam & slab grillages

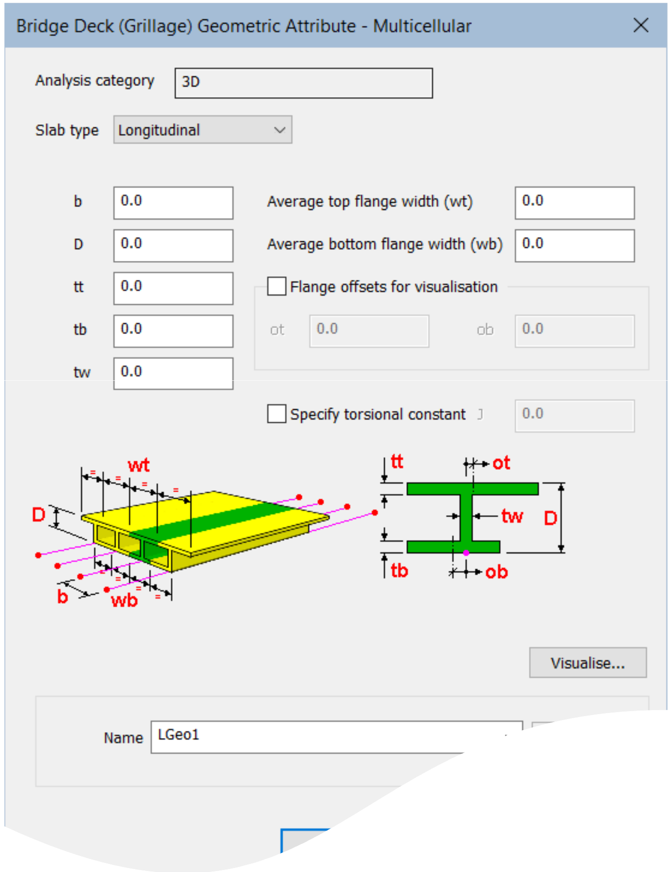


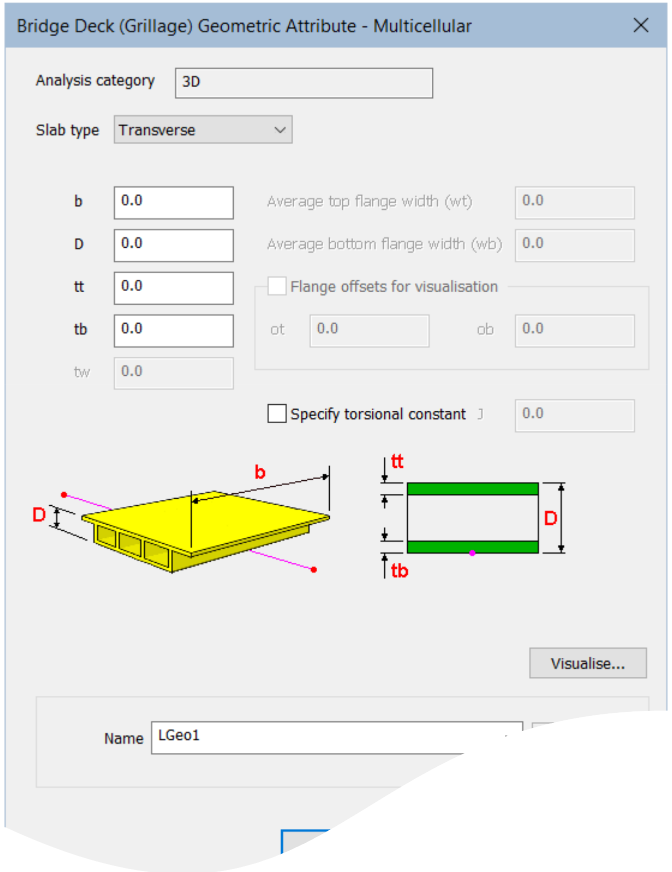
In-plane distortion of members in upstand grillage model



