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Design and Analysysof Twin Cell Box Culvert

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Abstract- **Box Culverts are required to be provided under earth embankment for crossing of water course like streams, Nallas 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 flood level on one side of road thereby decreasing the water head consequently reducing the flood menace. Culverts can be of different shapes such as arch, slab and box. These can be constructed with different material such as masonry (brick, stone etc) or reinforced cement concrete. Since culvert pass through the earthen embankment, these are subjected to same traffic loads as the road carries and therefore, required to be designed for such loads. The size, invert level, layout etc. are decided by hydraulic considerations and site conditions. The cushion depends on road profile at the culvert location. The structural design involves consideration of load cases (box empty, full, surcharge loads etc.) and factors like live load, effective width, braking force, dispersal of load through fill, impact factor, co-efficient of earth pressure etc. Relevant IRC Codes are required to be referred in the analysis and design of box culverts. The aim of this project is to model and analyze the box culvert using STAAD PRO software. This software is an effective and user friendly tool for three dimensional model generation, analysis and multi material design. The results obtained from STAAD PRO are compared with the manual calculations obtained using Excel. The structural elements of box culvert are designed to withstand maximum bending moment and shear force. The results obtained from STAAD are almost similar to manual calculations.**

Keywords- **Design coefficients, single cell, two cell, culvert, moment, axial thrust, shear.**

I.INTRODUCTION

Box culvert has many advantages compared to slab culvert or arch culvert. The box is structurally strong, stable and safe and easy to construct. The main advantage is, it can be placed at any elevation within the embankment with varying cushion which is not possible for other type of culverts. A multi cell box can cater for large discharge and can be accommodated within smaller height of embankment. It does not require separate elaborate foundation and can be placed on soft soil by providing suitable base slab projection to reduce base pressure within the safe bearing capacity of foundation soil.

Bearings are not needed. It is convenient to extend the existing culvert in the event of widening of the carriageway at a later date as per future requirement, without any problem of design and/or construction. The culvert cover up to waterways of 6 m (IRC: 5-1981) 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 top slab is supported over the vertical walls (abutments/ piers) but has no monolithic connection between them. A box culvert can have more than single and Double cell and can be placed such that the top slab is almost at road level and there is no cushion.

II. TYPES OF CULVERTS

Culverts are cross drainage works with clear span less than six meters. In any highway or railway project, the majority of cross drainage works fall under this category. Hence these structures collectively are important in any project, though the costs of the structures are small. Culverts may be classified according to function as highway or railway culvert. The loadings and structural details of the super structure would be different for these two classes. Based on the construction of the structure, they can be of the following types.

- Slab Culverts
- Pipe Culverts
- Box Culverts

1. Box Culverts:

Box Culverts are ideally suitable monolithic structures across a highway or railway embankment to balance the flood water on both sides. It consists of top slab, bottom slab and two vertical side walls. Reinforced concrete rigid frame box culverts are used for square or rectangular openings with span up to 6m. The top of the box section can be at the road level or can be at a depth below road level with a fill depending on site conditions.

2. Advantages of Box Culverts:

- Prevent Erosion
- Prevent Flooding
- Allow Water to Flow Unobstructed
- Divert Water for Farming/Engineering Purposes

3. Objective of The Project:

The aim of this study is to achieve the following goals: -

- To model and analyze box culvert using STAAD PRO software.
- To asses and compare the results of STAAD PRO and manual calculations.
- To design elements of the box culvert as per IS specifications.

4. Necessity of The Project:

Over the years ago engineers solving problems by using numerical methods. Due to development took place in structures and materials problems become more complex. They can't solved those structures by using numerical methods. So they are going to solve those methods by using computational methods using Software. Hence in the present study an analysis has been carried out by using STAAD Pro and the results obtained are compared that of manual calculations obtained using EXCEL and C++ coding. Also box culvert is designed for three conditions to study stresses in terms of bending moment and shear.

- No water flowing in the drain. The box culvert will be dry from inside, and sidewalls will be subjected to earth pressure from
- outside.
- Water in box, will be subjected to earth pressure from outside and water pressure from inside.
- Live load and dead load on top and water pressure from inside no live load on the sides.

5. Applications of Box Culvert:
These are the following applications of the box culvert.

5.1. Box Culverts in Road and Highway Construction:
Box culverts are prevalent features in road and highway construction. In order to withstand traffic loads and aggressive weather conditions, these culverts must be tough—that's why we recommend building yours out of concrete. These box culverts allow water to flow under roads and highways without impeding the flow of traffic.

