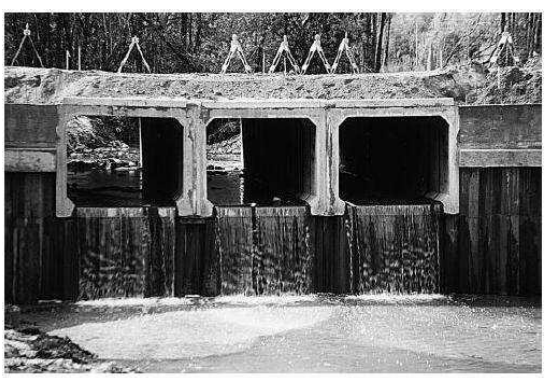
الملاحق:-

الشكل(أ) يوضح عبارات صندوقية

الشكل (ب) عبارة من الحديد المموج



الشكل (ج)عبارة صندوقية من الخرسانة مسبقة الصنع

الشكل (د) عبارة صندوقية من الخرسانة مسبقة الصنع

الشكل (هـ) عبارة صندوقية من الخرسانة مسبقة الصنع

الشكل (و) تشييد العبارات في الموقع

EXAMPLE 1-013

Frame – Simply Supported Beam on Elastic Foundation

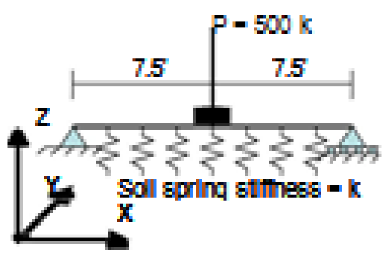
Example Description

This example uses a simply supported beam on elastic foundation to test the SAP2000 frame line spring assignment. The beam is 36 inches wide by 36 inches deep, 15 feet long and the soil subgrade modulus is 800 k/ft^3. A 500 kip vertical load is applied at the center of the beam and the self weight of the beam is ignored. The moment and deflection at the center of the beam are compared with independent results calculated using formulas presented in Timoshenko 1956.

The model is made up of two frame objects each 7.5 feet long. Three separate models are created. The models are identical, except for the discretization of the two frame objects. Models A, B and C discretize each frame object into 1, 4 and 100 frame elements respectively.

Important Note: Only bending deformations are considered in the analysis. Shear and axial deformations are ignored. In SAP2000 this is achieved by setting the property modification factor for area to 1,000 and setting the property modification factor for shear area to 0.

Geometry, Properties and Loading



Beam Material Properties

E = 3,600 k/in^2

Soil Properties

k = Modulus of foundation

= Beam width * subgrade modulus

= 3 ft * 800 k/ft^3

= 2,400 k/ft^2

Beam Section Properties

b = 36 in

d = 36 in

I = 139,968 in^4

Technical Features of SAP2000 Tested

- Frame line spring assignments
- Static analysis of beam on elastic foundation
- Automatic frame subdivision

Results Comparison

Independent results are hand calculated using formulas presented in Problem 3 on page 23 of Timoshenko 1956.

Model	# Elms.	Output Parameter	SAP2000	Independent	Percent Difference
A	1	U_z (@ L/2) in	-0.08854	-0.08933	-0.88%
		M_y (@ L/2) k-in	16,524	17,698	-8.16%
B	4	U_z (@ L/2) in	-0.08933	-0.08933	0%
		M_y (@ L/2) k-in	17,634	17,698	-0.36%
C	100	U_z (@ L/2) in	-0.08933	-0.08933	0%
		M_y (@ L/2) k-in	17,698	17,698	0%

Computer Files: Example 1-013a, Example 1-013b, Example 1-013c

Conclusion

As long as the beam discretization is sufficient, the SAP2000 results match exactly with the independent results.

