Study of Deck Bridge Culverts Under Different Mix Proportions And Span Configurations

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Abstract- *Culverts are required to be provided under earth embankment for crossing of water course like streams, Nallas etc. across the embankment, as road embankment cannot be allowed to obstruct the natural water way. This paper deals with the study of design parameters of box culverts like effect of co-efficient of earth pressure, angle of dispersion of live load and depth of cushion provided on top slab of box culverts. Present study has been performed to know how design of IRC-112 differs from IRC-21 and an attempt is made to study undefined parameters of IRC: 112- 2011 such as span to depth (L/d) ratio. Present study is performed on design of RC slab culvert using "working stress method" using "IRC: 21-2000 and limit state method using IRC: 112-2011" code specifications. It is observed that in working stress method, the allowable L/d ratio is 13 and in limit state method, the L/d ratio of 20 is most preferable. This paper deals with the study of design parameters of box culverts like effect of co-efficient of earth pressure, angle of dispersion of live load and depth of cushion provided on top slab of box culverts. This paper presents an overview of the design construction, and laboratory and field testing of a box culvert bridge reinforced with glass FRP (GFRP) bars. Here an effort has been made to shows the economic and effective design can be achieved by doing finite element analysis element analysis of a box culvert whose concept can be used for large structural design as well.*

Keywords: Analysis, investigation, cushion, box culverts

I. INTRODUCTION

A culvert is a structure providing passage over an obstacle without closing the way beneath. An opening through an embankment for the conveyance of water by mean of pipe or an enclosed channel. It is a transverse and totally enclosed drain under a road or railway.

It is well known that roads are generally constructed in embankment which comes in the way of natural flow of storm water (from existing drainage channels). As, such flow cannot be obstructed and some kind of cross Drainage works are required to be provided to allow Water to pass across the embankment. The structures to accomplish such flow across the road are called culverts, small and major bridges depending on their span which in turn depends on the discharge. The culvert covers up to waterways of 6 m (IRC: 5-1998) and can mainly be of two types, namely, box or slab. The box is one which has its top and bottom slabs monolithically connected to the vertical walls. In case of a slab culvert the two slabs is supported over the vertical walls (abutments/ piers) but has no monolithic connection between them. A box culvert can have more than single cell and can be placed such that the top slab is almost at road level and there is no cushion. A box can also be placed within the embankment where top slab is few meters below the road surface and such boxes are termed with cushion.

The size of box and the invert level depend on the Hydraulic requirements governed by hydraulic designs. The height of cushion is governed by the road profile at the location of the culvert. This Paper is devoted to box culverts constructed in reinforced concrete having one, two or three cells and varying cushion including no cushion. The main emphasis is on the methodology of design which naturally covers the type of loading as per relevant IRC Codes and their combination to produce the worst effect for a safe structure. The IS: 1893-1984[2](Clause 6.1.3) provide that box culverts need not be designed for earthquake forces, hence no earthquake forces are considered. Although box of maximum three cells has been discussed but in practice a box culvert can have more cells depending on the requirements at site.

II. METHODOLOGY

Analysis of Box Culvert : Analysis by Staad Pro

Analysis of box culvert has done by Staad Pro v8i in linear static analysis.

- First we have decide the span of box culvert in meter and length should be center to center.
- Then we have to create the new model in space and define the nodes of box culver in Staad.
- After that we have to assign the support condition and then assign the materials properties.

- Then after applied loading like dead load and live load and different combination of load for culvert

MODELING AND ANALYSIS

4.2 Analysis and Design of Box Culvert For Water Pressure and Surcharge Pressure for M25 Grade of Concrete

4.2.1 Analysis of Box Culvert For Water Pressure (M25)

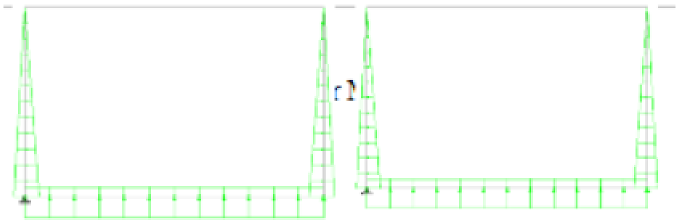


Fig 4.1: Design Data for Box Culvert for Water Pressure (M25)

