Line and area springs

Test Problem				
Name:	Line and area springs			
Description:	This test problem demonstrates and validates the application of line and area springs.			
Program:	SAP2000			
Version:	12.0.0			
Model ID:	na			

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Overview

When line or area springs are assigned to an object, SAP2000 generates equivalent joint springs at each node created during auto-meshing. Joint-spring stiffness is determined from tributary area and the line- or area-spring stiffness which is assigned to the object. As a result, joint springs which support interior joints are stiffer than those at corner joints. Since contact pressure is proportional to joint-spring deformation and the displacement of those joints to which springs are attached, users may obtain contact pressure through the product of spring-stiffness constant and displacement, available for output in both graphic and tabular format.

Example model

The example model, attached for reference, contains two area objects (2m x 2m and 1m x 1m), each auto-meshed into four area objects, two frame objects (2m and 1m), each auto-meshed into two frame objects, and one point object. A link (LIN1) is assigned to the area objects as an area spring, to the frame objects as a line spring, and to the point object as a joint link.

Link stiffness is defined as follows:

- 1kN/m when used as a joint link
- 1kN/m/m when used as a line spring
- 1kN/m/m² when used as an area spring

The values specified for Factors For Line, Area, and Solid Springs, available on the Link/Support Property Data menu, are explained in Figure 1:

Link/Support Property Data						
Link/Support Type Linear Property Name LIN1 Property Notes Modif Total Mass and Weight Mass Mass 0. Rotational Inertia 1 0. Weight 0. Rotational Inertia 2 0. Factors For Line, Area and Solid Springs Property is Defined for This Length In a Line Spring Property is Defined for This Area In Area and Solid Springs 1	spring stiffness is entered in kN/m/(1 m) units					
▼ R2 ▼ ▼ R3 ▼	OK Cancel					
Fix All Clear All						
X2.99 Y9.69 Z0.00 GLOBAL 💌 KN, m, C 💌						

Figure 1 - Link and support property data

The SPRING-LOAD load case applies a unit load to objects, including 1kN/m² for the area objects, 1kN/m for the frame objects, and 1kN for the point object. UZ displacement of 1m at all joints indicates consistency between applied loading and assigned stiffness.

The stiffness of automatically created internal springs could be indirectly determined by dividing joint reaction by its displacement. These values are available in the output tables. Here, internally created joints are preceded with a tilda (~).

Model screenshots and results

Area-spring and auto-mesh assignment

Object Model - Area Information		k							
Location Assignments Loads									
Label 2									
Section Property									
Section Name	ASEC1								
Section Type	Shell (Shell-Thin)			1					
Property Modifiers	None	KN, m, C 💌							
Material Overwrite	None								
Thickness Overwrite	None								
Joint Offset Overwrite	None	Reset All							
Local Axes	Default								
Area Spring									
Spring Type	Link Property								
Link Property	LIN1								
Link 1-Axis Orientation	Normal To Face								
Face	Тор								
Normal Orientation	Inward	Update Display							
Axis 2 Angle	0.								
Area Mass	None	Modify Display	• • • • • • • • • • • • • • • • • • •						
Automatic Area Mesh									
Mesh Type	2x2	<u> </u>							
Auto Edge Constraint	No	Const							
Material Temp	Default 🗸 🗸	Cancel							
Double click white background cel	l to edit item.								

Figure 2 - Area-spring and auto-mesh assignment

Equivalent joint springs

The software automatically creates equivalent joint springs which represent those line and area springs which are assigned to an object. These joint springs are displayed through View > Set Display Options > Show Analysis Model, as shown in Figures 3 and 4:

Display Options For Active Window								
Joints	Frames/Cables/Tendons	General	View by Colors of					
🗌 Labels	🔲 Labels	🔲 Shrink Objects	 Objects 					
🔽 Restraints	Sections	Extrude View	C Sections					
🔽 Springs	🔲 Releases	Fill Objects	C Materials					
🔲 Local Axes	🔲 Local Axes	🔽 Show Edges	C Color Printer					
🔲 Invisible	Frames Not in View	🔽 Show Ref. Lines	White Background, Black Objects					
Not in View	🔲 Cables Not in View	🔲 Show Bounding Boxes	C Selected Groups Select Groups					
	Tendons Not in View							
Areas	- Solids	- Links	Miscellaneous					
🗖 Labels	🗖 Labels	🗖 Labels	Show Analysis Model (If Available)					
Sections	Sections	Properties	Show Joints Only For Objects In View					
Local Axes	🗖 Local Axes	🔲 Local Axes						
🔲 Not in View	Not in View	Not in View						
C Apply to All Windows								
OK Cancel								

Figure 3 - Show analysis model

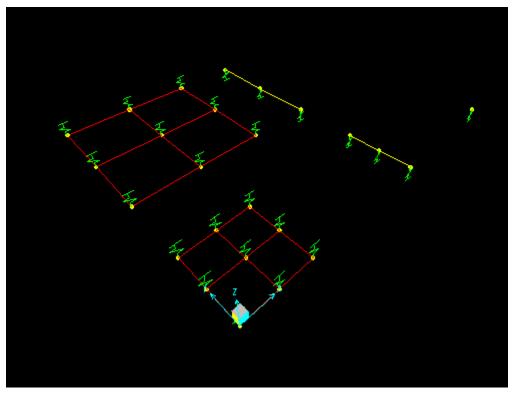


Figure 4 - Equivalent joint springs

Attachments

• SAP2000 V12.0.0 model (zipped .SDB file)