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Analysis of Vehicular Underpass for Different span arrangement by modified IRC 6:2014

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Abstract: - The Underpass RCC Bridge is very rarely adopted in bridge construction but recently the Underpass RCC Bridge is being used for traffic movement. In this paper, the comparative analysis of the vehicular underpass RCC Bridge is carried out. The analysis of underpass RCC Bridge is done by applying spring constant i.e. modulus of sub grade reaction to the raft, calculated assuming the young's modulus of soil. 2D model is prepared considering unit meter width and comparison is made on the basis of design forces i.e. Bending Moment and Shear Forces. In this study we show a percentage difference in design values for new and old IRC loadings. 2D model can be effectively used for analysis purpose for all the loading condition mentioned in IRC:6-2014, Standard Specifications and Code of Practice Road Bridges, The Indian Roads Congress.

Keywords: - RCC Underpass bridge, Spring Constants, Design forces.

I. INTRODUCTION

The Underpass RCC Bridge is very rarely adopted in bridge construction but recently the Underpass RCC Bridge is being used for traffic movement. Main attribute to the design concept were speedy construction, least disturbance to the traffic during construction, enhanced aesthetics, effective drainage and comfortable lighting. The vehicular underpass may subjected to road traffic (IRC loading) or train traffic (IRS loading), in this paper underpass is analyzed for IRC loadings (IRC:6-2014).
In this paper 2D analysis of underpass RCC bridge is carried out considering different loading conditions and different loading combinations which are considering from IRC:6-2014, "Standard Specifications And Code Of Practice Road Bridges" The Indian Roads Congress. The analysis of underpass RCC Bridge is done by applying spring constant i.e. modulus of subgrade reaction to the raft, calculated assuming the young's modulus of soil as 3000t/m^2.

1.1 Modeling of system

For the study of Underpass RCC Bridge, earth pressure acting on side walls of underpass RCC bridge because structure embedded as well as vertical loading due to imposed load and live load on the top of underpass RCC Bridge is considered. Also the impact and braking load corresponding to live load is considered as per IRC:6-2014. As there is a top loading, there is reaction at bottom also. Spring constants are applied to the raft calculated from book Bridge Deck Behavior by E.C.Hambly.

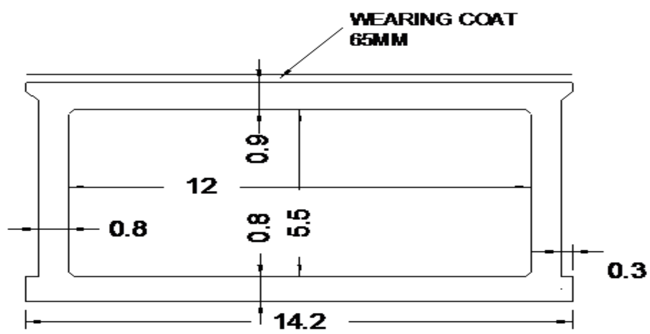

Figure 1. Schematic Diagram of RCC Underpass Bridge

Fig.1. shows the schematic drawing for RCC underpass which is analyzed in STAAD considering different load cases and combinations.

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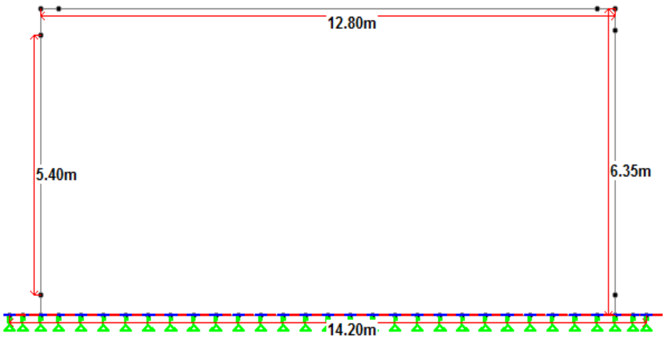

Figure 2. 2D Model of RCC Underpass Bridge

2D underpass RCC bridge model shown in fig.2 is analyzed considering soil structure interaction.

II. FORMULATION

2.1 Loads on the top of slab:-

Total load for bending moment and shear force is considered from IRC code rules specifying the loads for designing the superstructure and substructure of bridges and for assessing the strength of existing bridges.