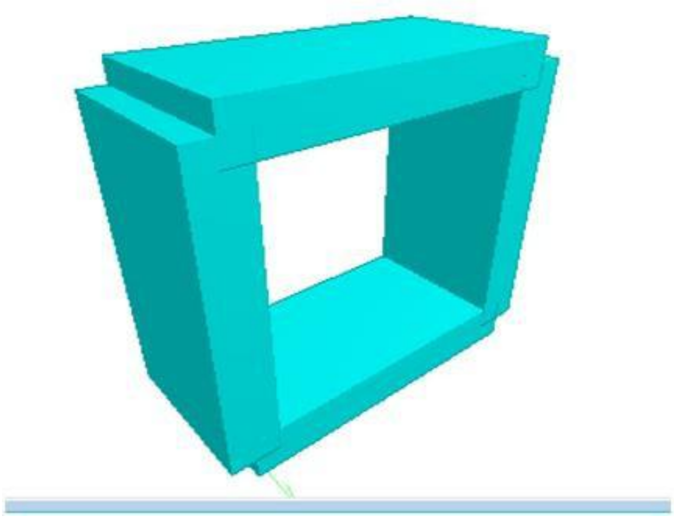


Fig 3.2: 3D model of box culvert in Staad Pro Earth pressure

Earth can exert pressure as active and passive. Minimum is active and maximum is passive earth pressure and the median is rest. The coefficient of earth pressure is calculated as shown below and the angle of repose is taken as 30°. Earth pressure due to Earth from side in lateral direction Earth Pressure due to Side earth from lateral direction = Ka*Unit Weight of Soil*Height of wall Surcharge is calculated as 1.2m height of soil rest on both sides of the box culvert. Earth Pressure due to Surcharge from top and live load effect on side walls. i.e Earth Pressure due to surcharge = Ka*q.

(a) Staad Loading for Water Pressure.

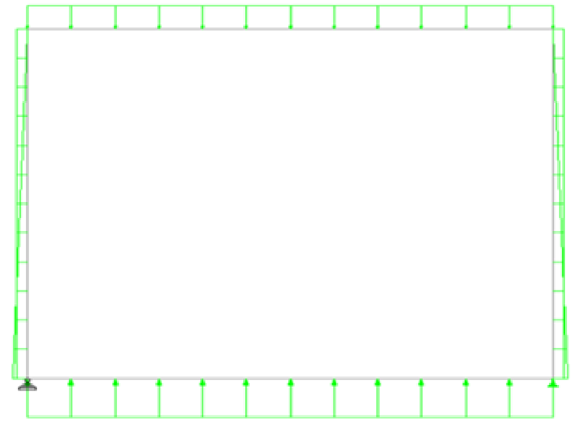


Figure 4.1 shows the excel sheet of box culvert for M25 grade of concrete. The different inputs data is shown in the figure.

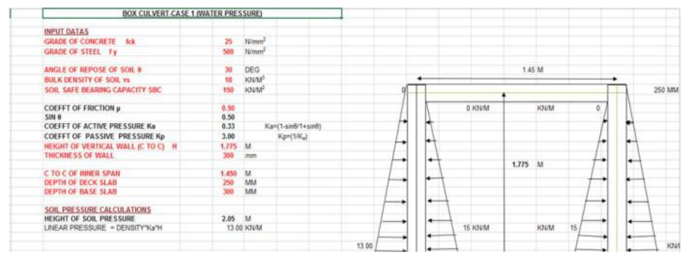


Figure 4.2shows the staad model of box culvert for M25 grade of concrete. The different inputs dimension is shown in the figure.

