CUSTOMER SUPPORT NOTE

# Modelling Steel-Concrete Composite Members Using Beam Elements

| Note Number: | **CSN/LUSAS/1006** |
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This support note is issued as a guideline only.

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# 1. Introduction

Steel-concrete composite members can be modelled using beam elements, shell elements, solid elements, or a combination of these element types. This technical note presents three methods for modelling steel-concrete composite members using beam elements.

# 2. Example

## 2.1 Description

In this example, a composite section is considered, comprising a concrete slab and a steel girder. Three methods for modelling composite members using beam elements are presented in Table 1.

| Methods | Geometric properties | Material properties |
|---|---|---|
| Method 1 | Arbitrary Section Property Calculator (ASPC) | Reference material attribute |
| Method 2 | Arbitrary Section Property Calculator (ASPC) | Arbitrary section material attribute |
| Method 3 | Bridge Deck (Grillage) geometric attribute | Bridge Deck (Grillage) material attribute |

***Table 1 – Three methods for modelling composite members using beam elements.***

## 2.2 Methods 1 and 2

### 2.2.1 Arbitrary Section Property Calculator

The *Arbitrary Section Property Calculator* can be accessed via Utilities > Section Property Calculator > Arbitrary Section. Sections created using the *Arbitrary Section Property Calculator* are stored as utilities under the *Utilities* treeview.

**Section Geometry**

The section geometry can be created manually or imported (Figure 1). The surface representing the top flange of the steel girder and the overlying concrete slab surface must share a common line to model composite action.

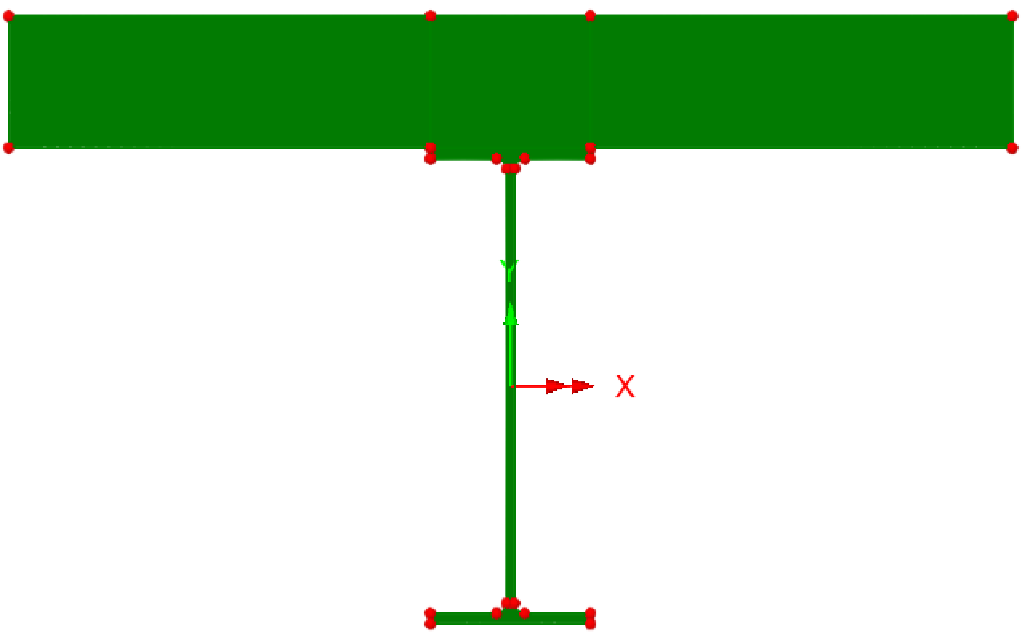


***Figure 1 – ASPC – Section geometry.***

### Material assignments

Two material attributes are required: one for the steel section and another for the concrete slab. The material assignments, along with the colour-coded section, are shown in Figure 2. In this example, steel is taken as the reference material, and the composite section is transformed into an equivalent steel section.