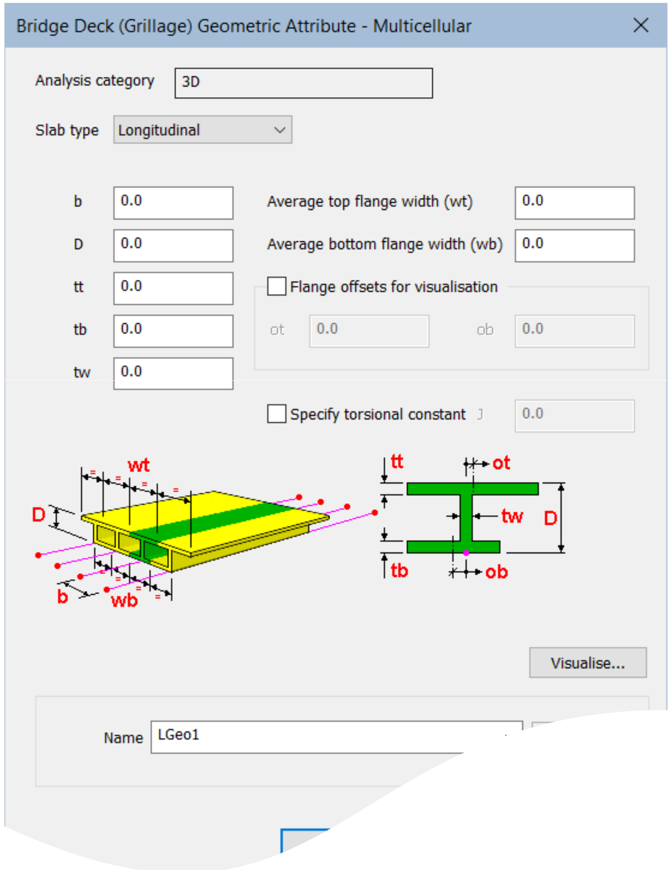
[where a 3D technique such as downstand grillage modelling is used] "...difficulties arise when in-plane effects are considered... the real problem is the occurrence of localmembers... which are clearly inconsistent with the behaviour of in-plane distortions of the grillage the bridge deck." Section 7.5

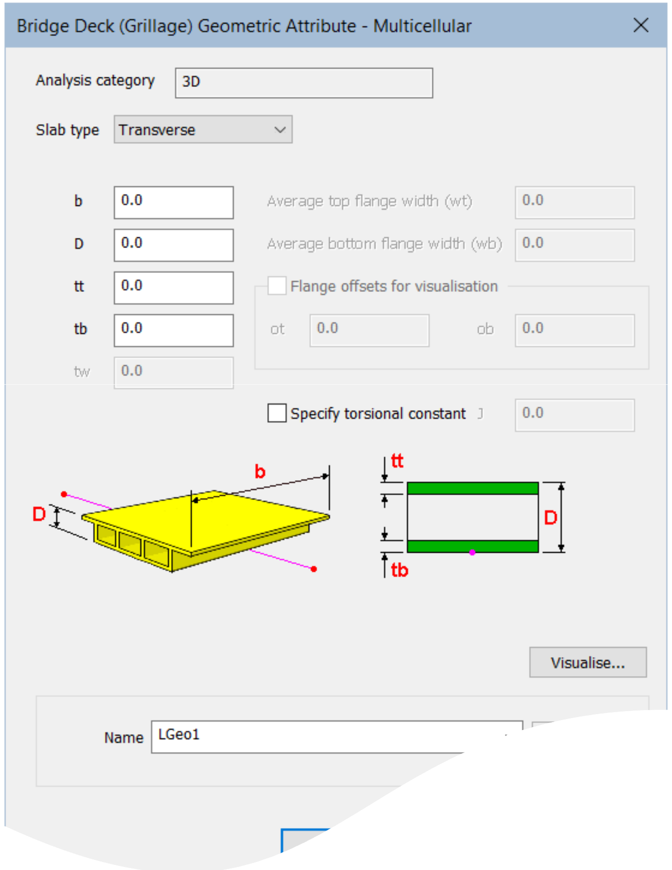
Grillage sections – Multicelular V21





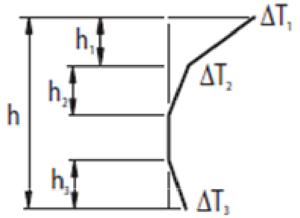
Grillage sections – Multicelular V21



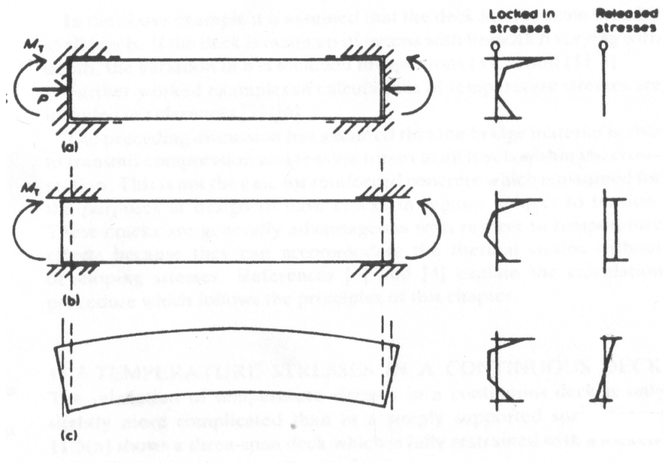


Temperature effects EU

- Varying temperature profiles (EN1991-1-5):