Dead load of box = Area x thickness x density

Total vertical pressure on top slab = Imposed load + Dead load + Live load

2.2 Loads on sidewalls:-

The coefficient of active earth pressure of the soil is given by the equation:

$$Ka = \frac{\cos^2(\emptyset - \propto)}{\cos^2 \propto \times \cos(\propto + \delta) \times \left(1 + \sqrt{\frac{\sin(\emptyset + \delta) - \sin(\emptyset - i)}{\cos(\alpha - \delta) - \cos(\alpha - i)}}\right)^2}$$

where,

γ = Density of soil,

ϕ = Angle of internal frictional

δ= angle of friction between wall and earth fill

Where value of δ is not determined by actual tests, the following values may be assumed.

(i) δ = 1/3 ø for concrete structures.

(ii) δ = 2/3 ø for masonry structures.

i = Angle which the earth surface makes with the horizontal behind the earth retaining structure

(*i* =0 0 for embedded structure).

Since this concrete structure is embedded in soil, the value of δ is considered as 1/3 ø (for concrete structures) considered for calculation of coefficient of active earth pressure of the soil.

2.3 Earth pressure acting on the sidewalls

2.3.1 Earth pressure due to backfill

Earth pressure center of top slab = Ka x γ x H
Earth pressure center of bottom slab = Ka x γ x H
2.3.2 Earth pressure due to dead load surcharge

Earth pressure acting on sidewalls:
At Top = Imposed load + Earth pressure on the top of slab + Live load
AT Bottom = Horizontal effect of surcharge + Earth pressure center of bottom slab

2.4 Reaction at the bottom of box

Self weight of box = Weight of top slab + Weight of bottom slab + Weight of side walls
Total reaction at bottom=Self weight of box +Weight of imposed load +Weight of live load
The boundary condition considered is fixed.

III. ANALYSIS OF 2D UNDERPASS RCC BRIDGE MODEL

A 2D underpass RCC bridge (Fig.2) is modeled considering 1m width for the following details shown below. Box dimensions: 12.8m x 1m x 6.35m (L x W x H) (Center to center). In addition to the dimensions mentioned in (Fig.1), following parameters are considered for the 2D analysis. Keeping all the parameters same, the analysis is carried out using STAAD.Pro (V8i) (programming software). The live load position for maximum bending moment at mid-span and at support and shear force at support is worked out by running the live load in STAAD model thought the span. The dispersed load area is calculated as per IRC:112-2011 Annex.B-3. In final model all live load with dispersed load is added with other load in different load combinations as per IRC:6.

Dimension of underpass RCC bridge considered for analysis are as follows:

Side wall thickness, = 800 mm
Clear height of box, = 550 0mm
Clear Span of VUP, , = 12000 m
Thickness of deck slab, = 900 mm
Thickness of base slab, = 800 mm
Base slab projection, = 300 mm
Thickness of fill over deck = 65mm
Idealised span of cell, = 12800 mm
Idealised height of box, H = 5500 + 900 / 2 + 800 /2
= 6350 mm
L = Clear Span + Dsw
Cantilever length of base slab Lc = 300 + 800 /2 = 700mm
Width of super structure b = 8500 mm
(2 lane carriage–way is considered in paper i.e. 7.5m + 0.5m crash barrier on both side)
Thickness of crash barrier = 500mm

The max BM and SF obtained for 2D underpass RCC bridge model considering soil stiffness are shown in TABLE 1. Shear force and bending moment diagram for dispersed class A load after combining with other load such as DL, earth pressure, Impact, braking is shown in (Fig.3 & 4)