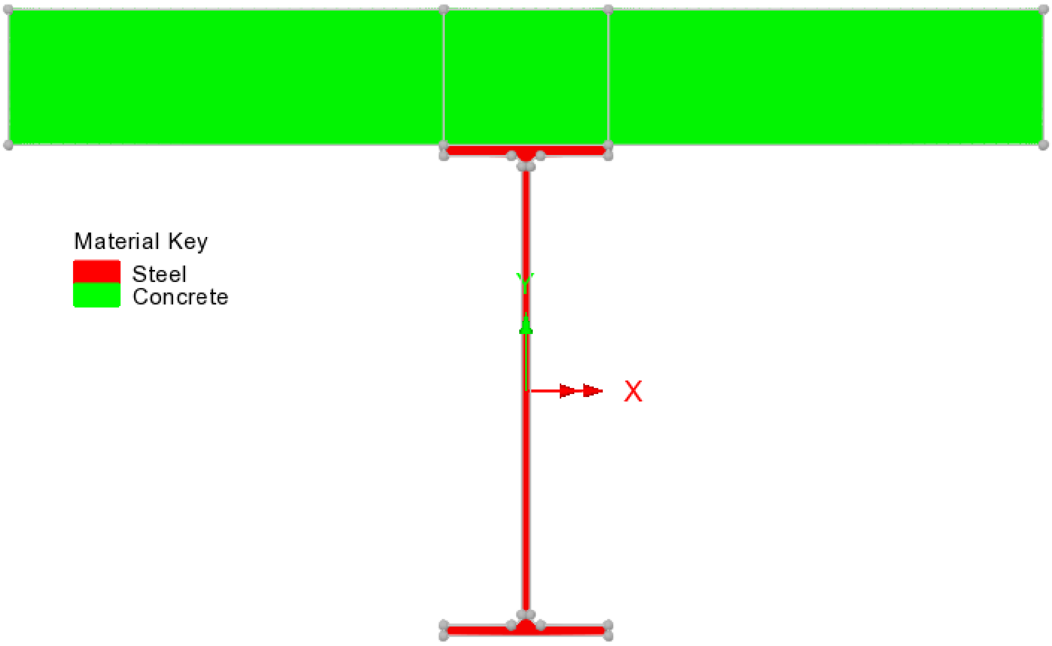


***Figure 2 – ASPC – Material assignments.***

### Section properties

Clicking the *Compute Properties* button discretises the section geometry using triangular elements and computes the corresponding section properties. The discretisation of the section is shown in Figure 3, and the resulting properties are presented in Figure 4.

