ASSESSMENT OF SOIL STRUCTURE INTERACTION ON RCC UNDERPASS BRIDGE

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Abstract - *The bridges are structure, which provides means of communication over a gap. Bridges provided passage for vehicular or other type of traffic. The Underpass RCC Bridge is very rarely adopted in bridge construction but recently the Underpass RCC Bridge is being used for traffic movement. Hence constructing Underpass Bridge is a better option where there is a constraint of space or land. The model is analyzed for bending moment, shear force and axial thrust for different loading combinations as per IRC: 6-2010 standards. As the box structure directly rests on soil and also soil pressure acts at the side walls. It is important to study the soil structure interaction of such structure. To study the response of structure with rigid supports, with soil structure interaction applied to base only and comparing the results.*

Key Words: *Analysis of RCC underpass Bride, Soil Structure Interaction.*

1. INTRODUCTION

The Underpass RCC Bridge is adopted in bridge construction and used for traffic movement and control. Since the availability of land in the city is less, such type of bridge utilizes less space for its construction. Hence constructing Underpass Bridge is a better option where there is a constraint of space or land.

The RCC Bridge consists of two horizontal and two vertical slabs. These are economical due to their rigidity and monolithic action. Separate foundations are not required, since the bottom slab resting directly on the soil, serves as raft slab. The barrel of the underpass should be of sufficient length to accommodate the carriageway and kerbs. For a Underpass bridge, the top slab is required to withstand dead loads, live loads from moving traffic, earth pressure on sidewalls and pressure on the bottom slab besides self weight of the slab.

2. DETAILS OF THE STRUCTURE

A. Modeling and Analysis

For the present study Two-dimensional cross sectional model is considered for the analysis. The analysis is carried out in STAAD. Pro V8i software. For the cross section model two-dimensional cross section of unit width is taken center-to-center distance between vertical members is taken as effective span for the horizontal members. For this model three types of foundation conditions are taken for the study:
Case A: Rigid frame with manually calculated upward pressure
Case B: Bottom slab resting on uniformly spaced springs with stiffness equal to modulus of sub grade reaction of soil.

B. Assumptions

In the proposed study, the single cell box structure of span 6.5m and width 9.5m including footpath and the double cell structure of span 6.9m and width 9.5m including footpath subjected to vehicle loading, dead load, and lateral earth pressure was taken for the proposed study.

C. Geometric Properties

Single cell

. Thickness of the top slab(t_s) = 0.50m
. Thickness of the bottom slab(t_s) = 0.50m
. Thickness of the vertical wall(t_w) = 0.5m
. Thickness of wearing coat (wc) = 0.08m
. Effective horizontal span for Bridge =6.5+ 0.5 = 7.0 m
. Effective vertical span =3.5+0.5 = 4m

Double cell

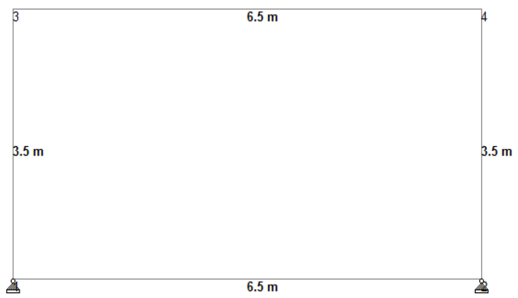
. Thickness of the top slab(t_s) = 3.3m
. Thickness of the bottom slab(t_s) 0.3m
. Thickness of the vertical wall(t_w) = 0.3m
. Thickness of wearing coat (wc) = 0.08m
. Effective horizontal span for Bridge =3.3+ 0.3 = 3.6 m
. Effective vertical span =2.8+0.3 = 3.1m

Live load is calculated manually and it is found that class AA Tracked load is maximum compared to other class loading as per IRC: 21-2000.