5.2 Box Culverts in Utility Work:
Utility work also utilizes box culverts. These culverts serve as utility tunnels that carry electricity, water and sewer lines. Sometimes, they also carry communication lines, such as telephone and cable television. Utility tunnels are ideal for cold climates where it's difficult to bury lines below the frost level. They can also be found in areas where the water table is too high to bury water and sewer mains, or in areas like Tokyo where utility poles are likely to succumb to earthquakes or storms.

5.3 Box Culverts in Railroads:
Railroad construction and maintenance relies on the use of box culverts. They can replace small bridges or create crossings over creeks or other waterways. Under track culverts are vital to the success of modern railroads.

III. VARIOUS TYPES OF BOX CULVERT

1. 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. A typical box culvert is shown in Fig.

2. 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 4m. 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. A typical section of precast box culvert is shown in Fig.

3. 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. A model of Cast in place concrete box culvert is shown in Fig.

IV. 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. 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. RCC box culverts comprising of top slab, base slab and stem are cast monolithically to carry live load, embankment load, water pressure and lateral earth pressure in a better way. The top of the box may be at road level or it may at a depth below the road level if the road is in embankment. The required height and number of boxes depends on hydraulic and other requirements at the site such as road level, nalla bed level, scour depth etc. The barrel of the box culvert should be of sufficient length to accommodate
the carriageway and the kerbs.

V. DESIGN CONSIDERATIONS

1. Loads:

The loads considered for the analysis of box culverts are Dead load, Live load, Soil pressure on side walls, Surcharge due to live load, and Water pressure from inside.

2. Uniform Distributed Load:

The weight of embankment, 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. For live load distribution, the width of dispersion perpendicular to the span is computed first. Width of dispersion parallel to the span is also calculated. Then the maximum magnitude of load is divided by width of dispersion parallel to span and width of dispersion perpendicular to the span to get the load intensity on the top slab.

3. Live Load:

For calculation of load dispersion along the traffic direction as per clause 305.16.3, IRC 21-2000, the effect of contact of the wheel or track load in the direction of span length shall be taken as equal to the dimension of the tyres contact area over the wearing surface of the slab in the direction of span. The effective width=beff=kx(1-x/lo)+bw. If the effective width is greater than the distance between wheel and tracks of the vehicle, overlapping of load dispersion occurs and not effective width is considered by taking the load dispersion due to both wheels without overlapping and for calculation of loads for both wheels and tracked vehicle.

3.1 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 850 mm and whose length is 290 mm. The tire pressure is assumed to be uniformly distributed over the rectangular contact area on continuous surfaces. All overabundance soil and other material from the exhuming including logs, stones and so forth would be expelled from the site and arranged to the areas affirmed by the architect. The most important step in the fixation of water way of a cross drainage structure is to determine the design flood discharge. An accurate determination of the discharge will-

- Govern the safety of the structure.
- Influence the selection of design of foundation, water way and protective works.
- Affect the cost of structure.

3.2 Weight of side walls :

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

3.3 Water pressure inside culvert:

The pressure distribution on side walls is assumed to be triangular with a maximum pressure intensity of p=wh at the base, where w is the density of water and h is the depth of flow. Designers need to consider two loading conditions:

- The culvert is full of water, and
- The culvert is empty.

3.4 Earth pressure on vertical side walls:

The earth pressure on the vertical side walls of the box culvert is computed according to the Coulomb's theory. The earth pressure intensity on the side walls is given by p=Ka H, where Ka is coefficient of active earth pressure is the density of soil and H is he vertical height of box.

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3.5 Uniform lateral load on side walls :

Uniform lateral pressure on vertical side walls is considered due to the sum of effect of embankment loading and live load surcharge. Also the uniform lateral pressure on vertical side walls is considered due to embankment loading alone.

3.6 Design moments, shears and thrusts :

The box culvert has to be analyzed for moments, shear forces and thrusts developed due to the various loading conditions by any classical methods such as moment distribution method, slope deflection method etc. It becomes very tedious for the designer to arrive at design forces for various loading conditions. Hence a study is made to arrive at the coefficients for moments, shear forces and axial thrusts for different loading cases and for different ratios of L/H = 1.0, L/H = 1.25, L/H = 1.5, L/H = 1.75 and L/H = 2.0 for Single, Two Cell and three cell box culvert.