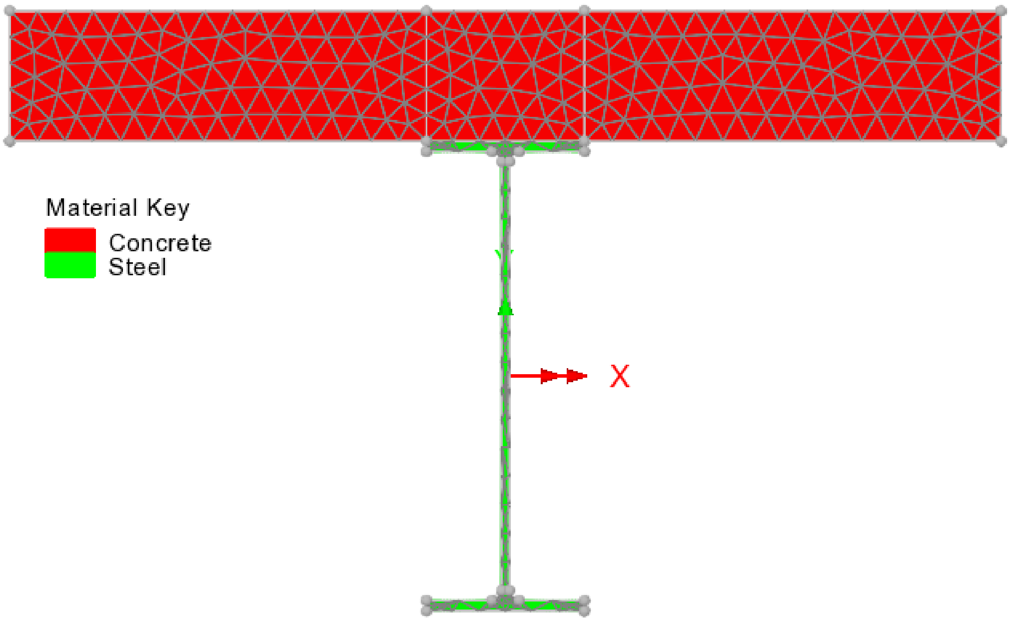


***Figure 3 – ASPC – Discretisation of section.***

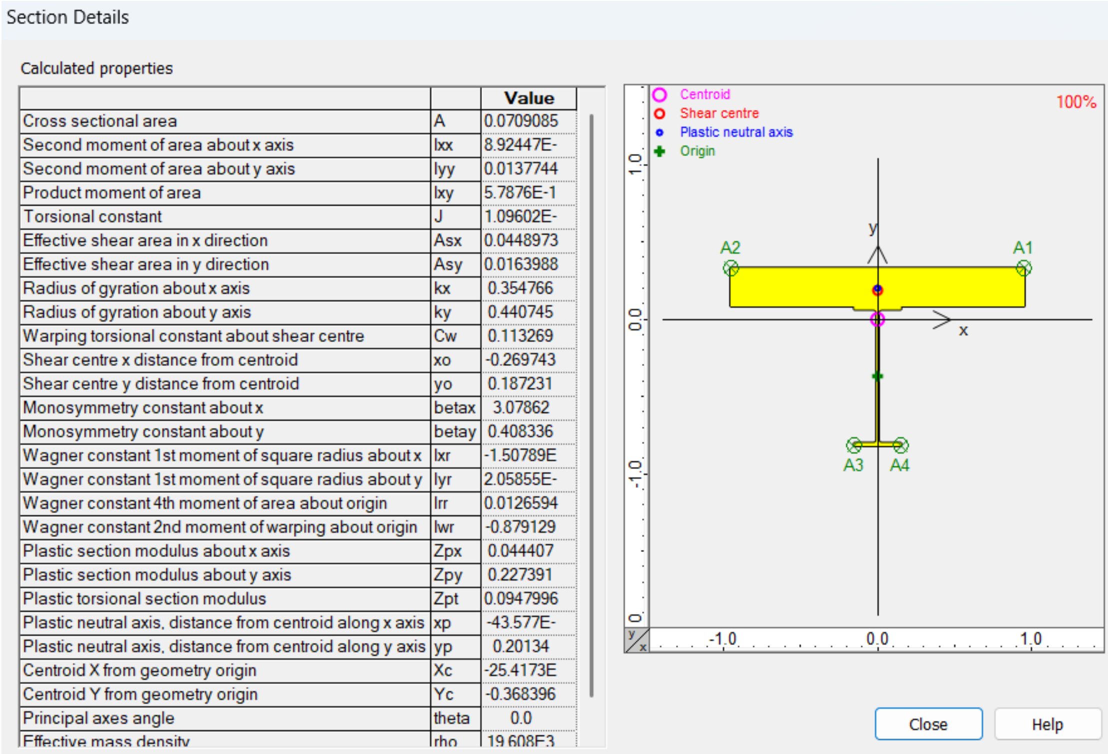


***Figure 4 – ASPC – Section properties.***

## 2.2.2 Method 1 – Geometric and material attributes

The first method involves selecting the *From arbitrary section* option in the geometric attribute dialog (Figure 5).