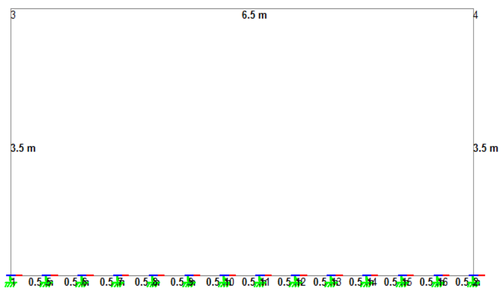
D. Idealization of the Structure

Single cell

CASE A: - For this case the structure is idealized as shown in the figure 1. In this case the following types of supports are provided below the vertical members. At the nodes 1, 2 supports are pinned.

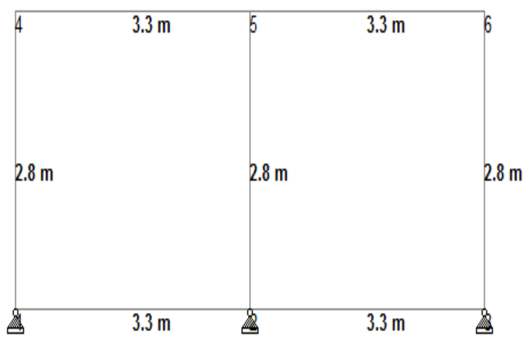


CASE B: - In this case the nodes are at equal spacing i.e. 0.5m in the bottom slab and spring supports having modulus of sub-grade reaction as stiffness are given at each node. The parametric study is carried out for different values of sub-grade modulus in the practical range named Ks = (5000,10000, 20000, 30000, 50000,70000) kN/m2/m.



Double cell

CASE A: - For this case the structure is idealized as shown in the figure 1. In this case the following types of supports are provided below the vertical members. At the nodes 1, 2 and 3supports are pinned.



CASE B: - In this case the nodes are at equal spacing i.e. 0.5m in the bottom slab and spring supports having modulus of sub-grade reaction as stiffness are given at
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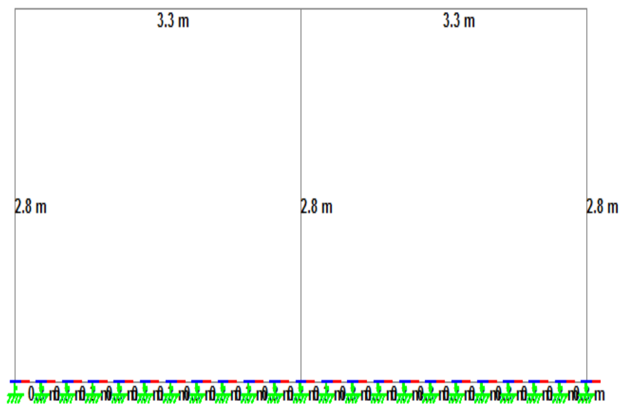

3. LOAD COMBINATION

The Underpass Bridge has been analyzed for its self weight superimposed dead load (due to wearing coat), live load (IRC Class AA Wheeled Vehicle) and earth pressure on sidewalls. The following loads to be considered for the analysis:

1.Dead Load
2. Live Load
3. Concentrated loads
4. Uniform distributed load
5. Weight of side walls
6. Earth pressure on vertical side walls
7. Uniform lateral load on side walls

The following load combinations are considered for the analysis:

Case 1: Dead load + live load+ earth pressure

Case 2. Dead load+ live load + earth pressure+ water pressure inside:

Case 3. Dead load+ live load + earth pressure+ water pressure inside no live load on side:
The above analysis is carried out for following support cases:

Case 1: Rigid supports with uniform soil pressure beneath the bottom slab.

Case 3: Springs supports at Base as well as side walls for different sub-grade modular
i.e.
a. Ks = 5000 kN/m2/m.
b. Ks = 10000 kN/m2/m.

c. Ks = 30000 kN/m2/m.
d. Ks = 50000 kN/m2/m.
e. Ks = 70000 kN/m2/m.