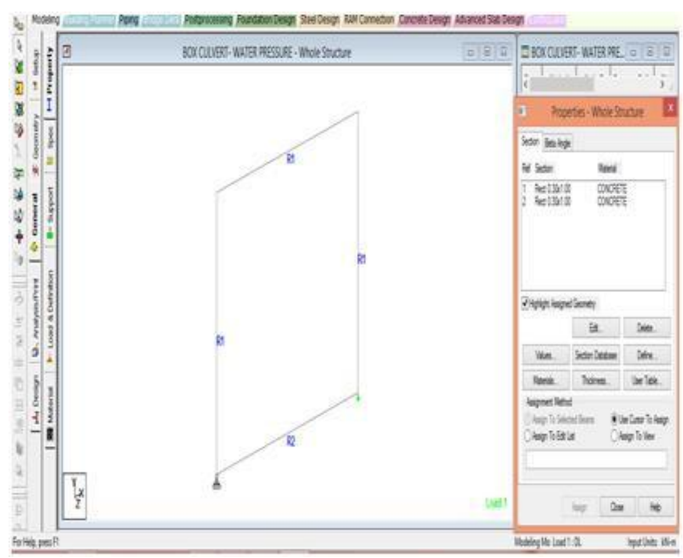


Fig 4.3: C/S of Box Culvert in Staad Pro (M25)

Figure 4.3shows the staad model of box culvert for M25 grade of concrete. The different properties of section is shown in the figure.

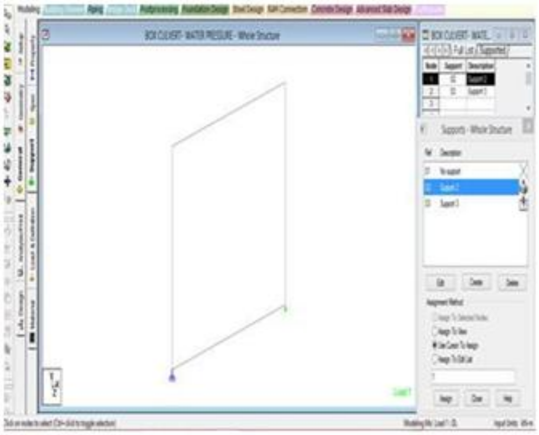


Fig 4.4: Support Condition of Box Culvert in Staad Pro (M25)

Figure 4.4shows the staad model of box culvert for M25 grade of concrete. The different supports is shown in the figure. One end is fixed and other is enforced support.

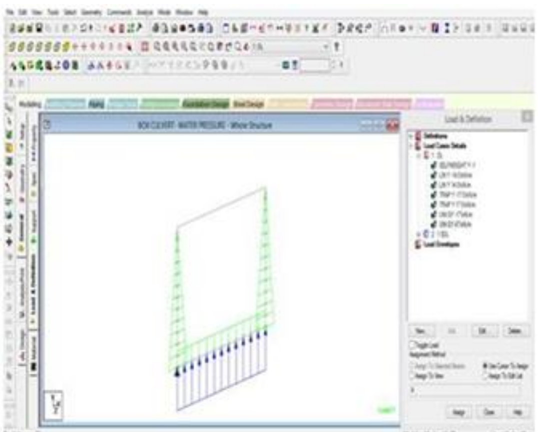


Fig 4.5: Loading Condition of Box Culvert in Staad Pro for First Case (M25)

Figure 4.5 shows the staad model of box culvert for M25 grade of concrete. The different different loading of section is shown in the figure. This diagram is showing the different loading for water pressure.

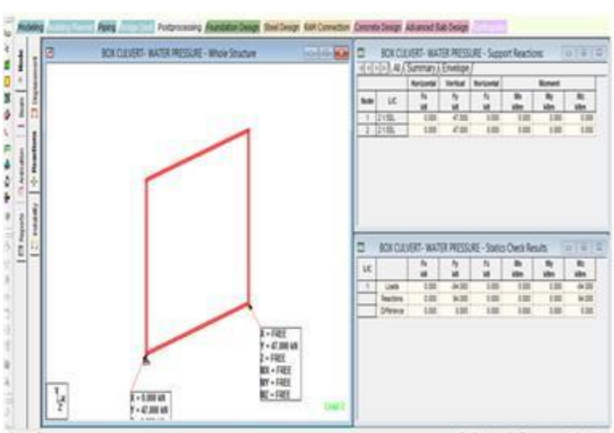


Fig 4.6: Reaction on Box Culvert in Staad Pro for First Case (M25)