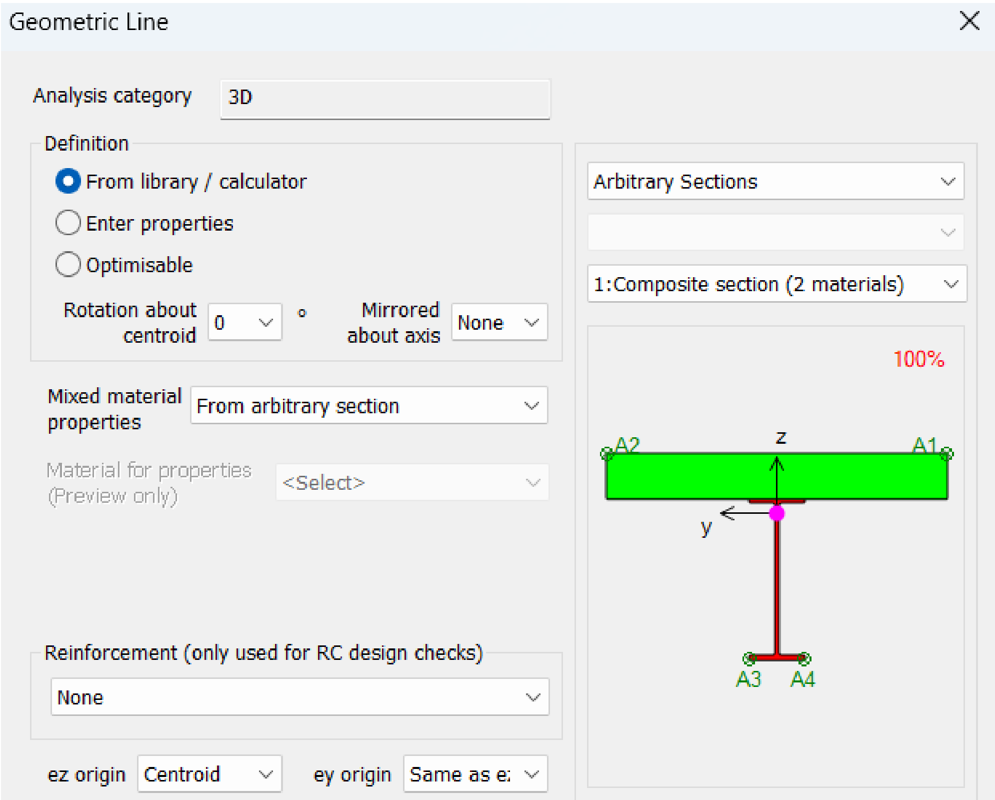


***Figure 5 – Method 1 – Geometric attribute.***

As mentioned earlier, steel is used as the reference material. Therefore, the material properties defined in the material attribute assigned to the line representing the composite beam must be identical to the steel properties used in the *ASPC*.

Additionally, since the section analysed in LUSAS is an equivalent steel section, the concrete slab stress results (Figure 6) must be transformed using the modular ratio.

For example, the stress at the top fibre of the concrete slab (at midspan) is:

-466.6E3 / 10.5 = -44.4E3 N/m$^2$

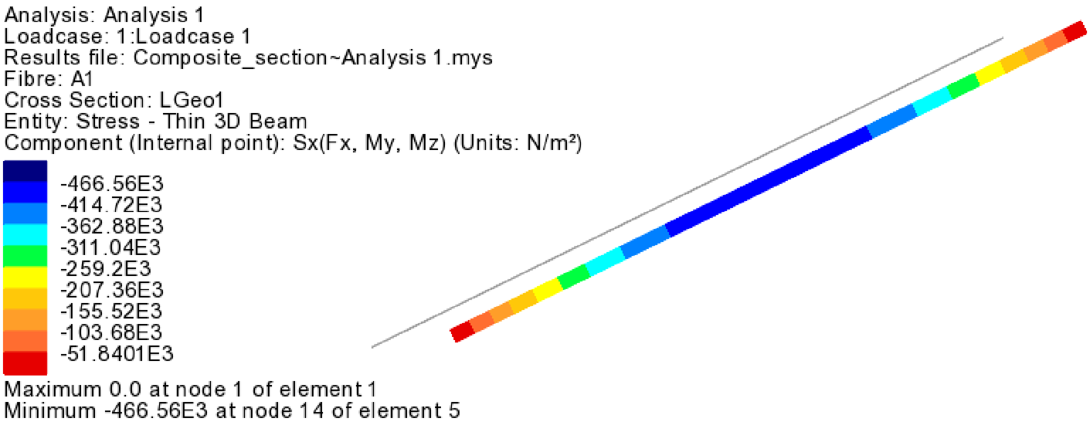


***Figure 6 – Method 1 – Stress contour plot – Top fibre of concrete slab.***

### 2.2.3 Method 2 – Geometric and material attributes

The second method involves selecting the *Using assigned compound material* option in the geometric attribute dialog (Figure 7).

