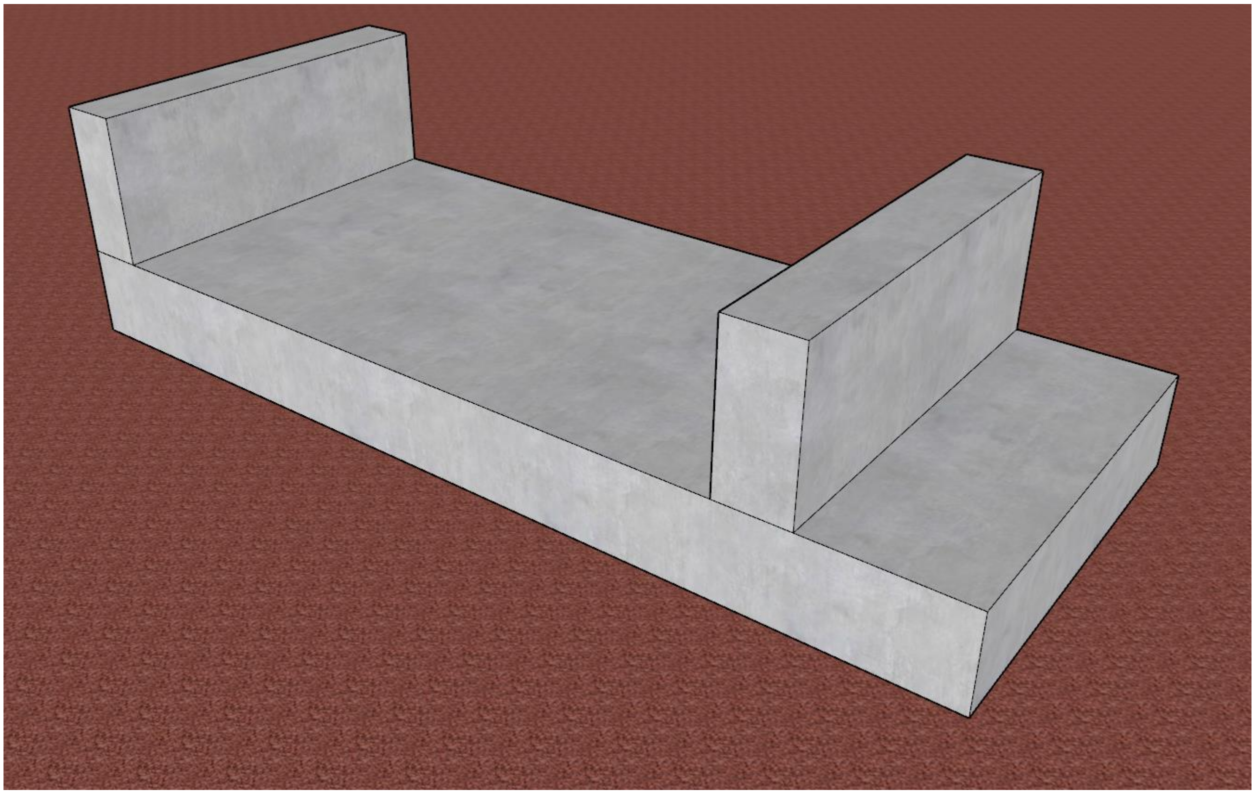
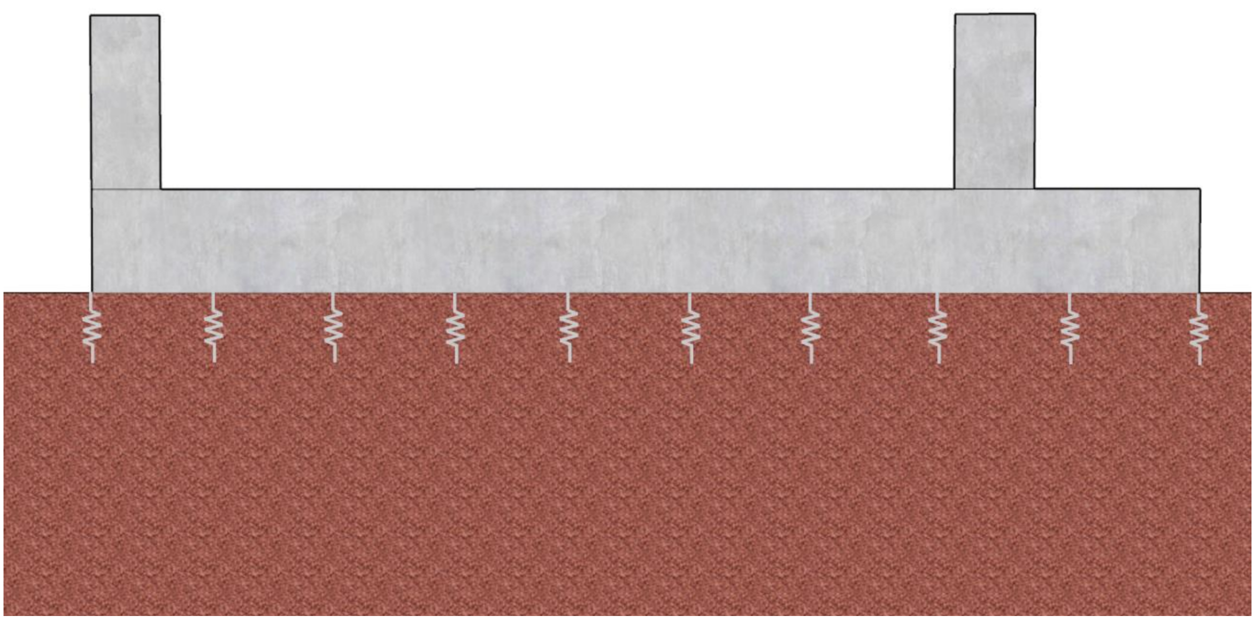
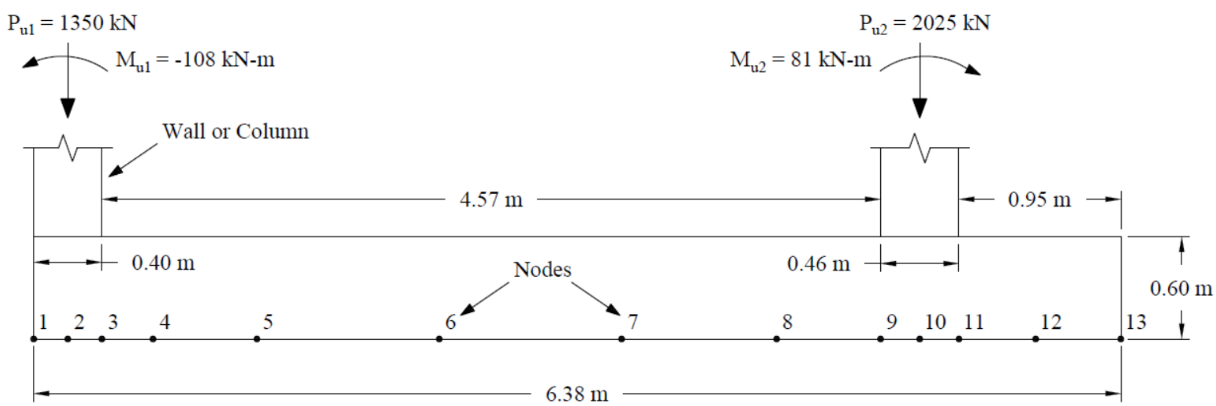
Beam on Elastic Foundation





Beam on Elastic Foundation

In some applications such as grade beams in prefabricated buildings and combined footings for industrial tanks and equipment, the member subjected to loads is supported on continuous elastic foundations such as soil or flowable fill. That is the reactions due to external loading is distributed along the length of the member. The figure below shows a general footing and load data, the loads are factored and may be obtained from building column reactions or an equipment vendor loading data. In this example, the loads are from a horizontal tank supports and are the full width of the footing. The finite element analysis results in the Reference are compared with results obtained from spBeam engineering software program from StructurePoint.



Span / Element	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13
Length, m	0.20	0.20	0.30	0.61	1.07	1.07	0.91	0.61	0.23	0.23	0.45	0.50

Figure 1 – Footing Cross-Section

Contents

Code

Building Code Requirements for Structural Concrete (ACI 318M-14) and Commentary (ACI 318RM-14)

Reference

Foundation Analysis and Design, 5th Edition, 1997, Joseph E. Bowles, McGraw-Hill Companies, Example 9-6

spBeam Engineering Software Program Manual v5.50, StructurePoint, 2018

Design Data

f_c' = 21 MPa

E_c = 21500 MPa

k_s = 22000 kN/m^3 (Soil Subgrade Modulus)

Footing length = 6.38 m

Footing width = 2.64 m

Loading:

P_{u1} = 1350 kN M_{u1} = -108 kN-m

P_{u2} = 2025 kN M_{u2} = 81 kN-m

Solution

1. Beam on Elastic Foundation Analysis - Finite Element Method

The reference mentions that the finite-element method (FEM) is one of the most efficient means for analyzing a beam-on-elastic foundation problem. It is easy to account for boundary conditions (such as a point where there is no rotation or translation), beam weight, and nonlinear soil effects. The reference used a FEM computer program to obtain text results output shown below.

```
 DATA SET FOR EXAMPLE 9-6 SI-UNITS

     ++++++++++++++++ THIS OUTPUT FOR DATA FILE:  EXAM96.DTA


SOLUTION FOR BEAM ON ELASTIC FOUNDATION--ITYPE = 0  +++++++


NO OF NP =  26   NO OF ELEMENTS, NM = 12   NO OF NON-ZERO P, NNZP =  4
  NO OF LOAD CASES, NLC =  1                     NO OF CYCLES NCYC =  1
NODE SOIL STARTS JTSOIL =  1
     NONLINEAR (IF > 0) =  1            NO OF BOUNDARY CONDIT NZX =  0
          MODULUS KCODE =  1                        LIST BAND IF > 0 =  0
                                                       IMET (SI > 0) =  1

MOD OF ELASTICITY E =    21500. MPA

MEMNO    NP1    NP2    NP3    NP4    LENGTH      WIDTH     INERTIA, M**4

    1      1      2      3      4      .200      2.640     .47520E-01
    2      3      4      5      6      .200      2.640     .47520E-01
    3      5      6      7      8      .300      2.640     .47520E-01
    4      7      8      9     10      .610      2.640     .47520E-01
    5      9     10     11     12     1.070      2.640     .47520E-01
    6     11     12     13     14     1.070      2.640     .47520E-01
    7     13     14     15     16      .910      2.640     .47520E-01
    8     15     16     17     18      .610      2.640     .47520E-01
    9     17     18     19     20      .230      2.640     .47520E-01
   10     19     20     21     22      .230      2.640     .47520E-01
   11     21     22     23     24      .450      2.640     .47520E-01
   12     23     24     25     26      .500      2.640     .47520E-01

THE INITIAL INPUT P-MATRIX ENTRIES
NP     LC      P(NP,LC)
 3      1      -108.000
 4      1      1350.000
19      1        81.000
20      1      2025.000

THE ORIGINAL P-MATRIX WHEN NONLIN > 0 ++++++
    1          .00          .00
    2      -108.00      1350.00
    3          .00          .00
    4          .00          .00
    5          .00          .00
    6          .00          .00
    7          .00          .00
    8          .00          .00
    9          .00          .00
   10        81.00      2025.00
   11          .00          .00
   12          .00          .00
   13          .00          .00

THE NODE SOIL MODULUS, SPRINGS AND MAX DEFL:
NODE      SOIL MODULUS    SPRING,KN/M    MAX DEFL, M
   1           22000.0       11616.0          .0500
   2           22000.0       11616.0          .0500
   3           22000.0       14520.0          .0500
   4           22000.0       26426.4          .0500
   5           22000.0       48787.2          .0500
```

6	22000.0	62145.6	.0500
7	22000.0	57499.2	.0500
8	22000.0	44140.8	.0500
9	22000.0	24393.6	.0500
10	22000.0	13358.4	.0500
11	22000.0	19747.2	.0500
12	22000.0	27588.0	.0500
13	22000.0	29040.0	.0500

BASE SUM OF NODE SPRINGS = 370550.4 KN/M NO ADJUSTMENTS
* = NODE SPRINGS HAND COMPUTED AND INPUT

MEMBER MOMENTS, NODE REACTIONS, DEFLECTIONS, SOIL PRESSURE, AND LAST USED P-MATRIX FOR LC = 1

MEMNO	MOMENTS--NEAR END	1ST, KN-M	NODE	SPG FORCE, KN	ROT, RADS	DEFL, M	SOIL Q, KPA	P-, KN-M	P-, KN
1	.014	-27.486	1	137.35	-.00253	.01182	260.12	.00	.00
2	-80.742	297.008	2	131.47	-.00253	.01132	248.99	-108.00	1350.00
3	-297.074	574.550	3	157.02	-.00250	.01081	237.91	.00	.00
4	-574.568	976.292	4	266.45	-.00237	.01008	221.82	.00	.00
5	-976.300	1223.258	5	427.76	-.00190	.00877	192.89	.00	.00
6	-1223.256	983.240	6	455.11	-.00075	.00732	161.11	.00	.00
7	-983.243	404.543	7	411.62	.00040	.00716	157.49	.00	.00
8	-404.557	-194.635	8	346.31	.00102	.00785	172.60	.00	.00
9	194.540	-468.397	9	207.48	.00108	.00851	187.13	.00	.00
10	549.286	-384.339	10	116.85	.00101	.00875	192.45	81.00	2025.00
11	384.351	-141.243	11	177.07	.00090	.00897	197.27	.00	.00
12	141.230	-.004	12	257.77	.00079	.00934	205.56	.00	.00
			13	282.44	.00075	.00973	213.97	.00	.00

