Comparative Analysis and Design of Deck Bridge Culvert for Different Mix Design and Span using STAAD pro

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Abstract:
Culverts are the structures which are used when the path of water in the natural stream crosses roads, railway lines, flyovers etc. They are normally cheaper than bridges, which make them the natural stream passes through channels. In this work, the review of various authors and their views in the design and analysis of culvert with software approach and comparison between software and manual approach has shown. The IS standard requirements in the design manual for roads and bridges (IRC-6-2000, IS 21-2000) is used in the structural designing of concrete culverts. In this paper study about the different classes of IRC loadings and their effect on without and with cushioning conditions imposed on culvert. The pressure cases are then checked for both with cushioning and without cushioning loading cases. The structure designing includes the considerations of pressure cases (empty, Full, surcharge load) and factors such as Impact load, Braking force, Dispersal of load through fill, Effective width, Coefficients of earth pressure, Live load etc. The structural elements are designed to withstand the maximum bending moments and shear forces respectively. In the present study, this paper provides full discussion on the provisions in the codes, considerations and justifications of all the above aspects of design.

Keywords: Culvert, Design Coefficients, Loadings Types, Moment, Shear, Pressure Cases, Staad pro.

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 or electrical cables 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 come 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 its size and the invert level depend on the Hydraulic requirements governed by hydraulic design. The height of cushion is governed by the road profile at the location of the culvert. [1]

This dissertation is devoted to culvert constructed in Reinforced Cement Concrete (RCC) 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 (Clause 6.1.3) provide that culverts need not be designed for earthquake forces, hence no earthquake forces are considered. Although of maximum three cells has been discussed but in practice a culvert can have more cells depending on the requirements at site. [1]

Types of Culverts

The types of culvert generally used for various purposes with its advantages and disadvantages are given below.

Pipe Culvert

It is a commonly used culvert having different shapes such as circular, elliptical and pipe arch. These sizes depend on the site conditions and restrains. This culvert is economical and can be constructed of any desired strength by proper mix design and reinforcement and is shown in figure no. 1.

The main advantage of pipe culvert is given below

- Any desired strength is achievable by proper mix design, thickness, and reinforcement.
- Economical.
- Easy to Install.
- Pipe culvert can withhold high tensile stresses and compressive stresses.
- As pipe culverts don't create barriers in the path, they provide a continuous surface over the pipe.

The main disadvantage of pipe culvert is that it can be easily corroded at the crown because of bacteria/organic matter and release of harmful gas, which is known as Crown corrosion.

Fig. 1 Pipe Culvert

Box Culvert

It is one which has its top and bottom slabs monolithically connected to the vertical walls having a rigid frame structure and easy to construct. It is commonly used in India where the soil below is weak due to non-perennial streams as the bottom slab of this culvert reduces the pressure on the soil and shown in figure no. 2.

The advantage of this type of culvert is given below

- The box culvert is a rigid frame structure and very simple in construction
- It is Suitable for non-perennial streams where scrub depth is not significant, but the soil is weak.
- The bottom slab of the box culvert reduces pressure on the soil.
- Box culverts are economical due to their rigidity and monolithic action and separate foundations are not required.
- It is used in special cases, weak foundation.

Fig.2 Box Culvert

Bridge Culvert

This culvert serves dual purpose, it acts both as bridge and a culvert. Generally, rectangular, bridge culverts are constructed on rivers and canals. A foundation is laid under the ground level and pavement surface is laid on top of the series of culverts. This type of culverts is most expensive and shown in figure no.3.

Following are the main advantages of bridge culvert:

- Extension of the network by acting as a repeater
- Very strong
- Allows traffic to pass on it
- Highly strong foundation.

Fig. 3 Bridge Culvert

Arch Culvert

It is constructed of metal, stone masonry, concrete and reinforced cement concrete. Generally, it is regarded as low-profile culvert, and it maintains the natural integrity of the wash bed.

The advantages of using arch culverts over traditional box culverts and pipe culverts are as follows:

- Cost savings
- Accelerated construction schedule
- Greater hydraulic efficiency
- Pleasing aesthetics
- Design-build advantage

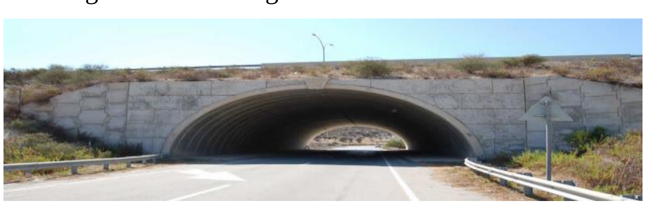


Fig. 4 Arch Culvert

II. LITERATURE REVIEW

A literature review is an evaluative report of in formation found in the literature related to your selected area of study. The review should describe, summaries, evaluate and clarify this literature. The review should provide the reader with a picture of the state of knowledge in the subject.

In the following, a summary of the article and paper found in the literature, about the irregularities, seismic analysis of regular and irregular structures and some of the project carried out with this type of seismic analysis is presented.