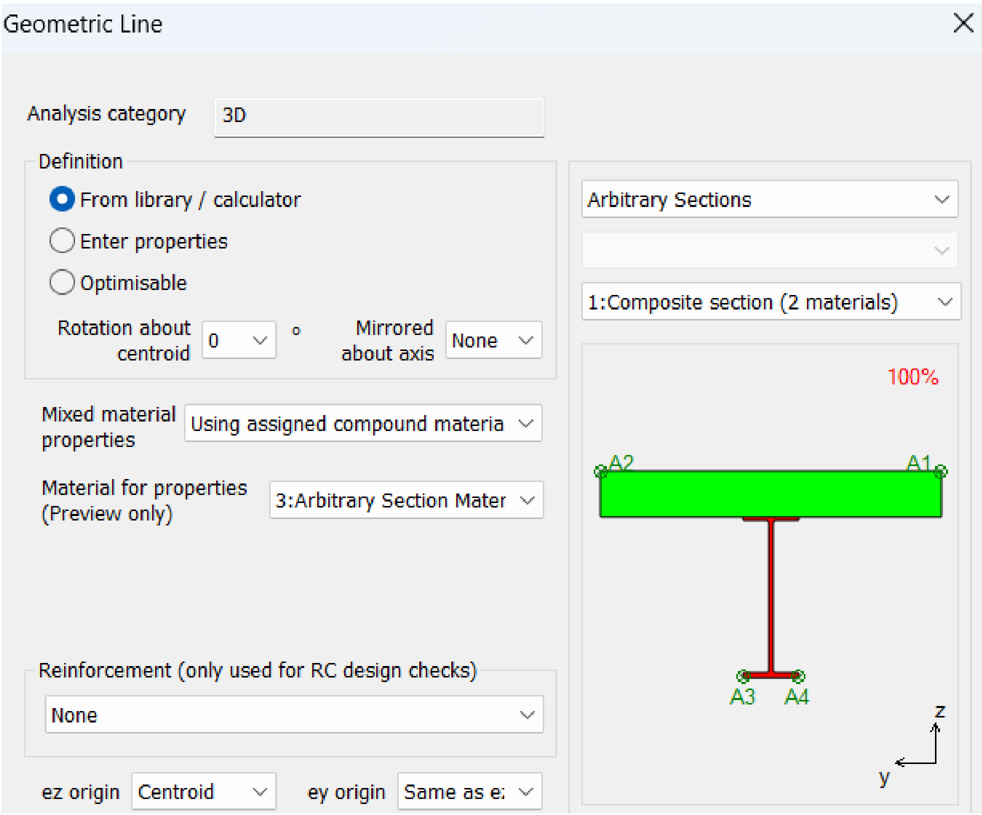


***Figure 7 – Method 2 – Geometric attribute.***

In this case, an *Arbitrary Section* material attribute (Attributes > Material > Arbitrary Section) must be assigned. The material attribute dialog is shown in Figure 8. In this example, the concrete slab is assumed to be fully cured, and its stiffness is accounted for by ticking the relevant option. The stiffness and mass of individual components can be omitted where appropriate by deselecting the relevant options.