$h_1 = 0.3h$ but ≤ 0.15m
$h_2 = 0.3h$ but ≥ 0.10m
but ≤ 0.25m
$h_3 = 0.3h$ but $\leq (0.10$m + surfacing depth in metres)
(for thin slabs, h_3 is limited by $h - h_1 - h_2$)



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Temperature effects EU

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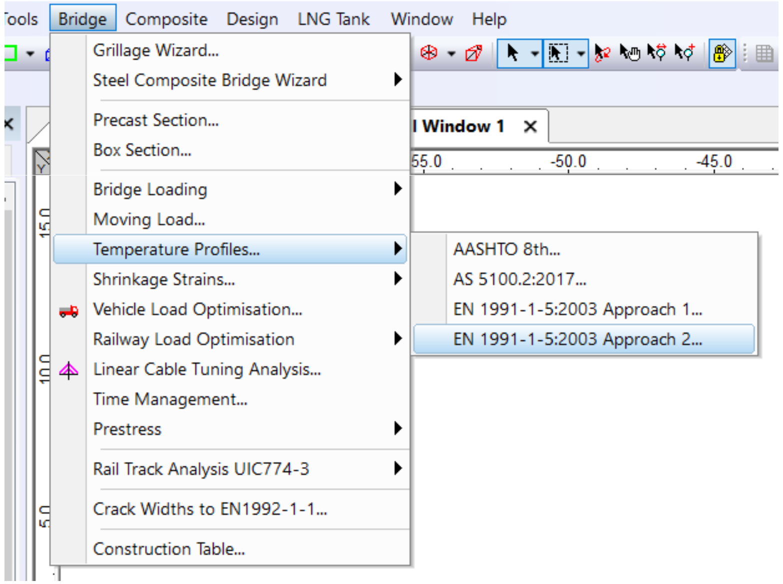
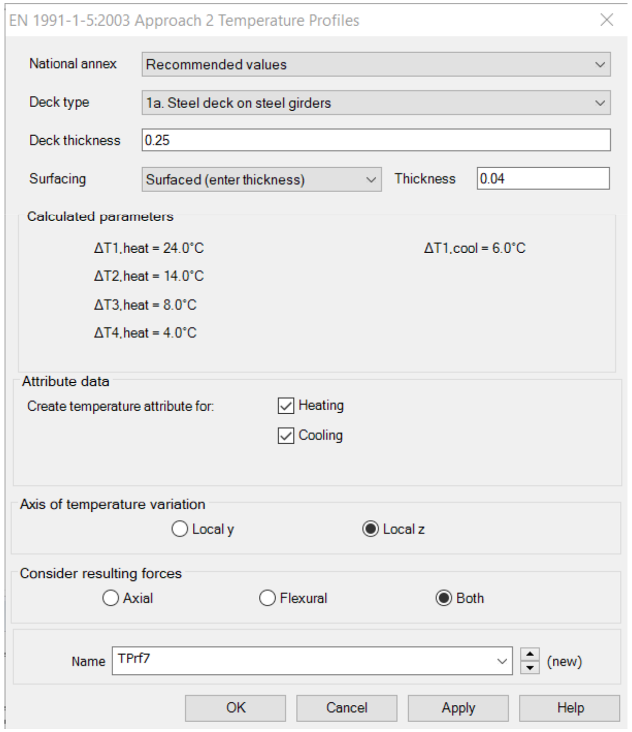
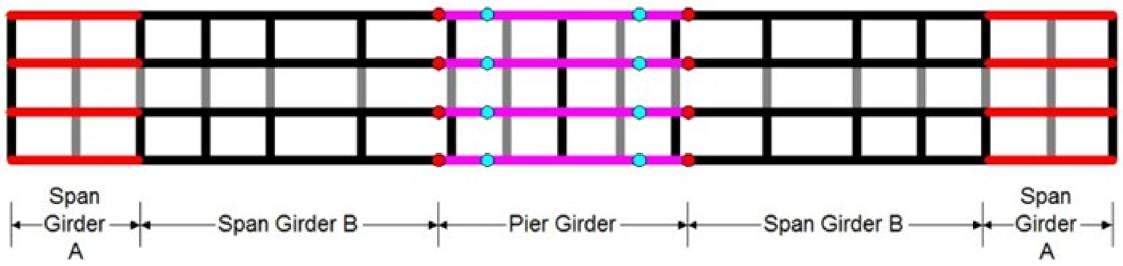