4. RESULTS AND DISCUSSIONS

Single cell

Table 4.1 Results for Load case 1 at Base Spring only

MEMBER	RESULT		BASE SPRING					
		RIGID	5000	10000	20000	30000	50000	70000
TOP SLAB	Max SF	125	125	125	125	125	125	125
	BM at Mid	-112	-106.42	-105.52	-104.21	-103.19	-101.7	-100.76
	BM at corner	92	97	98	100	101	102	103
BOTTOM SLAB	Max SF	169	127	123	117	113	106	101
	BM at Mid	141	98	88	73	62	47	37
	BM at corner	-133	-95	-86	-75	-68	-56	-48
SIDE SLAB	Max SF	66	53	51	48	47	51	53
	BM at Mid	73	56	53	48	45	39	36
	BM at corner	133	98	99	100	101	103	104

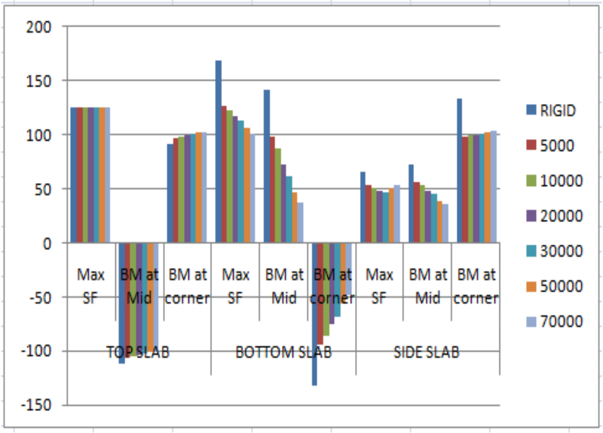

Fig. 4.1 Variation of Load case 1 at Base Spring only

Table 4.2 Results for Load case 2 at Base Spring only

MEMBER	RESULT		BASE SPRING					
		RIGID	5000	10000	20000	30000	50000	70000
TOP SLAB	Max SF	125	125	125	125	125	125	125
	BM at Mid	-117	-111.8	-110.87	-109.4	-108.29	-106.79	-105.63
	BM at corner	87	92	93	95	96	98	99
BOTTOM SLAB	Max SF	169	127	123	116	111	103	98
	BM at Mid	148	103	93	77	65	48	37
	BM at corner	-127	-86	-78	-68	-58	-45	-37
SIDE SLAB	Max SF	25	18	22	26	29	33	36
	BM at Mid	93	75	72	67	63	58	54
	BM at corner	127	92	93	95	96	98	104

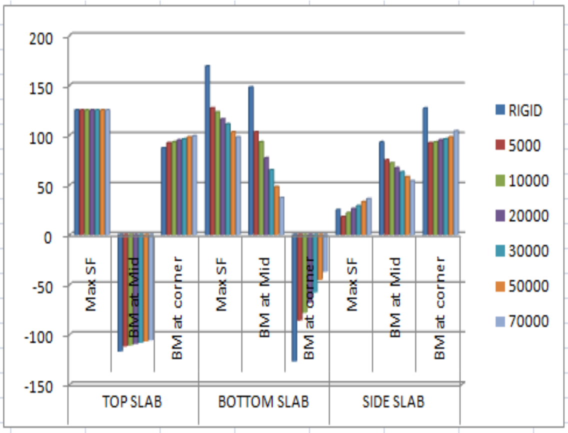

Fig. 4.2 Variation of Load case 2 at Base Spring only

Table 4.3 Results for Load case 3 at Base Spring only

MEMBER	RESULT		BASE SPRING					
		RIGID	5000	10000	20000	30000	50000	70000
TOP SLAB	Max SF	125	125	125	125	125	125	125
	BM at Mid	-121	-116.8	-115.9	-114.3	-113.1	-111.4	-110.3
	BM at corner	83	87	88	90	91	93	94
BOTTOM SLAB	Max SF	169	127	123	115	110	101	95
	BM at Mid	152	108	97	80	67	49	37
	BM at corner	-123	-76	-72	-60	-50	-36	-27
SIDE SLAB	Max SF	13	17	19	23	26	31	34
	BM at Mid	106	93	89	84	80	74	70
	BM at corner	123	87	88	90	91	91	94