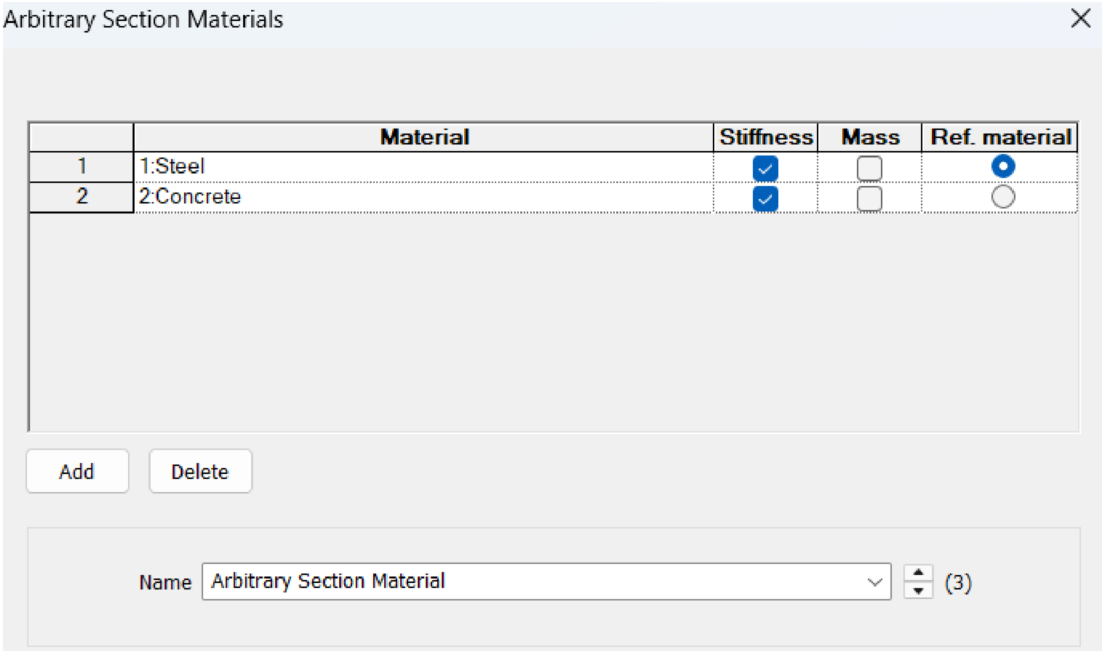


***Figure 8 – Method 2 – Material attribute.***

Another advantage of Method 2 over Method 1 is that the concrete slab stress results do not require transformation (see Figure 9).

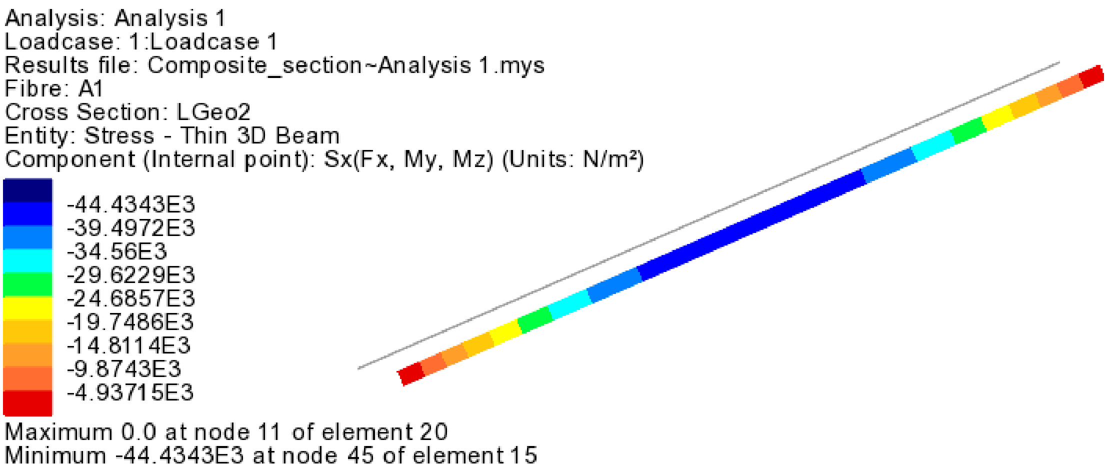


***Figure 9 – Method 2 – Stress contour plot – Top fibre of concrete slab.***

## 2.3 Method 3

### 2.3.1 Bridge Deck (Grillage) geometric attribute

Method 3 requires a *Bridge Deck (Grillage)* geometric attribute (Attributes > Geometric > Bridge Deck (Grillage)). In this example, the *Girder with Top Slab* option is used (see Figure 10). Method 3 can be particularly useful when code provisions or recommendations from the literature need to be considered. For example, the torsional constant may be taken as either the sum of the torsional constants of the slab and girder, the torsional constant of the girder alone, or a user-defined value. The available options are described in detail in the Help system.

