Analysis Of Underpass RCC Bridge

Mohankar R. H.[*], Pidurkar M. D.[*], Patil P.R. [*]
[*]*Asst. Professor, Civil Engineering Deptt.,*
J L. Chaturvedi College Of Engineering, Nagpur, MH. India

Abstract

The bridges are the structure, which provides means of communication over a gap. The railway and highway crossing form artificial gaps. The bridges provided passage for the vehicular or other traffic over these bridges. The bridges built to carry railway traffic are known as railway bridges. There are some bridges which carry the highway and railway traffic both, these bridges are known as combined highway and railway bridges.

The bridges are made of timber, stone masonry, brick masonry and reinforced cement concrete, pre-stressed concrete and steel. The timber bridges are used to short span, light load and for temporary purposes. The masonry bridges are used for short span. There are various types of RCC bridges, which are suitable for different spans and different conditions. In the past the bridges were mostly built in stone masonry or timber. The present day bridges are made in RCC, Pre-stressed concrete, structural steel or composite construction of RCC and structural steel.

Bridges having very long spans are built in structural steel or pre-stress concrete whereas for moderate span bridges are constructed in RCC. Durability, economy in cost of construction and flexibility of giving derived aesthetic treatment makes concrete an ideal material for construction of bridges. Bridges made with concrete are therefore commonly recommended for highway as well as railways.

Keywords: bridge,

1. Introduction

Bridges have always figured prominently in human history. They enhance the vitality of the cities and the cultural, social and economic improvement of the areas around them. Great battles have been fought for cities and their bridges. The mobility of army at war is often affected by the availability or otherwise of bridges. Bridges are Nations lifelines and backbones in the event of war. Bridges symbolize ideals and aspirations of humanity. They span barriers that divide, bring people, communities and transportation and facilitate commerce. Bridge construction constitutes an important element in communication and is an important factor in progress of civilization.

2. History of Bridge Development

The history of development of bridge construction is closed linked with the history of human civilization. Nature fashioned the first bridge. The tree fallen accidentally across the stream was the earliest example of a beam type bridge. Similarly the natural rock arch formed by erosion of the loose soil below was the earliest forever of the arch type bridge. Likewise the creepers hanging from tree to tree gave birth to suspension bridges. The primitive man imitated nature and learned to built beam and suspension bridges. Since the primitive man was a wanderer in search of food and shelter, the first structure he built was bridges.

3. Importance of Bridge

Bridges have always figured prominently in human history. They enhance the vitality of the cities and the cultural, social and economic improvement of the areas around them. Great battles have been fought for cities and their bridges. The mobility of army at war is often affected by the availability or otherwise of bridges. Bridges are Nations lifelines and backbones in the event of war. Bridges symbolize ideals and aspirations of humanity. They span barriers that divide, bring people, communities and transportation and facilitate commerce. Bridge construction constitutes an important element in communication and is an important factor in progress of civilization.

4. Classification of Bridges

Bridges may be classified in many ways, as follows-

a. According to material of construction of superstructure as timber masonry, steel, reinforced concrete and pre-stress concrete.
b. According to form or type of superstructure as slab, beam, truss, arch or suspension bridge.
c. According to inter span relation as simple, continuous or cantilever bridge.
d. According to position of bridge floor relative to superstructure as a deck, through, half-through or suspension bridge.
e. According to method of connection of different parts of superstructure particularly for steel structure as pin connected, riveted or welded bridge.
f. According to span length as culvert (less than 8m), minor bridge (8-30m) or long span bridge (more than 30m).

5. Mathematical formulation & Loading Details

5.1 Load calculations:

For calculating imposed load Length of sleeper and Dispersion ballast are considered IRC code for calculating SF and BM. Considering broad gauge loading, main line. From Bridges rules, the dispersion of load through sleepers and ballast. For type B.G. sleeper The load under sleeper shall be assumed to be dispersed at a slope not greater than half horizontal to one vertical (1V:0.5H) and As per clause 2.3.4.2(b), distribution through RC slab when there is effective lateral transmission of shear, the load may be further distributed in a direction at right angle to the span of slab equal to ¼ spans on one side of the loaded area in the case of simply supported, fixed and continuous span.

Dispersion width =Length of sleeper +2+ (length of box/4)

Equivalent Uniformly Distributed Load (EUDLL) for BM for live load for span 8 m =1193 kN from table 4.2 for 400 mm cushion.

Coefficient of dynamic augment (CDA)

CDA=0.15+ (8/ (6+Span))

UDL on top slab = weight x CDA/ (span x Dispersion width)

5.1.1 Loads on the top of slab:

Imposed load of track structure (Considering one track) is considered from IRC code to find out

Dead load of earth fill over the box =Area x Depth X Density

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

5.1.2 Loads on sidewalls:

As per clause 5.7.1 of IRS code for substructure and Foundation

Density of soil = γ

Angle of internal friction = ϕ

Angle of friction between wall and soil (For concrete structure) (δ) =ϕ/3

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

Hence Angle of earth face with vertical (For Embedded Structure) (i) =0

Surcharge angle = 90o

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

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

5.1.3Earth pressure acting on the sidewalls:

Earth pressure due to backfill

Earth pressure center of top slab = $Ka \times \gamma \times H$

Earth pressure center of bottom slab = $Ka \times \gamma \times H$

Earth pressure due to dead load surcharge

Earth pressure acting on sidewalls:

At Top = Imposed load of track + Earth pressure on the top of slab + Live load

AT Bottom = Horizontal effect of surcharge + Earth pressure center of bottom slab

Reaction at the bottom of box

Self weight of walls = weight of top slab+ weight of side walls+ weight of bottom slab

Total reaction at bottom = self weight of box +Live load on top slab + weight of imposed load

The forces acting on the box from all directions and the boundary condition are fixed

6. Analysis of 2D Plain Frame

The values of max bending moments at mid span and at corner along with max Shear force for all the loading cases considered are tabulated below. The box type structure is analyzed as 2D model and obtained values for max bending moment and shear force.