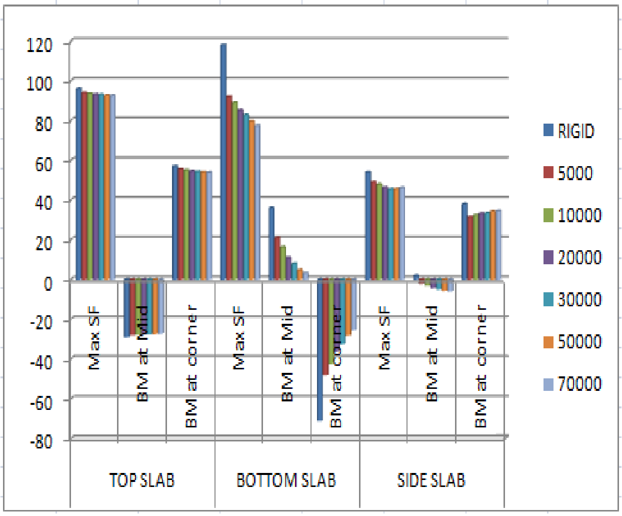

Fig. 4.3 Variation of Load case 3 at Base Spring only

Double Cell

Table 4.4 Results for Load case 1 at Base Spring

MEMBER	RESULT		BASE SPRING					
		RIGID	5000	10000	20000	30000	50000	70000
TOP SLAB	Max SF	96	93.96	93.56	93.12	93	92.6	92.52
	BM at Mid	-29	-27.9	-27.7	-27.59	-27.48	-27.38	-27.2
	BM at corner	57	55.57	55	54.55	54.27	54	53.84
BOTTOM SLAB	Max SF	118	92	89	85.24	82.8	79.57	77.34
	BM at Mid	36	20.96	16.29	10.95	8	4.86	3.24
	BM at corner	-71	-48	-42.48	-36.23	-32.47	-28.06	-25.43
SIDE SLAB	Max SF	54	49.09	47.89	46.33	45.51	45.56	46.11
	BM at Mid	2	-2	-3	-4.2	-4.86	-5.5	-5.9
	BM at corner	38	31.51	32.35	33.27	33.37	34.3	34.57

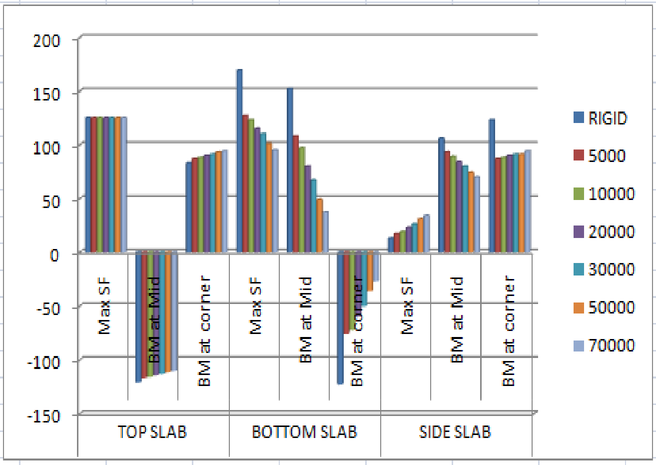

Fig. 4.4 Variation of Load case 1 at Base Spring only

Table 4.5 Results for Load case2 at Base Spring

MEMBER	RESULT		BASE SPRING					
		RIGID	5000	10000	20000	30000	50000	70000
TOP SLAB	Max SF	97	93.58	93.18	92.75	92.51	92.26	92.12
	BM at Mid	-30	-30.6	-30.2	-30.09	-30	-29.7	-29.59
	BM at corner	59	52.16	51.83	51.44	51.22	51.01	50.59
BOTTOM SLAB	Max SF	121	104.6	101.4	98.27	96.65	94.73	93.4
	BM at Mid	37	25.3	19.85	12.27	8.32	4.41	2.57
	BM at corner	-74	-60.71	-54.11	-46.65	-42.33	-37.38	-34.49
SIDE SLAB	Max SF	27.4	9.16	10.9	13	14.21	15.53	16.28
	BM at Mid	9.4	16.5	14.96	13.14	12	10.84	10.3
	BM at corner	31	29.39	30.34	31.39	31.97	52.59	32.92