Neha Kolate, Molly Mathew, Snehal Mali (2014)

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. The culverts are also required to balance the flood water on both sides of earth embankment to reduce the flood level on one side of road thereby decreasing the water head consequently reducing the flood menace. This paper deals with study of some of the design parameters of box culverts like angle of dispersion or effective width of live load, effect of earth pressure and depth of cushion provided on top slab of box culverts. Depth of cushion, coefficient of earth pressure for lateral pressures on walls, width or angle of dispersion for live loads on box without cushion and with cushion for structural deformations are important items. [2]

Shivanand Tenagi, R. Shreedhar (2015)

Reinforced concrete slab type decks are often referred to as culverts and are commonly used for small spans. Slab culverts are important hydraulic structures used in the construction of highway roads. In India, till now culverts are designed and constructed according to Indian road congress guidelines as per IRC: 21-2000 code in which working stress method is used. Recently Indian road congress has introduced another code IRC: 112-2011 for design of prestress and RCC bridges using limit state method. In regards to this, 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. Quantity of materials required in limit state method is compared with quantity of material required in working stress method and it is found that concrete can be saved up to 30 to 35% using limit state method. [3]

Virendrasinh.D Chauhan, Gunvant Solanki, Minu Tressa (2017)

As the numbers of bridges comes up it has become healthy to provide box type multi-barrel skew culvert where traffic moves on the top of continuous slab and water flows through barrels underneath it. Present situation of traffic requirements demand straight alignment of road in view of the fast traffic and this in turn necessities the use of skew crossings. By providing this type of alternatives, bridge span is in direction of road, we can directly provide skew culvert. on

Ajay R Polra, Prof. S. P. Chandresha, Dr. K. B. Parikh (2017)

A Reinforced concrete box culvert consists of bottom slab, top slab and two vertical side walls built monolithically and form a closed rectangular or square single cell. Multiple cell box culverts are obtained by inserting one or more intermediate vertical walls. If the discharge in a stream is large, multiple cell reinforced box culverts are ideal bridge structure. If the bearing capacity of the soil is low, the single box culvert becomes uneconomical because it requires higher thickness of the slabs and walls. In such cases, more than one box can be constructed side by side monolithically. 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. Coefficient of earth pressure for lateral pressure on walls, depth of cushion, width or angle of dispersion for live loads on box without cushion and with cushion for structural deformation are important items for designing the box culvert. [5]

John W. van de Lindt, Alexander J. Stone, and Suren Chen (2011)

The authors would like to thank all study panel members including Aziz Khan (Project Manager), MahmoodHasan, Trever Wang, An Tran, Matt Greer, and Teddy Meshesha for their support and advice during the project. The second author would also like to thank the American Institute of Steel Construction (AISC) – Rocky Mountain Region, for providing a Graduate Fellowship, which provided funding for the latter portion of his participation in this study. [7]

Ketan Kishor Sahu, Shraddha Sharma (2015)

A basic assumption in analysis of the box culvert is the displacement and forces are uniform in the longitudinal direction of the culvert. This assumption holds true certain type of loadings than others. For example soil loading applied to the surface or pavement maybe considered as uniform in the longitudinal direction. Analysis of box culvert done by stiffness matrix method. Single cell box structure is assumed as rigid frame structure consisting of top slab, bottom slab and two vertical side walls which forms a closed rigid box frame. It is assumed that structure is externally determinate. This paper is devoted to box culvert construction in reinforced concrete having one, two or three cells and varying their operating conditions and analysis for their design. [8]

Tarek Alkhrdaji, Antonio Nanni (2001)

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. The bridge was constructed to replace a bridge that was built in the early 1980s and consisted of three concrete-incased corrugated steel pipes. Due to excessive corrosion of the steel pipes, the original bridge became unsafe to operate. The new box culvert units were designed for maximum forces determined in accordance with AASHTO design guidelines. A concrete precast fabricated the box culvert units that were reinforced entirely with GFRP bars pre-bent and cut to size by the manufacturer. Two specimens were tested in the lab to verify their design and performance. [9]

Saurav, Ishaan Pandey (2017)

There are several researches already have been done on behavior of reinforced concrete (RC) box culvert in past with different conditions of loads. The design and analysis of box culvert is a complex task. The present era offers the finite element analysis of 3D model of structures, making it easier through software. The conventional methods have been used extensively for design but the use of finite element methods (FEM) has not been so popular yet. Finite element analysis of box culvert for parametric studies has been carries out, even for different aspects ratio. 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. [10]

Mathematical Modelling

Modelling and Design

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

Analysis of Box Culvert For Water Pressure (M25)

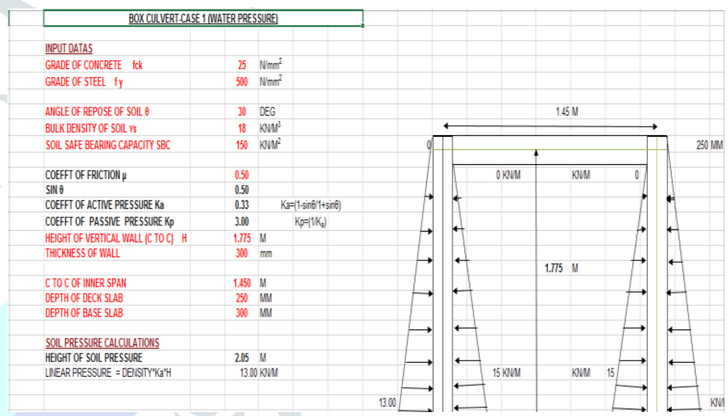


Fig. 5 Design Data for Box Culvert for Water Pressure (M25)

Figure 5 shows the excel sheet of box culvert for M25 grade of concrete. The different inputs data is shown in the figure.

