

# Comparison and Study of Different Aspect Ratio of Box Culvert

Ketan Kishor Sahu<sup>1</sup> Shraddha Sharma<sup>2</sup>

<sup>1</sup>M. Tech Scholar <sup>2</sup>Assistant Professor

<sup>1,2</sup>Department of Civil Engineering

<sup>1,2</sup>BIT Durg, C.G., India

**Abstract**— 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 for certain type of loadings than others. For example soil loading applied to the surface or pavement maybe considered as uniform in the longitudinal direction. Solution therefore is independent of one of the three orthogonal axes and can be formulated in remaining two axes. Thus problem can be treated as two dimensional. Analysis of box culvert is done by stiffness matrix method. The model with respect to support conditions has been considered. Box culvert is assumed as externally determinate assuming discrete boundary conditions. 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. Also the pressure distribution at the bottom is assumed linear and bottom chord members are continuously supported. Axial and shear deformations are neglected. Based on above assumptions analysis is carried out by staad pro software.

It is well known that roads are generally constructed in embankments 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. This Paper is devoted to box culverts constructed in reinforced concrete having one, two or three cells and varying their operating conditions and analysis for their design. The cost by considering optimum thicknesses and the cost without considering optimum thicknesses are compared. Accordingly results are presented which justifies that optimum thicknesses presented over here are leads to economical design of box culvert. An attempt is made to generate the charts of bending moments for top and bottom members. Such that from these charts at any intermediate aspect ratio the values of bending moments can be evaluated. The average percentage reduction in the cost for single cell, double cell and triple cell is presented.

**Key words:** box culvert, single and double cell, compressive strength

## I. INTRODUCTION

### A. Box Culverts

Where pipe solutions are inappropriate, box culverts are the default buried structure type. Their larger openings are often required to provide adequate hydraulic capacity. Box culverts are also frequently used for pedestrian or cattle underpasses.

The reinforcement used in concrete box culverts can be either conventional bar reinforcement or welded wire

fabric. Welded wire fabric has yield strength slightly larger than conventional bar reinforcement.

### B. Precast Concrete Box Culverts

Standard designs for precast concrete box culverts are available with spans varying from 2 to 5 m and rises varying from 1.5 to 4 m. Standard precast concrete box culverts are typically fabricated in 2 m sections; however larger boxes are fabricated in 1.5 m sections to reduce section weight. The designs utilize concrete strengths are suitable for fill heights ranging from less than 0.6 m to a maximum of 7.5 m. Box culverts outside of the standard size ranges must be custom designed.

Each culvert size has three or four classes. Each class has specified wall and slab thicknesses, reinforcement areas, concrete strength, and fill height range to which it applies.

To prevent corrosion at the ends of welded wire fabric, nylon boots are required on the ends of every fourth longitudinal wire at the bottom of the form. A maximum of two layers of welded wire fabric can be used for primary reinforcement. If two layers are used, the layers may not be nested.

### C. Cast-In-Place Concrete Box Culverts

The first box culverts constructed in Minnesota were made of cast-in-place concrete. The performance of these structures over the years has been very good. Currently, most box culvert installations are precast due to the reduced time required for plan production and construction. Cast-in-place culverts continue to be an allowable option.

### D. Buried Structures

Buried structures serve a variety of purposes. They are typically used for conveying water. At other times they are used to provide a grade separated crossing for pedestrian and bicycle traffic. A variety of structure and material types are used. The most prevalent types are pipes and box culverts. Buried structures with horizontal dimensions less than 3 m are not classified as bridges. Typically these smaller buried structures do not require extensive design and are selected from standard design tables. Buried structures with horizontal dimensions greater than or equal to 3 m are considered bridges and require a plan prepared by the Bridge Office. All box culverts require a Bridge Office prepared plan as well. In addition to pipes and box culverts, precast concrete arches, precast three-sided structures, and long-span corrugated steel structures are used as buried structures.

Buried structures carry vertical loads through a combination of internal capacity and soil arching around the structure; this is termed soil-structure interaction. The means by which a buried structure carries vertical load varies significantly between different structure types due to their relative stiffness. Concrete box culverts and rigid pipes are

classified as rigid culverts and are assumed to carry the design loads internally with limited requirements or benefit of the soil. Flexible pipe structures (corrugated steel, thermoplastic, etc.) carry loads through soil-structure interaction. For this reason, material and installation requirements of the pipe and soil are well defined including trench or embankment conditions and backfilling and compaction procedures to ensure that the assumed soil-structure capacity is provided and that settlements are not excessive. AASHTO has developed empirical equations for different pipe types to allow for a simplified procedure that closely matches 3D soil-structure interaction models.

#### E. Geotechnical Properties

Typically, one or more soil borings will be obtained during the preliminary design process. Foundation recommendations based on field data and the hydraulic requirements will also be assembled during the preliminary design process. MnDOT Spec 2451 describes the excavation, foundation preparation, and backfill requirements for bridges and miscellaneous structures. Maximum and minimum load factors for different load components should be combined to produce the largest load effects. The presence or absence of water in the culvert should also be considered when assembling load combinations.

#### F. Design Guidance for Box Culverts

##### 1) Geometry

The minimum wall thickness for all box culverts is 200 mm. The minimum slab thickness for culverts with spans of 1.8 m to 2.4 m is 200 mm. The minimum top slab thickness is 200 mm, and the minimum bottom slab is 250 mm for all culverts with spans larger than 2.4 m. The slab and/or wall thickness is increased when shear requirements dictate or the maximum steel percentages are exceeded. All standard box culverts have haunches that measure 300 mm vertically and horizontally.

##### 2) Structural Analysis

Various methods can be used to model culverts. Based on past experience, MnDOT prefers a 2-Dimensional (2D) plane frame model be used to analyze culverts. The model is assumed to be externally supported by a pinned support on one bottom corner and roller support on the other bottom corner. The stiffness of the haunch is included in the model. The model is assumed to be in equilibrium so external reactions to loads applied to the structure are assumed to act equal and opposite. This section will assume a 2D plane frame model when referring to modeling, applied loads, and self-weight.