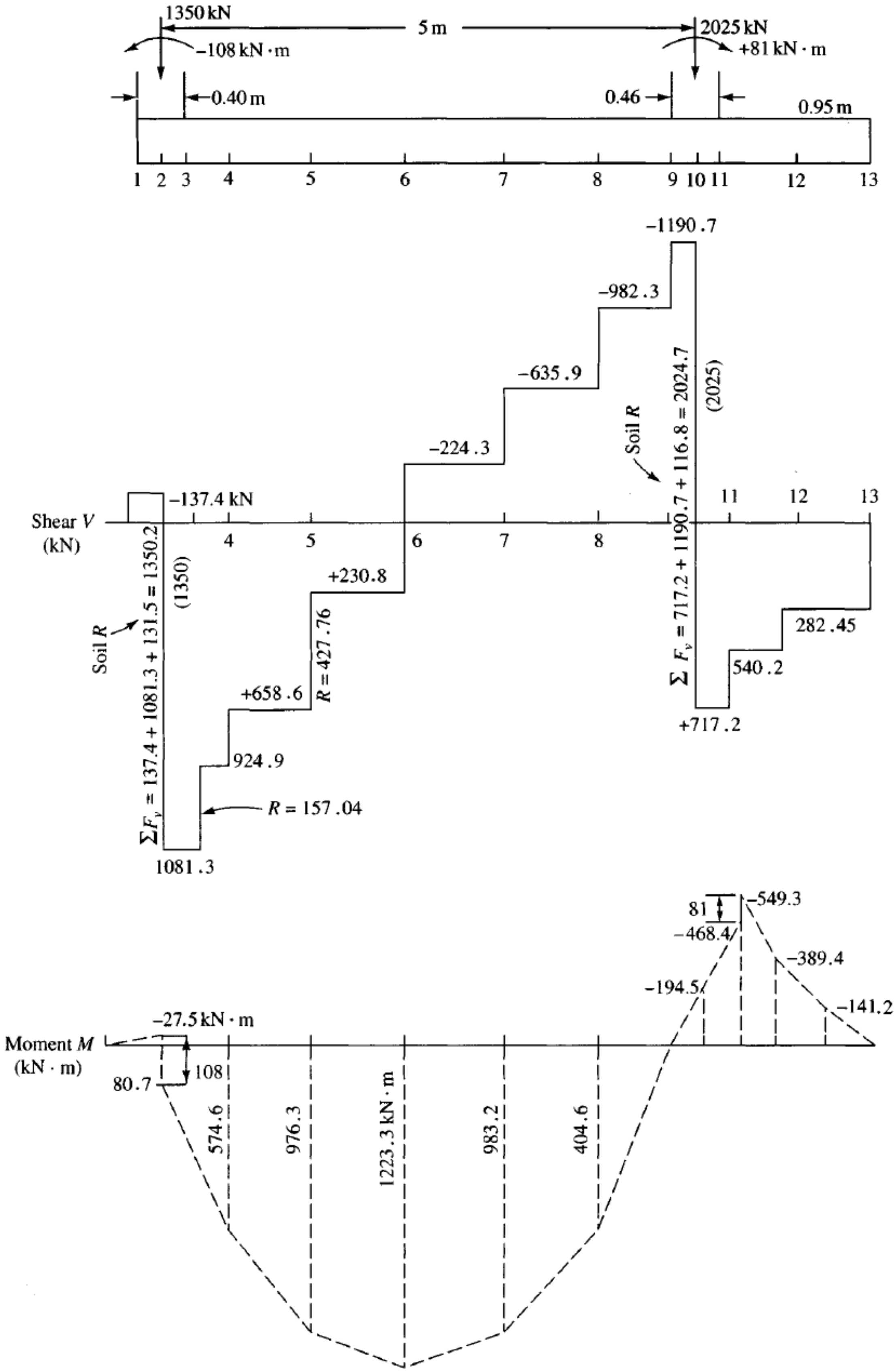
SUM SPRING FORCES = 3374.71 VS SUM APPLIED FORCES = 3375.00 KN

(*) = SOIL DISPLACEMENT > XMAX SO SPRING FORCE AND Q = XMAX*VALUE ++++++++++++
NOTE THAT P-MATRIX ABOVE INCLUDES ANY EFFECTS FROM X > XMAX ON LAST CYCLE ++++++++++

FOLLOWING IS DATA SAVED TO DATA FILE: BEAM1.PLT

REFER TO "READ" STATEMENT 2040 FOR FORMAT TO USE FOR PLOT PROGRAM ACCESS

					SHEAR V(I,1),V(I,2)		MOMENT MOM(I,1),MOM(I,2)	
NODE	LENGTH	KS	COMP X,MM	XMAX	LT OR T	RT OR B	LT OR T	RT OR B
1	.000	22000.0	11.824	50.000	.00	-137.36	.0	.0
2	.200	22000.0	11.318	50.000	-137.36	1081.33	-27.5	80.7
3	.400	22000.0	10.814	50.000	1081.33	924.92	297.0	297.1
4	.700	22000.0	10.083	50.000	924.92	658.56	574.6	574.6
5	1.310	22000.0	8.768	50.000	658.56	230.80	976.3	976.3
6	2.380	22000.0	7.323	50.000	230.80	-224.31	1223.3	1223.3
7	3.450	22000.0	7.159	50.000	-224.31	-635.93	983.2	983.2
8	4.360	22000.0	7.846	50.000	-635.93	-982.28	404.5	404.6
9	4.970	22000.0	8.506	50.000	-982.28	-1190.68	-194.6	-194.5
10	5.200	22000.0	8.748	50.000	-1190.68	717.16	-468.4	-549.3
11	5.430	22000.0	8.967	50.000	717.16	540.24	-384.3	-384.4
12	5.880	22000.0	9.344	50.000	540.24	282.45	-141.2	-141.2
13	6.380	22000.0	9.726	50.000	282.45	.00	.0	.0


1350 kN
5 m
2025 kN
−108 kN · m
+81 kN · m
0.40 m
0.46
0.95 m
1 2 3 4 5 6 7 8 9 10 11 12 13
Shear V
(kN)
−1190.7
−982.3
−635.9
−224.3
−137.4 kN
+230.8
+658.6
924.9
1081.3
R = 157.04
R = 427.76
+717.2
540.2
282.45
Soil R
ΣF_v = 137.4 + 1081.3 + 131.5 = 1350.2
(1350)
Σ F_v = 717.2 + 1190.7 + 116.8 = 2024.7
(2025)
Moment M
(kN · m)
−27.5 kN · m
80.7
108
574.6
976.3
1223.3 kN · m
983.2
404.6
−194.5
−468.4
81
−549.3
−389.4
−141.2

2. Beam on Elastic Foundation Analysis and Design - spBeam Software

spBeam is widely used for analysis, design and investigation of beams, one-way slab systems (including standard and wide module joist systems) and beams on elastic foundations per latest American (ACI 318) and Canadian (CSA A23.3) codes. spBeam can be used for new designs or investigation of existing structural members subjected to flexure, shear, and torsion loads. With capacity to integrate up to 20 spans and two cantilevers of wide variety of floor system types, spBeam is equipped to provide cost-effective, accurate, and fast solutions to engineering challenges.

spBeam provides top and bottom bar details including development lengths and material quantities, as well as live load patterning and immediate and long-term deflection results. Using the moment redistribution feature engineers can deliver safe designs with savings in materials and labor. Engaging this feature allows up to 20% reduction of negative moments over supports reducing reinforcement congestions in these areas.

Beam analysis and design requires engineering judgment in most situations to properly simulate the behavior of the targeted beam and take into account important design considerations such as: designing the beam as rectangular or T-shaped sections; using the effective flange width or the center-to-center distance between the beam and the adjacent beams. Regardless which of these options is selected, spBeam provide users with options and flexibility to:

1. Design the beam as a rectangular cross-section or a T-shaped section.
2. Use the effective or full beam flange width.
3. Include the flanges effects in the deflection calculations.
4. Invoke moment redistribution to lower negative moments
5. Using gross (uncracked) or effective (cracked) moment of inertia
6. Design the beam as singly or doubly reinforced section.
7. Analyze and Design beams on elastic foundations.

For illustration and comparison purposes, the following figures provide a sample of the results obtained from an spBeam analysis model created for the beam on elastic foundation covered in this case study. Note that the vertical support spring constant, K_z, input in spBeam is calculated as the soil subgrade modulus, k_s, given in the reference multiplied by the tributary area of the node. For end nodes (node 1 and 13), the vertical support spring constants are doubled to comply with the recommendation in the reference for a beam on elastic foundation problem.

Highlights of the resulting output are shown below. Detailed output is provided in the Appendix.

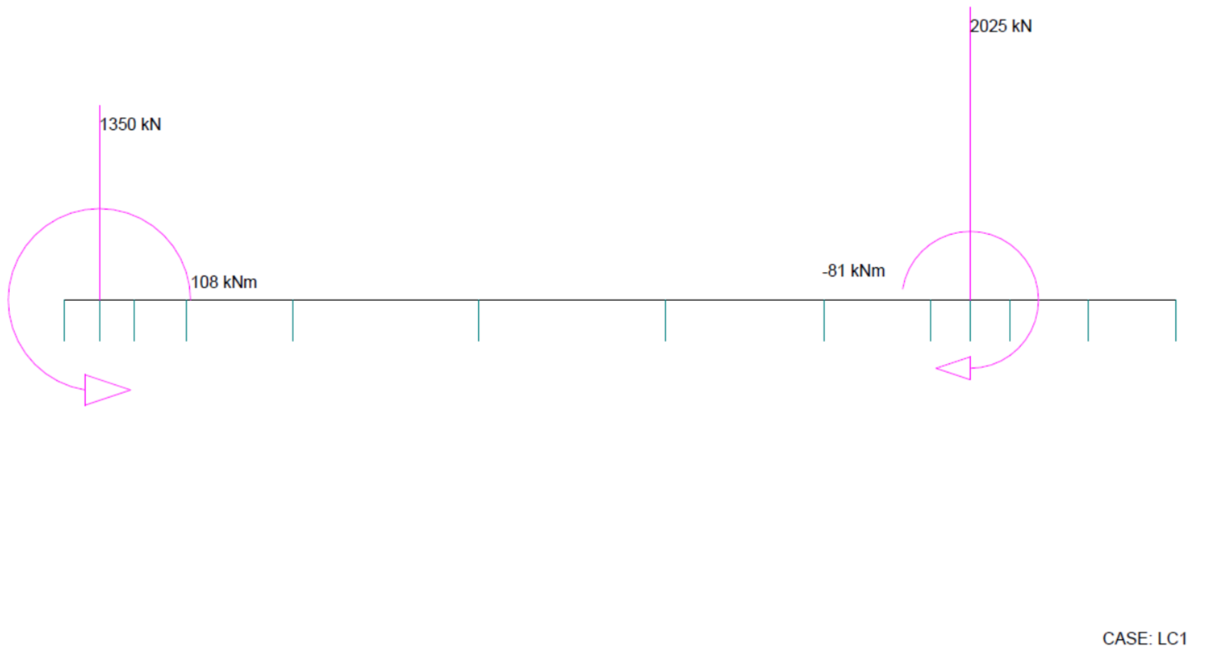


Figure 2 – Applied Loads (spBeam)

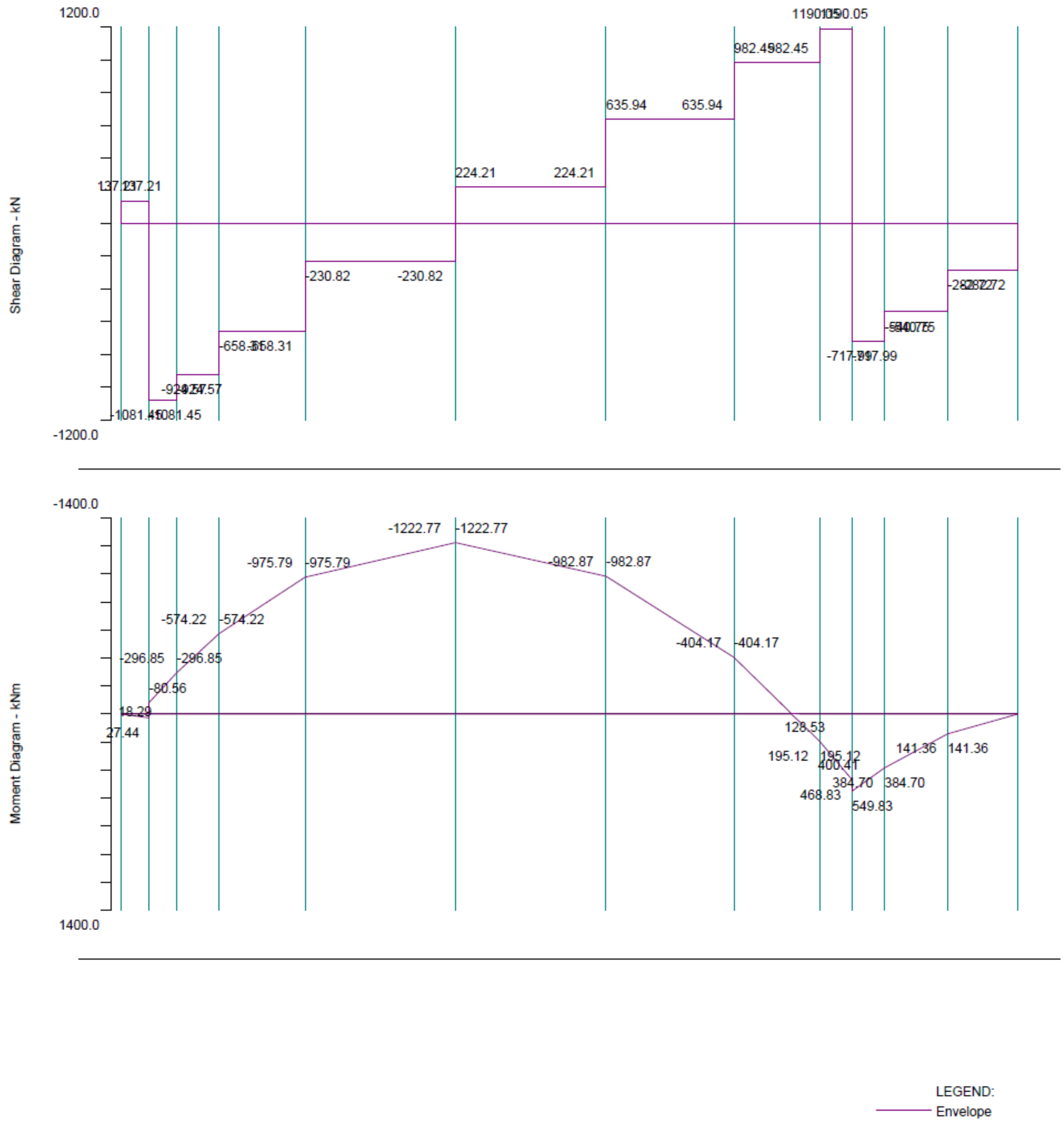


Figure 3 – Internal Forces Diagrams (spBeam)