VI. DESIGN DETAILS OF BOX CULVERT

1. Box Details:

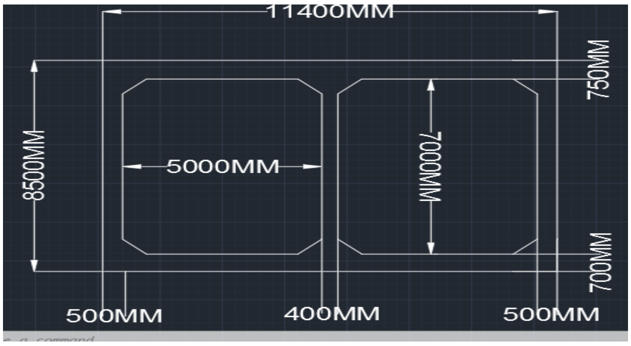

Fig .1 Box

Dimensions:

Tabel no.1.

1.	Box Effective Span	=	2 x 5 m
2.	Barrel Length of Box	=	12 m
3.	No. of cell	=	2m
4.	Bottom slab thickness	=	0.7m
5.	Top slab thickness	=	0.75m
6.	Side Wall thickness	=	0.5m
7.	Clear Vent(Vertical)	=	7m
8.	Wall height	=	8.5m
9.	Haunch horizontal (Bottom slab)	=	0.6m
10.	Haunch vertical (Bottom slab)	=	0.2m
11.	Haunch horizontal (Top slab)	=	0.6m
12.	Haunch vertical (top slab)	=	0.2m

2. Materials:

Grade of Concrete - M25 (Moderate) Grade of Steel - Fe500
Clear cover - 75mm

VII. DESIGN PARAMETERS FOR RCC DESIGN

1.Reinforcement: (Ref :- IRC.112-2001)

Grade of steel - Fe500
Characteristic strength of steel (fy) - 500N/mm^2
Material Factor (ϒs) - 1.15
Modulus of Elasticity (Es) - 20000 N/mm2

2.Concrete:(Ref:- IRC-112-2011)

Grade of Concrete - M25 (Moderate)
Characteristic strength of steel (fck) - 25 N/mm^2
Material Factor (ϒs) - 1.5
Coefficient of Friction (μ) - 0.50
Modulus of Elasticity (Ec) - 25000 N/mm2
Design value considered (0.446*fck) - 11.15 N/mm2

3.Constants:

Modular Ratio M = Es(1+ φ) / Ec

VII. LOAD CALCULATIONS

1. Dead Load (Ref:-IRC: 6-2014)

Volume of top slab = 2 x 5.45 x 0.75 x 1 = 8.175 m3
Volume of bottom slab = 2 x 5.45 x 0.70 x 1 = 7.63 m3
Volume of side walls = 2 x 7.725 x 0.5 x 1 = 7.725 m3
Volume of Mid wall = 7.725 x 0.4 x 1 = 3.09 m3
Total volume = 26.62 m3
Therefore, total weight of concrete = 26.62 x 25 = 665.5 KN Effective width = 0.25 + 5 +0.4 +5 +0.25 = 10.9 m
Therefore, Base pressure due to self-weight = 665.5/10.9 × 1 = 61.05KN/m

2. Earth Pressure:

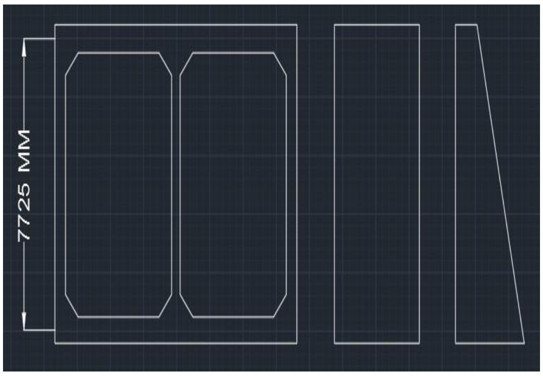

Fig . 2 Earth Pressure

3.Load Calculation :
3.1 Top Slab :
3.1.1. Dead Load :
Weight of wearing course:
= 0.065 x 22
= 1.43 KN/$m2$ = So we provide 2 KN/$m2$ (0.065 – Wearing coat thickness)
Self weight of top state
= 0.75 x 25
=18.75 KN/$m2$

