Composite section

Tutorial

Name:	Composite section
Description:	Several approaches to the modeling of composite sections.
Program:	SAP2000
Version:	12.0.0
Model ID:	na

This article is for SAP2000, but the same concepts apply also to CSiBridge.

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SAP2000 provides various ways to model the composite behavior of a beam-slab assembly. Attached are four SAP2000 models which demonstrate various approaches. The geometric and material properties of the model used for comparison are listed as follows:

- Slab width = 2.0m
- Slab thickness = 0.2m
- Total girder height = 1.2m
- Top and bottom flange width = 1.0m
- Top and bottom flange thickness = 0.1m
- Web thickness = 0.1m
- Applied load at midspan = 100kN
- Modulus of elasticity, E = 33000000 kN/m^2
- Span length L = 20m
- Boundary condition: fixed at both ends

Midspan deflections are calculated as follows:

- Naked girder, = 0.0018m
- Composite girder, = 0.00083m

Model overview

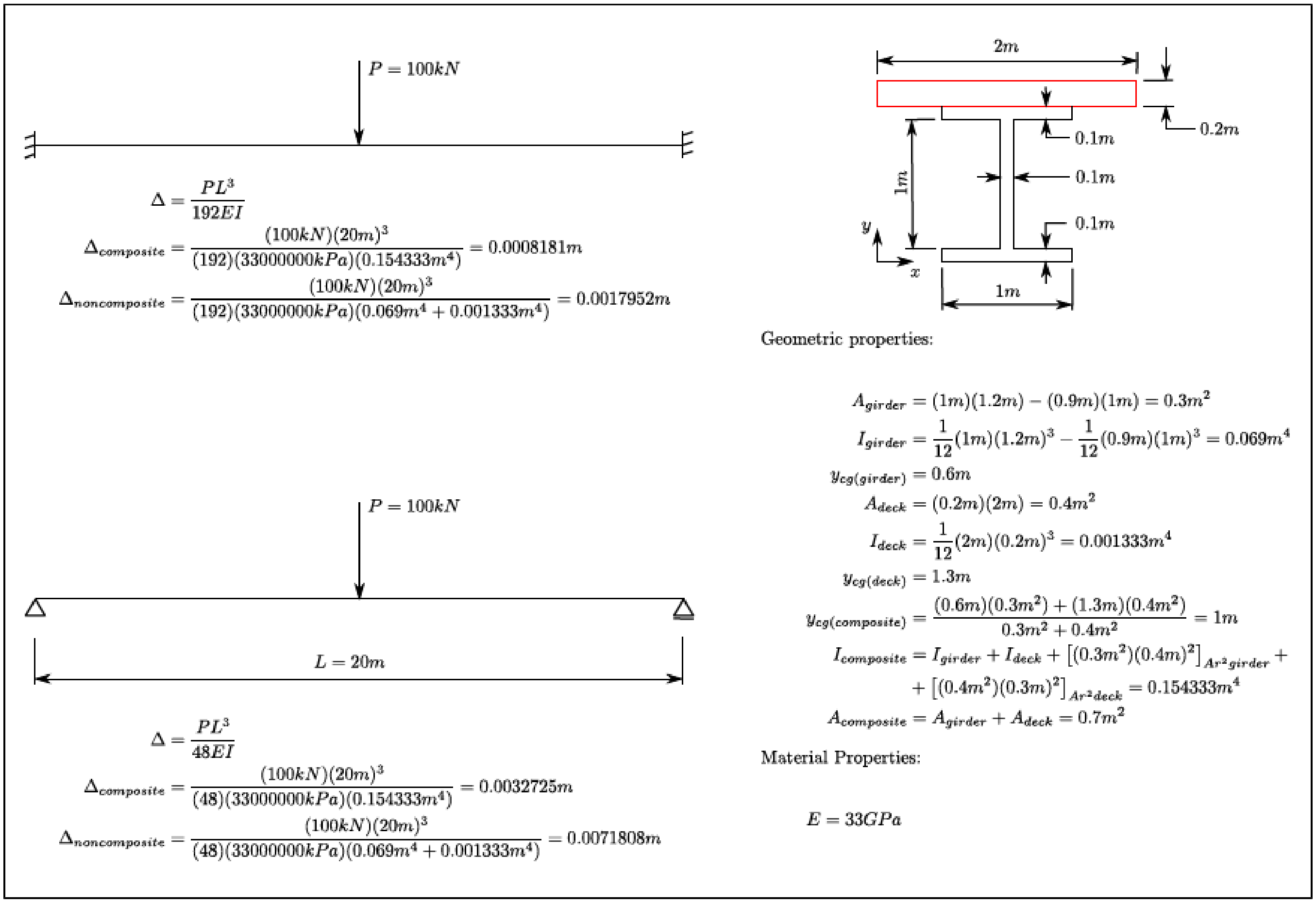

Figure 1 - Model overview

Approaches to modeling composite behavior

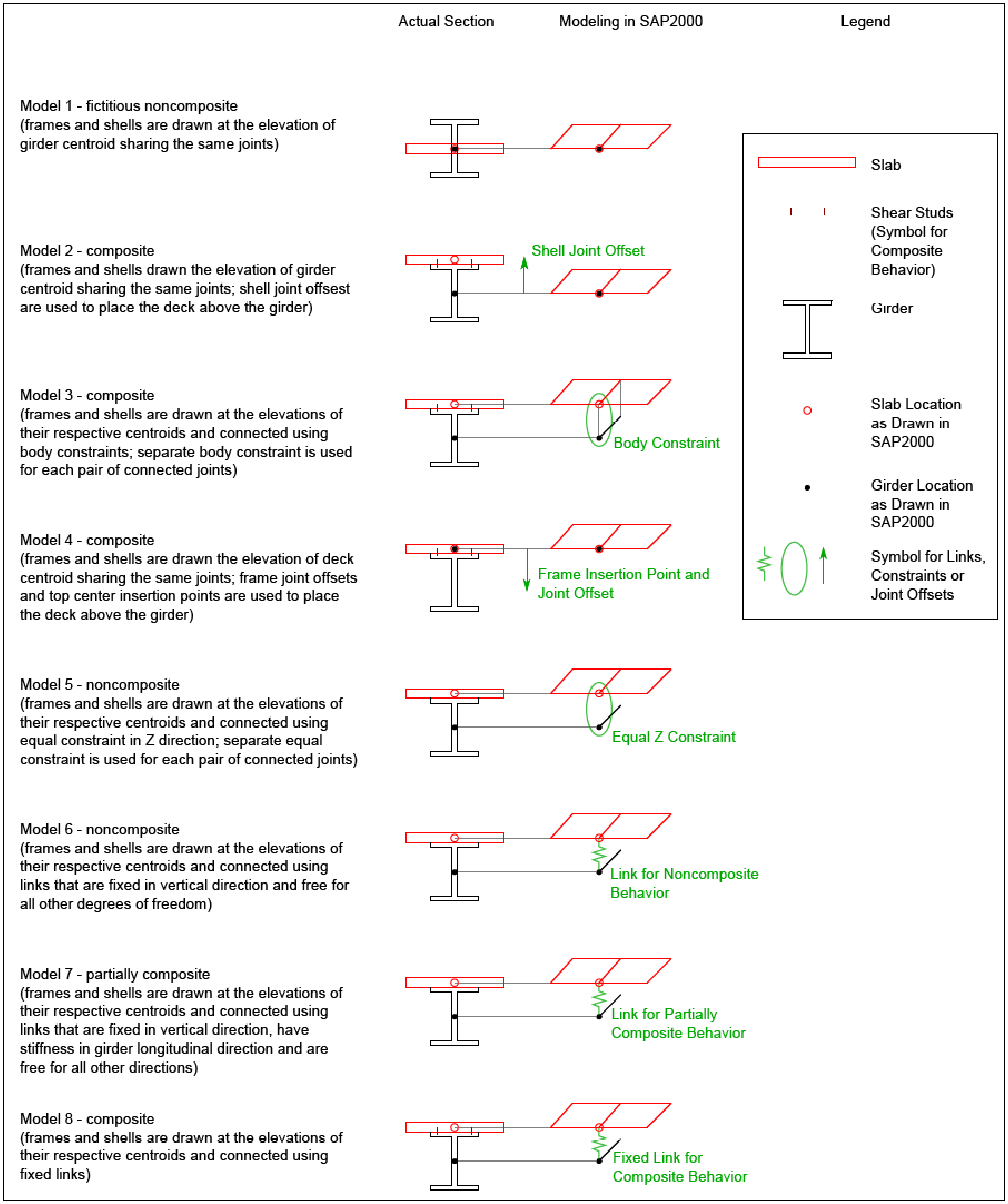

Figure 2 - Modeling composite behavior

Fixed-beam model

The eight approaches to modeling composite behavior, described above, are applied using eight different beam models which are fixed at either end. Results are summarized as follows:

Beam Designation	Behavior	Midspan Deflection [mm]	Comments
Theoretical Beam	composite	0.8181	Theoretical deflection is based on the PL^3/192EI formulation. Please note that SAP2000 calculations produce slightly greater values because shear deformation is considered in deflection.