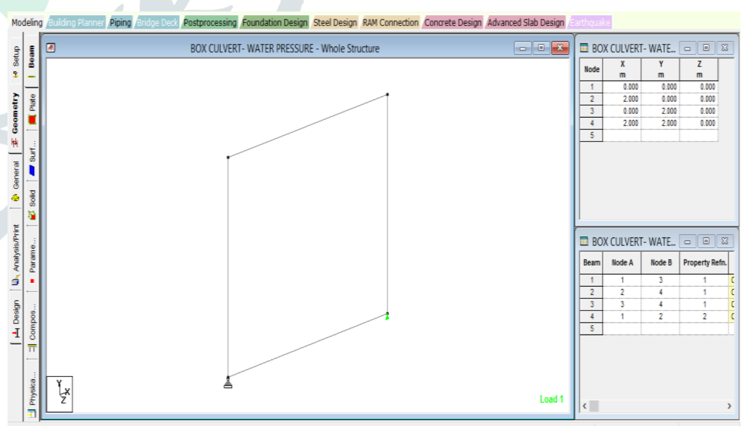


Fig. 6 Dimension of Box Culvert (M25)

Figure 6 shows the staad model of box culvert for M25 grade of concrete. The different inputs dimension is shown in the figure.

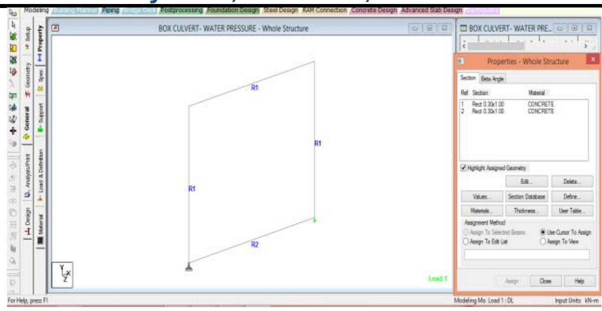


Fig. 7 C/S of Box Culvert in Staad Pro (M25)

Figure 7 shows the staad model of box culvert for M25 grade of concrete. The different properties of section is shown in the figure.

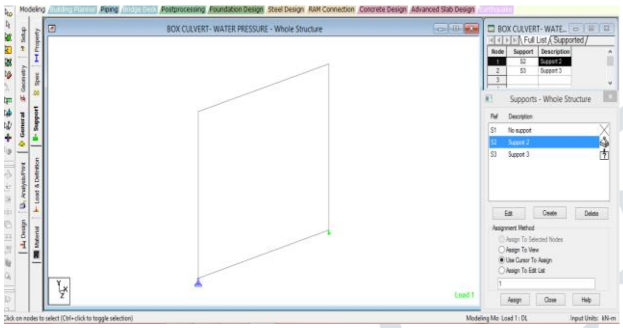


Fig. 8 Support Condition of Box Culvert in Staad Pro (M25)

Figure 8 shows 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.

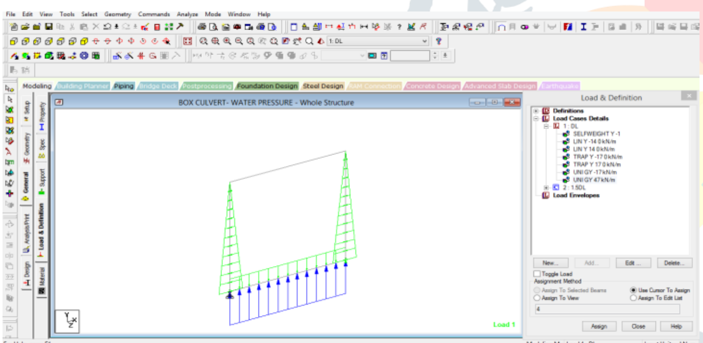


Fig. 9 Loading Condition of Box Culvert in Staad Pro for First Case (M25)

Figure 9 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.

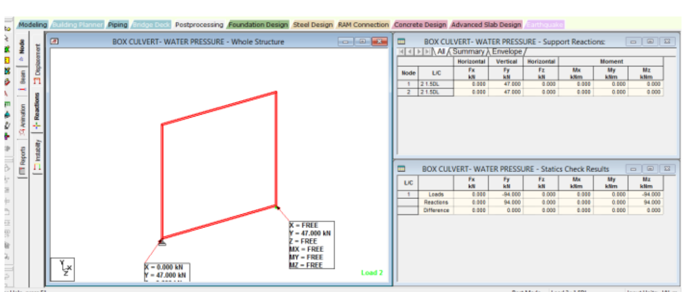


Fig. 10 Reaction on Box Culvert in Staad Pro for First Case (M25)

Figure 10 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.