Total = DL + LL = 20.75 KN/$\boldsymbol{m2}$

3.1.2 Live Load
Dispersal perpendicular to span
= 0.84 + 2 x 0.065
= 0.97 m
Dispersal in span direction
= 4.57 + 2 x t
t = 0.065
= 4.57 + 2 x 0.065
= 4.7 m

P/A = 350/ 4.7 x 0.97
= 76.771N/$m2$
(25 % of 76.77 KN/$m2$)

Total Load :
D.L + L.L = 20.75 + 95.96=116.7125 KN/$\boldsymbol{m2}$s

3.2 Bottom Slab :
3.2.1. Dead Load :

Load from top slab = 20.75 KN/$m2$
Load of walls = 10 (0.5x2+0.4) x25/11.4
= 51.45 KN/$m2$

3.2.2. Live Load:

(Dispersed Live Load)
Live load = 21 KN/$m2$ (As per IRC 6 - 2014, Clause - 208) Total Load = DL + LL
= 72.45 KN/$m2$

3.2.3 Side Wall:

C-1 Box empty earth premier at bare due to live load surcharge:
= 1.2 x 0.5 x 20
= 12 KN/$m2$
C-2 Box empty earth Pressure at bar due to earth fill:
= 20 x 0.5 x 8.5
= 85 KN/$m2$
C-3 Box full Live Load surcharge on side fill:
Earth pressure at base due to live load Surcharge = 12 KN/$m2$

Earth pressure at base due to submerged earth = (20-10) x 8.5 x 0.5 = 42.5 KN/$m2$ Earth Pressure due to live load = 0

4. Base Pressure:
4.1 Dead Load:

Load from top state and walls including wearing course = 51.45 KN/$m2$ Self weight of Bottom Slab = 0.7 x 25
= 17.5 KN/$m2$
Total Load = 68.95 KN/$m2$

4.2 Live Load:

(I) There is no live load coming from top slab without impact = 21 KN/ $m2$
(T.L + L.L) Bare pressure = 89.95 KN/$m2$ (Is safe for S.B.C of 150 KN/$m2$)

IX. MOMENT CALCULATION

1. Top Slab:
F.E.M due to Dead Load = 20.75 x 8.5 x 8.5/12
= 124.93 KNm.
F.E.M due to Live Load = 95.96 x 8.5 x 8.5/12
= 577.76 Knm. Total F.E.M = 702.69 KNm
Mid span moment due to dead load = 20.75 x 8.8 x8.5/8 = 187.41 KNm. Mid span moment due to Live load = 95.8.5 x 8.5/8 = 134.6 KNm.
Total mid span moment due to live load = 866.66 KNm.

2. Bottom Slab:
F.E.M due to Dead Load = 51.45 x 8.5 x 8.5/12 = 309.772 KNm.
F.E.M due to Live Load = 21x 8.5 x 8.5/12 = 126.44 KNm.
Total F.E.M = 436.21KNm.
Mid span moment due to dead load = 51.45 x 8.5 x 8.5/8 = 464.66 KNm. Mid span moment due to Live load = 21 x 8.5 x 8.5/8 = 189.656 KNm. Total mid span moment due to live load = 654.32 KNm.

3. Side Wall:
Box empty, surcharge load on side fill F.E.M at top due to dead load :
= 85 x 8.5 x8.5/30
= 204.71 KNm.
F.E.M due to live load at top = 12x 8.5 x 8.5/12
= 72.25 KNm.
Total fixed end moment at top = 276.96 KNm.
F.E.M due to dead load at base = 85 x 8.5 x 8.5/20
= 307.1 KNm.
F.E.M due to Live load at base = 72.25 KNm.
Total F.E.M at base = 379.313 KNm.
Mid span moment due to dead load :
= 85 x 8.5 x 8.5/16
= 383.83 KNm.
Mid span moment due to live load = 12 x 8.5 x 8.5/8
= 108.375 KNm.

Total mid span moment = 492.1 KNm.