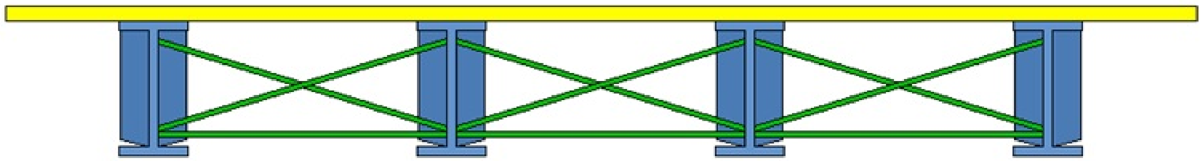
Multi-span composite bridge with bracing demo

- Creating the base analysis with section properties

Summary data

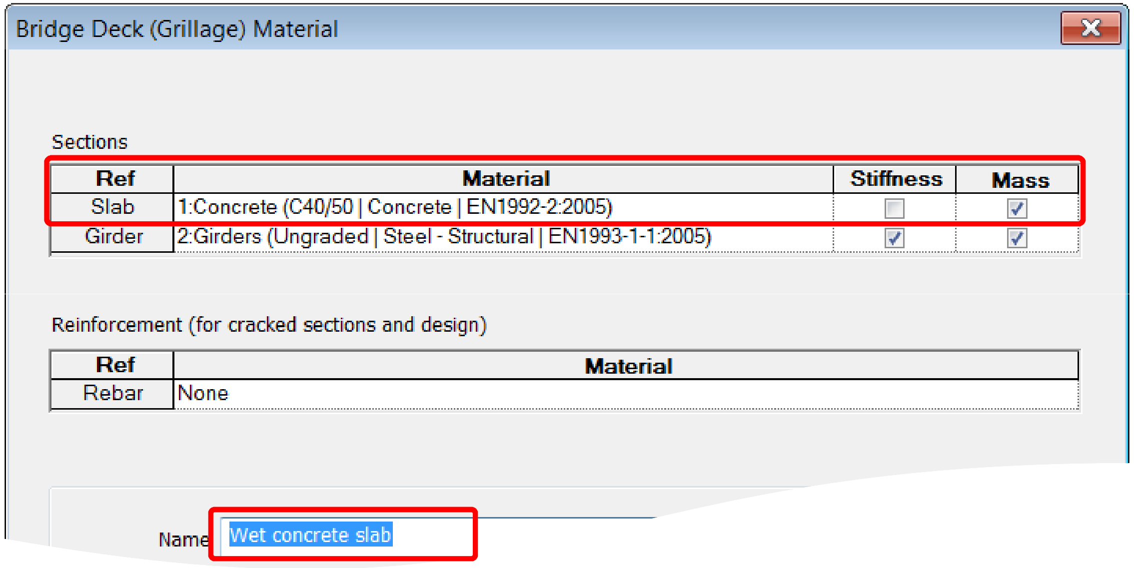


Plan on proposed grillage model



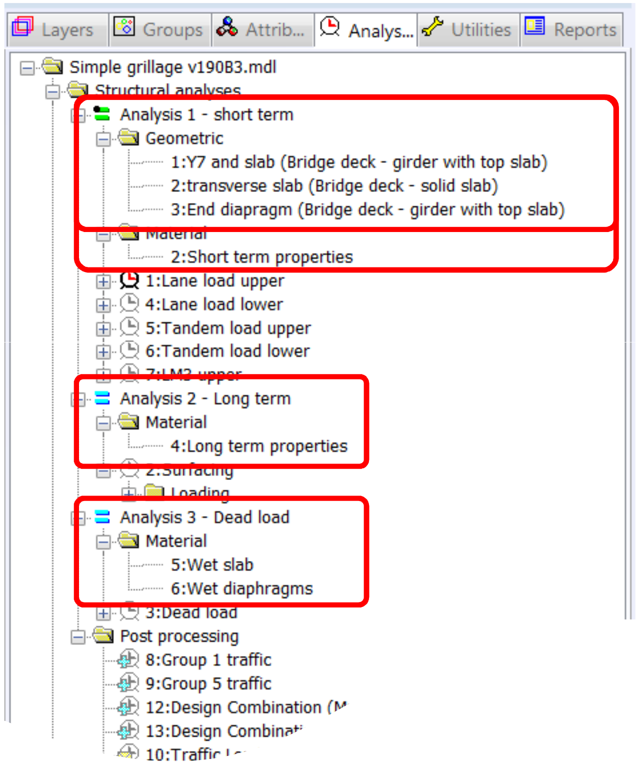
Indicative Cross Section

Grillage – material attributes



- Short-term
- Long-term
- Wet concrete…
- Include or exclude stiffness/mass

Multiple analyses



- Geometric attributes in Base Analysis
- Short-term material in Base Analysis
- Analysis 2 = long term
  - e.g. concrete slab $E = E_{cm} / 3$