##### 3) Self-Weight (DC)

The self-weight of the top slab must be resisted by the top slab. The benefit of axial compression from the self-weight of the top slab and walls is not included in the analysis. The top slab, wall, and all haunch weights are applied to the bottom slab as an upward reaction from the soil in an equivalent uniform pressure. The bottom slab weight is not applied in the model because its load is assumed to be directly resisted by the soil.

##### 4) Earth Vertical (EV)

The design fill height is measured from the top surface of the top slab to the top of the roadway or fill. The design fill height is denoted by the abbreviations of H or DE depending

on the equation used. Earth vertical loads refer to soil and pavement loads above the culvert and in adjacent regions slightly outside the span of the culvert based on the soil-structure interaction factor. Culvert walls are assumed to be frictionless, so no vertical component of the earth horizontal resultant force is considered.

The soil-structure interaction factor ( $F_e$ ) is used to adjust the vertical earth load carried by the culvert. It is intended to approximate the arching effects of some of the overburden soil to adjacent regions slightly outside the span of the culvert and account for installation conditions. Culverts placed in trench conditions need to carry less vertical load than those constructed in embankment conditions, because the consolidated material in the adjacent trench walls is typically stiffer than new embankment material. Conservatively assume culverts are installed in embankment conditions.

##### 5) Earth Horizontal (EH)

For design and analysis purposes, the equivalent fluid method is used. The maximum for lateral earth pressure on the walls based on at rest pressure is 0.060 kcf.

This is computed by taking  $k_0$

$$k_0 = 1 - \sin(x)$$

Where  $x = 30^\circ$

$$= 1 - \sin(30^\circ) = 0.5$$

The resultant earth horizontal force is assumed to act perpendicular to the culvert walls. For maximum force effects, use a strength limit state load factor of 1.35 and a service limit state load factor of 1.0.

For minimum force effects, the condition of submerged soil pressure acting on the walls is taken as one-half of the earth weight acting on the outside walls, or 0.030 kcf. Use a strength limit state load factor of 0.9 and a service limit state load factor of 1.0.

#### G. Water (WA)

Designers need to consider two loading conditions:

1) The culvert is full of water, and 2) the culvert is empty.

##### 1) Design Vehicular

1) Live Load (LL): The approximate strip method is used for design with the 1 foot wide design strip oriented parallel to the span. The design live loads applied to the top slabs of box culverts include the HL-93 truck and tandem loads for box culverts of any span length. For box culverts with spans of 4.5 m or greater lane loads are also applied to the top slabs of box culverts. This practice is consistent with previous versions of the AASHTO Standard Specifications for Highway Bridges.

2) Tire Contact Area: The tire contact area of a wheel consisting of one or two tires is assumed to be a single rectangle, whose width is 500 mm and whose length is 250 mm. The tire pressure is assumed to be uniformly distributed over the rectangular contact area on continuous surfaces.

3) Dynamic Load Allowance (IM): The dynamic load allowance (IM) for culverts and other buried structures is reduced based on the depth of fill over the culvert. AASHTO LRFD requires that IM be considered for fill heights of up to 2.5 m. The equation to calculate the dynamic load allowance is as follows:

$IM = 33 (1.0 - 0.125 DE) \geq \%$  (for strength and service limit states)

Where:

DE = the minimum depth of earth cover above the structure (meter)

#### H. Limit States and Load Combinations

**Axial Thrust:** Do not consider the benefit of axial thrust in the design of box culverts for the strength limit state. It may be used in the service limit state crack control check.

**Flexure:** Flexural reinforcement is designed for positive and negative moment at all design.

- 1) **Crack Control:** Restrict the stress in the reinforcement to 60% of the yield strength. For welded wire fabric, assume a maximum spacing of 100 mm. Check crack control using the Class II exposure condition ( $e = 0.75$ ). Compute the tensile stress in the steel reinforcement at the service limit state using the benefits of axial thrust. Fabricators have discretion in choosing wire spacing, but the spacing cannot exceed 100 mm.
- 2) **Maximum Reinforcement:** The standards and typical designs use a resistance factor of 1.0 with a section that is tension controlled. Special designs may require a reduced resistance factor, reinforcement is limited to 0.6pb. This ensures that the reinforcement is not too congested, allowing for easier and more efficient fabrication.
- 3) **Minimum Reinforcement:** MnDOT requires reinforcement in all slabs and walls in both directions on both faces regardless of fill height. In top and bottom slabs for all fill heights, use  $0.002 \times b \times h$ . Distribution reinforcement is not needed, since a distribution slab is required for all boxes with less than 0.6 m of fill.
- 4) A minimum amount of reinforcement is required to be placed in each face in each direction in the top and bottom slabs and walls for all box sections regardless of cover. The MnDOT minimum value for this reinforcement is  $0.6 \text{ mm}^2$ , which is greater than the AASHTO minimum.
- 5) **Shear Critical Section:** Because of the 1:1 slope of the haunch, the critical section for shear may be taken at past the tip of the haunch.

**Shear in Slabs of Box Culverts with Less Than 0.6 m of Fill and Walls of Box Culverts at All Fill Heights:** For top slabs of boxes with less than 0.6 m of fill and walls of boxes at all fill heights calculate the shear resistance using the greater of that.

**Shear in Slabs of Box Culverts with 0.6 m of Fill or Greater:** For top and bottom slabs of boxes with 0.6 m of fill or greater calculate the shear resistance using the shear provisions specific to slabs of box culverts. For slabs of boxes with thicknesses greater than 300 mm, contact the MnDOT Bridge Standards Unit for shear provisions.

By-products are similar to those between superplasticizer and Portland cement.

## II. METHODOLOGY

**Culvert Design Standards Construction Material and Pipe Size:** Within the City, culverts shall be constructed from corrugated steel, Aluminized Steel (ASP), Plastic Pipe (PVC) or aluminium, reinforced concrete pipe or box culvert, or corrugated metal. Other materials for

construction shall be subject to the approval of the Stormwater Manager.