X. MOMENT DISTRIBUTION

Distribution factor = 0.5

Table no. 2 Moment Dstributon

JOINT	A		B		C		D	
MEMBER	AB	AD	BA	BC	CB	CD	DC	DA
D.F	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
F.E.M	-690.66	276.96	690.66	-276.96	379.313	-436.21	436.21	-379.313
DIST	206.52	206.52	-206.52	-206.52	28.45	28.45	-28.45	-28.45
C.O	-103.26	-14.225	103.26	14.225	-103.26	-14.25	103.26	14.225
DIST	58.74	58.74	-58.74	-58.74	58.74	58.7	-58.74	-58.74
C.O	-29.37	-29.37	29.37	29.37	-29.37	-29.37	29.37	29.37
DIST	29.37	29.37	-29.37	-29.37	29.37	29.37	-29.37	-29.37
C.O	-14.68	-14.68	14.68	14.68	-14.68	-14.68	14.68	14.68
DIST	14.68	14.68	-14.68	-14.68	14.68	14.68	-14.68	-14.68
C.O	-7.34	-7.34	7.34	7.34	-7.34	-7.34	7.34	7.34
DIST	7.34	7.34	-7.34	-7.34	7.34	7.34	-7.34	-7.34
C.O	-3.67	-3.67	3.67	3.67	-3.67	-3.67	3.67	3.67
DIST	3.67	3.67	-3.67	-3.67	3.67	3.67	-3.67	-3.67
C.O	-1.84	-1.84	1.84	1.84	-1.84	-1.84	1.84	1.84
DIST	1.84	1.84	-1.84	-1.84	1.84	1.84	-1.84	-1.84
C.O	-0.92	-0.92	0.92	0.92	-0.92	-0.92	0.92	0.92
DIST	0.92	0.92	-0.92	-0.92	0.92	0.92	-0.92	-0.92
TOTAL	-528.8	528.8	528.8	528	363.2	363.2	452.3	-452.3

1. Maximum Support Moments:

MAB = 528.8 KNm MDC = 452.31 KNm MAD = 528.8 KNm MDA = 452.3 KNm

2. Mid Span Moments :

MAB = 1036 – 528.8 = 507.2 KNm.
MDC = 654.32 – 452.3 = 202.2 KNm.
MAD = 492.1 – (528.8+452.3)/2 = 1.55 KNm.

3. Breaking Force:

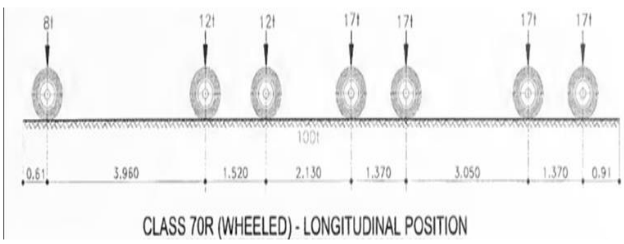

Fig. 3 Breaking Force

3.1 70R Tracked Load:

As per IRC - 6-2014, The breaking force shall be 20% for the first lane road. The breaking force = 350x20/100 =70KN.
Load on top of the box which will affect the box = 11.4x70/4.7 = 169.79 KN.

3.2 Moment due to Breaking force :

MAD = MDA = MCB = MBC = 169.79x8.5/2
= 721KNm.
After distribution of moment among all the members a moment of 46.155KNm is equal to 46.2 KNm is obtained.

Table no.3 Moment due to Breaking force

Load	Case	MaximumDistributed moments at supports			
		M_{AB}	M_{DC}	M_{AD}	M_{DA}
Total Load	Max of all cases	528.8	452.3	528.8	452.3
B.F	Distributed momentsatsupport	361	361	361	361
Design Moments	Support moments including breaking	889.8	813.3	889.8	813.3

4. Moment and reinforcement at salient section :

4.1 Top Slab :
Maximum Moment Support/ Midspan including breaking = 121.83 KNm Depth req = □ ((889.8 x 102)/(1000 x k))
k = Moment of Resistance (Constant) = 1.105 Mpa
= ((889.8 x 102) / (1000 x 1.105))
= 897 mm
Ast = (889.8 x 106) / (200 x 0.902 x 362) Ast = 5498.74 mm2

4.2 Check for Shear :
Shear Force @ deff from face of wall Vu = (116.71 (3-2(0.897 + 0.05)) / 2 Vu = 221/2
Vu = 110.5 KN
Shear stress = Vu / bd

= (110.5 x 103) / (1000 x 897)