- Analysis 3 = wet concrete
  - slab stiffness switched off

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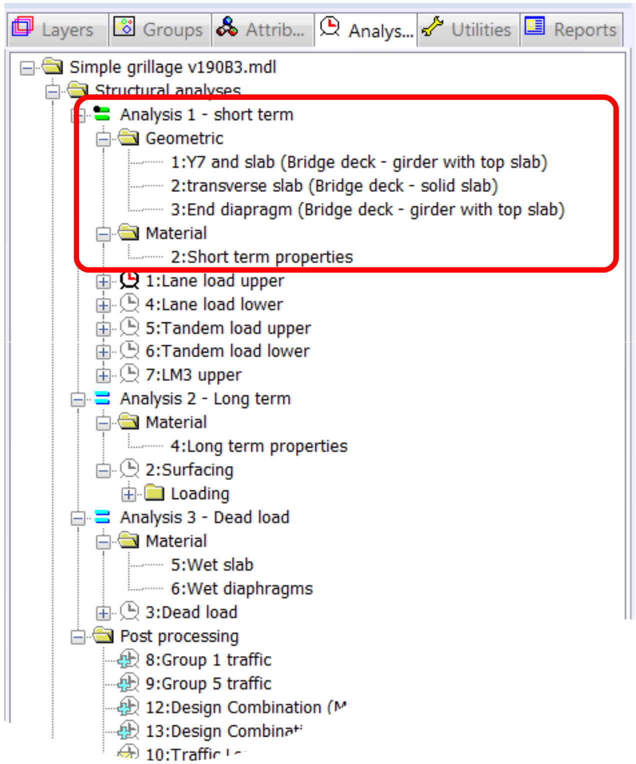
Multiple analyses



- Geometric attributes in Base Analysis
- Short-term material in Base Analysis
- It is important to have the base analysis with short-term material properties as this is the analysis that will be used for VLO

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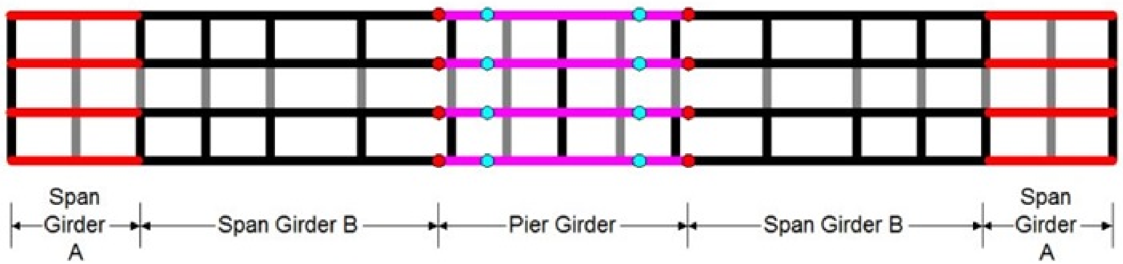
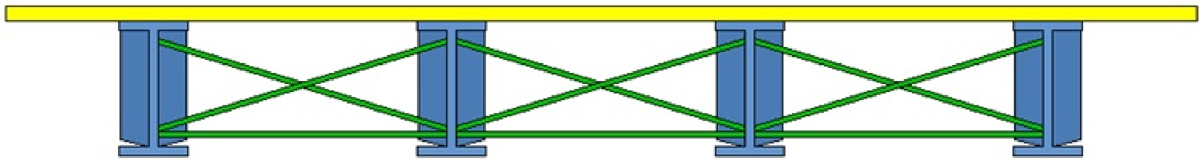
Multi-span composite bridge with bracing demo