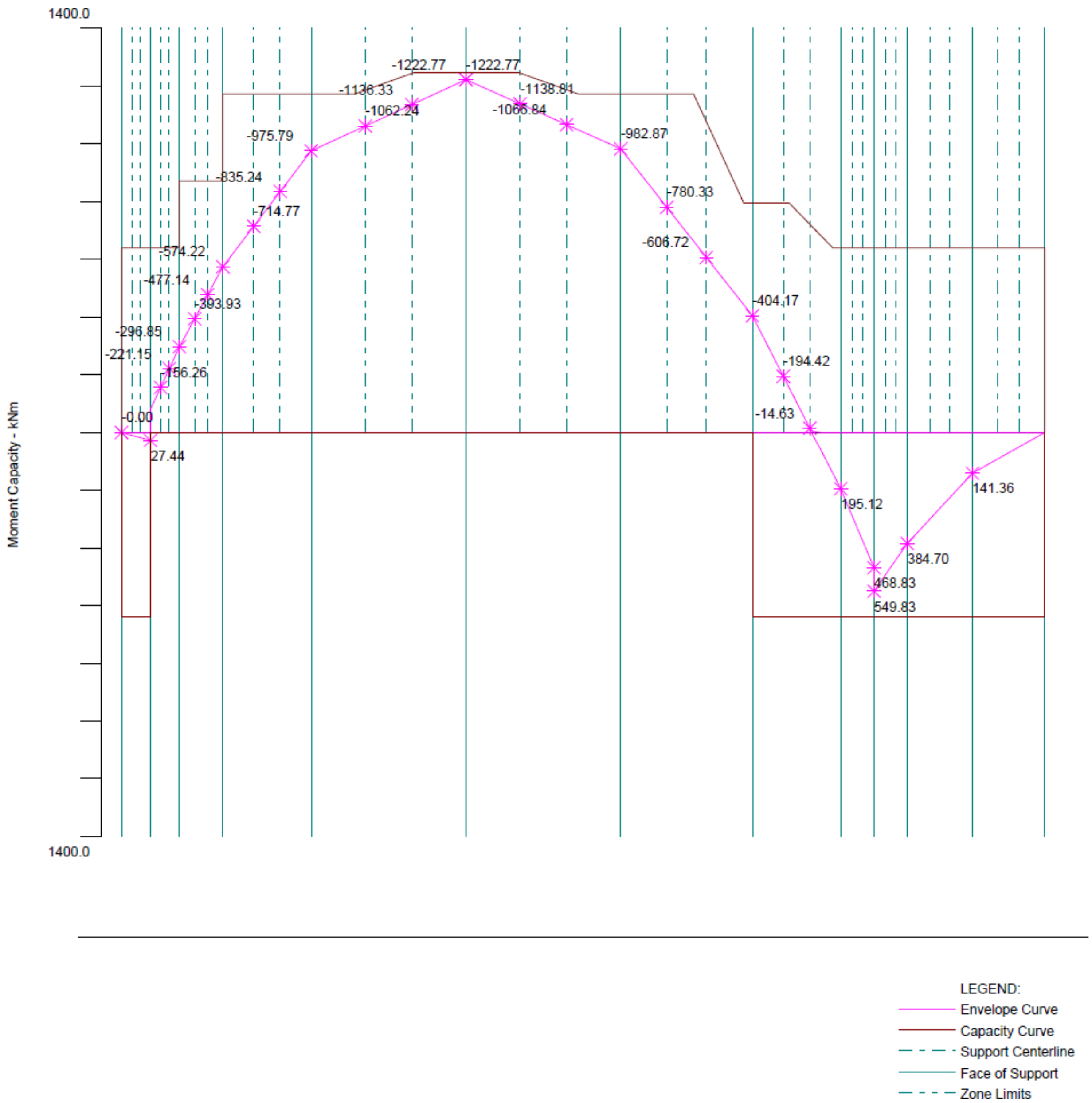


Figure 4 – Moment Capacity Diagram (spBeam)

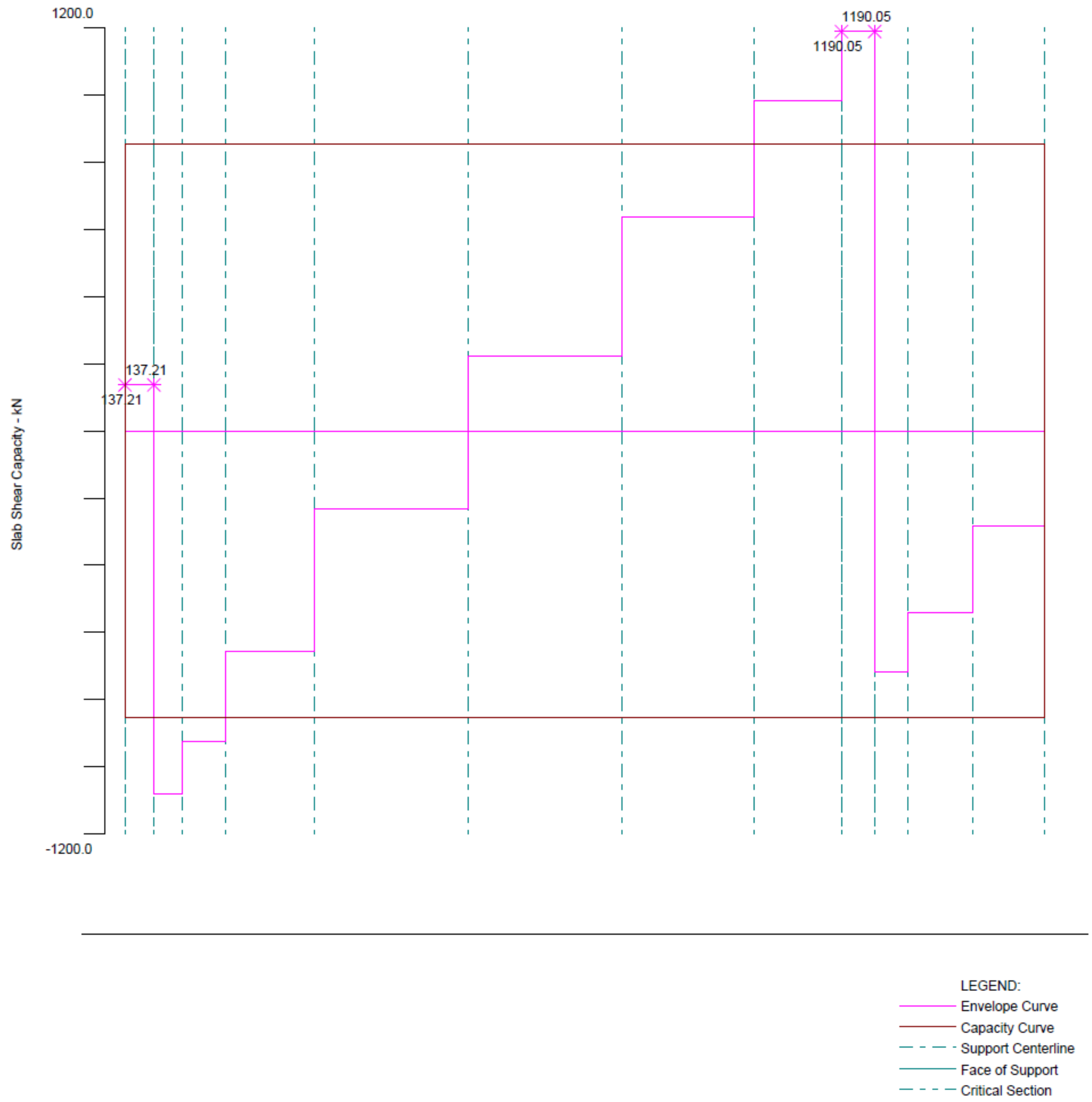


Figure 5 – Shear Capacity Diagram (spBeam)

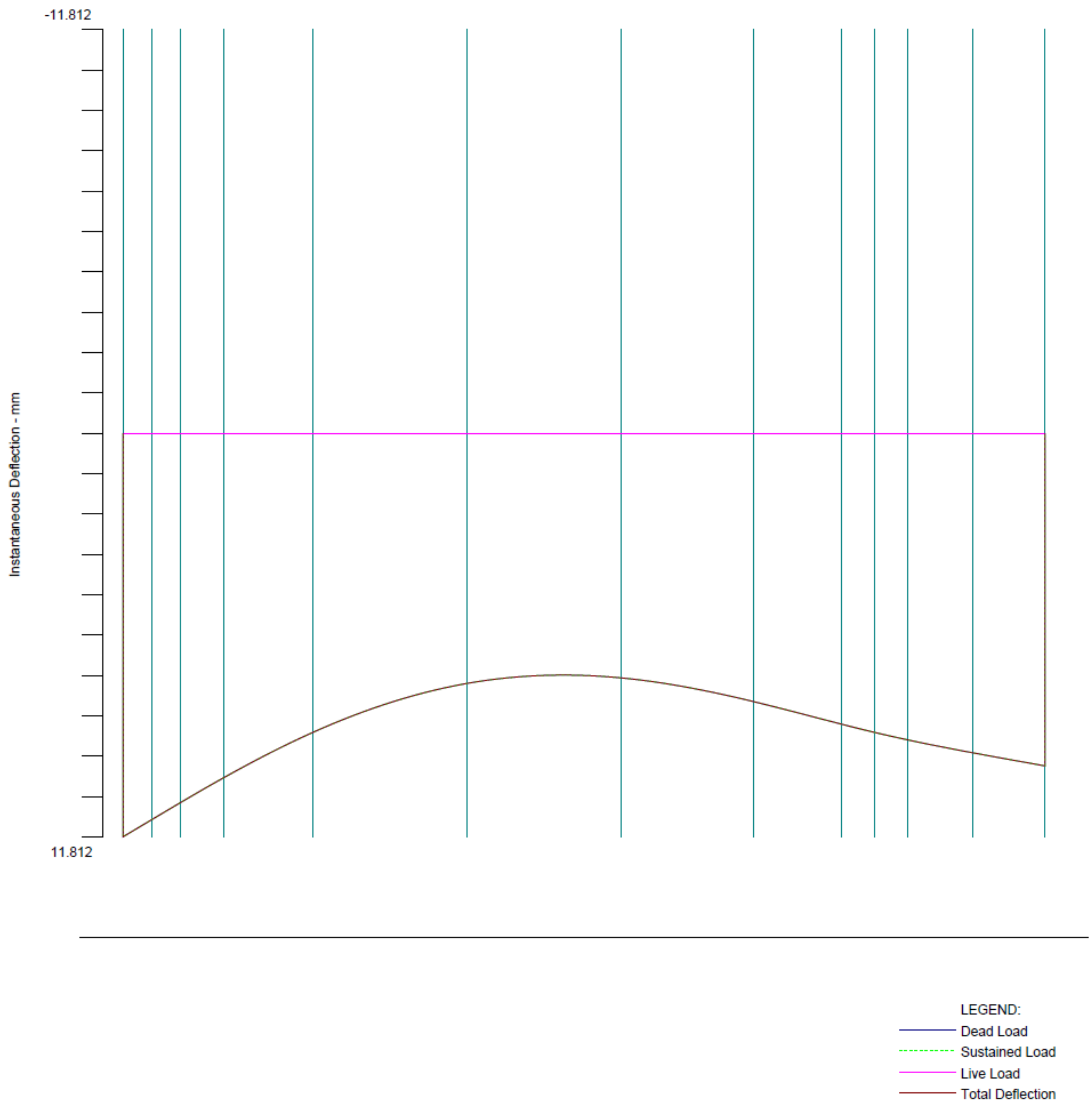


Figure 6 – Deflection Diagram (spBeam)

3. Comparison of Design Results

Table 1 - Comparison of Results (Shear and Bending Moment)							
Span	Node	Shear, kN			Bending Moment, kN-m		
		Reference*	spBeam	Difference, %	Reference*	spBeam	Difference, %
1-2	1	-137.36	137.21	-0.11	0.00	0.00	0.00
	2	-137.36	137.21	-0.11	-27.50	27.44	-0.22
2-3	2	1081.33	-1081.45	0.01	80.70	-80.56	-0.17
	3	1081.33	-1081.45	0.01	297.00	-296.85	-0.05
3-4	3	924.92	-924.57	-0.04	297.10	-296.85	-0.08
	4	924.92	-924.57	-0.04	574.60	-574.22	-0.07
4-5	4	658.56	-658.31	-0.04	574.60	-574.22	-0.07
	5	658.56	-658.31	-0.04	976.30	-975.79	-0.05
5-6	5	230.80	-230.82	0.01	976.30	-975.79	-0.05
	6	230.80	-230.82	0.01	1223.30	-1222.77	-0.04
6-7	6	-224.31	224.21	-0.04	1223.30	-1222.77	-0.04
	7	-224.31	224.21	-0.04	983.20	-982.87	-0.03
7-8	7	-635.93	635.94	0.00	983.20	-982.87	-0.03
	8	-635.93	635.94	0.00	404.60	-404.17	-0.11
8-9	8	-982.28	982.45	0.02	404.60	-404.17	-0.11
	9	-982.28	982.45	0.02	-194.60	195.12	0.27
9-10	9	-1190.68	1190.05	-0.05	-194.50	195.12	0.32
	10	-1190.68	1190.05	-0.05	-468.40	468.83	0.09
10-11	10	717.16	-717.99	0.12	-549.30	549.83	0.10
	11	717.16	-717.99	0.12	-384.30	384.70	0.10
11-12	11	540.24	-540.75	0.09	-384.40	384.70	0.08
	12	540.24	-540.75	0.09	-141.20	141.36	0.11
12-13	12	282.45	-282.72	0.10	-141.20	141.36	0.11
	13	282.45	-282.72	0.10	0.00	0.00	0.00

* Shear and Moment Diagrams sign convention is based on the downward force being positive in the reference

Table 2 - Comparison of Results (Deflections and Support Reactions)							
Span	Node	Deflections, mm			Support Reactions, kN		
		Reference	spBeam	Difference, %	Reference	spBeam	Difference, %
1-2	1	11.82	11.81	-0.08	137.35	137.21	-0.10
	2	11.32	11.31	-0.09	131.47	131.34	-0.10
2-3	2						
	3	10.81	10.80	-0.09	157.02	156.88	-0.09
3-4	3						
	4	10.08	10.07	-0.10	266.45	266.26	-0.07
4-5	4						
	5	8.77	8.76	-0.11	427.76	427.49	-0.06
5-6	5						
	6	7.32	7.32	0.00	455.11	455.03	-0.02
6-7	6						
	7	7.16	7.16	0.00	411.62	411.73	0.03
7-8	7						
	8	7.85	7.85	0.00	346.31	346.51	0.06
8-9	8						
	9	8.51	8.51	0.00	207.48	207.61	0.06
9-10	9						
	10	8.75	8.75	0.00	116.85	116.96	0.09
10-11	10						
	11	8.97	8.97	0.00	177.07	177.24	0.10
11-12	11						
	12	9.34	9.35	0.11	257.77	258.02	0.10
12-13	12						
	13	9.73	9.74	0.10	282.44	282.72	0.10
				∑	3374.7	3375	0.01

The results of the reference used illustrated above are in precise agreement with the automated results obtained from the spBeam program.