The minimum pipe size for culverts within a public ROW shall be a 600 mm diameter round culvert, or shall have a minimum cross sectional area of 1.4 m<sup>2</sup> for arch shapes, and 1.8 m<sup>2</sup> for elliptical shapes. Roadside ditch culverts for driveways shall be a minimum of 300 mm diameter Culvert Design Standards Construction Material and Pipe Size: Within the City, culverts shall be constructed from corrugated steel, Aluminized Steel (ASP), Plastic Pipe (PVC) or aluminium, reinforced concrete pipe or box culvert, or corrugated metal. Other materials for construction shall be subject to the approval of the Stormwater Manager.

The minimum pipe size for culverts within a public ROW shall be a 600 mm diameter round culvert, or shall have a minimum cross sectional area of 1.4 m<sup>2</sup> for arch shapes, and 1.8 m<sup>2</sup> for elliptical shapes. Roadside ditch culverts for driveways shall be a minimum of 300 mm diameter round, or have a minimum cross sectional area of 0.79 m<sup>2</sup>. **Inlet and Outlet Configuration:** Within the City, all culverts are to be designed with headwalls and wing walls or with flared end sections at the inlet and outlet. Downstream flared-end sections shall require cut-off walls. Flared-end sections are only allowed on pipes with diameters of 1 m (or equivalent) or less. Additional protection in the form of concrete will also be required at the inlet and outlet due to the potential scouring velocities.

Headwalls, wing walls, and flared-end sections should be designed and constructed to complement the existing landforms of the site and blend with the natural surrounding environment, to the greatest extent possible.

**Hydraulic Data:** When evaluating the capacity of a culvert, the following data shall be used:

- 1) **Roughness Coefficient**
- 2) **Entrance Loss Coefficients**
- 3) **Capacity Curves:** There are many charts, tables, and curves in the literature for the computation of culvert hydraulic capacity. To assist in the review of the culvert design computations and to obtain uniformity for analysis.
- 4) **Velocity Considerations:** In the design of culverts, both the minimum and maximum velocities must be considered. A minimum velocity of three feet per second at the outlet is required. The maximum velocity is dictated by the channel conditions at the outlet. If the outlet velocities are less than 1.5 m per second for grassed channels, then the minimum amount of protection is required due to the eddy currents generated by the flow transition. Higher outlet velocities will require substantially more protection. A maximum outlet velocity of 3.5 m per second is recommended with erosion protection.
- 5) **Headwater Considerations:** The maximum headwater for the 100-year design flow will normally be 1.5 times the culvert diameter, or 1.5 times the culvert rise dimension for non-round shapes. Also, the headwater depth may be limited by the street overtopping requirements for headwater depths greater than 1.5, the applicant shall submit detailed calculations determining the outlet velocity. If the outlet velocity is greater than 12 fps, an energy dissipater will be required.

- 6) **Trash Racks:** Due to differing site conditions, trash racks may be required at the entrance of culverts for some installations as designated by the City. Trash racks are required for all pond outlets. Routine cleaning of the trash racks is required to remove the collection of debris. Trash racks are not typically required at entrances to culverts crossing local streets or at culverts within the right-of-way which cross driveways, unless a safety hazard is identified. Trash racks are typically required at entrances to culverts in all other situations, for purposes of safety, water quality, and/or maintenance.

The following criteria shall be used for design of trash racks for storm drainage applications:

- 1) **Inlet and Outlet Configuration:** Within the City, all culverts are to be designed with headwalls and wing walls or with flared-end sections at the inlet and outlet. Downstream flared-end sections shall require cut-off walls. Flared-end sections are only allowed on pipes with diameters of 1 m (or equivalent) or less. Additional protection in the form of concrete will also be required at the inlet and outlet due to the potential scouring velocities.
- 2) **Headwalls, wing walls, and flared-end sections** should be designed and constructed to complement the existing landforms of the site and blend with the natural surrounding environment, to the greatest extent possible.
- 3) **Hydraulic Data:** When evaluating the capacity of a culvert, the following data shall be used:

A. *Roughness Coefficient Entrance Loss Coefficients*

1) *Capacity Curves:*

There are many charts, tables, and curves in the literature for the computation of culvert hydraulic capacity. To assist in the review of the culvert design computations and to obtain uniformity for analysis.

2) *Velocity Considerations:*

In the design of culverts, both the minimum and maximum velocities must be considered. A minimum velocity of three feet per second at the outlet is required. The maximum velocity is dictated by the channel conditions at the outlet. If the outlet velocities are less than 1.5 m per second for grassed channels, then the minimum amount of protection is required due to the eddy currents generated by the flow transition. Higher outlet velocities will require substantially more protection. A maximum outlet velocity of 3.5 m per second is recommended with erosion protection.

3) *Headwater Considerations:*

The maximum headwater for the 100-year design flow will normally be 1.5 times the culvert diameter, or 1.5 times the culvert rise dimension for non-round shapes. Also, the headwater depth may be limited by the street overtopping requirements for headwater depths greater than 1.5, the applicant shall submit detailed calculations determining the outlet velocity. If the outlet velocity is greater than 12 fps, an energy dissipater will be required.

4) *Trash Racks:*

Due to differing site conditions, trash racks may be required at the entrance of culverts for some installations as designated by the City. Trash racks are required for all pond outlets. Routine cleaning of the trash racks is required to

remove the collection of debris. Trash racks are not typically required at entrances to culverts crossing local streets or at culverts within the right-of-way which cross driveways, unless a safety hazard is identified. Trash racks are typically required at entrances to culverts in all other situations, for purposes of safety, water quality, and/or maintenance.