- Including the stage construction sequence

Summary data

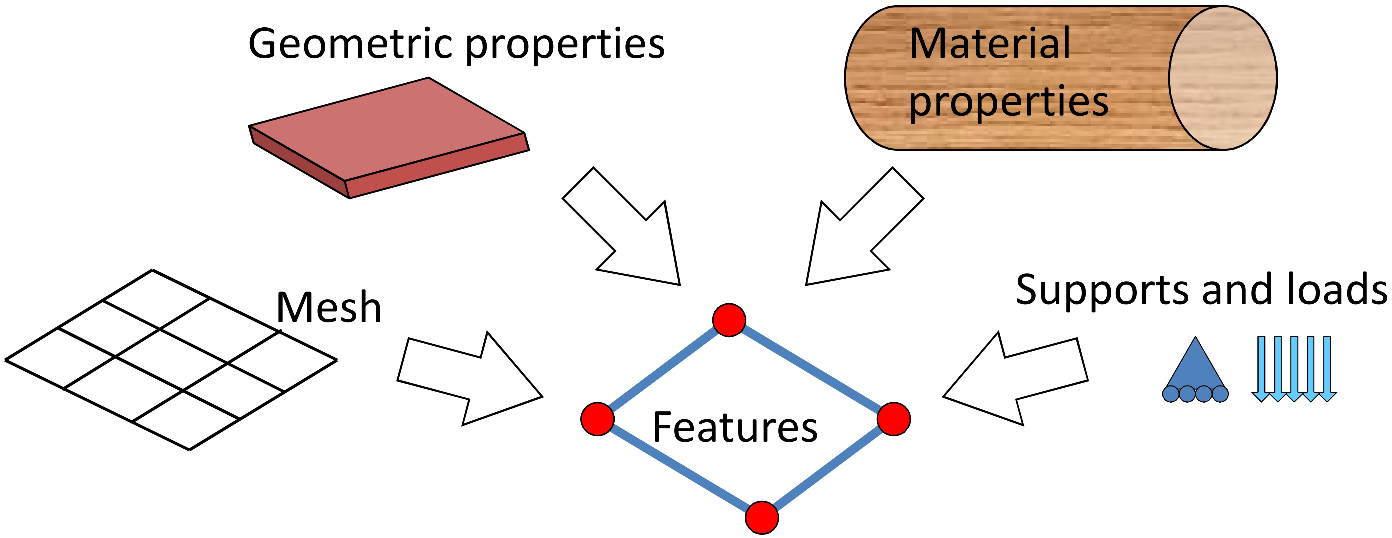


Plan on proposed grillage model



Indicative Cross Section

LUSAS Model Attributes



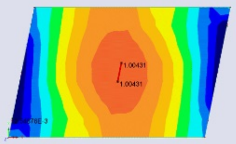
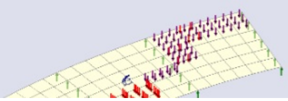
DEFINE and ASSIGN

Basic checklist

- Reactions
- Deformed shape
- Magnitude of deformations
- Warning or error messages
- Mesh refinement

Learn more

- LUSAS examples manual
  - https://www.lusas.com/user_area/documentation/V20_0/worked_examples/index.html
  - Every step with explanation

Wood-Armer Bridge Slab Assessment 	2D, Simple Slab, Skew Angle, Wood Armer Reinforcement, Wood Armer Assessment, Safety Factors, Self Weight, General Loading, Knife Edge Loading, General Patch Loading, Combination, Contour Plotting, Display Peak Values.	Updated for V20*
Grillage Load Optimisation 	2D, Inplane, Grillage, Vehicle Load optimisation, Load visualisation, Influence surface, Basic Load Combination, Smart Load Combination, Envelope.	Updated for V20
Bridge Slab Traffic Load Optimisation 	2D, Plate, Slab, Modelling, Eurocode, Element Axes, Influence Surface, LUSAS TLO, Vehicle Load Optimisation, Load Combination, Bending Moments, Reactions, Transformed Results, Peak Values.	Updated for V20

Worked Example and Quiz

- Complete Multi-span composite bridge with bracing example
- Session 2 Quiz, on the module and Multi-span composite bridge with bracing example at:
  - https://www.lusas.com/grillage_oct_23/index.html (https://www.lusas.com/grillage_oct_23/index.html)
  - Username: **session2**
  - Password: **IcyDog21##**
- Questions on the module, example or quiz can be sent to:
  - onlinetraining@lusas.com

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Online training course

Thank you for attending the session

Contact: onlinetraining@lusas.com