Staged-construction operations

> ℹ The staged-construction applications described in this article were written in context with SAP2000, while they also apply to CSiBridge.

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Change sections

Section properties may be changed for various structural objects throughout the course of staged construction. This enables both the simulation of structural changes which occur from stage to stage, and the modeling of multiple configurations within the same structure. When section properties are changed for a stressed object, the software automatically removes the object, replaces its response with equivalent forces, adds the new section, then reverses the equivalent forces. Forces then redistribute both within the new object and throughout the structure.

Additional details are available in the CSI *Analysis Reference Manual* (Nonlinear Static Analysis > Staged Construction > Changing Section Properties, page 447).

Change modifiers

To apply staged construction to composite sections, property modifiers may be changed through either of two procedures. This may be a suitable application, for example, when a precast girder initially supports its own weight and the weight of wet concrete before the slab cures and becomes a composite deck system.

The two options for changing property modifiers are described as follows:

1. If the composite section is modeled as a single frame object, only the supporting girder should be modeled initially. First, frame property modifiers should be created through Define > Named Property Sets > Frame Modifiers. Next, apply the Change Modifiers option within staged construction to account for the increased stiffness and weight of the composite section, as shown in Figure 1:
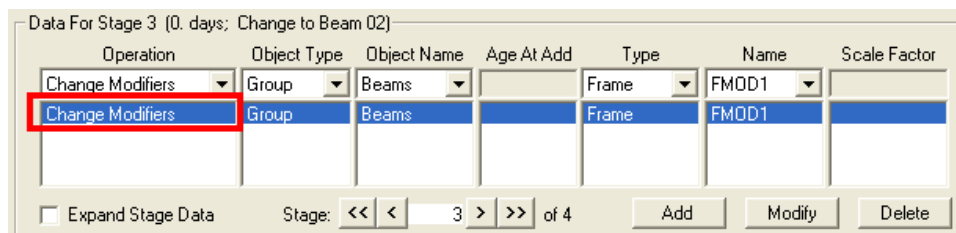

Figure 1 - Change modifiers

2. The second option is to explicitly model the individual components of a composite section. For example, a frame object may model the girder, then a shell object may model the slab. To simulate the hardening of concrete within the deck, the deck slab could be initially modeled with negligible stiffness (1e-4) and its full weight, then in a later construction stage, stiffness could be increased to its full value through property modifiers.

Change supports

Frame releases and a dummy frame object may be assigned to change the support or restraint type within staged construction. This may be accomplished through the following process:

1. Define short and stiff frame objects to represent bearings.
2. Assign frame releases which represent the final bearing condition of these frame objects by selecting Define > Named Property Sets > Frame Releases.

3. Within the staged-construction load case, use the Change Releases operation to change the frame releases, as shown in Figure 2:

Figure 2 - Change releases

Please note that when property modifiers are changed within a staged-construction load case, they do not change the response of the structure up to that stage, and only affect subsequent response. In other words, the effect is incremental. This means that the approach previously described will work well when adding restraints to change supports, but it will not capture the redistribution of internal forces when supports are changed by removing restraints, in which case it would be more appropriate to add and remove links. This is accomplished by first removing the link objects which simulate the previous support condition, then by replacing with links which simulate the new supports.

Additional details are available in the CSI *Analysis Reference Manual* (Frame Element > End Releases > Named Property Sets, page 116).

Change frame releases

Frame releases may be changed through the following process:

- Define frame end releases through Define > Named Property Sets > Frame Releases.

- Apply the end releases by selecting Change Releases within the staged-construction load case.