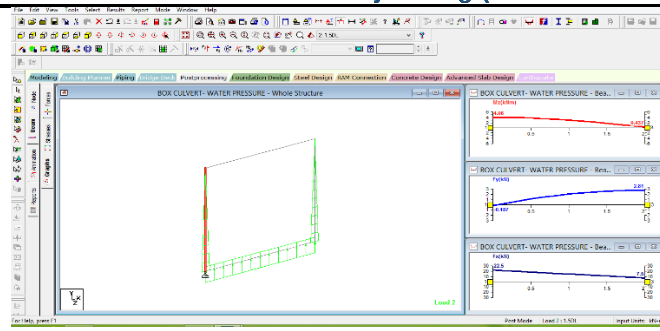


Fig. 11 Bending Moment on Box Culvert in Staad Pro for First Case (M25)

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.

III. METHODOLOGY

1 Methodology

A box culvert is to be designed to remain safe for the following cases:

Case I. When the top slab carries surcharge on the top slab and soil pressure.

Case II. When the culvert has water pressure acting against it walls.

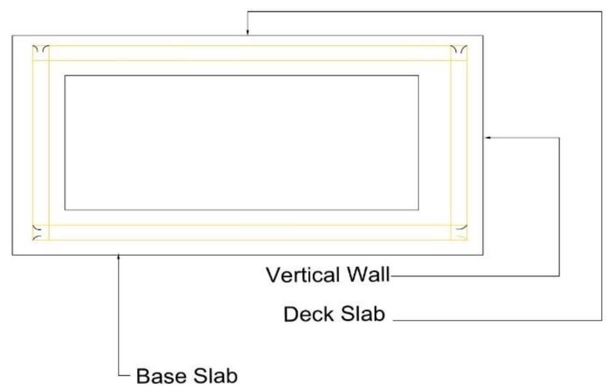


Fig 3.1:- Box culvert and its different parts

Analysis

Linear Static Analysis

A linear static analysis is an analysis where a linear relation holds between applied forces and displacements. In practice, this is applicable to structural problems where stresses remains in the linear elastic range of the used material. It can be done by Staad Pro software. In linear static analysis stiffness matrix is constant.

Nonlinear Analysis

A nonlinear analysis is an analysis where a nonlinear relation holds between applied forces and displacements. Nonlinear effects can originate from geometrical nonlinearity's (i.s. large deformations), materials nonlinearity's and contact. In nonlinear analysis stiffness matrix is not constant.

Overview of Staad Pro V8i

STAAD or (STAAD.Pro) is a structural analysis and design software application originally developed by Research Engineers International in 1997. In late 2005, Research Engineers International was bought by Bentley Systems.

It can make use of various forms of analysis from the traditional static analysis to more recent analysis methods like p-delta analysis, geometric non-linear analysis, Pushover analysis (Static-Non Linear Analysis) or a buckling analysis. It can also make use of various forms of dynamic analysis methods from time history analysis to response spectrum analysis. The response spectrum analysis feature is supported for both user defined spectra as well as a number of international code specified spectra.

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

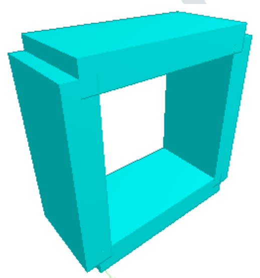


Fig 3.2: 3D model of box culvert in Staad Pro

Loads on Box Culverts

Dead Load

Box Culverts are subjected to dead load comprising of self-weight of top and bottom slab of the culvert and two side walls of the structure. Super imposed dead load consisting of rail weigh, sleeper weight, ballast cushion and formation layer. Theses loads are applied on the transverse beams in grillage analysis by using effective area method. Directly applied on the top slab in Finite element method. Self-weight is calculated based on clear dimensions of the culvert and thickness of the culvert. Super imposed dead load is calculated from IRS Standards and Specifications code of practice.

Live load

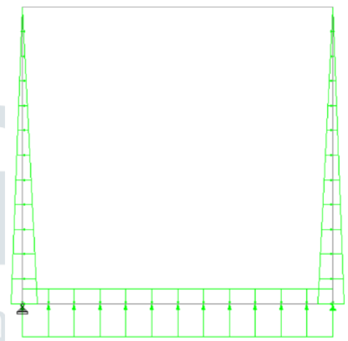
Live load on culvert is vehicular loading. The vehicular live load consists set of wheel loads moving on top slab of culvert. These loads are distributed through sleepers and ballast cushion which is on top slab of the culvert. For that loads we are calculating the results. Indian Railway Standards (IRS) recommends different types of loading. Here, we considering the broad gauge of 1676mm width of rails. For broad gauge IRS given two types of loading. One is 25t Loading – 2008 and another one is DFC Loading (32.5t axle load). In 25t loading maximum axle load is 245.2 KN and train weight of 91.53 KN/m and in 32.5t loading maximum axle load is 245.25 KN and train weight of 118.93 KN/m. In this paper we study the structural responses by applying 25t loading – 2008