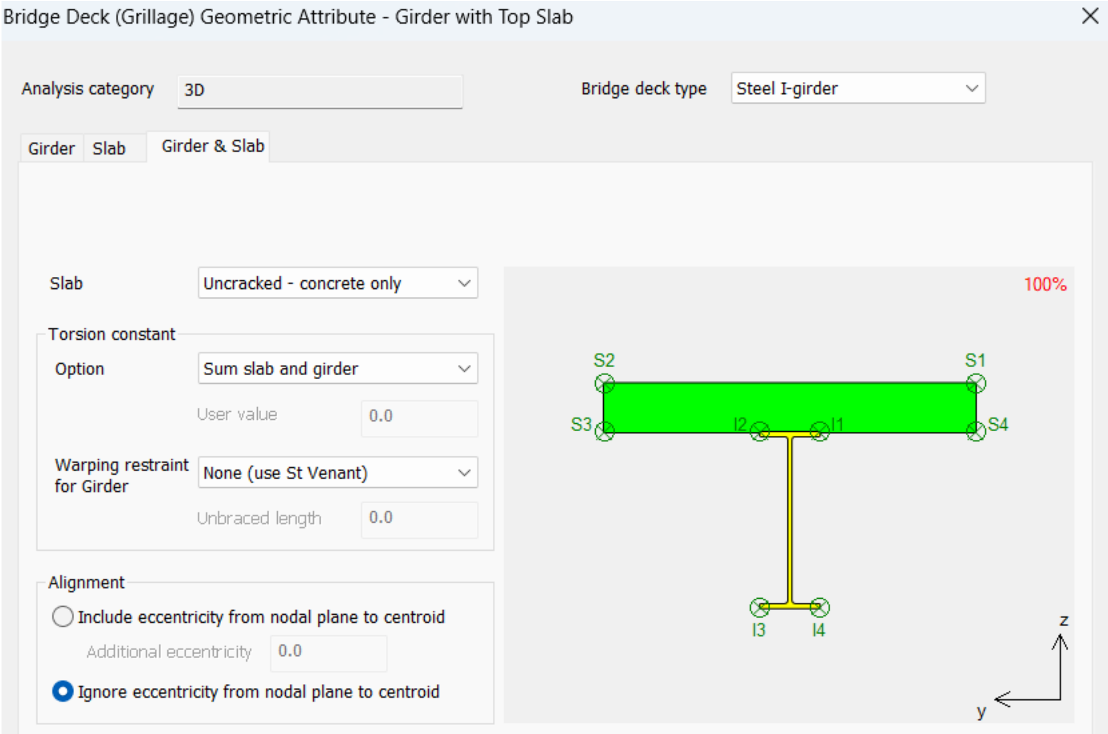


*Figure 10 – Method 3 – Geometric attribute.*

In this example, the *Uncracked – concrete only* option is used because the slab is in compression. Cases in which the slab is in overall tension and the concrete does not contribute to stiffness are covered by the *Cracked in tension* option. In addition, Method 3 allows reinforcement to be included in a relatively straightforward manner. Including reinforcement in Methods 1 or 2 is more complex and time-consuming.

### 2.3.2 Bridge Deck (Grillage) material attribute

Method 3 requires a *Bridge Deck (Grillage)* material attribute (Attributes > Material > Bridge Deck (Grillage)). Figure 11 shows the material attribute dialog, which is similar to that presented in Figure 8.