= 0.123 N/mm2

Steel Percentage = (Ast x 100) / bd
= (5498.74 x 100) / (1000 x 897)
Steel % = 0.613 Permissible Shear Stress
= 0.123 + (((0.613 - 0.5)0.05) / 0.25)
= 0.145 N/mm2
Increase tension steel to increase permissible shear stress Required steel
= (((0.123 – 0.0434)0.25) / 0.05) + 0.5
= 0.39 %
Steel area = (0.9 x 1000 x 897) / 100
= 3498 mm2
Hence, provide tension steel 3498 mm2 in place of 5498 mm2 required for moment only

4.3 Bottom Slab :

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Bending Moment (Max) = 813.3 KNm d = □ ((813.3 x 106) / (1000 x 1.105))
d = 857.9 mm
Provided 858 mm is OK
Ast = (813.3 x 106) / (200 x 0.902 x 858)
Ast = 5254.5 mm2

4.4 Check for Shear :
Shear Force = 72.45 (3-2(0.858 + 0.05)) / 2
= 42.89 KN
Shear Stress
= Vu / bd
= (42.89 x 103) / (1000 x 858)
= 0.049 N/mm2 < 0.2715 N/mm2

4.5 Side Walls :

Moment at junction is same as slabs hence same tensile bars shall continue.
RA= ((12 x 4.25) / 2) + (1/2) x 85 x 4.25 x (1/3)
= 25.5 + 60.21
= 85.71KN
RD = ((12 x 4.25) / 2) + 85 x 4.25 x 1/3
= 25.5 + 120.42
= 145.92 KN
S.F @ deff from
D = RD - (85 + 29.65) / 2 x 0.442 - 12 x 0.442
= 145.92 – 113.83
= 32.09 KN
Shear Stress
= (32.09 x 103) / (1000 x 750)
= 0.0428 N/mm2 < 0.10 N/mm2

Hence, Safe.

8.5 / 85 = 7.83 / x
x = 78.3
7.83 / 78.3 = 0.62 / x
x = 6.2

A = RA - 1/2 x 6.2 x 0.62 - 12 x 0.62
= 85.7 – 5.013
= 80.18 KN
Shear Stress
= (80.18 x 103) / (1000 x 700)
= 0.014 N/mm2 < 0.1 N/mm2
Hence, Safe.

XI. STADD INPUT FILE

STAAD SPACE
START JOB INFORMATION ENGINEER DATE 12-Jun-20 END JOB INFORMATION INPUT WIDTH 79
UNIT METER KIP JOINT COORDINATES
1 0.609601 1.524 0; 4 11.0096 1.524 0; 5 0.609601 -6.97601 0;
6 11.0096 -6.97601 0; 7 5.80961 1.524 0; 8 5.80961 -6.97601 0; MEMBER INCIDENCES
1 1 7; 2 1 5; 3 4 6; 4 5 8; 5 7 4; 6 8 6; 7 7 8; DEFINE MATERIAL START ISOTROPIC CONCRETE
E 4.88249e+006 POISSON 0.17
DENSITY 5.29683 ALPHA 5.5e-006 DAMP 0.05
TYPE CONCRETE STRENGTH FCU 6199.99 END DEFINE MATERIAL MEMBER PROPERTY
1 5 PRIS YD 0.75 ZD 12
4 6 PRIS YD 0.7 ZD 12
2 3 7 PRIS YD 0.5 ZD 12 CONSTANTS
MATERIAL CONCRETE ALL SUPPORTS
5 6 FIXED
LOAD 1 LOADTYPE Dead TITLE LOAD CASE 1 SELFWEIGHT Y -20.75 LIST 1 4 TO 6
MEMBER LOAD 1 5 UNI GY -95.96
4 6 UNI GY 30.7
2 3 LIN Y 12 85
2 3 LIN Y 42.5 85
LOAD 2 LOADTYPE Live REDUCIBLE TITLE LOAD CASE 2 PERFORM ANALYSIS PRINT ALL
START CONCRETE DESIGN CODE INDIAN
WIDTH 11.4 MEMB 1 5 END CONCRETE DESIGN FINISH