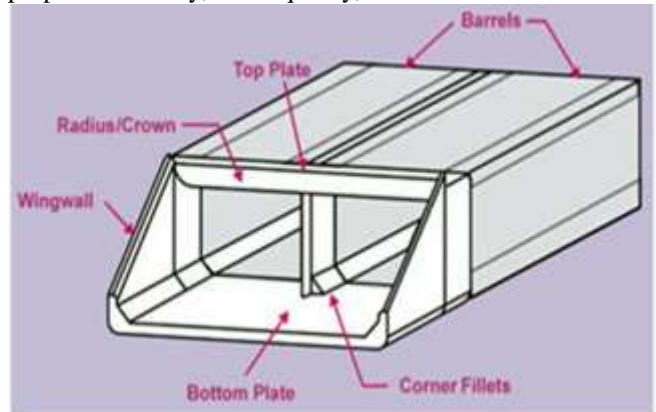
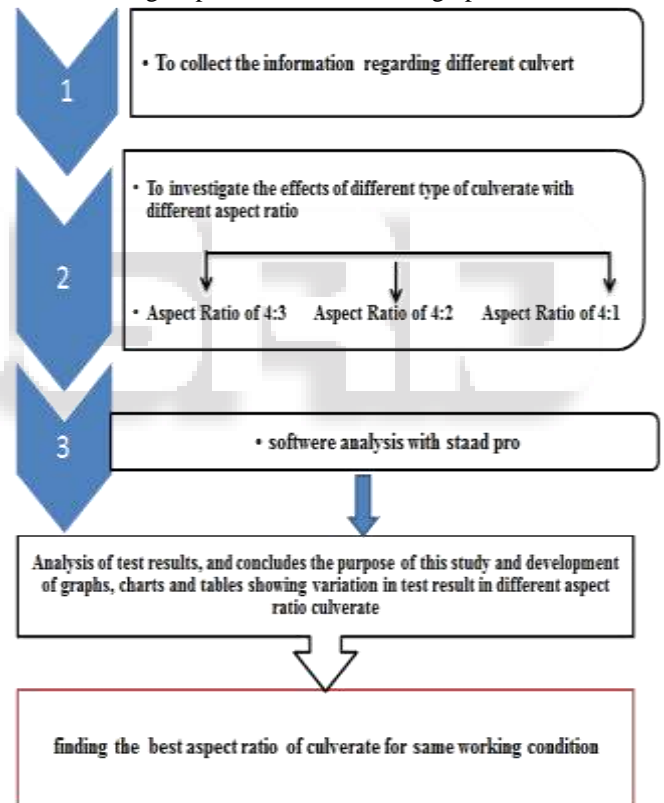


Fig. 2.1: Pre- cast concrete

The following step to be follow for design procedure



III. DESIGN PROCEDURE

A. *General Aspects*

Box culverts are drainage structures which consist of two horizontal slabs and two or more vertical walls. The slabs and walls are built monolithically, and are ideally installed for a road or a railway bridge crossing with high embankments crossing a stream with a limited flow. Reinforced concrete rigid frame box culverts with square or rectangular openings are used up to spans of 4.0 m. The height of the vent (h) does not exceed 3.0 m.

Box culverts are economical due to their rigidity and monolithic action and separate foundations are not

required since the bottom slab resting directly on the soil, serves as raft foundation. For small discharges, single celled box culvert is used and for large discharges, multi-celled box culverts can be employed. The barrel of the box culvert should be of sufficient length to accommodate the carriage way and the kerbs.

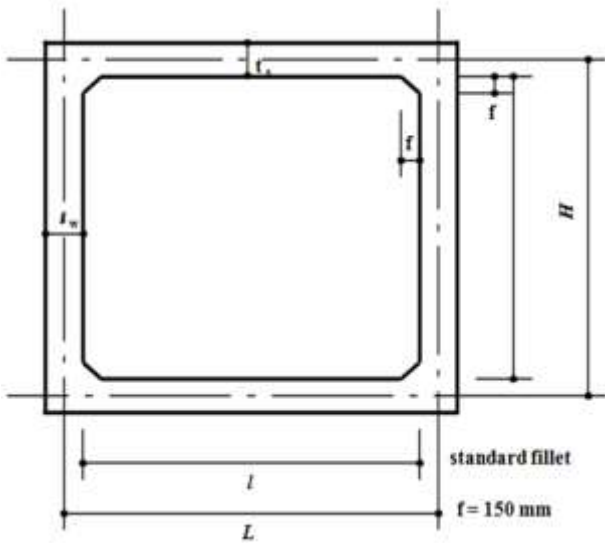


Fig. 3.1: Single cell box culvert

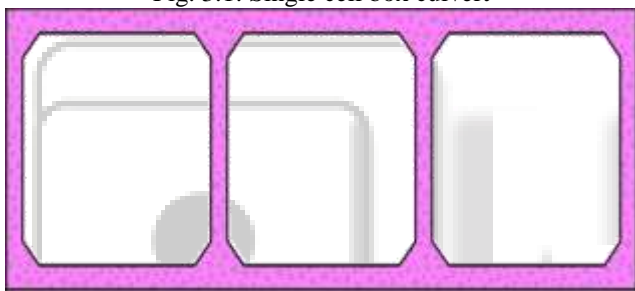


Fig. 3.2: Triple cell box culvert

### B. Analysis Assumptions

- 1) Frame: The box culvert shall be analyzed, as a rigid frame with all corner connections considered rigid.
- 2) Sidesway: Sidesway is not considered in the analysis.
- 3) Section Properties: The centerlines of slab, walls and floor are used for computing section properties and for dimensional analysis. Standard fillets which are not required for moment or shear or both shall not be considered in computing section properties.
- 4) Minimum Thickness: The following minimum thickness shall be used.

Top slab:

$t_s = 200$  mm, but taken as 80-100mm per 1.00m length of the span.

Floor slab:

$t_f = 250$  mm

Wall:

$t_w = 25$  mm per 300 mm of wall height but not less than 230 mm.

- 5) Design Loads: The structural design of a reinforced concrete box culvert comprises the detailed analysis of rigid frame for moments, shear forces and thrusts due to various types of loading conditions outlined below:

- Concentrated Loads
- Uniform Distributed Loads
- Weight of Side Walls

- Water Pressure Inside Culvert
  - Earth Pressure on Vertical Side Walls
  - Uniform Lateral Load on Side Walls
- 6) Concentrated Loads: In cases where the top slab forms the deck of the bridge, concentrated loads due to the wheel loads of the BS 5400 HB type loading have to be considered.