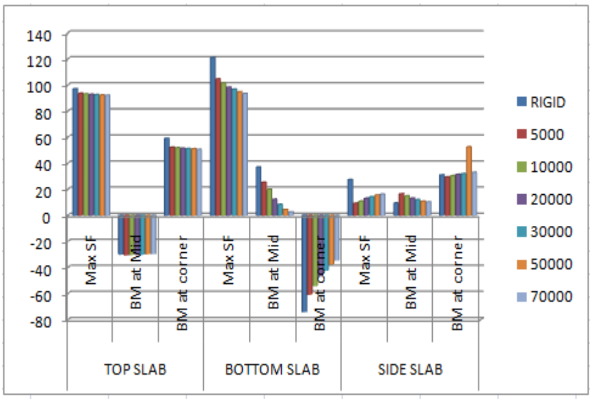

Fig. 4.5 Variation of Load case 2 at Base Spring only

Table 4.6 Results for Load case3 at Base Spring

MEMBER	RESULT		BASE SPRING					
		RIGID	5000	10000	20000	30000	50000	70000
TOP SLAB	Max SF	101	100	99.6	99	98.67	98.28	98.05
	BM at Mid	-32	-30.9	-30.74	-30.5	-30.3	-30.18	-30.09
	BM at corner	63.2	62.39	62.08	61.36	60.95	60.47	60.19
BOTTOM SLAB	Max SF	124	97.27	93.87	89.6	86.95	83.45	81.05
	BM at Mid	38.7	23.85	17.66	11.24	7.8	4.28	2.57
	BM at corner	-77.4	-52.44	-46.03	-38.69	-34.42	-29.54	-26.7
SIDE SLAB	Max SF	3.11	2.74	4.38	6.32	7.45	8.74	9.49
	BM at Mid	20.6	15.8	14.6	13.1	12.2	11.23	10.65
	BM at corner	23	18.4	19.4	20.65	21.36	22.17	22.64

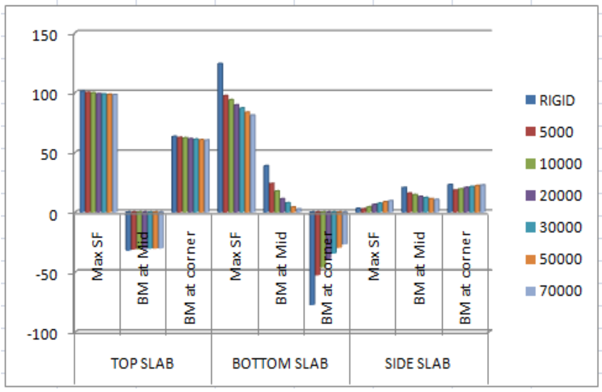

Fig. 4.6 Variation of Load case 3 at Base Spring only

5. CONCLUSIONS

1.The structure which analyzed with rigid support condition gives flawed results as compared to soil structure interaction by study of soil structure interaction. Therefore it is impossible to neglecting soil structure interaction.

2.The value of shear force, corner bending moment, and center bending moment of bottom slab decreases about 0% ,5%,4% from rigid support condition to soil structure interaction.

3.The value of SF, corner BM, and center BM of bottom slab decreases about 24%, 30%, 30% from rigid support to soil structure interaction

4.The value of SF, corner BM, and center BM of side wall decreases about 20%, 30%, 13% from rigid support to soil structure interaction.

5. For load combination 3 (Dead load+ earth pressure+ water pressure) SF and BM gives considerably results as compared to other load combination.

6.There for SF and BM values are lesser with soil structure interaction .

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