Earth pressure

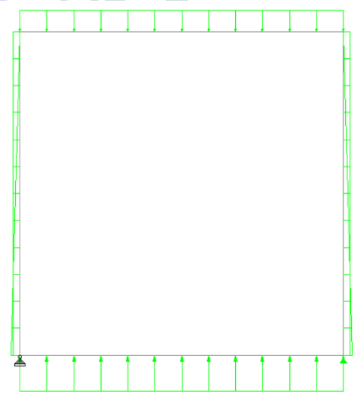
Earth can exert pressure as active and passive. Minimum is active and maximum is passive earth pressure and the median is rest. The coefficient of earth pressure is calculated as shown below and the angle of repose is taken as 30°. Earth pressure due to Earth from side in lateral direction Earth Pressure 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

Design of Box Culvert

As stated earlier, the analysis is done in Staad Pro and the snaps from the software are shown in figure no. 3.3 and figure no. 3.4.



(a)



(b)

Figure No. 3.3:- (a) Staad Loading for Water Pressure. (b) Staad Loading for Surcharge.

IV. RESULT & DISSCUSION

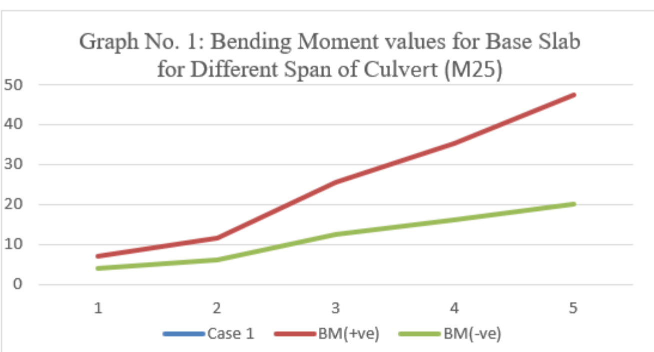
Table 1: SF and BM values for Different Span of Culvert (M25)

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
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
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
3.5	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
4	Case 1	47.30	20.20	67.50	0.00	23.70	22.50	29.30	16.30
	Case 2	93.80	93.70	188.0	69.70	73.80	143.0	93.70	97.80

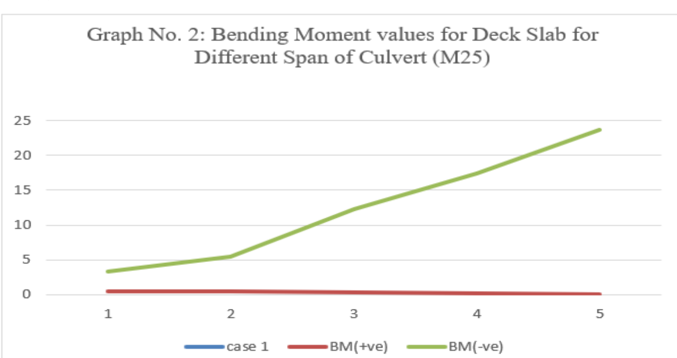
Above table 4.1 shows the values of bending moment and shear force values for different component of culvert for M25 grade of concrete. This tables shows the different span condition. Different component is deck slab, base slab and vertical wall. There are two case for design.

Case 1. Water Pressure

Case 2. Surcharge Pressure

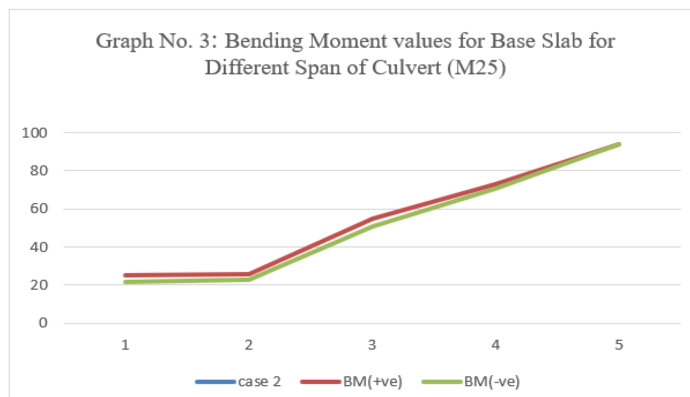


Graph No. 1 shows the Bending Moment values for Base Slab for Different Span of Culvert for water pressure that is case first. Two lines shows that one line is for positive bending moment and other is for negative bending moment. Grade of concrete used is M25.



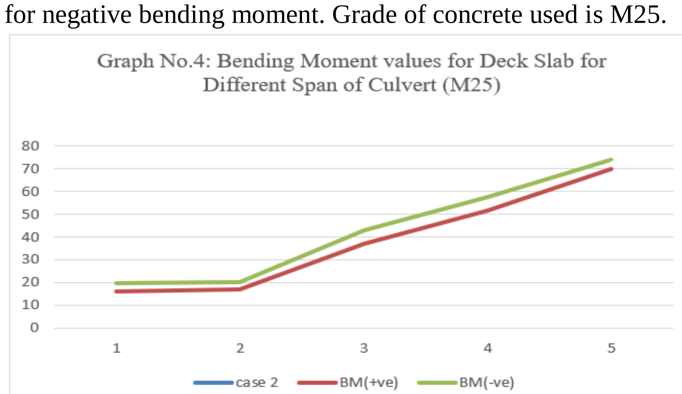
Graph No. 2 shows the Bending Moment values for Deck Slab for Different Span of Culvert for water pressure that is case first.