Figure 4.6 shows the staad model of box culvert for M25 grade of concrete. Staad model shows the reaction values in the section for water pressure. This value will be neutralize after that

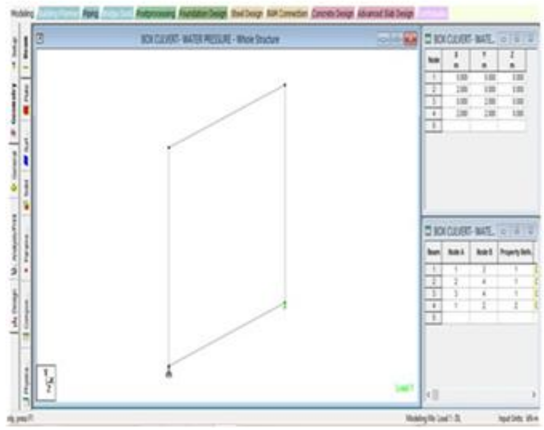


Fig 4.7: Bending Moment on Box Culvert in Staad Pro for First Case (M25)

Figure 4.7 shows the staad model of box culvert for M25 grade of concrete. Staad model shows the bending moments values for section for different section of box culvert like deck slab, base slab and vertical wall.

4.2.2 Analysis of Box Culvert For Surcharge Pressure (M25)

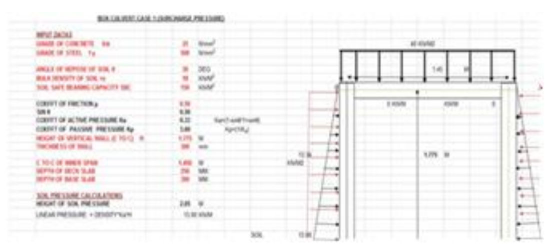


Fig 4.8: Design Data for Box Culvert for Surcharge Pressure (M25)

Figure 4.8 shows the excel sheet of box culvert for M25 grade of concrete. The different inputs data is shown in the figure.

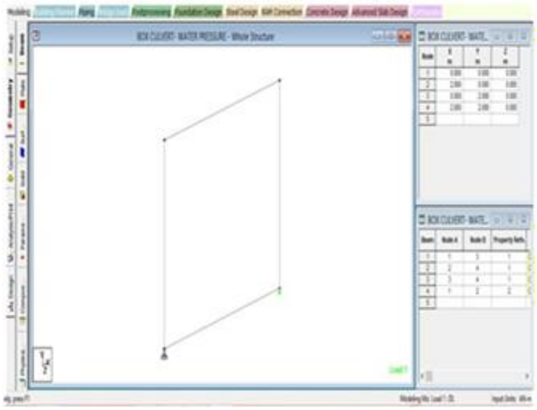


Fig 4.9: Dimension of Box Culvert for Different Thickness of deck slab in Staad Pro (M25)

Figure 4.9shows the staad model of box culvert for M25 grade of concrete. The different inputs dimension is shown in the figure.

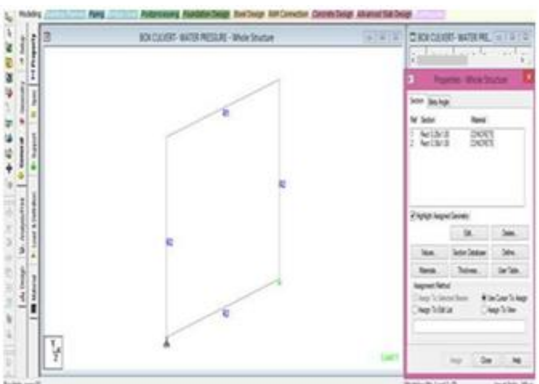


Fig 4.10: C/S of Box Culvert for Different Thickness of deck slab in Staad Pro (M25)

Figure 4.10shows the staad model of box culvert for M25 grade of concrete. The different properties of section is shown in the figure.