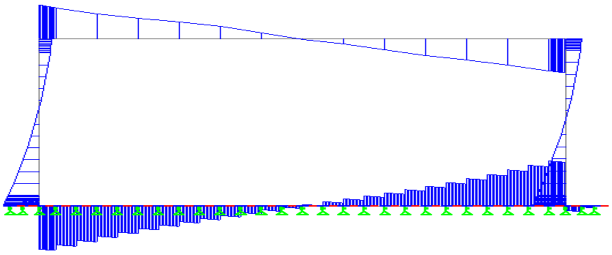

Figure 3. SF diagram for Class A Load

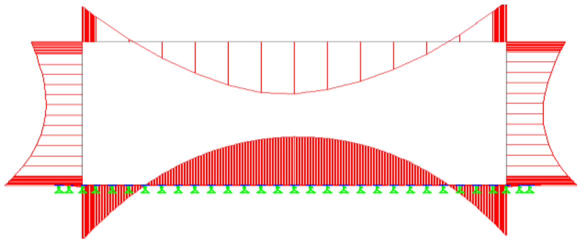

Figure 4. BMD for Class A Load

3.1 Validation of results

The bending moment results obtained by slope deflection method and STAAD program for 2 dimensional model of underpass RCC bridge are approximately same. The slight variation of results may be due to the variation of moment of inertia values. Based on this validity of results further analysis of same 2D model for various combinations of loading cases was carried out.

IV. COMPARISON OF RESULT OF UNDERPASS RCC BRIDGE MODEL FOR DIFFERENT LIVE LOADS

The comparison of the maximum bending moment and shear force values obtained for different live load cases for 2D underpass RCC bridge models which are considered with soil stiffness are compared. The comparison between newly added Special Vehicle with old vehicles such as class A, 70R trains are made and results are tabulated in TABLE 1 to 4. The values of bending moment and shear force for 2D model for all loading cases and combinations considered for the analysis purpose from IRC: 6-2014, "Standard Specifications and Code of Practice Road Bridges" The Indian Roads Congress.

Table 1. Comparison of Max BM and Max SF (Class A and Special Vehicle)

Members	Design Values	Class A	Special Values	Percentage Difference
Top Slab	BM at mid	45.039	49.430	8.883
	BM at Support	35.337	36.776	3.913
	SF at Support	22.138	28.488	22.291
Bottom Slab	BM at mid	41.400	48.800	15.164
	BM at Support	47.100	52.300	9.943
	SF at Support	29.100	34.000	14.412
Side Wall	BM at mid	21.800	27.000	19.259
	BM at Support	45.400	50.300	9.742
	SF at Support	15.200	14.800	-2.703

Table 2. Comparison of Max BM and Max SF (70R Tracked Vehicle and Special Vehicle)

Members	Design Values	70R Tracked	Special Values	Percentage Difference
Top Slab	BM at mid	45.533	49.43	7.88
	BM at Support	36.494	36.776	0.77
	SF at Support	24.4691	28.4876	14.11
Bottom Slab	BM at mid	41.000	48.800	15.98
	BM at Support	47.500	52.300	9.18
	SF at Support	30.700	34.000	9.71
Side Wall	BM at mid	21.900	27.000	18.89
	BM at Support	47.400	50.300	5.77
	SF at Support	15.500	14.800	-4.73

Table 3. Comparison of Max BM and Max SF (70R Wheeled Vehicle and Special Vehicle)

Members	Design Values	70R Wheeled	Special Values	Percentage Difference
Top Slab	BM at mid	49.154	49.43	0.56
	BM at Support	40.805	36.776	-10.96
	SF at Support	29.2201	28.4876	-2.57
Bottom Slab	BM at mid	46.100	48.8	5.53
	BM at Support	52.100	52.3	0.38
	SF at Support	34.000	34	0.00
Side Wall	BM at mid	25.900	27	4.07
	BM at Support	50.700	50.3	-0.80
	SF at Support	15.700	14.8	-6.08

Table 4. Comparison of Max BM and Max SF (70R Boggie Load and Special Vehicle)

Members	Design Values	70R Boggie	Special Values	Percentage Difference
Top Slab	BM at mid	45.079	49.43	8.80
	BM at Support	34.451	36.776	6.32
	SF at Support	24.4549	28.4876	14.16
Bottom Slab	BM at mid	39.800	48.8	18.44
	BM at Support	44.700	52.3	14.53
	SF at Support	30.400	34	10.59
Side Wall	BM at mid	21.000	27	22.22
	BM at Support	45.700	50.3	9.15
	SF at Support	15.900	14.8	-7.43

V. CONCLUSION

From the analysis it can be observed that bending moment and shear force obtained for different live load cases are different and when compared with new IRC load i.e. Special vehicle, it is found that design values for special vehicle are more as compared to other live loads such as Class A, 70R tracked vehicle, 70R wheeled vehicle and 70R boggie load. Hence, in analysis and design of underpass special vehicle shall be considered as per IRC: 6-2014 amendment 1.

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