If  $P$  = wheel load due to HB loading which include the impact factor of 0.25%, the dispersal length =  $1.75D$ , and  $D$  = depth of soil fill, then the load intensity on the culvert slab,

$$W = (P/(1.75D)) \text{ kN/m} \quad \dots(1)$$

The soil reaction of the bottom slab is assumed to be uniform. The notations used for the box culvert and the type of loadings to be considered.

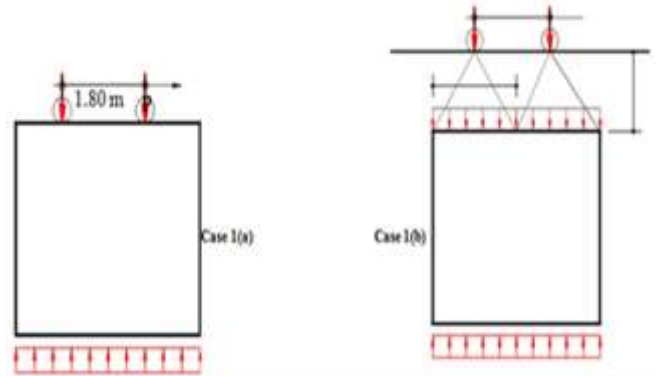


Fig. 3.3: Concentrated Loads

### C. Uniform Distributed Loads

The weight of embankment, wearing coat and, deck slab and the track load are considered to be uniformly distributed loads on the top slab with the uniform soil reaction on the bottom slab.

Minimum  $D = 300$  mm

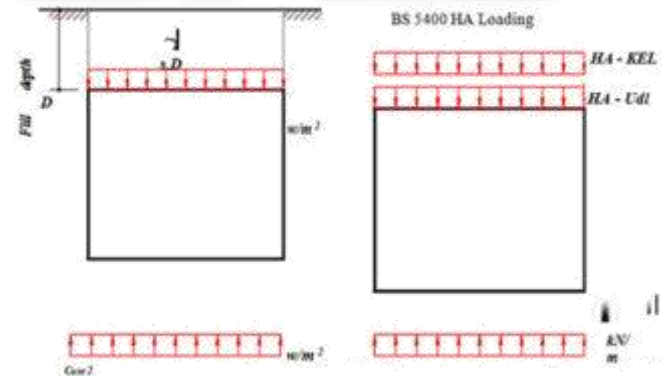


Fig. 3.4: Uniform distributed loads

The self-weights of two side walls acting as concentrated loads are assumed to produce uniform soil reaction on the bottom slab.

$W_w$  = is the weight of one wall, and is given by:

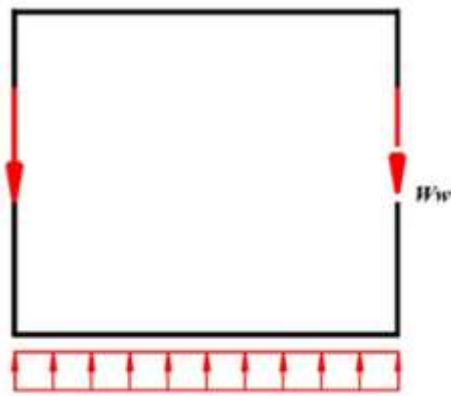
$$W_w = t_w H \sigma_c \text{ kN/m transversal}$$

Where,

$t_w$  = wall thickness

$H$  = height of wall, and

$\sigma_c$  = density of concrete =  $24 \text{ kN/m}^3$



Case 3

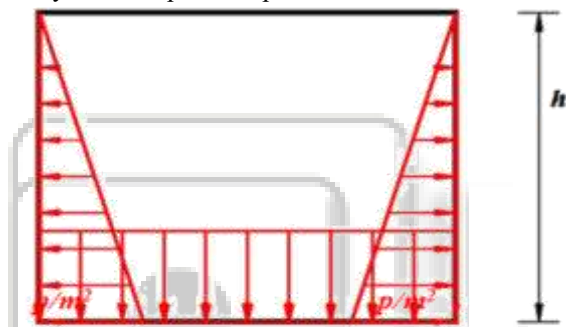
Fig. 3.5: Load from vertical side walls

#### D. Water Pressure inside Culvert

When the culvert is full with water, the pressure distribution on side walls is assumed to be triangular with a maximum pressure intensity of  $p = \sigma wh$  at the base.

Where  $w$  = density of water and  $h$  is the depth of flow.

Intensity of water pressure  $p = \sigma wh$



Case 4

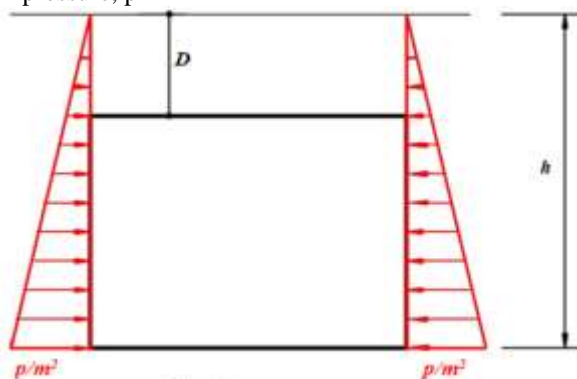
Fig. 3.6: Water Pressure

#### E. Earth Pressure on Vertical Side Walls

The earth pressure on the vertical side walls of the box culvert is computed according to the Coloumb's Theory.

The distribution of soil pressure on the side wall is shown

Soil pressure,  $p$



Case 5

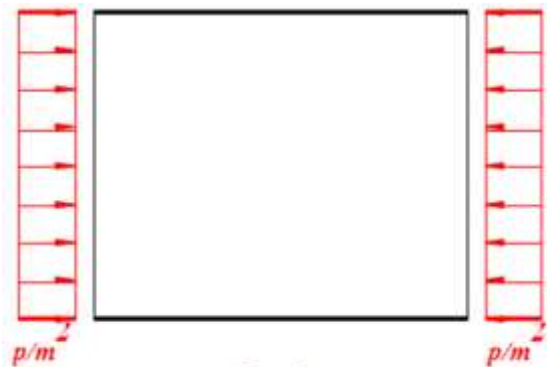
Fig. 3.7: Soil pressure

#### F. Uniform Lateral Load on Side Walls

Uniform lateral pressure on vertical side walls has to be considered due to the effect of live load surcharge. Also trapezoidal pressure distribution on side walls due to embankment loading can be obtained by combining the cases (5) and (6).