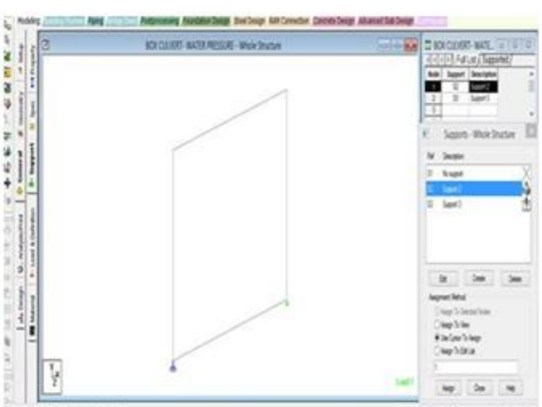


Fig 4.11: Support of Box Culvert for Different Thickness of deck slab in Staad Pro (M25)

Figure 4.11shows the staad model of box culvert for M25 grade of concrete. The different supports is shown in the figure. One end is fixed and other is enforced support.

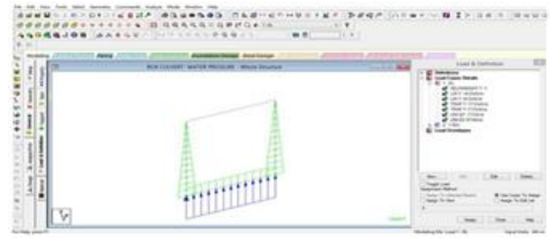


Fig 4.12: Loading Condition of Box Culvert for Different Thickness of deck slab in Staad Pro (M25)

Figure 4.12 shows the staad model of box culvert for M25 grade of concrete. The different different loading of section is shown in the figure. This diagram is showing the different loading for water pressure.

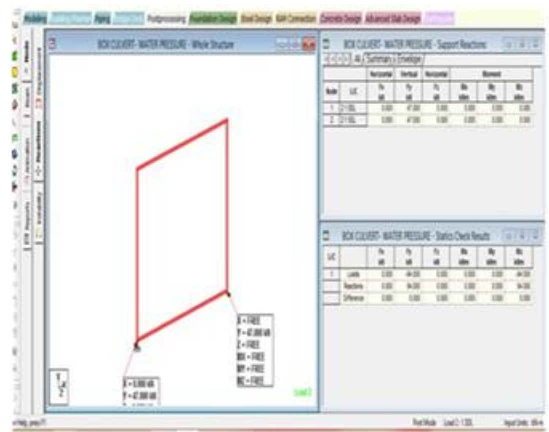


Fig 4.13: Reaction of Box Culvert for Different Thickness of deck slab in Staad Pro (M25)

Figure 4.13 shows the staad model of box culvert for M25 grade of concrete. Staad model shows the reaction values in the section for water pressure. This value will be neutralize after that.

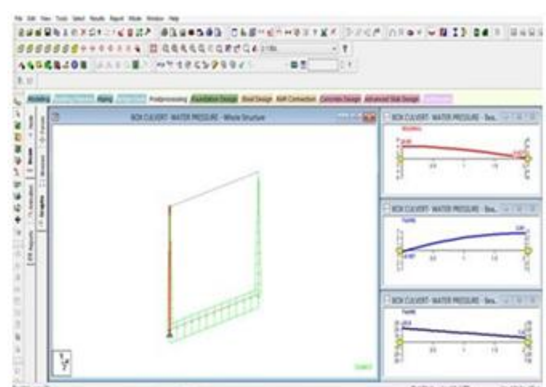


Fig 4.13: Reaction of Box Culvert for Different Thickness of deck slab in Staad Pro (M25)

Figure 4.13 shows the staad model of box culvert for M25 grade of concrete. Staad model shows the bending moments values for section for different section of box culvert like deck slab, base slab and vertical wall.