Two lines shows that one line is for positive bending moment and other is for negative bending moment. Grade of concrete used is



Graph No. 3 shows the Bending Moment values for Base Slab for Different Span of Culvert for water pressure that is case second. Two lines shows that one line is for positive bending moment and other is

for negative bending moment. Grade of concrete used is M25.

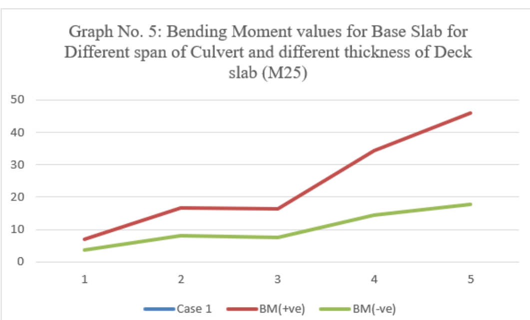


Graph No. 4 shows the Bending Moment values for Deck Slab for Different Span of Culvert for water pressure that is case second. Two lines shows that one line is for positive bending moment and other is for negative bending moment. Grade of concrete used is M25.

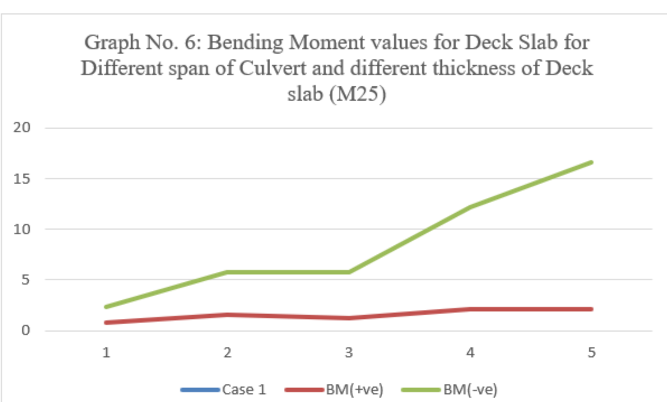
Table 2: SF and BM values for Different span of Culvert and different thickness of Deck slab (M25)

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
2	Case 1	6.90	3.72	21.30	0.79	2.33	6.25	3.79	2.55
	Case 2	16.60	14.00	61.30	11.90	11.20	46.30	14.00	23.60
2.5	Case 1	16.60	8.29	39.80	1.59	5.73	11.70	9.31	5.96
	Case 2	25.50	23.30	76.60	22.30	3.64	32.00	22.30	32.00
3	Case 1	16.40	7.54	31.90	1.29	5.74	9.38	9.55	5.71
	Case 2	54.20	49.20	141.00	41.30	36.70	104.0	49.20	62.30
3.5	Case 1	34.30	14.50	55.80	2.15	12.20	16.40	20.90	11.60
	Case 2	72.40	68.30	161.00	56.90	49.30	121.0	68.30	78.10
4	Case 1	45.90	17.80	63.80	2.17	16.60	18.80	29.30	15.20
	Case 2	61.90	60.60	123.00	50.20	42.30	92.50	60.60	63.70

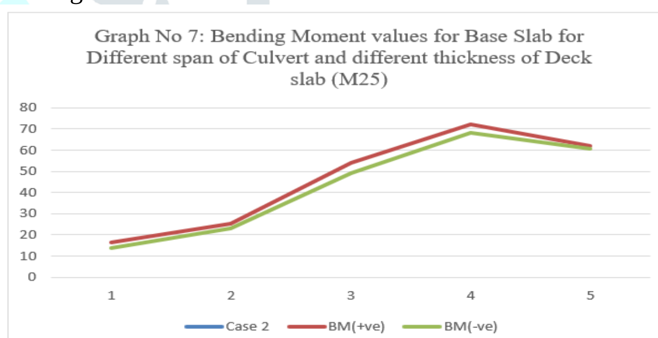
Above table 2 shows the values of bending moment and shear force values for different component of culvert for M25 grade of concrete. This tables shows the different span condition and different thickness of deck slab . Different component is deck slab, base slab and vertical wall. There are two case for design.
Case 1. Water Pressure
Case 2. Surcharge Pressure