Uniform lateral pressure due to the effect of surcharge loads is obtained from:

$$p = \text{surcharge loads} \left( \frac{1 - \sin \phi}{1 + \sin \phi} \right)$$



Case 6

Fig. 3.8: Lateral load due to surcharge loads

#### G. Design of Critical Sections

The maximum design moments resulting from the combination of the various loading cases are determined. The moments at the centre of span of top and bottom slabs and the support sections and at the centre of the vertical walls are determined by suitably combining, the different loading patterns. The maximum moments generally develop for the following loading conditions:

- 1) When the slab supports the dead and live loads and the culvert is empty.
- 2) When the top slab supports the dead and live loads and the culvert is running full.
- 3) When the sides of the culvert do not carry the live load and the culvert is running full.

The slab of the box culvert is reinforced on both faces with fillets at the inside corners.

#### H. Design Data

Determination of Discharge:

As per rational formula,  $Q = \frac{250}{9} \times C \times A \times R$

For Catchment Area = 365 Hact

Where,

$C$  = Impermeability factor = 0.7

$A$  = Catchment area in Hact. = 365

$R$  = Average Rainfall intensity in CM per Hour = 2.5

Available Discharge for 2.5 cm/Hr., Rainfall = 17.74 m<sup>3</sup>/sec

Similarly for the following catchment area discharge has been worked out.

Design of Box Culvert Section:

Where,

$Q$  = Discharge

$A$  = Area of the drain

$V$  = Velocity

As per Manning's Formula  $V = \frac{1 \times R^{2/3} \times S^{1/2}}{\eta}$

Where,

$R$  = Hydraulic Mean Depth =  $\frac{A}{P}$

$S$  = Gradient of drain 1 in 500

$\eta$  = Roughness coeff.

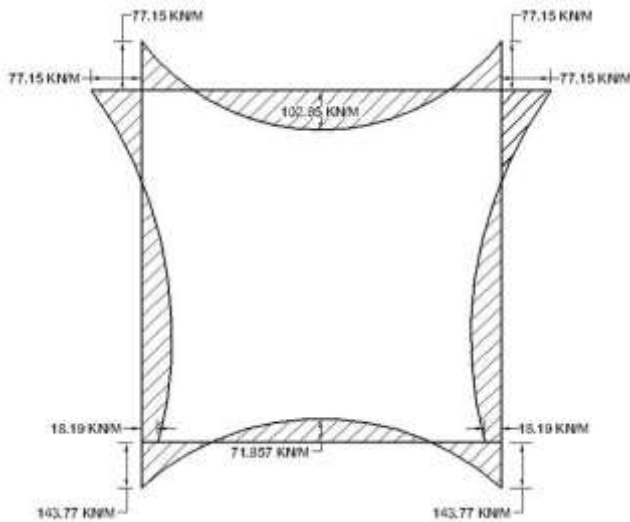


Fig. 3.9: Bending moment, Size 4.00 x 2.00 m

S. No.	Required Discharge = Q (IN Cumecs)	Aspect Ratio	Bed width (m)	Top width of drain (m)	Depth of Water (m)	Gradient	Value = n	Area = A (m <sup>2</sup> )	Perimeter = P (n)	Hydraulic Mean Depth = R=A/P	R <sup>2</sup> /3	Velocity = V (m <sup>3</sup> /s)	Volume of Concrete (m <sup>3</sup> )	Available Discharge = Q (IN Cumecs)	Section will be Safe
1	17.74	1:1	4	4	4	1: 500	0.02	16.00	12.0	1.33	1.21	2.71	6.08	43.34	OK
2	17.74	1:1.3	4	4	3	1: 500	0.02	12.00	10.00	1.20	1.13	2.53	5.48	30.30	OK
3	17.74	1:2	4	4	2	1: 500	0.02	8.00	8.00	1.00	1.00	2.24	4.88	17.89	OK

Table 3.2: Designing various Hydraulic Parameter of the Box Culvert with respect to different sizes respectively

S. No.	% changes in Velocity	% changes in Depth Of Water	% changes in Perimeter	% changes in Area	% changes in Hydraulic Mean Depth	% changes in Volume of Concrete	S. No.	Aspect Ratio	Top Slab (kN/m)	Bottom Slab (kN/m)	Vertical Side Walls on Top End (kN/m)	Vertical Side Walls on Bottom End (kN/m)
1	-	-	-	-	-	-	1.	4:4	83.61	152.47	83.61	65.61
2	7.00%	25.00%	16.67%	25.00%	10.00%	9.868%	2.	4:3	74.75	148.12	74.75	14.00
							3.	4:2	77.15	143.77	77.15	18.19

Table 4.2: Comparative for End Moments Values

#### IV. RESULT AND DISCUSSION

On the basis of software analys Comparative Table for changing in Percentages for Hydraulic Parameter of the Box Culvert.

Aspect Ratio	% change in velocity	% change in depth of water	% change in Perimeter	% change in Area	% change in Hydraulic Mean Depth	% change in Volume of concrete
4:4	-	-	-	-	-	-
4:3	7.00	25.00	16.67	25.00	10.00	9.868
4:2	17.00	50.00	33.33	50.00	25.00	19.737

Table 4.1: Hydraulic Parameters of Box Culvert

Note: Here a Positives sign shows percentages savings.