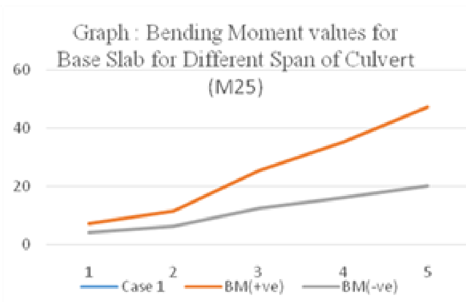
III. RESULTS AND DISCUSSION

SF and BM values for Different Span of Culvert (M25)

SPAN (m)	CASES	BASE SLAB	DECK SLAB				VERTICLE WALL		
		BM(+ve)	BM(-ve)	SF Max	BM(+ve)	BM(-ve)	SF Max	BM Max	SF Max
1	Case 1	7.19	4.06	22.50	0.44	3.31	7.50	4.06	2.81
	Case 2	25.20	21.70	93.80	15.90	19.70	17.30	21.70	36.70
2	Case 1	11.50	6.08	28.10	0.43	5.43	9.38	6.47	4.35
	Case 2	25.80	23.10	78.10	16.90	20.20	59.40	23.10	33.10
3	Case 1	25.50	12.50	50.60	0.33	12.30	16.90	14.80	9.49
	Case 2	54.70	50.80	141.0	37.20	43.00	107.0	50.80	64.20
4	Case 1	35.40	16.30	59.10	0.18	17.40	19.70	21.20	12.60
	Case 2	73.10	70.50	164.0	51.60	57.50	125.0	70.40	4.29
5	Case 1	47.30	20.20	67.50	0.00	23.70	22.50	29.30	16.30
6	Case 2	93.80	93.70	188.0	69.70	73.80	143.0	93.70	97.80

Above table 4.1 shows the values of bending moment and shear force values for different component of culvert for M25 grade of concrete. This tables shows the different span condition. Different component is deck slab, base slab and vertical wall. There are two case for design.

Case 1. Water Pressure Case 2. Surcharge Pressure



IV. RESULTS AND DISCUSSION

Table 4.1:- SF and BM values for Different Span of Culvert (M25)

SPAN (m)	CASES	BASE SLAB			DECK SLAB			VERTICLE WALL	
		3	BM(-ve)	SF Max	BM(+ve)	BM(-ve)	SF Max	BM Max	SF Max
2	Case 1	7.19	4.06	22.50	0.44	3.31	7.50	4.06	2.81
	Case 2	25.20	21.70	93.80	15.90	19.70	17.30	21.70	36.70
2.5	Case 1	11.50	6.08	28.10	0.43	5.43	9.38	6.47	4.35
	Case 2	25.80	23.10	78.10	16.90	20.20	59.40	23.10	33.10
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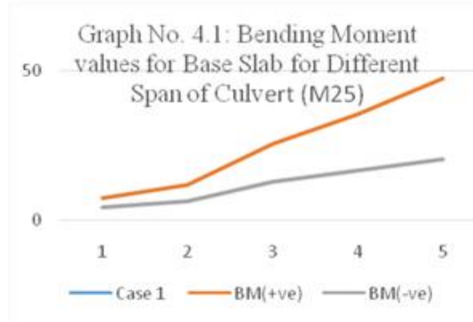

Above table 4.1 shows the values of bending moment and shear force values for different component of culvert for M25 grade of concrete. This tables shows the different span condition. Different component is deck slab, base slab and vertical wall. There are two case for design.

V. CONCLUSION

1. We have seen that if we decrease the thickness of deck slab then the moment is decreasing as compare to same thickness.
2. When the top slab carries the dead load and live load and culvert is empty that case is unnecessary for Design purpose.
3. When the top slab carries the dead load and live load and culvert full of empty that case is very important aspect as per Design Purpose.
4. When the sides of the culvert do not carry the live load and the culvert is full that also important aspect as per Design Prospective.
5. As compare to the small bridge, Culvert are many advantage in small scale bridge modern time.
6. For short span bridges section of bridge is not economical in that Case Box culvert are very economical.
7. For short span bridges section culvert is most economical as compare to bridge having small section.
8. For short span, culvert has more strength as compare to bridges as compare to small scale bridges.
9. Widening of carriage way in culvert is easy as compare to bridges, due to it's cost effectiveness.

VI. ACKNOWLEDGEMENTS

In Future, further work can be done in this project on culvert for different thickness of different parts of culvert likes as deck slab, vertical wall and base slab.

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