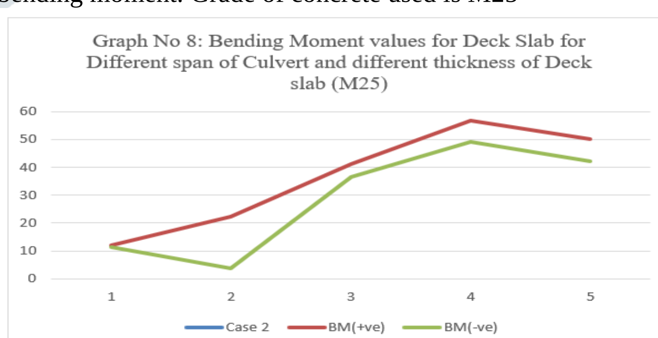
Graph No. 5 shows the Bending Moment values for Base Slab for Different Span of Culvert and different thickness of deck slab for water pressure that is case first. Two lines shows that one line is for positive bending moment and other is for negative bending moment. Grade of concrete used is M25



Graph No. 6 shows the Bending Moment values for Deck Slab for Different Span of Culvert and Different thickness of Deck slab for water pressure that is case first. Two lines shows that one line is for positive bending moment and other is for negative bending moment. Grade of concrete used is M25.



Graph No. 7 shows the Bending Moment values for Base Slab for Different Span of Culvert and Different thickness of Deck slab for water pressure that is case second. Two lines shows that one line is for positive bending moment and other is for negative bending moment. Grade of concrete used is M25



Graph No. 8 shows the Bending Moment values for Deck Slab for Different Span of Culvert and Different thickness of Deck slab for water pressure that is case second. Two lines shows that one line is for positive bending moment and other is for negative bending moment. Grade of concrete used is M25.

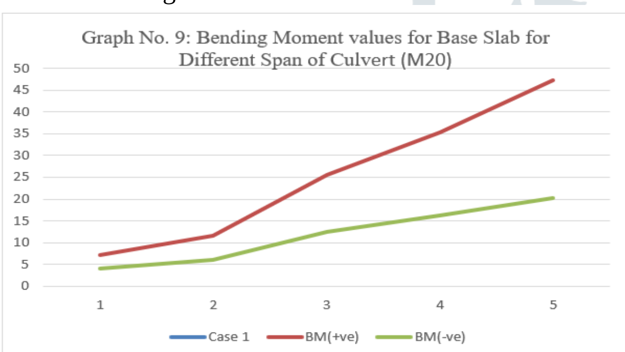
Table 3 : SF and BM values for Different Span of Culvert (M20)

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
2	Case 1	7.18	4.06	22.51	0.44	3.30	7.50	4.05	2.80
	Case 2	25.19	21.70	93.81	15.91	19.71	17.29	21.71	36.71
2.5	Case 1	11.50	6.07	28.11	0.42	5.42	9.39	6.48	4.32
	Case 2	25.81	23.09	78.10	16.89	20.21	59.39	23.11	33.10
3	Case 1	25.49	12.50	50.60	0.32	12.30	16.89	14.80	9.49
	Case 2	54.69	50.80	141.0	37.20	43.00	107.0	50.80	64.20
3.5	Case 1	35.40	16.30	59.10	0.17	17.40	19.70	21.21	12.60
	Case 2	73.10	70.50	164.0	51.61	57.50	125.0	70.40	4.28
4	Case 1	47.30	20.21	67.50	0.01	23.70	22.50	29.29	16.30
	Case 2	93.80	93.70	188.0	69.70	73.80	143.0	93.70	97.80

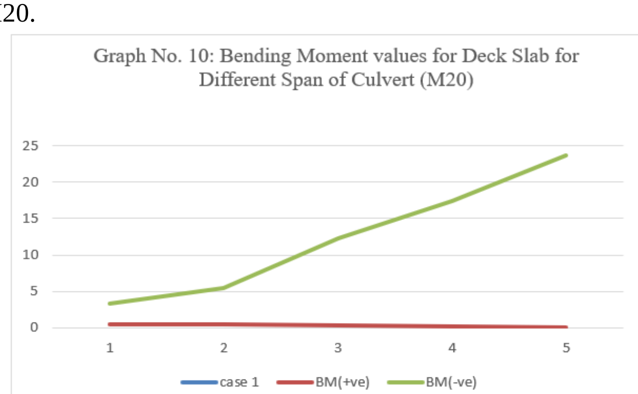
Above table 3 shows the values of bending moment and shear force values for different component of culvert for M20 grade of concrete. This tables shows the different span condition. Different component is deck slab, base slab and vertical wall. There are two case for design.

Case 1. Water Pressure

Case 2. Surcharge Pressure

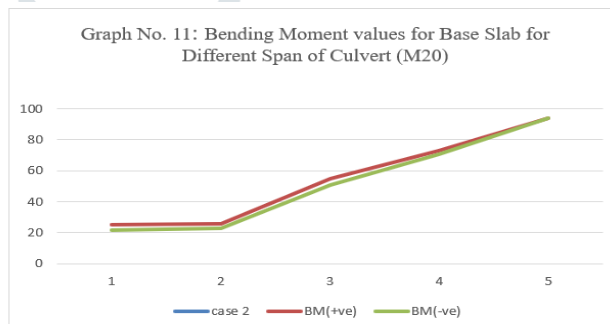


Graph No. 9 shows the Bending Moment values for Base Slab for Different Span of Culvert for water pressure that is case first. Two lines shows that one line is for positive bending moment and other is for negative bending moment. Grade of concrete used is M20.