4. Observations

4.1 Beam on Elastic Foundation – Flexural Reinforcement Design and Detailing

For this example, multiple spans are assigned in the spBeam model to capture the location of all the nodes the reference used in their finite element model. Using this approach leads to the minimum reinforcement required for each of the theoretical model spans. Investigation mode in spBeam allows the user to adjust the minimum required reinforcement (as designed) to meet detailing requirement (as detailed) as shown below:

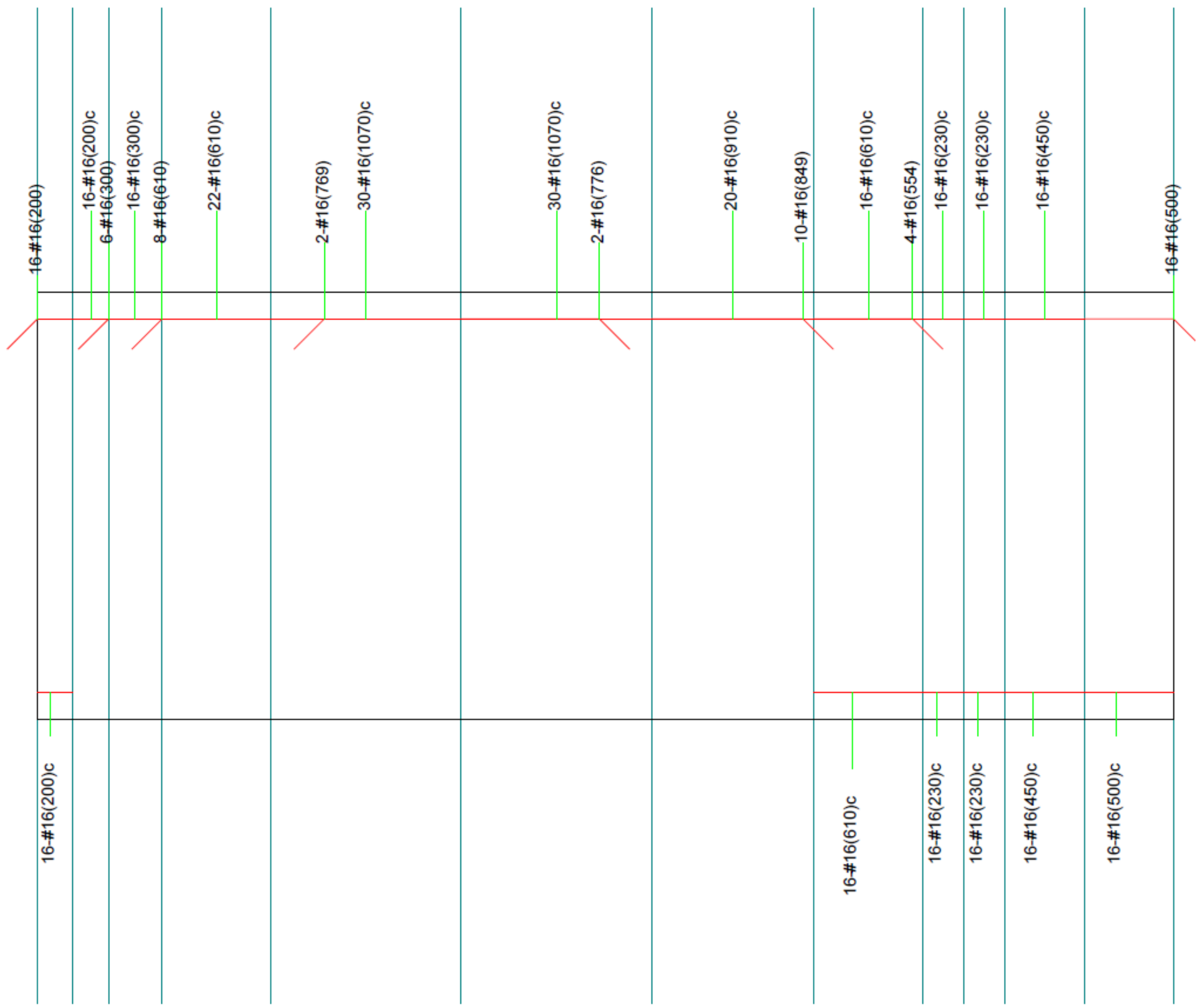


Figure 7 – As Designed Flexural Reinforcement – Design Mode (spBeam)

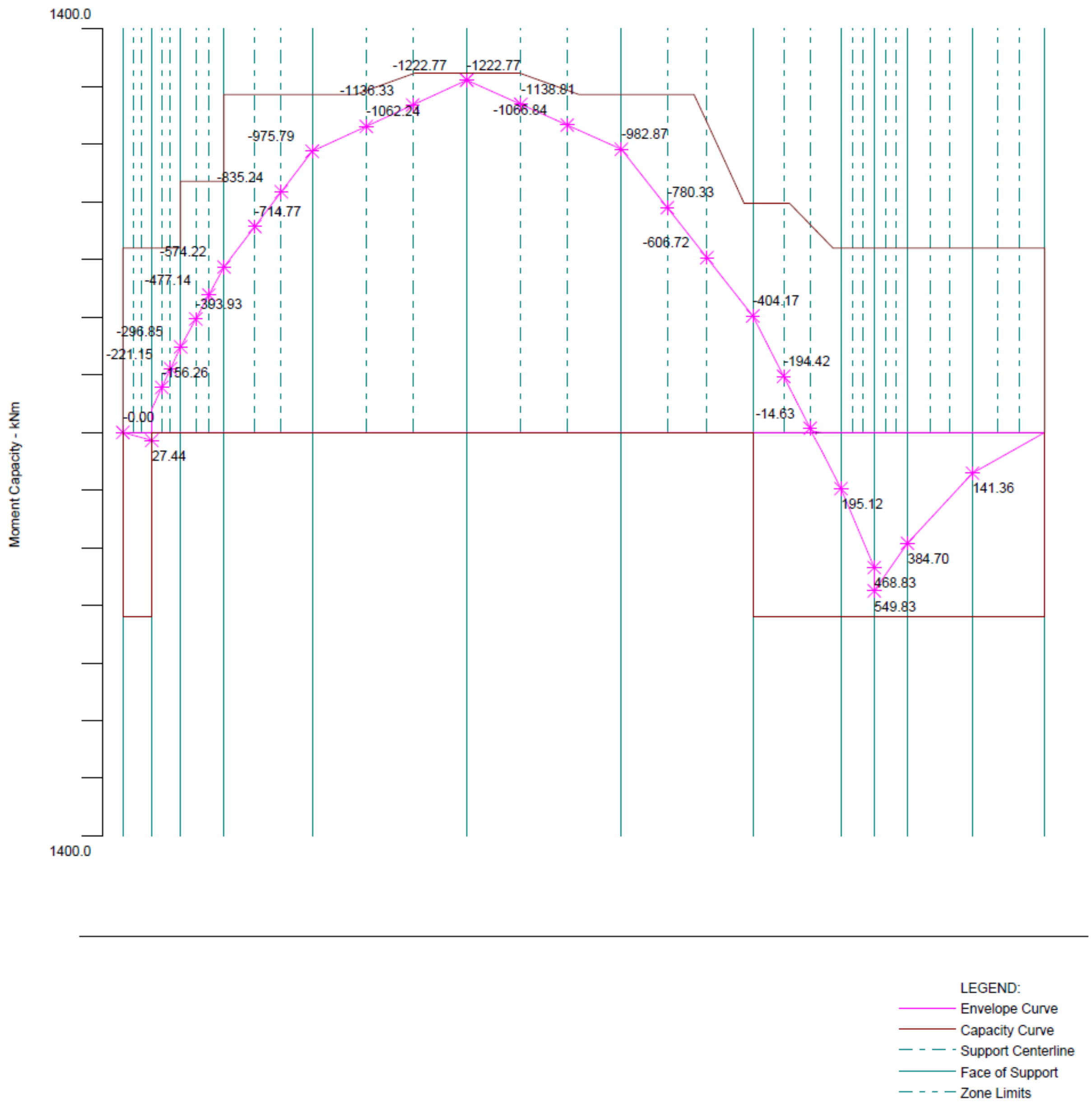


Figure 8 – Moment Capacity for As Designed Flexural Reinforcement – Design Mode (spBeam)

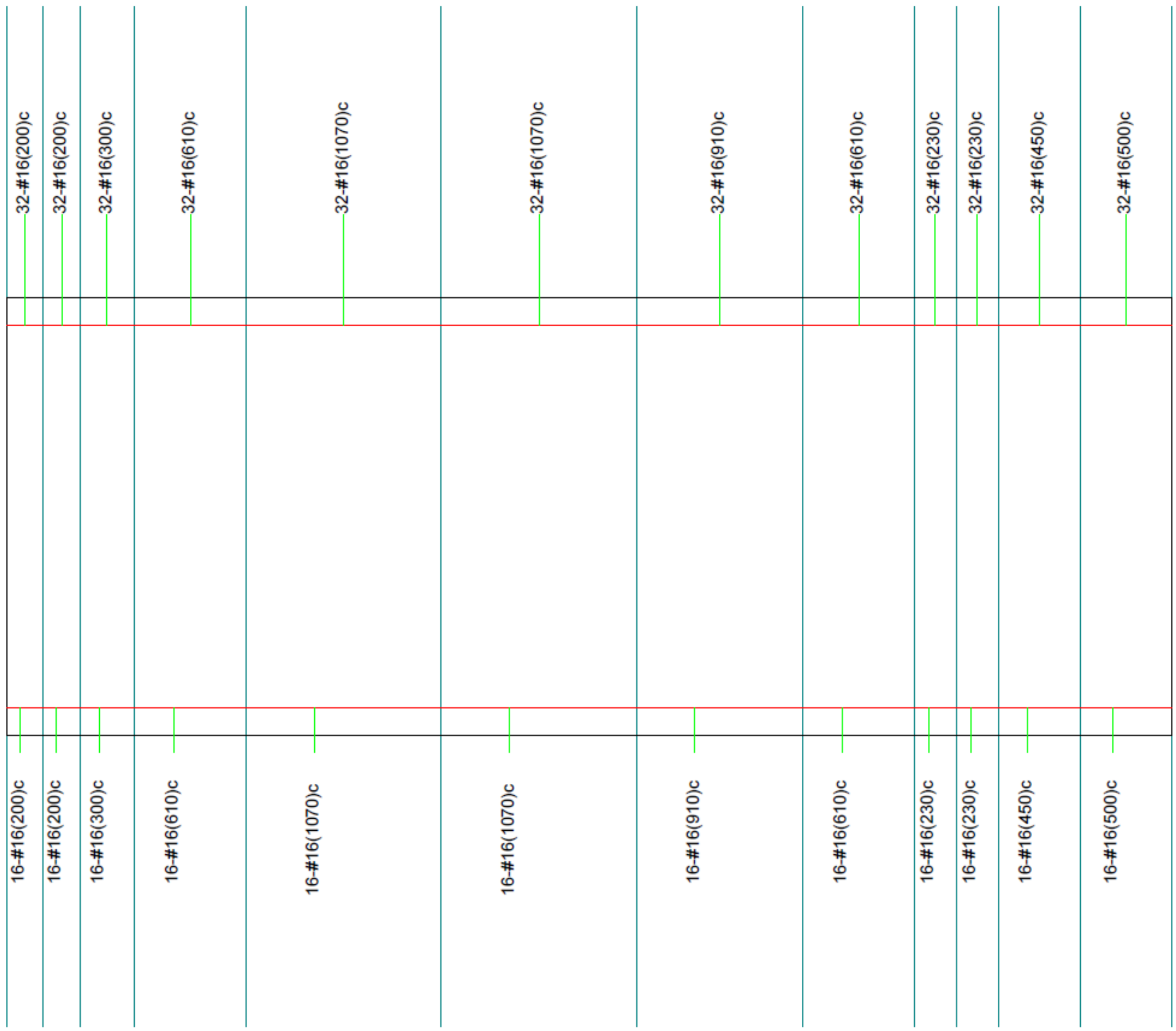


Figure 9 – As Detailed Flexural Reinforcement – Investigation Mode (spBeam)