Beam 1 (top beam)	nocomposite	1.7938	The deck-slab center line coincides with the section neutral axis. Therefore, the deck-slab contribution to section flexural stiffness will be negligible. Further, because there is no composite action, midspan deflection should be close to that of a naked girder.
Beam 2	composite	0.8313	In this model, slab shell objects are drawn at the girder center of gravity (COG), and then offset vertically, above the girder, to model composite action. The shells are offset such that the slab soffit is located above the girder top flange.
Beam 3	composite	0.8313	In this model, the girder and the slab are drawn at their respective center-lines. The corresponding girder and slab joints are then connected through body constraints.
Beam 4	composite	0.8313	In this model, composite action is modeled using frame insertion points.
Beam 5	noncompost ite	1.7938	Equal constraints are used to model noncomposite behavior.
Beam 6	noncomposi te	1.7938	Links are used to model noncomposite behavior.
Beam 7	partially composite	1.0302	Links are used to model partially composite behavior.
Beam 8 (bottom beam)	composite	0.8313	Links are used to model composite behavior.

As implied by the list above, the composite action of a beam-slab assembly may be modeled using either area offsets, body constraints, frame insertion points, or links.

Simply supported beam model

The eight approaches to composite-behavior modeling, described above, are applied using eight different simply supported beam models. Results are summarized as follows:

Beam Designation	Behavior	Midspan Deflection [mm]	Comments
Theoretical Beam	composite	3.2725	Theoretical deflection is based on the PL^3/48EI formulation. Please note that SAP2000 calculations produce slightly greater values because shear deformation is considered in deflection.