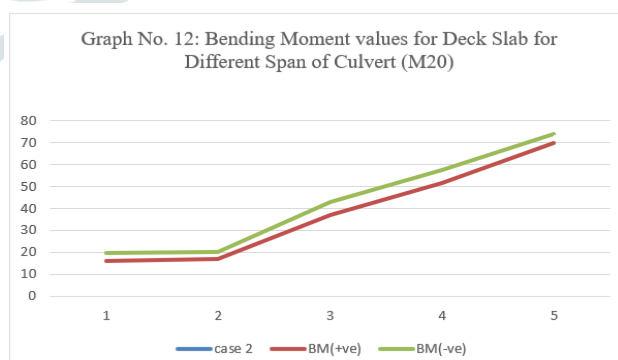


Graph No. 10 shows the Bending Moment values for Deck Slab for Different Span of Culvert for water pressure that is case first. Two lines shows that one line is for positive bending moment and other is for negative bending moment. Grade of concrete used is M20.

Graph No. 11 shows the Bending Moment values for Base Slab for Different Span of Culvert for water pressure that is case second. Two lines shows that one line is for positive bending moment and other is for negative bending moment. Grade of concrete used is M20.



Graph No. 12 shows the Bending Moment values for Deck Slab for Different Span of Culvert for water pressure that is case second. Two lines shows that one line is for positive bending moment and other is for negative bending moment. Grade of concrete used is M20.



V. CONCLUSION

1. The specified reinforcement and spacing for the bridge are going to be figure out by analysis the value from staad pro.
2. This will give the entire study and behavior of bridge Structure under different IRC loadings condition on staad pro.
3. The software are very helpful for constructing the economically bridge structure.
4. It's observed that the design mixture of concrete taken in the staad pro is M30, manually design by M35
5. Maximum BM occurs within the class AA Tracked loading vehicle so this loading is the most crucial case for maximum BM in longitudinal girder
6. The bending moment value occur in the outer girder is above the bending moment value occur within the inner girder.
7. The shear force value occur within the inner girder is more than the shear force value within the outer girder.
8. Maximum SF occurs for class AA Tracked vehicle loading so class AA Tracked vehicle loading case is the most crucial case for optimum Shear force in longitudinal girder.
9. Within the design of slab panel, Maximum shear force and the maximum bending moment value occur in the in the class AA tracked loading hence class AA tracked vehicle case is the most crucial case in the term of maximum shear force and bending moment.
10. According to the courbon's method, the very best importance given to the Outer Girder and Second for Inner Girder.
11. Here we will clearly see the effect of the pigeauds method over the effective width method within the slab panel where the pigeauds method will be used for higher span, and use for two-way slab also.

VI REFERENCES

[1] Vikram N. Kamble, "Analysis and Design of deck slab culvert" Yashwantrao chavhan college of Engineering, 2015-16.

[2] Neha Kolate, Molly Mathew, Snehal Mali, "Analysis and design of RCC box culvert",International Journal of Scientific & Engineering Research, Volume 5, Issue 12, December-2014.

[3] Shivanand tenagi, R shreedhar, "Comparitive study of slab culvert design using IRC 112:2011 and IRC 21:2000", International Journal for scientific research and developement, Vol. 3, Issue 5, 2015.

[4] Virendrasinh.D Chauhan, Gunvant Solanki, Minu Tressa., "Analysis and design of box type multibareel skew culvert", International Journal of Advance Engineering and Research Development, Vol. 4, Issue 11, Number 2017.

[5] Ajay R Polra, Prof. S. P. Chandresha, Dr. K. B. Parikh (2017), "A Review paper on analysis and cost comparison of box culvert for different aspects ratio of cells",International Journal Engineering trends and Technology, Vol. 44, Feb-2017.

[6] Charles Seim, Phillip Yen, PH.D. P.E (2004), "Seismic Retroffitting manual for steel Truss Highway Bridges'', World Conference on Earthquake Engineering, Paper No.1033, August 2004.

[7] John W. van de Lindt, Alexander J. Stone, and Suren Chen (2011), "Development of steel Design Details and selection Criteria for cost-effective and innovative Steel Bridges in Colorodo" , Colarodo Department of Transportation DTD Applied Research and Innovation, Report No. CDOT 2008-12, December 2008.

[8] Ketan Kishor Sahu, Shraddha Sharma (2015), "Comparison and Study of Different Aspect Ratio of Box Culvert", International Journal for Scientific Research & Development, Vol. 3, Issue 07, 2015.

[9] Alkhrdaji, T., and A. Nanni, "Design, Construction, and Field-Testing of an RC Box Culvert Bridge Reinforced with Glass FRP Bars", Non-Metallic Reinforcement for Concrete Structrues-FRPRCS Cambridge, July 16-18, 2001, PP. 1055-1064.

[10] Saurav, Ishaan Pandey (2017), "Economic Design of RCC Box Culvert through Comparative study of Conventional and Finite Element Method", International Journal of Engineering and Technology, Vol 9 No 3 Jun-Jul 2017.