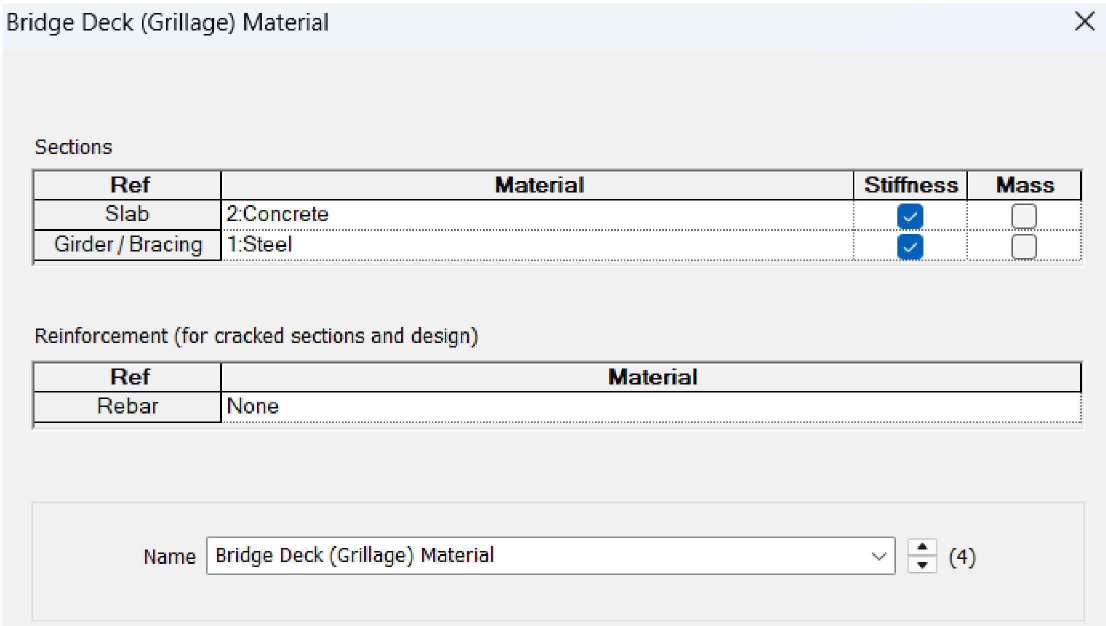


*Figure 11 – Method 3 – Material attribute.*

The stiffness or mass of individual components may be ignored if required. In addition, Method 3 allows reinforcement material to be defined for determining cracked section properties and for performing design calculations. As in Method 2, the concrete slab stress results do not require transformation (see Figure 12).

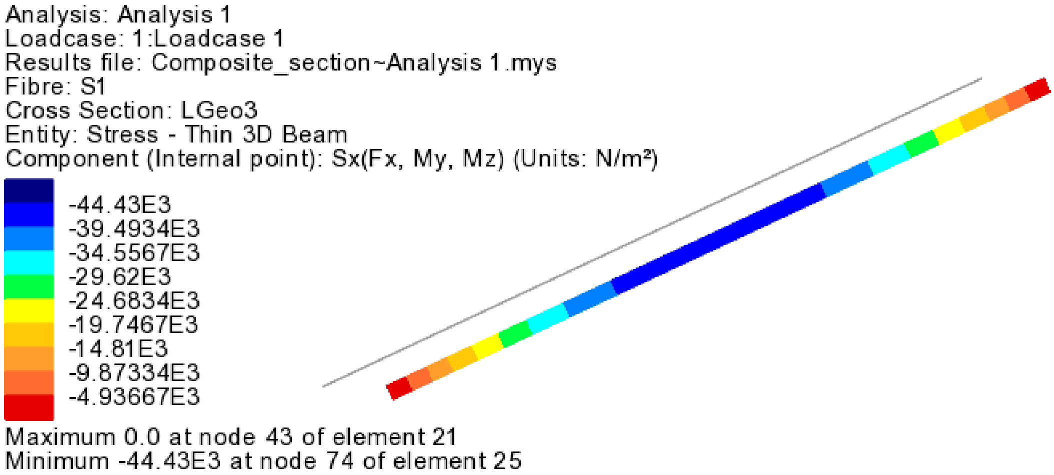


***Figure 12 – Method 3 – Stress contour plot – Top fibre of concrete slab.***

## 3. Summary

This technical note presents three approaches for modelling steel-concrete composite members using beam elements.

Method 2 is similar to Method 1 but offers greater versatility, as it allows stiffness and mass contributions from individual components to be selectively omitted where appropriate (for example, in a “bare steel” condition, the concrete slab of a composite beam contributes to its mass but not to its stiffness). Method 2 is also useful when considering section shapes not supported by Method 3.

Method 3 is more suitable for applications where design code provisions or recommendations from the literature are to be considered. In this method, cracked section properties and reinforcement can be included in a relatively straightforward manner.

If you have any doubts or require specific advice for your type of analysis, please contact the LUSAS Technical Support team at support@lusas.com.