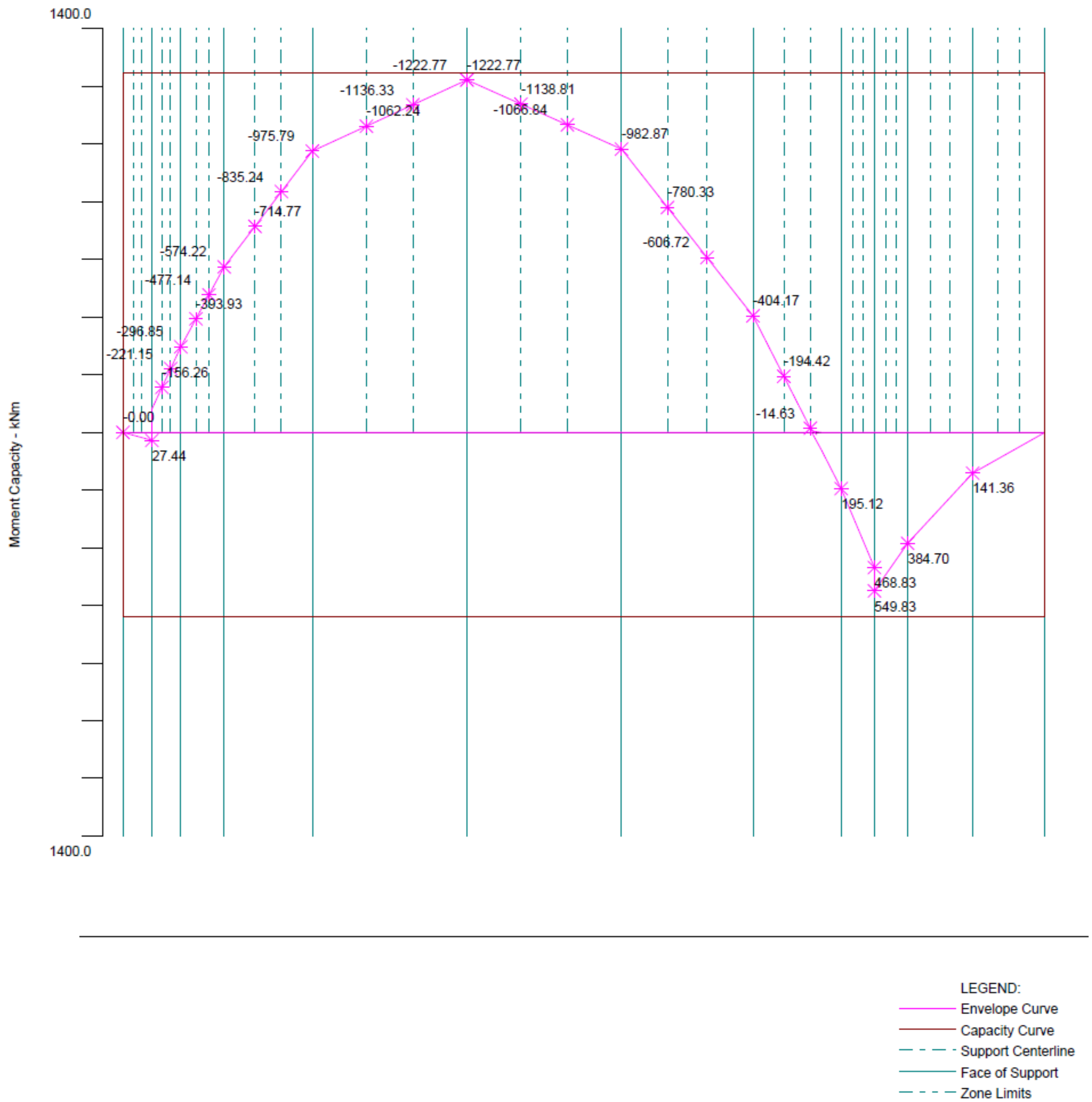


Figure 10 – Moment Capacity for As Detailed Flexural Reinforcement – Investigation Mode (spBeam)

4.2 Beam on Elastic Foundation – Beam Shear Strength

spBeam shows that this beam on elastic foundation has insufficient one-way shear strength near the piers as indicated by the capacity curve (brown line). The following options among others can be used to increase the one-way (beam) shear capacity:

1. Adding transverse reinforcement (shear stirrups).
2. Increase the beam thickness and/or width.
3. Increase the concrete compressive strength.
4. Refine the loading and load application.

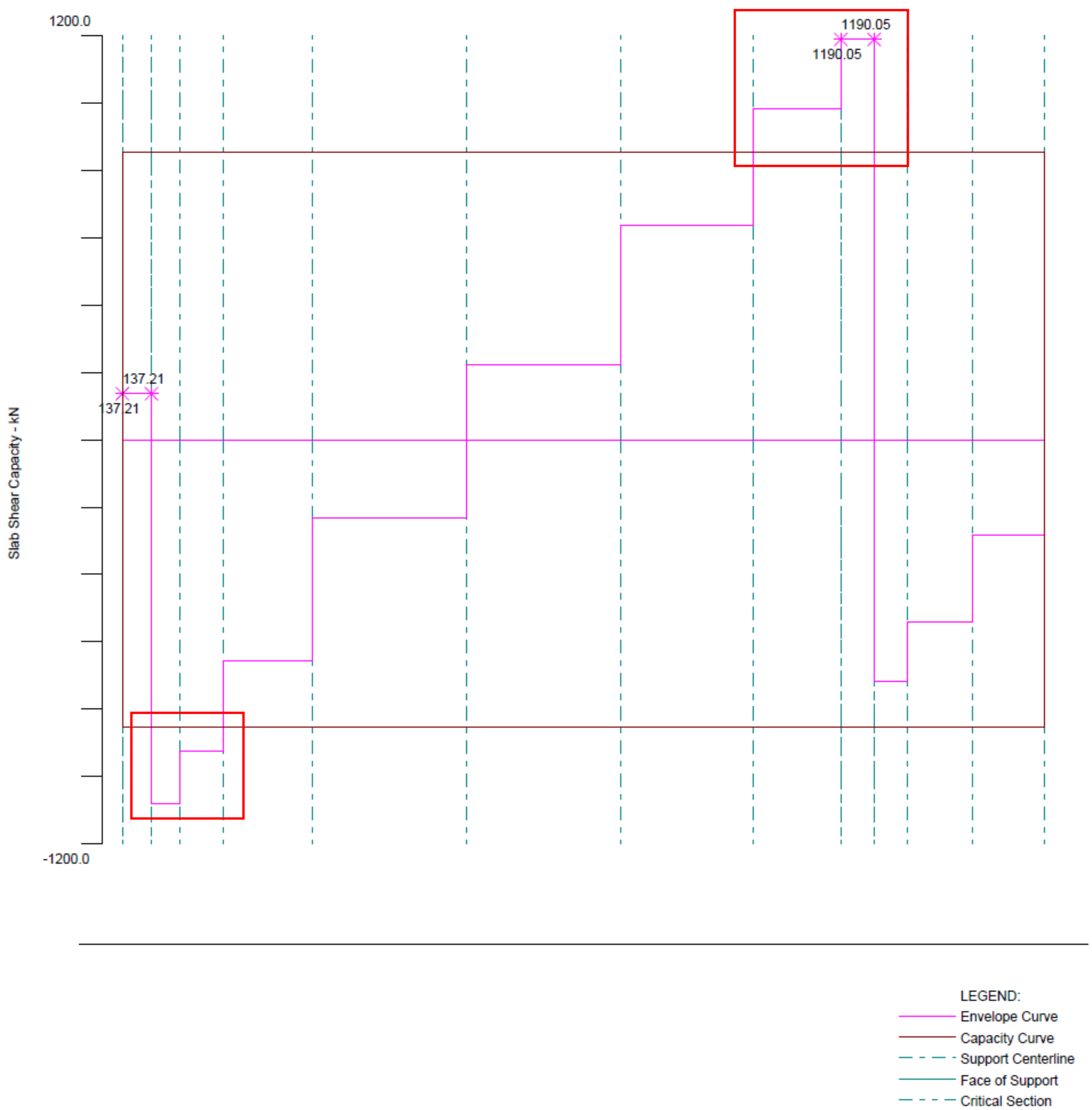


Figure 11 – Beam on Elastic Foundation Shear Strength (spBeam)

5. Conclusions

Simple, quick, yet accurate analysis results of spBeam Program for internal forces (Shear & Bending Moment), deflections, and support reactions are in agreement with the Finite Element Method analysis by Bowles. Similarly, as shown below, spMats engineering software program from StructurePoint can be utilized to model the beam on elastic foundation and use the Finite Element Method. A sample of spMats FEM analysis results is given below for the displacement contours showing close agreement with spBeam results and reference values.

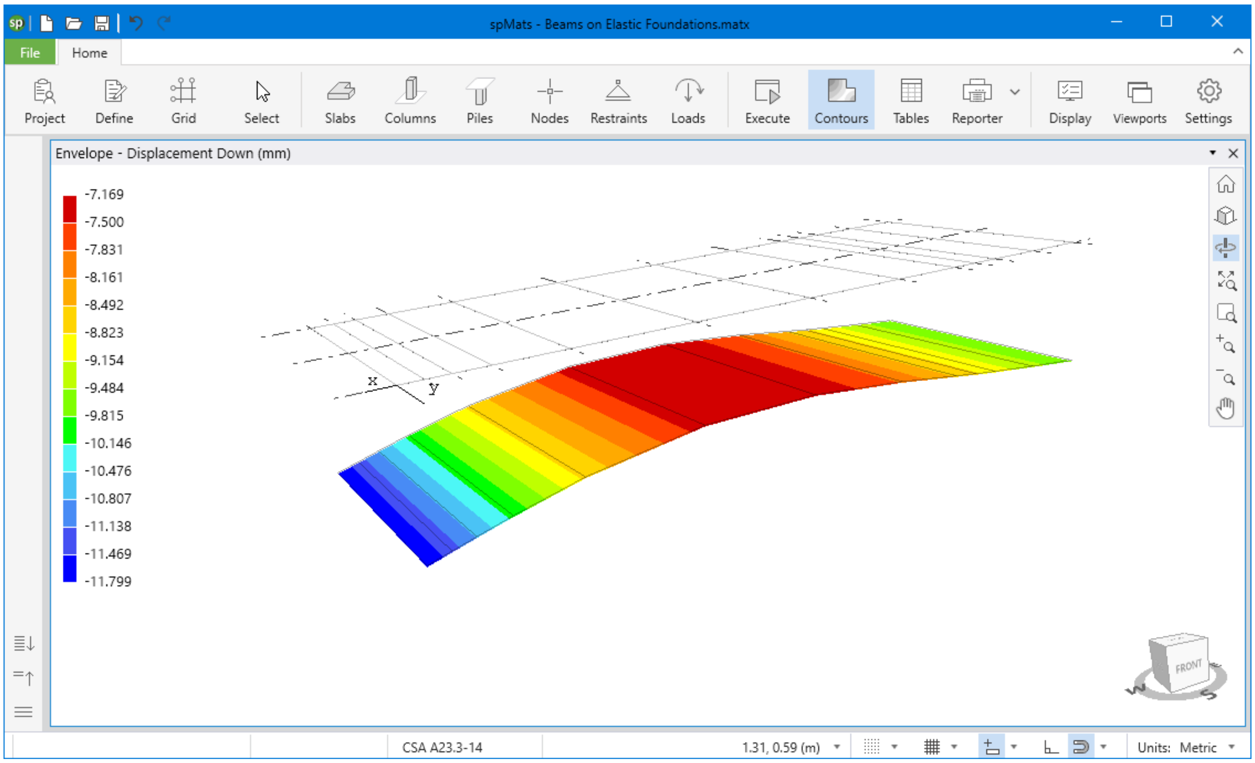
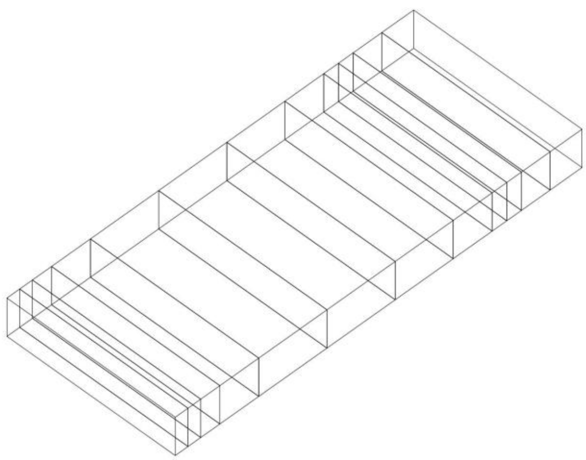


Figure 12 – Displacement View for the Combined Footing (spMats)

6. Appendix – spBeam Detailed Results Output

spBeam v5.50
A Computer Program for Analysis, Design, and Investigation of
Reinforced Concrete Beams and One-way Slab Systems



STRUCTUREPOINT - spBeam v5.50
Licensed to: StructurePoint. License ID: 72371-1071678-4-1DCAA-1DCAA
C:\StructurePoint Design Examples\Beams_on_Elastic_Foundations.slb

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7/21/2020
3:12 PM

Contents

1. Input Echo

1.1. General Information

File Name	C:\StructureP...\Beams_on_Elastic_Foundations.slb
Project	Beams_on_Elastic_Foundations
Frame	
Engineer	SP
Code	ACI 318M-14
Reinforcement Database	ASTM A615M
Mode	Design
Number of supports =	13
Floor System	One-Way/Beam

1.2. Solve Options

Live load pattern ratio = 100%
Deflections are based on gross section properties.
Long-term deflections are calculated for load duration of 60 months.
0% of live load is sustained.
Compression reinforcement calculations NOT selected.
Default incremental rebar design selected.
Moment redistribution NOT selected.
Effective flange width calculations selected.
Rigid beam-column joint NOT selected.
Torsion analysis and design NOT selected.

1.3. Material Properties

1.3.1. Concrete: Slabs / Beams

w_c	2400	kg/m³
f'_c	21	MPa
E_c	21500	MPa
f_r	3.2078	MPa

1.3.2. Concrete: Columns

w_c	2400	kg/m³
f'_c	21	MPa
E_c	21500	MPa
f_r	3.2078	MPa

1.3.3. Reinforcing Steel

f_y	413.69	MPa
f_{yt}	413.69	MPa
E_s	199950	MPa
Epoxy coated bars	No	

1.4. Reinforcement Database

Size	Db	Ab	Wb	Size	Db	Ab	Wb
	mm	mm²	kg/m		mm	mm²	kg/m
#10	10	71	1	#13	13	129	1
#16	16	199	2	#19	19	284	2
#22	22	387	3	#25	25	510	4
#29	29	645	5	#32	32	819	6
#36	36	1006	8	#43	43	1452	11
#57	57	2581	20				

1.5. Span Data

1.5.1. Slabs

Span	Loc	L1	t	wL	wR	bE_{ff}	H_{min}
		m	mm	m	m	mm	mm
1	Int	0.200	600	1.320	1.320	2640	8
2	Int	0.200	600	1.320	1.320	2640	7
3	Int	0.300	600	1.320	1.320	2640	11
4	Int	0.610	600	1.320	1.320	2640	22
5	Int	1.070	600	1.320	1.320	2640	38
6	Int	1.070	600	1.320	1.320	2640	38
7	Int	0.910	600	1.320	1.320	2640	32
8	Int	0.610	600	1.320	1.320	2640	22
9	Int	0.230	600	1.320	1.320	2640	8
10	Int	0.230	600	1.320	1.320	2640	8
11	Int	0.450	600	1.320	1.320	2640	16
12	Int	0.500	600	1.320	1.320	2640	21

1.6. Support Data

1.6.1. Columns

Support	c1a	c2a	Ha	c1b	c2b	Hb	Red %
	mm	mm	m	mm	mm	m	
1	0	0	0.000	0	0	0.000	100
2	0	0	0.000	0	0	0.000	100
3	0	0	0.000	0	0	0.000	100
4	0	0	0.000	0	0	0.000	100
5	0	0	0.000	0	0	0.000	100
6	0	0	0.000	0	0	0.000	100
7	0	0	0.000	0	0	0.000	100
8	0	0	0.000	0	0	0.000	100
9	0	0	0.000	0	0	0.000	100
10	0	0	0.000	0	0	0.000	100
11	0	0	0.000	0	0	0.000	100
12	0	0	0.000	0	0	0.000	100
13	0	0	0.000	0	0	0.000	100

