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

On this page:

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/m²
- 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

<table>
<thead>
<tr>
<th>Actual Section</th>
<th>Modeling in SAP2000</th>
<th>Legend</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model 1</strong> - fictitious noncomposite&lt;br&gt;(frames and shells are drawn at the elevation of girder centroid sharing the same joints)</td>
<td><img src="image" alt="Model 1" /></td>
<td><img src="image" alt="Legend" /></td>
</tr>
<tr>
<td><strong>Model 2</strong> - composite&lt;br&gt;(frames and shells drawn the elevation of girder centroid sharing the same joints; shell joint offset are used to place the deck above the girder)</td>
<td><img src="image" alt="Model 2" /></td>
<td></td>
</tr>
<tr>
<td><strong>Model 3</strong> - composite&lt;br&gt;(frames and shells are drawn at the elevations of their respective centroids and connected using body constraints; separate body constraint is used for each pair of connected joints)</td>
<td><img src="image" alt="Model 3" /></td>
<td></td>
</tr>
<tr>
<td><strong>Model 4</strong> - composite&lt;br&gt;(frames and shells are drawn the elevation of deck centroid sharing the same joints; frame joint offsets and top center insertion points are used to place the deck above the girder)</td>
<td><img src="image" alt="Model 4" /></td>
<td></td>
</tr>
<tr>
<td><strong>Model 5</strong> - noncomposite&lt;br&gt;(frames and shells are drawn at the elevations of their respective centroids and connected using equal constraint in Z direction; separate equal constraint is used for each pair of connected joints)</td>
<td><img src="image" alt="Model 5" /></td>
<td></td>
</tr>
<tr>
<td><strong>Model 6</strong> - noncomposite&lt;br&gt;(frames and shells are drawn at the elevations of their respective centroids and connected using links that are fixed in vertical direction and free for all other degrees of freedom)</td>
<td><img src="image" alt="Model 6" /></td>
<td></td>
</tr>
<tr>
<td><strong>Model 7</strong> - partially composite&lt;br&gt;(frames and shells are drawn at the elevations of their respective centroids and connected using links that are fixed in vertical direction, have stiffness in girder longitudinal direction and are free for all other directions)</td>
<td><img src="image" alt="Model 7" /></td>
<td></td>
</tr>
<tr>
<td><strong>Model 8</strong> - composite&lt;br&gt;(frames and shells are drawn at the elevations of their respective centroids and connected using fixed links)</td>
<td><img src="image" alt="Model 8" /></td>
<td></td>
</tr>
</tbody>
</table>

**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 | nocomposite | 7.1752 | Equal constraints are used to model noncomposite behavior.
Beam 6 | nocomposite | 7.1752 | 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:

<table>
<thead>
<tr>
<th>Beam Designation</th>
<th>Behavior</th>
<th>Midspan Deflection [mm]</th>
<th>Comments</th>
</tr>
</thead>
</table>
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 | nocomposite | 7.1752 | Equal constraints are used to model noncomposite behavior. |
Beam 6 | nocomposite | 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.