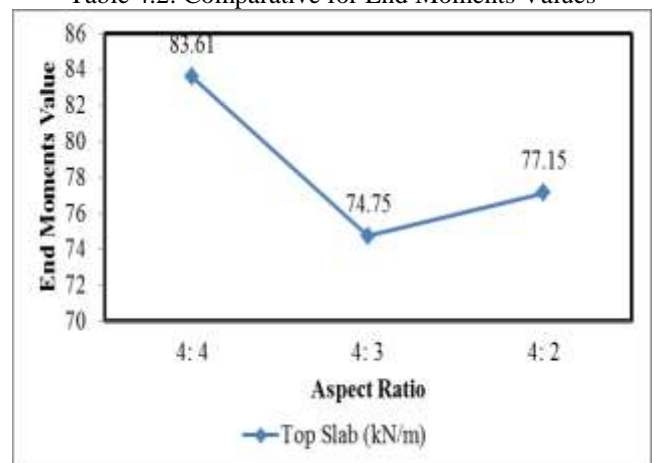


Fig. 4.1: Comparative for End Moments Values of Top Slab

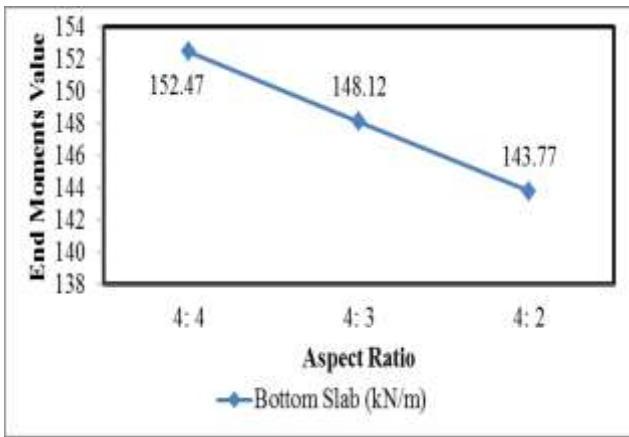


Fig. 4.2: Comparative for End Moments Values of Bottom Slab

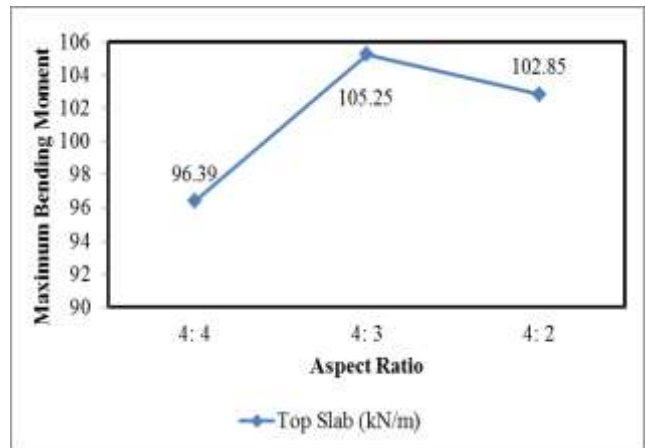


Fig. 4.5: Comparative for Maximum Bending Moment of Top Slab

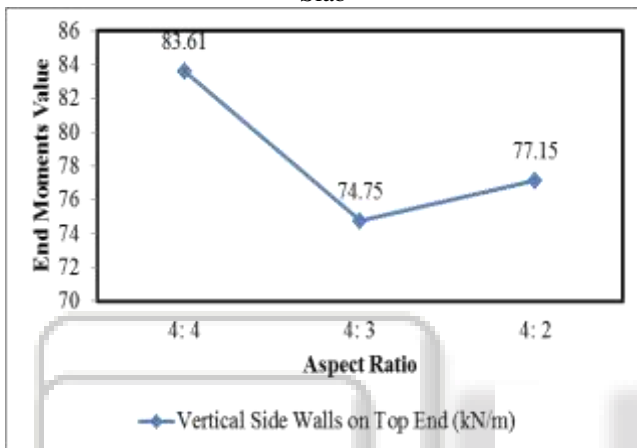


Fig. 4.3: Comparative for End Moments Values of Vertical Side Walls on Top End

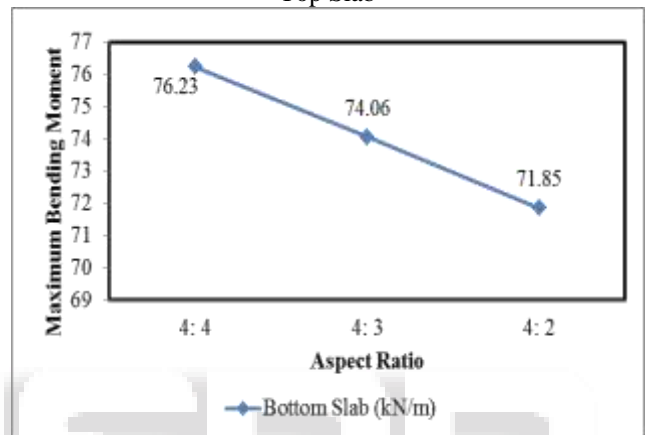


Fig. 4.6: Comparative for Maximum Bending Moment of Bottom Slab

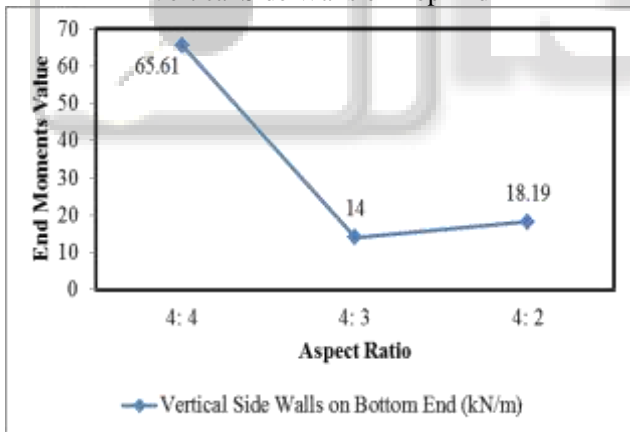


Fig. 4.4: Comparative for End Moments Values of Vertical Side Walls on Bottom End