XII. STADD RESULTS

1. Top Slab

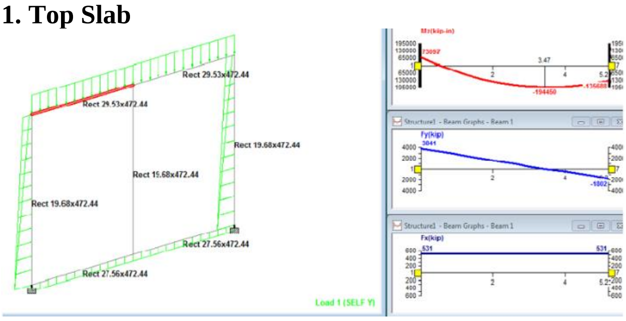

Fig . 4. Top Slab

2. Top Slab

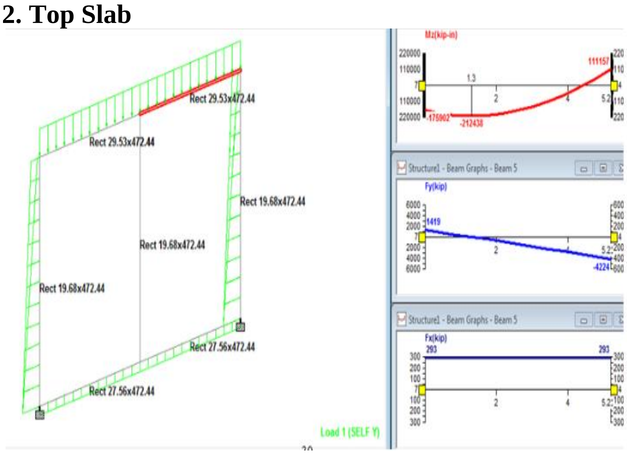

Fig 5. Top Slab

3. Side wall

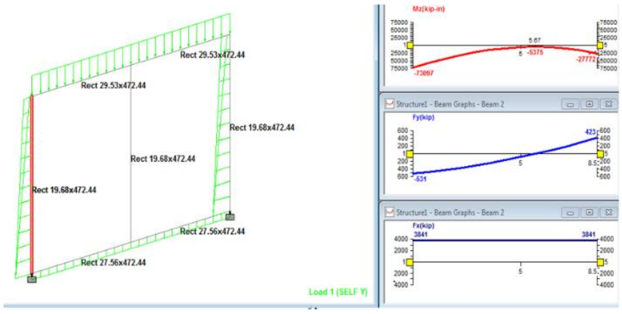

Fig no. 6. Side wall

4. Side wall

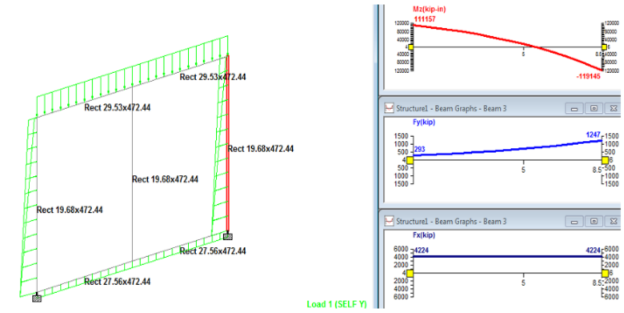

Fig no. 7. Side wall

5. Bottom slab

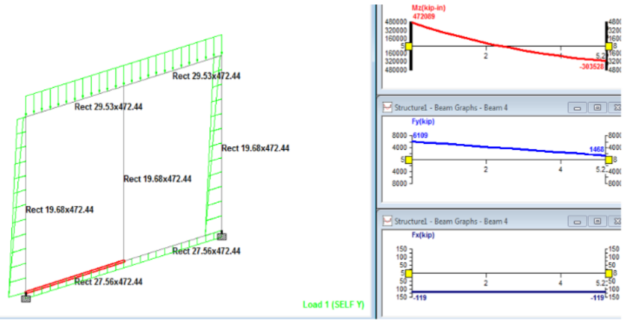

Fig no. 8. Bottom slab

6. Bottom Slab

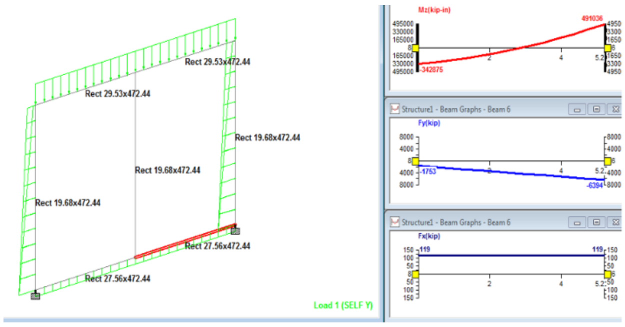

Fig no. 9. Bottom slab

7. Intermediate Wall

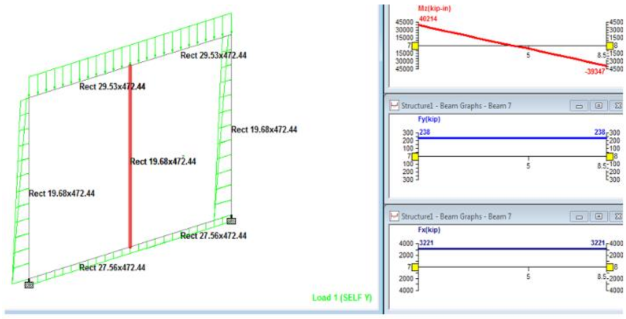

Fig no. 10. Intermediate Wall

8. Displacement

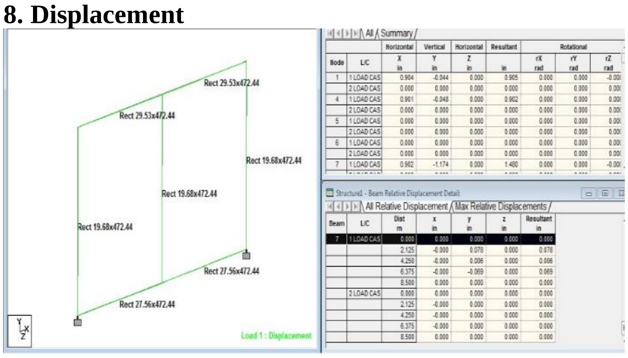

Fig no. 11. Displacement

9. Total Structure Beam Force

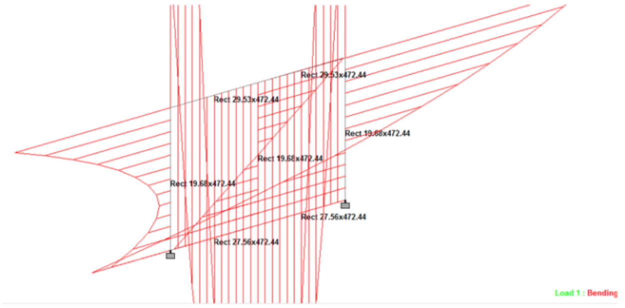

Fig no.12. Total Structure Beam Force

XIII. CONCLUSIONS

The following conclusions are drawn from the study.

- Box culvert is used for cross drainage works across high embankments.
- It is easy to add length in the event of widening of the road using STAAD PRO.
- The design of box culvert is covered by using three load cases. The values of design moments etc are marginally more than (close to) the values given by manual calculations for the three load cases.
- The study shows that the maximum positive moment develop at the centre of top and bottom slab for the condition that the Sides of the culvert not carrying the live load and the culvert is running full of water that is case 1 condition.

- The maximum negative moments develop at the support sections of the bottom slab for the condition that the culvert is empty and the top slab carries the dead load and live load.