1.6.2. Boundary Conditions

Support	Spring		Far End	
	K_z	K_{ry}	Above	Belo
	kN/mm	kN-mm/rad		
1	11.616	0	Fixed	Fixe
2	11.616	0	Fixed	Fixe
3	14.52	0	Fixed	Fixe
4	26.43	0	Fixed	Fixe
5	48.79	0	Fixed	Fixe

$$K_z = \begin{Bmatrix} k_s \times A_T & \text{for Interior Nodes} \\ 2 \times k_s \times A_T & \text{for End Nodes} \end{Bmatrix}$$

Where:

k_s the is soil subgrade modulus (kN/mm³)

A_T is the node tributary area (mm²)

K_z is the vertical support spring constant (kN/mm)

Support	Spring K_z kN/mm	Spring K_{ry} kN-mm/rad	Far End Above	Far End Below
6	62.15	0	Fixed	Fixed
7	57.5	0	Fixed	Fixed
8	44.14	0	Fixed	Fixed
9	24.39	0	Fixed	Fixed
10	13.36	0	Fixed	Fixed
11	19.75	0	Fixed	Fixed
12	27.59	0	Fixed	Fixed
13	29.04	0	Fixed	Fixed

$$K_z = \begin{cases} k_s \times A_T & \text{for Interior Nodes} \\ 2 \times k_s \times A_T & \text{for End Nodes} \end{cases}$$

Where:

k_s is the soil subgrade modulus (kN/mm^3)

A_T is the node tributary area (mm^2)

K_z is the vertical support spring constant (kN/mm)

1.7. Load Data

1.7.1. Load Cases and Combinations

Case	LC1
Type	DEAD
U1	1.000

1.7.2. Point Forces

Case/Patt	Span	Wa kN	La m
LC1	1	1350.00	0.200
	9	2025.00	0.230

1.7.3. Point Moments

Case/Patt	Span	Wa kNm	La m
LC1	1	108.00	0.200
	9	-81.00	0.230

1.8. Reinforcement Criteria

1.8.1. Slabs and Ribs

	Units	Top Bars Min.	Top Bars Max.	Bottom Bars Min.	Bottom Bars Max.
Bar Size		#16	#25	#16	#25
Bar spacing	mm	25	457	25	457
Reinf ratio	%	0.14	5.00	0.14	5.00
Clear Cover	mm	38		38	

There is NOT more than 300 mm of concrete below top bars.

1.8.2. Beams

	Units	Top Bars Min.	Top Bars Max.	Bottom Bars Min.	Bottom Bars Max.	Stirrups Min.	Stirrups Max.
Bar Size		#16	#25	#16	#25	#10	#16
Bar spacing	mm	25	457	25	457	152	457
Reinf ratio	%	0.14	5.00	0.14	5.00		
Clear Cover	mm	38		38			
Layer dist.	mm	25		25			
No. of legs						2	6
Side cover	mm					38	
1st Stirrup	mm					76	

There is NOT more than 300 mm of concrete below top bars.

2. Design Results

2.1. Top Reinforcement

Notes:
*3 - Design governed by minimum reinforcement.

Span	Zone	Width	M_{max}	X_{max}	$A_{s,min}$	$A_{s,max}$	$A_{s,req}$	Sp_{Prov}	Bars
		m	kNm	m	mm²	mm²	mm²	mm	
1	Left	2.64	0.00	0.000	0	20114	0	0	---
	Midspan	2.64	0.00	0.100	0	20114	0	0	---
	Right	2.64	0.00	0.200	3168	20114	0	165	16-#16 *3
2	Left	2.64	156.26	0.070	3168	20114	762	165	16-#16 *3
	Midspan	2.64	221.15	0.130	3168	20114	1082	165	16-#16 *3
	Right	2.64	296.85	0.200	3168	20114	1456	165	16-#16 *3
3	Left	2.64	393.93	0.105	3168	20114	1940	165	16-#16 *3
	Midspan	2.64	477.14	0.195	3168	20114	2357	165	16-#16 *3
	Right	2.64	574.22	0.300	3168	20114	2848	120	22-#16 *3
4	Left	2.64	714.77	0.214	3168	20114	3566	120	22-#16
	Midspan	2.64	835.24	0.397	3168	20114	4189	120	22-#16
	Right	2.64	975.79	0.610	3168	20114	4923	88	30-#16
5	Left	2.64	1062.24	0.375	3168	20114	5380	88	30-#16
	Midspan	2.64	1136.33	0.696	3168	20114	5774	88	30-#16
	Right	2.64	1222.77	1.070	3168	20114	6237	83	32-#16
6	Left	2.64	1222.77	0.000	3168	20114	6237	83	32-#16
	Midspan	2.64	1138.81	0.375	3168	20114	5787	88	30-#16
	Right	2.64	1066.84	0.696	3168	20114	5404	88	30-#16
7	Left	2.64	982.87	0.000	3168	20114	4960	88	30-#16
	Midspan	2.64	780.33	0.319	3168	20114	3904	132	20-#16
	Right	2.64	606.72	0.592	3168	20114	3014	132	20-#16 *3
8	Left	2.64	404.17	0.000	3168	20114	1991	132	20-#16 *3
	Midspan	2.64	194.42	0.214	3168	20114	950	165	16-#16 *3
	Right	2.64	14.63	0.397	3168	20114	71	165	16-#16 *3
9	Left	2.64	0.00	0.000	3168	20114	0	165	16-#16 *3
	Midspan	2.64	0.00	0.115	0	20114	0	0	16-#16
	Right	2.64	0.00	0.230	3168	20114	0	165	16-#16 *3
10	Left	2.64	0.00	0.000	3168	20114	0	165	16-#16 *3
	Midspan	2.64	0.00	0.115	0	20114	0	0	16-#16
	Right	2.64	0.00	0.230	3168	20114	0	165	16-#16 *3
11	Left	2.64	0.00	0.000	3168	20114	0	165	16-#16 *3
	Midspan	2.64	0.00	0.225	0	20114	0	0	16-#16
	Right	2.64	0.00	0.450	3168	20114	0	165	16-#16 *3
12	Left	2.64	0.00	0.000	3168	20114	0	165	16-#16 *3
	Midspan	2.64	0.00	0.250	0	20114	0	0	---
	Right	2.64	0.00	0.500	0	20114	0	0	---

2.2. Top Bar Details

Span	Left				Continuous		Right			
	Bars	Length	Bars	Length	Bars	Length	Bars	Length	Bars	Length
		m		m		m		m		m
1	---		---		---		16-#16	0.20	---	
2	---		---		16-#16	0.20	---		---	
3	---		---		16-#16	0.30	6-#16	0.30	---	
4	---		---		22-#16	0.61	8-#16	0.61	---	
5	---		---		30-#16	1.07	2-#16	0.77	---	
6	2-#16	0.78	---		30-#16	1.07	---		---	
7	10-#16	0.85	---		20-#16	0.91	---		---	
8	4-#16	0.55	---		16-#16	0.61	---		---	
9	---		---		16-#16	0.23	---		---	
10	---		---		16-#16	0.23	---		---	
11	---		---		16-#16	0.45	---		---	
12	16-#16	0.50	---		---		---		---	

2.3. Top Bar Development Lengths

Span	Left				Continuous		Right			
	Bars	DevLen	Bars	DevLen	Bars	DevLen	Bars	DevLen	Bars	DevLen
		mm		mm		mm		mm		mm
1	---		---		---		16-#16	300.00	---	
2	---		---		16-#16	300.00	---		---	
3	---		---		16-#16	309.17	6-#16	300.00	---	
4	---		---		22-#16	399.51	8-#16	344.35	---	
5	---		---		30-#16	403.83	2-#16	408.96	---	
6	2-#16	408.96	---		30-#16	404.76	---		---	
7	10-#16	346.95	---		20-#16	409.61	---		---	
8	4-#16	300.00	---		16-#16	300.00	---		---	
9	---		---		16-#16	0.00	---		---	
10	---		---		16-#16	0.00	---		---	
11	---		---		16-#16	0.00	---		---	
12	16-#16	300.00	---		---		---		---	

2.4. Bottom Reinforcement

Notes:
*3 - Design governed by minimum reinforcement.

Span	Width	M_{max}	X_{max}	$A_{s,min}$	$A_{s,max}$	$A_{s,req}$	Sp_{Prov}	Bars
	m	kNm	m	mm²	mm²	mm²	mm	
1	2.64	27.44	0.200	3168	20114	133	165	16-#16 *3
2	2.64	0.00	0.100	0	20114	0	0	---
3	2.64	0.00	0.150	0	20114	0	0	---
4	2.64	0.00	0.305	0	20114	0	0	---
5	2.64	0.00	0.535	0	20114	0	0	---
6	2.64	0.00	0.535	0	20114	0	0	---
7	2.64	0.00	0.455	0	20114	0	0	---
8	2.64	195.12	0.610	3168	20114	953	165	16-#16 *3
9	2.64	468.83	0.230	3168	20114	2316	165	16-#16 *3
10	2.64	549.83	0.000	3168	20114	2725	165	16-#16 *3
11	2.64	384.70	0.000	3168	20114	1894	165	16-#16 *3
12	2.64	141.36	0.000	3168	20114	689	165	16-#16 *3

2.5. Bottom Bar Details

	Long Bars			Short Bars		
Span	Bars	Start	Length	Bars	Start	Length
		m	m		m	m
1	16-#16	0.00	0.20	---		
2	---			---		
3	---			---		
4	---			---		
5	---			---		
6	---			---		
7	---			---		
8	16-#16	0.00	0.61	---		
9	16-#16	0.00	0.23	---		
10	16-#16	0.00	0.23	---		
11	16-#16	0.00	0.45	---		
12	16-#16	0.00	0.50	---		

2.6. Bottom Bar Development Lengths

	Long Bars		Short Bars	
Span	Bars	DevLen	Bars	DevLen
		mm		mm
1	16-#16	300.00	---	
2	---		---	
3	---		---	
4	---		---	
5	---		---	
6	---		---	
7	---		---	
8	16-#16	300.00	---	
9	16-#16	303.68	---	
10	16-#16	357.33	---	
11	16-#16	300.00	---	
12	16-#16	300.00	---	

2.7. Flexural Capacity

	Top							Bottom					
Span	x	$A_{s,top}$	ΦM_n-	M_u-	Comb	Pat	Status	$A_{s,bot}$	ΦM_n+	M_u+	Comb	Pat	Status
	m	mm²	kNm	kNm				mm²	kNm	kNm			
1	0.000	3184	-640.12	0.00	U1	All	OK	3184	640.12	0.00	U1	All	OK
	0.070	3184	-640.12	0.00	U1	All	OK	3184	640.12	9.60	U1	All	OK
	0.100	3184	-640.12	0.00	U1	All	OK	3184	640.12	13.72	U1	All	OK
	0.130	3184	-640.12	0.00	U1	All	OK	3184	640.12	17.84	U1	All	OK
	0.200	3184	-640.12	0.00	U1	All	OK	3184	640.12	27.44	U1	All	OK
2	0.000	3184	-640.12	-80.56	U1	All	OK	0	0.00	0.00	U1	All	OK
	0.070	3184	-640.12	-156.26	U1	All	OK	0	0.00	0.00	U1	All	OK
	0.100	3184	-640.12	-188.70	U1	All	OK	0	0.00	0.00	U1	All	OK
	0.130	3184	-640.12	-221.15	U1	All	OK	0	0.00	0.00	U1	All	OK
	0.200	3184	-640.12	-296.85	U1	All	OK	0	0.00	0.00	U1	All	OK
3	0.000	4378	-871.63	-296.85	U1	All	OK	0	0.00	0.00	U1	All	OK
	0.105	4378	-871.63	-393.93	U1	All	OK	0	0.00	0.00	U1	All	OK
	0.150	4378	-871.63	-435.53	U1	All	OK	0	0.00	0.00	U1	All	OK
	0.195	4378	-871.63	-477.14	U1	All	OK	0	0.00	0.00	U1	All	OK
	0.300	4378	-871.63	-574.22	U1	All	OK	0	0.00	0.00	U1	All	OK
4	0.000	5970	-1173.05	-574.22	U1	All	OK	0	0.00	0.00	U1	All	OK
	0.214	5970	-1173.05	-714.77	U1	All	OK	0	0.00	0.00	U1	All	OK
	0.305	5970	-1173.05	-775.01	U1	All	OK	0	0.00	0.00	U1	All	OK
	0.344	5970	-1173.05	-800.91	U1	All	OK	0	0.00	0.00	U1	All	OK
	0.397	5970	-1173.05	-835.24	U1	All	OK	0	0.00	0.00	U1	All	OK