The results is only for max value are getting during the analysis are as below.

Table 1. Max BM & Max. SF of 2D model without soil stiffness

Member of box	SF & BM for max Loading	
Top slab	SF in kN	456.33
	BM at mid span in kN-m	572.72
	BM at corner in kN-m	339.94
Bottom slab	SF in kN	259.92
	BM at mid span in kN-m	372.73
	BM at corner in kN-m	147.11
Side wall	SF in kN	79.68
	BM at mid span in kN-m	204.67
	BM at corner in kN-m	339.94

The SFD and BMD for most critical load combination considered are as shown in figure 5.15 and 5.16 respectively.

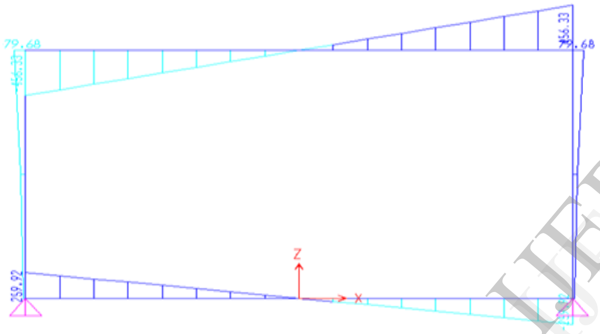

Figure 1. Shear Force Diagram

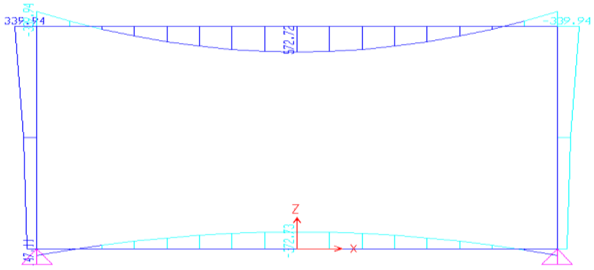

Figure 2. Bending Moment Diagram

6.1 Analysis by considering spring constant for soil stiffness

FEM model of the frame with springs considering the stiffness of the stiffness of surrounding soil.

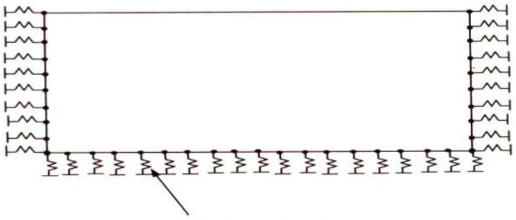
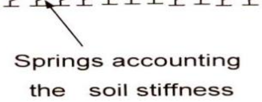

Figure 3. FEM model of the frame

The stiffness of the surrounding soil is the function of the modulus of sub grade reaction of the soil and can be calculated as fallows

Soil stiffness (K) kN/m = Modulus of sub grade
X Area in contact
Reaction (Ks) (kN/m)
with soil (m^2)

The modulus of sub-grade reaction varies with the type of soil and has specific range for each of the soil as shown in table

Table 2. Modulus of sub- grade reaction for different types of soil

Type of Soil	Modulus of sub-grade reaction (Ks) (kN/m^2)
Loose sand	4800-16000
Medium dense sand	9600-80000
Dense sand	64000-128000
Clayey medium dense sand	32000-80000
Silty medium dense sand	24000-48000

For present case, Medium dense soil has been considered with modulus of sub-grade reaction as 9600-80000 kN/m^2

A 2D frame has been analyzed by considering the value of soil stiffness is 960 kN/m^2

Table 3. Max BM & Max. SF of 2D model with soil stiffness

Member of box	SF & BM for max Loading with soil stiffness 960kN/m	
Top slab	SF in kN	456.33
	BM at mid span in kN-m	567.35
	BM at corner in kN-m	345.31
Bottom slab	SF in kN	245.33
	BM at mid span in kN-m	386.82
	BM at corner in kN-m	135.03
Side wall	SF in kN	87.79
	BM at mid span in kN-m	192.45
	BM at corner in kN-m	345.31

4. Results and discussions

The analysis of 2-D frame model is carried out for without soil stiffness and with soil stiffness (960 kN/m).

Table 4. Comparison of 2D frame model without soil stiffness and soil stiffness

Member of box	Parameters	2D Model Without soil stiffness	2D Model With soil stiffness	% Diff.
Top Slab	Max SF	456.33	456.33	0
	BM at Mid Span	572.72	567.35	5.37
	BM at corner	339.94	345.31	-5.37
Bottom Slab	Max SF	259.92	245.33	14.59
	BM at Mid Span	372.73	386.82	-14.09
	BM at corner	147.11	135.03	12.08
Side walls	Max SF	79.68	87.79	-8.11
	BM at Mid Span	204.67	192.45	12.22
	BM at corner	339.94	345.31	-5.37

5. Conclusion

From the analysis of 2-D frame model without soil stiffness and with soil stiffness the results for BM at mid span are differ for top slab 5.3%, for bottom slab 14.0% and for side slab 12.2%. And for SF in Top slab it is same but bottom slab it is 14% less, in side wall it increased by 8.11%

6. References

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