Beam 1 (top beam)	nocomposite	7.1752	The deck-slab center line coincides with the section neutral axis. Therefore, the deck-slab contribution to section flexural stiffness will be negligible. Further, because there is no composite action, midspan deflection should be close to that of a naked girder.
Beam 2	composite	3.2624	In this model, slab shell objects are drawn at the girder center of gravity (COG), and then offset vertically, above the girder, to model composite action. The shells are offset such that the slab soffit is located above the girder top flange.
Beam 3	composite	3.2624	In this model, the girder and the slab are drawn at their respective center-lines. The corresponding girder and slab joints are then connected through body constraints.
Beam 4	composite	3.2624	In this model, composite action is modeled using frame insertion points.
Beam 5	noncompost ite	7.1752	Equal constraints are used to model noncomposite behavior.
Beam 6	noncomposi te	7.1752	Links are used to model noncomposite behavior.
Beam 7	partially composite	3.5036	Links are used to model partially composite behavior.
Beam 8 (bottom beam)	composite	3.2624	Links are used to model composite behavior.

Attachments

- Modeling composite behavior in SAP2000.zip (zipped SDB file), which contains:

- SAP2000 V12.0.0 file which demonstrates the modeling of composite behavior for eight fixed beams.
- SAP2000 V12.0.0 file which demonstrates the modeling of composite behavior for eight simply supported beams.
- Sketches which illustrate the modeling of composite, noncomposite, and partially composite behavior.