HAND CALCULATION

From Problem 3 on page 23 of Timoshenko 1956

$$Y_c = \frac{PB}{2K} \frac{\sinh BL - \sin BL}{\cosh BL + \cos BL}$$

$$M_c = \frac{P}{4B} \frac{\sinh BL + \sin BL}{\cosh BL + \cos BL}$$

where,

Y_c = center deflection

M_c = center Moment

P = Center concentrated load

L = Beam length

K = Modulus of foundation (Force/Length²)

E = Modulus of elasticity of beam

I_z = Moment of inertia of Beam

$$B = \sqrt[4]{\frac{K}{4EI}}$$

$P = 500^k$

$L = 15\,ft = 180\ in$

$$K = \left(\frac{2400\ K}{ft^2}\right)\left(\frac{1\ ft^2}{144\ in^2}\right) = 16.66666667\ \frac{K}{in^2}$$

$E = 3600\ K/in^2$

$$I = \frac{36 \times 36^3}{12} = 139968\ in^4$$

$$\beta = \sqrt[4]{\frac{16.66666667}{4 \times 3600 \times 139968}} = \frac{0.009535959}{in}$$

$\beta L = 0.009535959 \times 180 = 1.71647262$

$$Y_c = \frac{500 \times 0.009535959}{2 \times 16.66666667}\ \frac{\sinh(1.71647262) - \sin(1.71647262\,rad)}{\cosh(1.71647262) + \cos(1.71647262\,rad)}$$

$$= 0.14303939\left(\frac{2.6925828 - 0.9894080}{2.8722817 + (-0.1451616)}\right)$$

$Y_c = \underline{\underline{0.08933\ in \downarrow}}$

$$M_c = \frac{500}{4 \times 0.009535959}\ \frac{\sinh(1.71647262) + \sin(1.71647262\,rad)}{\cosh(1.71647262) + \cos(1.71647262\,rad)}$$

$$= 13108.278\left(\frac{2.6925828 + 0.9894080}{2.8722817 + (-0.1451616)}\right)$$

$M_c = \underline{\underline{17698\ k\text{-}in}}$

❖ جدول التحليل الانشائي :-

TABLE 7.3 Force Components for Different Cases of Loading

Loading Case

Section	Forces	Case-2	Case-3	Case-4	Case-5	Case-6(a)	Case-6(b)
$B-1$	M	63.2	1.66	6.82	−4.13	−9.6	−1.92
	N	0	0	−18.18	+11.0	+34.65	+6.93
$A-2$	M	−31.6	1.66	6.82	−4.13	−9.6	−1.92
	N	0	0	−18.18	+11.0	−34.65	−6.93
	V	115.5	0	0	0	0	0
$A-3$	M	−31.6	1.66	6.82	−4.13	−9.6	−1.92
	N	115.5	0	0	0	0	0
	V	0	0	18.18	−11.0	−34.65	−6.93
$E-4$	M	−31.6	−3.32	−15.45	−9.36	+19.2	+3.84
	N	115.5	+39.6	0	0	0	0
$D-5$	M	−31.6	−0.317	8.26	−5.00	−9.6	−1.92
	N	115.5	+79.2	−36.26	+21.9	0	0
	V	0	0	0	0	+34.65	+6.93
D-6	M	−31.6	−8.23	8.26	−5.00	−9.6	−1.92
	N	0	0	0	0	+34.65	+6.93
	V	−115.5	−79.2	−36.26	+21.9	0	0
$C-7$	M	63.2	11.56	8.26	−5.00	−9.60	−1.92
	N	0	0	−36.26	+21.9	+34.65	+6.93

Moments are in kN.m

Shear force and thrusts are in kN.

المراجع :

- دليل تصميم العبارات (وزارة الشؤون البلدية والقروية)
- مقرر الانشاءات المائية للفصل الدراسي التاسع 2014-2015 للدكتور/الصادق الهادي الحسن
- الانترنت Wikipedia
- krishna raju - advanced reinforced concrete design
- Joseph E. Bowles-Foundation Analysis and Design -McGraw-Hill Science_Engineering_Math (1995)
- ACI 318-11
- ACI design hampo
- Aashto LRDF british design specification
- KSA- MOMRA Bridge, Tunnel, Culvert and Pedasterian Design Specifications.
- C.jeremy hung,PE,James monsees ,PHD ,nasri munfah and John wisniewki , technical manual for design and construction of road tunnel-civil elements march 2009 .
- Mallik and rangasami , khanna publishers , reinforced concrete design , new delhi 1976 .
- University of warwick 1st,5st july 2013 BTS tunnel design and construction .