		Top					Bottom				
Span	x	$A_{s,top}$	ΦM_n-	M_u-	Comb Pat	Status	$A_{s,bot}$	ΦM_n+	M_u+	Comb Pat	Status
	m	mm²	kNm	kNm			mm²	kNm	kNm		
	0.610	5970	-1173.05	-975.79	U1 All	OK	0	0.00	0.00	U1 All	OK
5	0.000	5970	-1173.05	-975.79	U1 All	OK	0	0.00	0.00	U1 All	OK
	0.301	5970	-1173.05	-1045.18	U1 All	OK	0	0.00	0.00	U1 All	OK
	0.375	6042	-1186.47	-1062.24	U1 All	OK	0	0.00	0.00	U1 All	OK
	0.535	6198	-1215.56	-1099.28	U1 All	OK	0	0.00	0.00	U1 All	OK
	0.696	6354	-1244.57	-1136.33	U1 All	OK	0	0.00	0.00	U1 All	OK
	0.710	6368	-1247.11	-1139.58	U1 All	OK	0	0.00	0.00	U1 All	OK
	1.070	6368	-1247.11	-1222.77	U1 All	OK	0	0.00	0.00	U1 All	OK
6	0.000	6368	-1247.11	-1222.77	U1 All	OK	0	0.00	0.00	U1 All	OK
	0.367	6368	-1247.11	-1140.54	U1 All	OK	0	0.00	0.00	U1 All	OK
	0.375	6360	-1245.71	-1138.81	U1 All	OK	0	0.00	0.00	U1 All	OK
	0.535	6204	-1216.71	-1102.82	U1 All	OK	0	0.00	0.00	U1 All	OK
	0.696	6048	-1187.62	-1066.84	U1 All	OK	0	0.00	0.00	U1 All	OK
	0.776	5970	-1173.05	-1048.85	U1 All	OK	0	0.00	0.00	U1 All	OK
	1.070	5970	-1173.05	-982.87	U1 All	OK	0	0.00	0.00	U1 All	OK
7	0.000	5970	-1173.05	-982.87	U1 All	OK	0	0.00	0.00	U1 All	OK
	0.319	5970	-1173.05	-780.33	U1 All	OK	0	0.00	0.00	U1 All	OK
	0.455	5970	-1173.05	-693.52	U1 All	OK	0	0.00	0.00	U1 All	OK
	0.502	5970	-1173.05	-663.34	U1 All	OK	0	0.00	0.00	U1 All	OK
	0.592	5459	-1077.26	-606.72	U1 All	OK	0	0.00	0.00	U1 All	OK
	0.849	3980	-794.98	-442.70	U1 All	OK	0	0.00	0.00	U1 All	OK
	0.910	3980	-794.98	-404.17	U1 All	OK	0	0.00	0.00	U1 All	OK
8	0.000	3980	-794.98	-404.17	U1 All	OK	3184	640.12	0.00	U1 All	OK
	0.214	3980	-794.98	-194.42	U1 All	OK	3184	640.12	0.00	U1 All	OK
	0.254	3980	-794.98	-154.68	U1 All	OK	3184	640.12	0.00	U1 All	OK
	0.305	3845	-768.77	-104.52	U1 All	OK	3184	640.12	0.00	U1 All	OK
	0.397	3602	-721.65	-14.63	U1 All	OK	3184	640.12	0.00	U1 All	OK
	0.554	3184	-640.12	0.00	U1 All	OK	3184	640.12	140.06	U1 All	OK
	0.610	3184	-640.12	0.00	U1 All	OK	3184	640.12	195.12	U1 All	OK
9	0.000	3184	-640.12	0.00	U1 All	OK	3184	640.12	195.12	U1 All	OK
	0.081	3184	-640.12	0.00	U1 All	OK	3184	640.12	290.92	U1 All	OK
	0.115	3184	-640.12	0.00	U1 All	OK	3184	640.12	331.98	U1 All	OK
	0.150	3184	-640.12	0.00	U1 All	OK	3184	640.12	373.04	U1 All	OK
	0.230	3184	-640.12	0.00	U1 All	OK	3184	640.12	468.83	U1 All	OK
10	0.000	3184	-640.12	0.00	U1 All	OK	3184	640.12	549.83	U1 All	OK
	0.081	3184	-640.12	0.00	U1 All	OK	3184	640.12	492.04	U1 All	OK
	0.115	3184	-640.12	0.00	U1 All	OK	3184	640.12	467.27	U1 All	OK
	0.150	3184	-640.12	0.00	U1 All	OK	3184	640.12	442.50	U1 All	OK
	0.230	3184	-640.12	0.00	U1 All	OK	3184	640.12	384.70	U1 All	OK
11	0.000	3184	-640.12	0.00	U1 All	OK	3184	640.12	384.70	U1 All	OK
	0.158	3184	-640.12	0.00	U1 All	OK	3184	640.12	299.53	U1 All	OK
	0.225	3184	-640.12	0.00	U1 All	OK	3184	640.12	263.03	U1 All	OK
	0.293	3184	-640.12	0.00	U1 All	OK	3184	640.12	226.53	U1 All	OK
	0.450	3184	-640.12	0.00	U1 All	OK	3184	640.12	141.36	U1 All	OK
12	0.000	3184	-640.12	0.00	U1 All	OK	3184	640.12	141.36	U1 All	OK
	0.175	3184	-640.12	0.00	U1 All	OK	3184	640.12	91.89	U1 All	OK

Span	Top						Bottom				
	x	$A_{s,top}$	ΦM_n-	M_u-	Comb Pat	Status	$A_{s,bot}$	ΦM_n+	M_u+	Comb Pat	Status
	m	mm²	kNm	kNm			mm²	kNm	kNm		
	0.200	3184	-640.12	0.00	U1 All	OK	3184	640.12	84.82	U1 All	OK
	0.250	3184	-640.12	0.00	U1 All	OK	3184	640.12	70.68	U1 All	OK
	0.325	3184	-640.12	0.00	U1 All	OK	3184	640.12	49.48	U1 All	OK
	0.500	3184	-640.12	0.00	U1 All	OK	3184	640.12	0.00	U1 All	OK

2.8. Slab Shear Capacity

Span	b	d	V_{ratio}	ΦV_c	V_u	X_u	
	mm	mm		kN	kN	m	
1	2640	554	1.000	854.47	137.21	0.00	
2	2640	554	1.000	854.47	0.00	0.00	
3	2640	554	1.000	854.47	0.00	0.00	
4	2640	554	1.000	854.47	0.00	0.00	
5	2640	554	1.000	854.47	0.00	0.00	
6	2640	554	1.000	854.47	0.00	0.00	
7	2640	554	1.000	854.47	0.00	0.00	
8	2640	554	1.000	854.47	0.00	0.00	
9	2640	554	1.000	854.47	1190.05	0.00	*EXCEEDED
10	2640	554	1.000	854.47	0.00	0.00	
11	2640	554	1.000	854.47	0.00	0.00	
12	2640	554	1.000	854.47	0.00	0.00	

2.9. Material TakeOff

2.9.1. Reinforcement in the Direction of Analysis

Top Bars	248.0 kg	<=>	38.88 kg/m	<=>	14.726 kg/m²
Bottom Bars	55.1 kg	<=>	8.64 kg/m	<=>	3.273 kg/m²
Stirrups	0.0 kg	<=>	0.00 kg/m	<=>	0.000 kg/m²
Total Steel	303.2 kg	<=>	47.52 kg/m	<=>	17.999 kg/m²
Concrete	10.1 m³	<=>	1.58 m³/m	<=>	0.600 m³/m²

3. Deflection Results: Summary

3.1. Section Properties

3.1.1. Frame Section Properties

Notes:
M+ve values are for positive moments (tension at bottom face).
M-ve values are for negative moments (tension at top face).

Span	Zone	M_{+ve}			M_{-ve}		
		I_g	I_{cr}	M_{cr}	I_g	I_{cr}	M_{cr}
		mm⁴	mm⁴	kNm	mm⁴	mm⁴	kNm
1	Left	4.752e+010	6.9818e+009	508.12	4.752e+010	0	-508.12
	Midspan	4.752e+010	6.9818e+009	508.12	4.752e+010	6.9818e+009	-508.12
	Right	4.752e+010	6.9818e+009	508.12	4.752e+010	6.9818e+009	-508.12
2	Left	4.752e+010	0	508.12	4.752e+010	6.9818e+009	-508.12
	Midspan	4.752e+010	0	508.12	4.752e+010	6.9818e+009	-508.12
	Right	4.752e+010	0	508.12	4.752e+010	6.9818e+009	-508.12
3	Left	4.752e+010	0	508.12	4.752e+010	6.9818e+009	-508.12
	Midspan	4.752e+010	0	508.12	4.752e+010	9.1828e+009	-508.12
	Right	4.752e+010	0	508.12	4.752e+010	9.1828e+009	-508.12
4	Left	4.752e+010	0	508.12	4.752e+010	9.1828e+009	-508.12
	Midspan	4.752e+010	0	508.12	4.752e+010	1.1909e+010	-508.12
	Right	4.752e+010	0	508.12	4.752e+010	1.1909e+010	-508.12

Span	Zone	M_{+ve} I_g mm⁴	M_{+ve} I_{cr} mm⁴	M_{+ve} M_{cr} kNm	M_{-ve} I_g mm⁴	M_{-ve} I_{cr} mm⁴	M_{-ve} M_{cr} kNm
5	Left	4.752e+010	0	508.12	4.752e+010	1.1909e+010	-508.12
	Midspan	4.752e+010	0	508.12	4.752e+010	1.2282e+010	-508.12
	Right	4.752e+010	0	508.12	4.752e+010	1.2558e+010	-508.12
6	Left	4.752e+010	0	508.12	4.752e+010	1.2558e+010	-508.12
	Midspan	4.752e+010	0	508.12	4.752e+010	1.2293e+010	-508.12
	Right	4.752e+010	0	508.12	4.752e+010	1.1909e+010	-508.12
7	Left	4.752e+010	0	508.12	4.752e+010	1.1909e+010	-508.12
	Midspan	4.752e+010	0	508.12	4.752e+010	1.1909e+010	-508.12
	Right	4.752e+010	0	508.12	4.752e+010	8.4658e+009	-508.12
8	Left	4.752e+010	6.9818e+009	508.12	4.752e+010	8.4658e+009	-508.12
	Midspan	4.752e+010	6.9818e+009	508.12	4.752e+010	8.2181e+009	-508.12
	Right	4.752e+010	6.9818e+009	508.12	4.752e+010	6.9818e+009	-508.12
9	Left	4.752e+010	6.9818e+009	508.12	4.752e+010	6.9818e+009	-508.12
	Midspan	4.752e+010	6.9818e+009	508.12	4.752e+010	6.9818e+009	-508.12
	Right	4.752e+010	6.9818e+009	508.12	4.752e+010	6.9818e+009	-508.12
10	Left	4.752e+010	6.9818e+009	508.12	4.752e+010	6.9818e+009	-508.12
	Midspan	4.752e+010	6.9818e+009	508.12	4.752e+010	6.9818e+009	-508.12
	Right	4.752e+010	6.9818e+009	508.12	4.752e+010	6.9818e+009	-508.12
11	Left	4.752e+010	6.9818e+009	508.12	4.752e+010	6.9818e+009	-508.12
	Midspan	4.752e+010	6.9818e+009	508.12	4.752e+010	6.9818e+009	-508.12
	Right	4.752e+010	6.9818e+009	508.12	4.752e+010	6.9818e+009	-508.12
12	Left	4.752e+010	6.9818e+009	508.12	4.752e+010	6.9818e+009	-508.12
	Midspan	4.752e+010	6.9818e+009	508.12	4.752e+010	6.9818e+009	-508.12
	Right	4.752e+010	6.9818e+009	508.12	4.752e+010	0	-508.12

3.2. Instantaneous Deflections

3.2.1. Extreme Instantaneous Frame Deflections and Corresponding Locations

Span	Direction	Value	Units	Dead	Live Sustained	Live Unsustained	Live Total	Total Sustained	Total Dead+Live
1	Down	Def	mm	11.81	---	---	---	11.81	11.81
		Loc	m	0.000	---	---	---	0.000	0.000
	Up	Def	mm	---	---	---	---	---	---
		Loc	m	---	---	---	---	---	---
2	Down	Def	mm	11.31	---	---	---	11.31	11.31
		Loc	m	0.000	---	---	---	0.000	0.000
	Up	Def	mm	---	---	---	---	---	---
		Loc	m	---	---	---	---	---	---
3	Down	Def	mm	10.80	---	---	---	10.80	10.80
		Loc	m	0.000	---	---	---	0.000	0.000
	Up	Def	mm	---	---	---	---	---	---
		Loc	m	---	---	---	---	---	---
4	Down	Def	mm	10.07	---	---	---	10.07	10.07
		Loc	m	0.000	---	---	---	0.000	0.000
	Up	Def	mm	---	---	---	---	---	---
		Loc	m	---	---	---	---	---	---
5	Down	Def	mm	8.76	---	---	---	8.76	8.76
		Loc	m	0.000	---	---	---	0.000	0.000
	Up	Def	mm	---	---	---	---	---	---
		Loc	m	---	---	---	---	---	---
6	Down	Def	mm	7.32	---	---	---	7.32	7.32
		Loc	m	0.000	---	---	---	0.000	0.000
	Up	Def	mm	---	---	---	---	---	---
		Loc	m	---	---	---	---	---	---

Span	Direction	Value	Units	Dead	Live Sustained	Live Unsustained	Live Total	Total Sustained	Total Dead+Live
7	Down	Def	mm	7.85	---	---	---	7.85	7.85
		Loc	m	0.910	---	---	---	0.910	0.910
	Up	Def	mm	---	---	---	---	---	---
		Loc	m	---	---	---	---	---	---
8	Down	Def	mm	8.51	---	---	---	8.51	8.51
		Loc	m	0.610	---	---	---	0.610	0.610
	Up	Def	mm	---	---	---	---	---	---
		Loc	m	---	---	---	---	---	---
9	Down	Def	mm	8.75	---	---	---	8.75	8.75
		Loc	m	0.230	---	---	---	0.230	0.230
	Up	Def	mm	---	---	---	---	---	---
		Loc	m	---	---	---	---	---	---
10	Down	Def	mm	8.97	---	---	---	8.97	8.97
		Loc	m	0.230	---	---	---	0.230	0.230
	Up	Def	mm	---	---	---	---	---	---
		Loc	m	---	---	---	---	---	---
11	Down	Def	mm	9.35	---	---	---	9.35	9.35
		Loc	m	0.450	---	---	---	0.450	0.450
	Up	Def	mm	---	---	---	---	---	---
		Loc	m	---	---	---	---	---	---
12	Down	Def	mm	9.74	---	---	---	9.74	9.74
		Loc	m	0.500	---	---	---	0.500	0.500
	Up	Def	mm	---	---	---	---	---	---
		Loc	m	---	---	---	---	---	---

3.3. Long-term Deflections

3.3.1. Long-term Deflection Factors

Notes:
Deflection multiplier, Lambda, depends on moment sign at sustained load level and Rho' in given zone.
Rho' is assumed zero because Compression Reinforcement option is NOT selected in Solve Options.