- The maximum negative moment develop at the centre of vertical wall when the culvert is running full and when Uniform lateral pressure due to superimposed dead load acts only.
- The maximum shear forces develop at the corners of top and bottom slab when the culvert is running full and the top slab. carries the dead and live load,
- The study shows that there is significant contribution to positive normal thrust at centre of vertical wall (section E4) due to superimposed dead load & live load and weight of side walls.
- The study shows that the multi celled box culverts are more economical for larger spans compared to single cell box.
- culvert as the maximum bending moment and shear force values decreases considerably, thus requiring thinner sections.
- The increase in manual values of maximum bending moment is observed when ratios of L/H 1:1.25 and 1:1.50 are compareto that of L/H 1:1 and are in the order of 29% to 47% in centre of top slab and 27% to 44% in centre of bottom slab.
- However the support moments by 28% to 44% for top slab and by 27% to 60% for bottom slab.
- Similarly a side wall varies from 40% to 60%.

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[4] IRC: 78-2014 Standard Specifications and Code of Practice for Road Bridges,
Section: VII Foundations and Substructures

[5] IRC: SP 13 -2004 Guidelines for the Design of Small Bridges and Culverts

[6] IS: SP16-1980 Design Aids for Reinforced Concrete to IS 456:1978

[7] Atlas of State wise Generalized Iso-Pluvial Maps of Southern India, Indian Meteorological Department September 2007