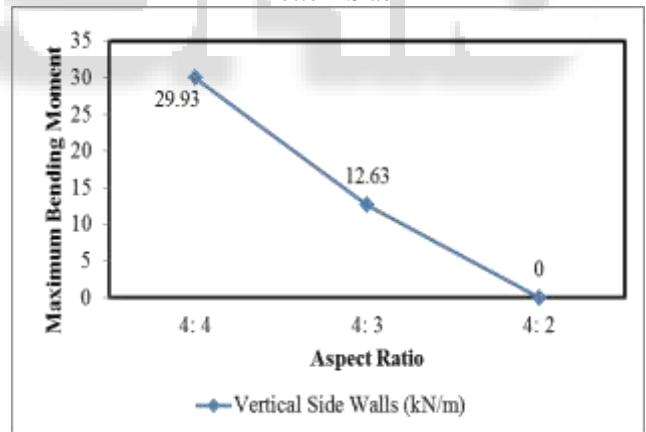


Fig. 4.7: Comparative for Maximum Bending Moment of Vertical Side Walls

S. No.	Aspect Ratio	Top Slab (kN/m)	Bottom Slab (kN/m)	Vertical Side Walls (kN/m)
1.	4:4	96.39	76.23	29.93
2.	4:3	105.25	74.06	12.63
3.	4:2	102.85	71.85	0.00

Table 4.3: Comparative for Maximum Bending Moment Values

## V. SUMMARY AND CONCLUSION

### A. Summary

With respect to Aspect Ratio of 4:4 we found out the percentage changes for velocity, depth of water, perimeter, area, hydraulic mean depth and changes in volume of concrete.

#### 1) Comparison of Aspect Ratio of 4:3:

- For Aspect Ratio of 4:3 we found percentage change in velocity is 7.00 percent change in depth is 25.00 percent, change in perimeter is 16.67 percent, change in area is 25.00 percent, change in hydraulic mean depth is

- 10.00 percent, change in volume of concrete is 9.868 percent.
  - The moments value are less as compared to Aspect Ratio of 4:4 size of box culvert. On top slab 74.75 kN/m, on bottom slab 148.12 kN/m and on vertical side walls 74.75 kN/m.
  - The value of maximum bending moment will be more, it is 105.25 kN/m, on top slab but less on bottom slab i.e., 74.06 kN/m and 12.63 kN/m on vertical side walls.
- 2) *Comparison of Aspect Ratio of 4:2:*
- For Aspect Ratio of 4:2 we found percentage change in velocity is 17.00 percent change in depth is 50.00 percent, change in perimeter is 33.33 percent, change in area is 50.00 percent, change in hydraulic mean depth is 25.00 percent, change in volume of concrete is 19.737 percent.
  - The moments values are less as compared to Aspect Ratio of 4:4, size of box culvert. On top slab 77.15 kN/m, on bottom slab 143.77 kN/m. For vertical side walls top end portion values will be 77.15 kN/m and for vertical side walls bottom end portion values will be 18.19 kN/m
  - The value of maximum bending moment will be more, it is 102.85 kN/m, on top slab but less on bottom slab i.e., 71.85 kN/m.

## VI. CONCLUSION

Hence with the help of this designing part there are three different sections ,with the L:H aspect ratio of 4:2, size of box culvert will be more economical ,because the percentage saving will be more in velocity,depth of water,perimeter, area, hydrolic mean depth,volume of concrete, and the end moments values will be less minimum as on top slab, bottom slab, vertical side wall portion as well as the maximum bending moment of this section will be more safe, compared to other sections choosing simultaneously.

## REFERENCES

- [1] Kaniraj, "Design Aids in Soil Mechanics and Foundation Engineering", Edition-1, Tata McGraw Hill, 2004.
- [2] Desai and Abel, "Introduction to Finite element method", 10th Edition, 1972.
- [3] Bathe, "Finite element Procedure", ISBN-0-13 301458-4, 1996.
- [4] Chopra, "Dynamics of Structures", 3rd Edition, September 2006.
- [5] Dr. B.C. Punamia, "R.C.C. Design (Reinforced Concrete Structure)", Laxmi Publisher, 2006.
- [6] Pankaj Agrawal and Manish Shrikhande, "Earthquake Resistant Design of Structures", New Delhi, 2006.
- [7] Thandavamoorthy, "Analysis of Structure", Oxford University Press.
- [8] A.M. Neville, "Properties of Concrete", Fourth Edition, 1995.
- [9] Essam A. Mostafa, "Cost Analysis for Bridge and Culvert", 1-3 April 2003.
- [10] Ronald A. Cook, David Bloomquist and et. al., "Evaluation of Precast Box Culvert Systems", March 2002.

- [11] Gilbert Gedeon, P.E., Conduits, "Culverts and Pipes - Design and Installation", 31 March 1998.
- [12] Mark Rossow, "Culvert Characteristics" (Birm), PHD, PE, Retired.
- [13] Larry J. Miller and Stephan A. Durham, "Comparison of Standard Load and Load and Resistance Factor Bridge Design Specifications for buried Concrete Structures".
- [14] Dr. Chris Allington, "Experimental Verification of Humes Precast Concrete Box Culverts".
- [15] Guillermo R. Giannico and Jon A. Souder, "The effects of tide gates on estuarine habitats and migratory", Oregon State University, 2004.
- [16] North Dakota Department of Transportation Bismarck, North Dakota, "Standard specifications for Road and Ridge Construction", October 2002.
- [17] Sushil Kumar Yadav Dyce/N.C. Rly Course No. 724, "Project Report on use of special steel for Girder Bridges on Indian Railways".
- [18] Alkhrdaji, T., and A. Nanni, "Design, construction, and field-testing of an RC box culvert bridge reinforced with GFRP bars, "Design, Construction, and field-testing of an RC Box Culvert Bridge Reinforced with glass FRP bars," Non-metallic Reinforcement for Concrete Structures", pp.1055-18, July 16-18, 2001.
- [19] Code of Practice for the Design of sub-structures and Foundations of Bridges, Government of India Ministry of Railways (Railway Board).
- [20] Bridget Mccrea, "The two-piece Box Culvert a two-piece precast concrete box culvert replaces Ohio's failing steel structures", 2006.
- [21] D.S. Cheema, "Durability of geopolymer concrete box culverts – a green alternative, 34th Conference on our world in Concrete & Structures", 16 – 18 August 2009.