Time dependant factor for sustained loads = 2.000

Span	Zone	M_{+ve} $A_{s,top}$ mm²	M_{+ve} b mm	M_{+ve} d mm	M_{+ve} Rho' %	M_{+ve} Lambda	M_{-ve} $A_{s,bot}$ mm²	M_{-ve} b mm	M_{-ve} d mm	M_{-ve} Rho' %	M_{-ve} Lambda
1	Midspan	----	----	----	0.000	2.000	----	----	----	0.000	2.000
2	Midspan	----	----	----	0.000	2.000	----	----	----	0.000	2.000
3	Midspan	----	----	----	0.000	2.000	----	----	----	0.000	2.000
4	Midspan	----	----	----	0.000	2.000	----	----	----	0.000	2.000
5	Midspan	----	----	----	0.000	2.000	----	----	----	0.000	2.000
6	Midspan	----	----	----	0.000	2.000	----	----	----	0.000	2.000
7	Midspan	----	----	----	0.000	2.000	----	----	----	0.000	2.000
8	Midspan	----	----	----	0.000	2.000	----	----	----	0.000	2.000
9	Midspan	----	----	----	0.000	2.000	----	----	----	0.000	2.000
10	Midspan	----	----	----	0.000	2.000	----	----	----	0.000	2.000
11	Midspan	----	----	----	0.000	2.000	----	----	----	0.000	2.000
12	Midspan	----	----	----	0.000	2.000	----	----	----	0.000	2.000

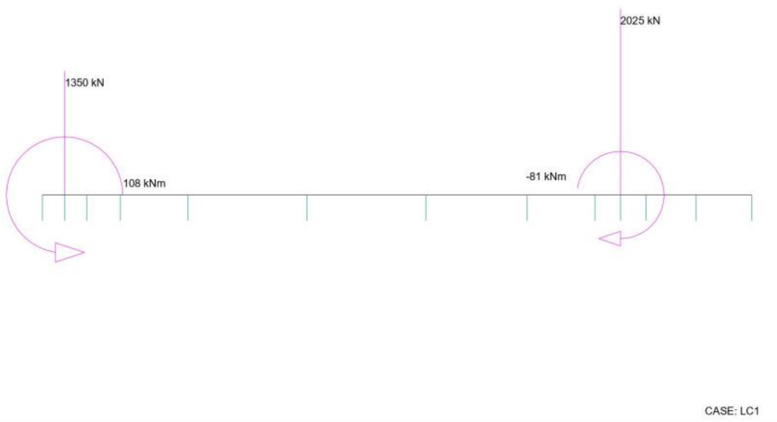
3.3.2. Extreme Long-term Frame Deflections and Corresponding Locations

Notes:
Incremental deflections due to creep and shrinkage (cs) based on sustained load level values.
Incremental deflections after partitions are installed can be estimated by deflections due to:
- creep and shrinkage plus unsustained live load (cs+lu), if live load applied before partitions,
- creep and shrinkage plus live load (cs+l), if live load applied after partitions.
Total deflections consist of dead, live, and creep and shrinkage deflections.

Span	Direction	Value	Units	cs	cs+lu	cs+l	Total
1	Down	Def	mm	23.62	23.62	23.62	35.44
		Loc	m	0.000	0.000	0.000	0.000
	Up	Def	mm	---	---	---	---
		Loc	m	---	---	---	---
2	Down	Def	mm	22.61	22.61	22.61	33.92
		Loc	m	0.000	0.000	0.000	0.000
	Up	Def	mm	---	---	---	---
		Loc	m	---	---	---	---
3	Down	Def	mm	21.61	21.61	21.61	32.41
		Loc	m	0.000	0.000	0.000	0.000
	Up	Def	mm	---	---	---	---
		Loc	m	---	---	---	---
4	Down	Def	mm	20.15	20.15	20.15	30.22
		Loc	m	0.000	0.000	0.000	0.000
	Up	Def	mm	---	---	---	---
		Loc	m	---	---	---	---
5	Down	Def	mm	17.52	17.52	17.52	26.29
		Loc	m	0.000	0.000	0.000	0.000
	Up	Def	mm	---	---	---	---
		Loc	m	---	---	---	---
6	Down	Def	mm	14.64	14.64	14.64	21.96
		Loc	m	0.000	0.000	0.000	0.000
	Up	Def	mm	---	---	---	---
		Loc	m	---	---	---	---
7	Down	Def	mm	15.70	15.70	15.70	23.55
		Loc	m	0.910	0.910	0.910	0.910
	Up	Def	mm	---	---	---	---
		Loc	m	---	---	---	---
8	Down	Def	mm	17.02	17.02	17.02	25.54
		Loc	m	0.610	0.610	0.610	0.610
	Up	Def	mm	---	---	---	---
		Loc	m	---	---	---	---
9	Down	Def	mm	17.51	17.51	17.51	26.26
		Loc	m	0.230	0.230	0.230	0.230
	Up	Def	mm	---	---	---	---
		Loc	m	---	---	---	---
10	Down	Def	mm	17.95	17.95	17.95	26.92
		Loc	m	0.230	0.230	0.230	0.230
	Up	Def	mm	---	---	---	---
		Loc	m	---	---	---	---
11	Down	Def	mm	18.70	18.70	18.70	28.06
		Loc	m	0.450	0.450	0.450	0.450
	Up	Def	mm	---	---	---	---
		Loc	m	---	---	---	---
12	Down	Def	mm	19.47	19.47	19.47	29.21
		Loc	m	0.500	0.500	0.500	0.500
	Up	Def	mm	---	---	---	---
		Loc	m	---	---	---	---

4. Diagrams

4.1. Loads



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File: C:\StructurePoint Design Examples\Beams_on_Elastic_Foundations.slb

Project: Beams_on_Elastic_Foundations

Frame:

Engineer: SP

Code: ACI 318M-14

Date: 07/21/20

Time: 15:12:17

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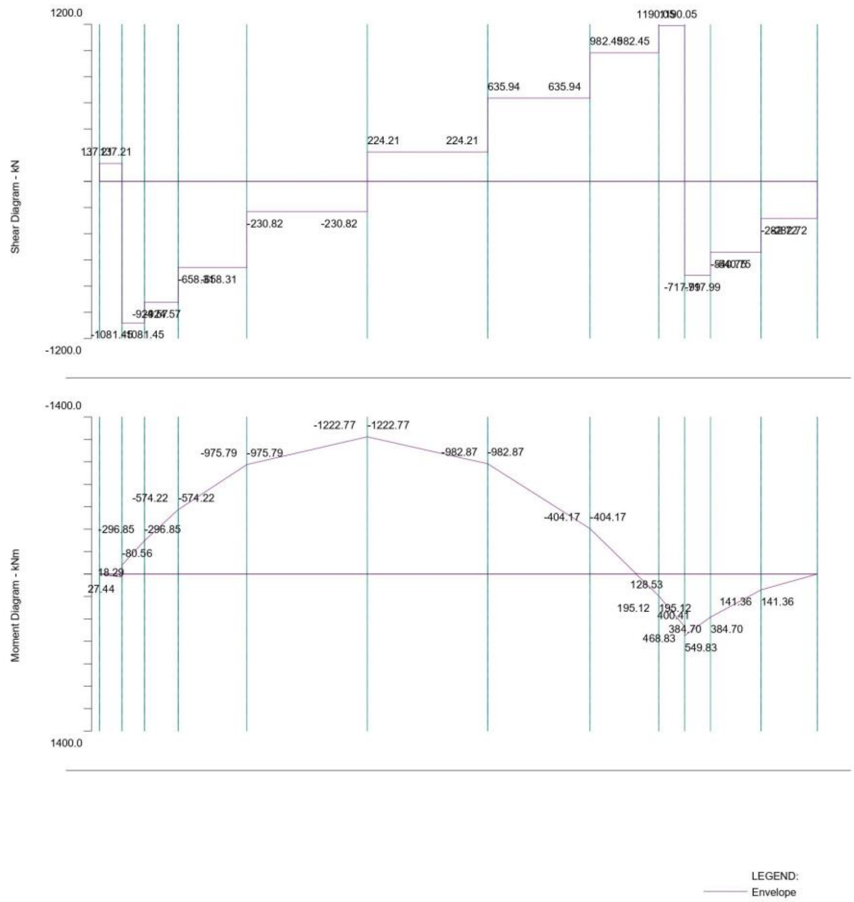
4.2. Internal Forces



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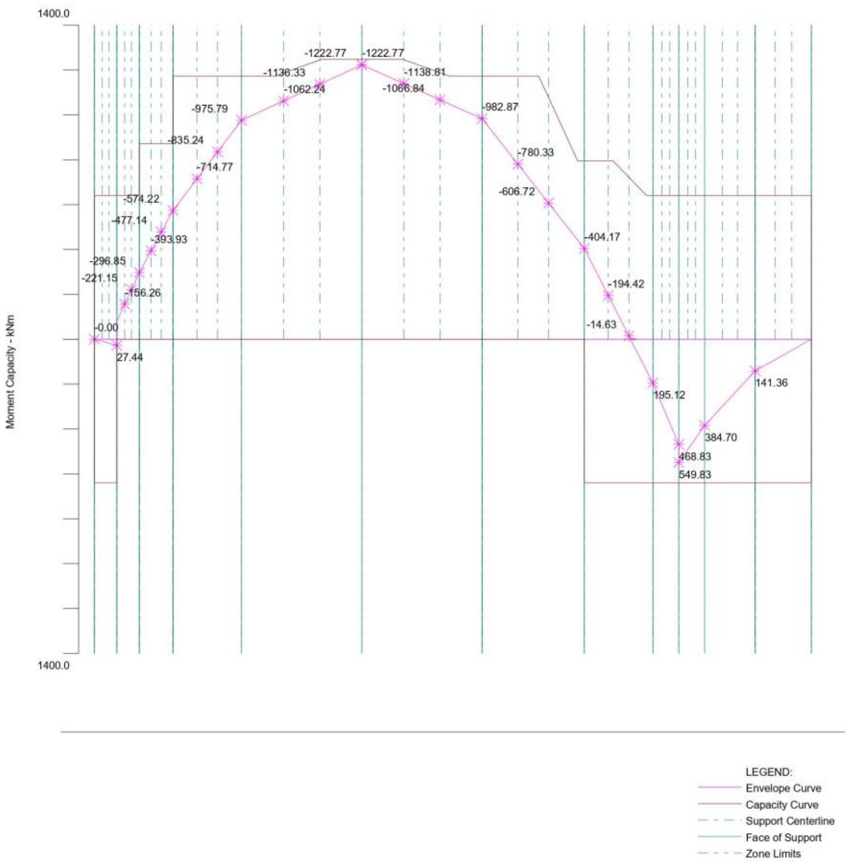
4.3. Moment Capacity



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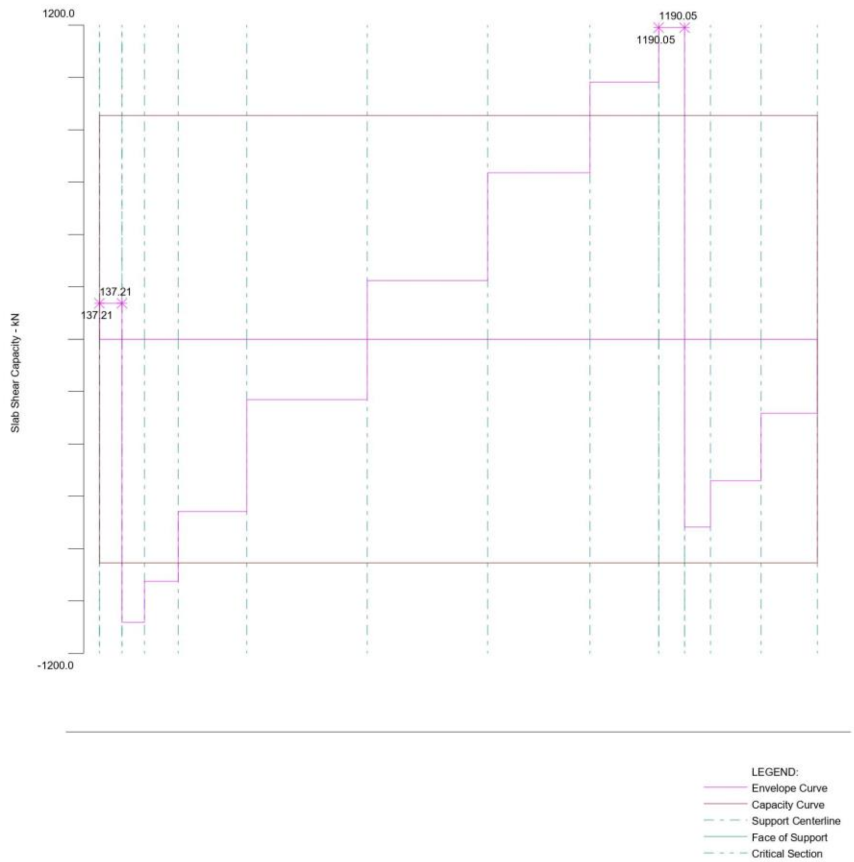
4.4. Shear Capacity



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Engineer: SP

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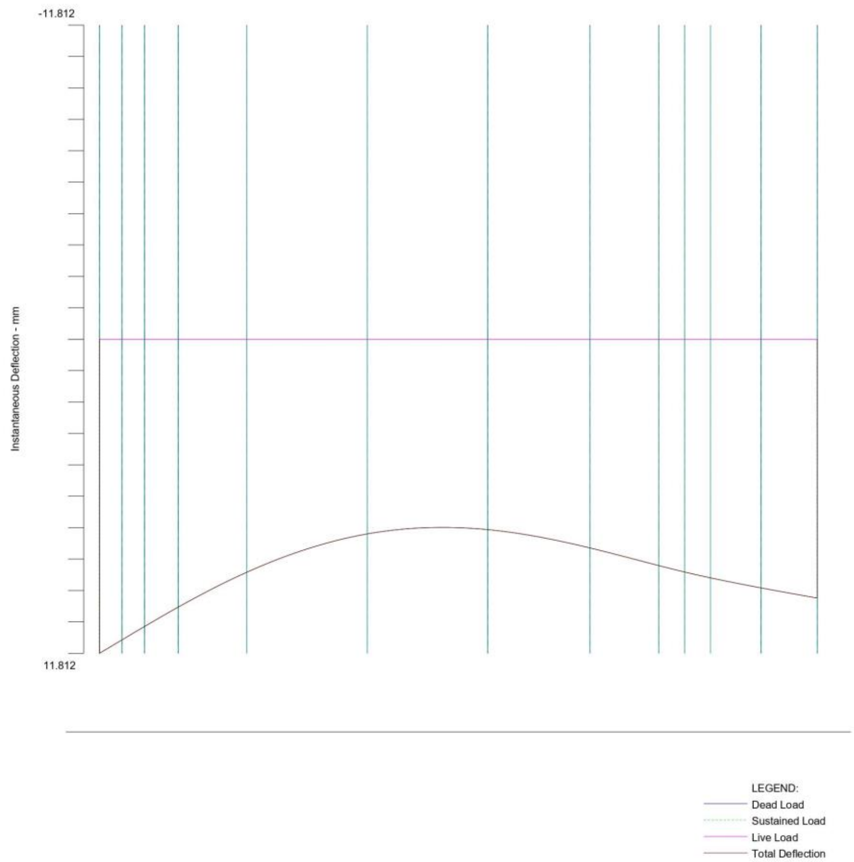
4.5. Deflection



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4.6. Reinforcement

Flexural and Transverse Reinforcement

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Engineer: SP

Code: ACI 318M-14

Date: 07/21/20

Time: 15:12:17