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Analysis of RCC Culvert By Using Software

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Abstract - *In this paper analysis of culvert by using software for different L/H ratio with angle of friction. Culverts are provided to allow water to pass through the embankment and follow natural course of flow and road passes and culverts are also provided to balance the water level on both sides of embankment during floods, such culverts are termed as balancers. 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*

Key Words: Staad pro, culvert, L/H ratio, Angle of friction

1. INTRODUCTION

A culvert is any structure not classified as a bridge that provides an opening under a roadway, and other type of access or utility. It is well known that roads are generally constructed in embankment which comes in the way of natural flow of storm water (from existing drainage channels). 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:

1. Concentrated Loads
2. Uniform Distributed Loads
3. Weight of Side Walls
4. Water Pressure inside Culvert
5. Earth Pressure on Vertical Side Walls
6. Uniform Lateral Load on Side Wall

In finite element methodology; One of the main objectives of selecting a numerical model is to reduce the infinite degrees of freedom system to a limited degree of freedom, which will represent the significant physical behavior of the system. Numerical methods are most frequently using to get those solutions of the problems. So we are discretizing the problem by using Finite element techniques because of its practicality and versatility.

Procedure for computational modeling using FEM:

_ Modeling
_ Meshing (Discretization)
_ Specification of material
_ Assigning Restrains
_ Applying Loading

2. OBJECTIVES

1) To study the effect of cushion in RCC culvert by analysis for different cases like traffic condition, Soil condition, hydrological condition.`
2) Structural designing of RCC culvert considering various load cases including factors like effective live loads, effective width, and coefficient of earth pressure.
3) The principal objectives of the project are to investigate basic parameters like shear force and bending moments for culvert with and without cushion.

3. LITERATURE REVIEW

1) **B.N. Sinha, R.P. Sharma (2009):** This Paper deals with box culverts made of RCC, with and without cushion. 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 scope of this Paper has been further restricted to the structural design of box. 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.

2) **Miss Apurva J Chavan, Prof K.K.Tolani, Prof Chetan G. Joshi(2017):** In this research, a steel box girder is analyzed by ANSYS program. The objective of this analysis is to model the box girder in an ANSYS FEM design. This task involves examining the stress patterns obtained using static three-dimensional finite element modeling.

3) **Y. Vinod Kumar, Dr. Chava Srinivas(2015):**In this paper we also study about design of box culvert and comparative study of reinforcement details. Vent size of the culvert is fixed based on flood discharge from upstream side. Clear dimensions of the box culvert is 3mX3m. Thickness of slab is 400mm.Grade of concrete is M30, grade of steel is Fe415 and angle of repose is 300.

4. METHODOLOGY

1) Structural designing of RCC culvert considering various load cases including factors like effective live loads, effective width, and coefficient of earth pressure

2) Net ultimate bearing capacity , Earth pressure on walls ,Deck slab Axial forces ,Side Wall Axial forces, Deck slab Shear forces ,Side wall Shear forces ,Base slab Shear forces , Deck slab Bending moments

3) Modeling and analysis of culvert by STAAD pro.

5. MODELING AND ANALYSIS

5.1 Problem statement

The RCC Culvert is analyzed is for dead load, live load, earth pressure & water pressure using STAAD-Pro software.

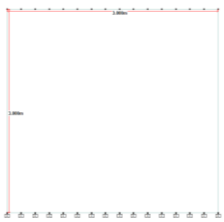

Figure 4.1 Elevation of RCC box culverts

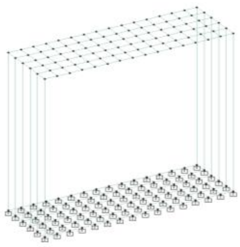

Figure 4.2 Isometric view of RCC box culverts

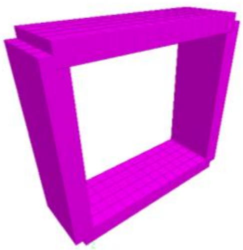

Figure 4.3 3D view of RCC box culverts

5.2 Properties

Top slab thickness – 300mm
Side wall thickness – 300mm
Bottom slab thickness – 300mm
Grade of concrete – M30
Grade of steel – Fe550

5.3Loads on culverts

Dead load:: Self weight of culvert
Live load :: 166.5 kN/m^2
Dry earth pressure:: 42.7 kN/m^2
Submerged earth pressure :: 19kN/m^2
Water pressure :: 30 kN/m^2

5.4 Load combinations

Dead load+Dry earth pressure
Dead load+Dry earth pressure + Live load
Dead load+ Submerged earth pressure
Dead load+ Submerged earth pressure+Live load
Submerged earth pressure+ Water pressure
Submerged earth pressure+ Water pressure+Live load

6. RESULTS AND GRAPHS

6.1 Introduction

The RCC box Culvert with angle of internal friction Φ = 18,22,25,28,30 and L/H ratio = 1, 1.5, 2

Table 5.1:Net ultimate bearing capacity - Qnu (kN/m^2)

Angle of internal friction Φ	L/H Ratio		
	L/H = 1	L/H = 1.5	L/H = 2
18	110.844	158.5368	206.2296
22	180.756	257.4792	334.2024
25	247.824	352.152	456.48
28	369.648	522.4464	675.2448
30	450.864	635.976	821.088

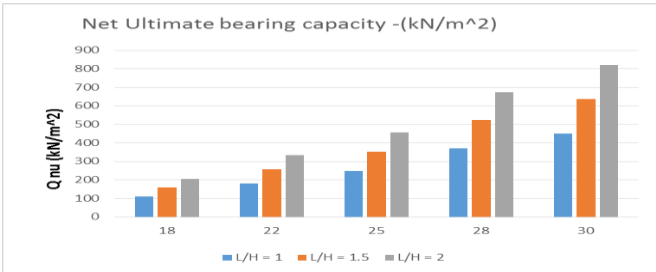

Figure 5.1: Net ultimate bearing capacity - Qnu (kN/m^2)

Table 5.2:Earth pressure on walls - Pnu (kN/m^2)

Angle of internal friction Φ	L/H Ratio		
	L/H = 1	L/H = 1.5	L/H = 2
18	42.745619	96.177643	170.982477
22	36.839617	82.889139	147.358469
25	32.861801	73.939052	131.447204
28	29.230685	65.769041	116.922739
30	26.986861	60.720438	107.947446

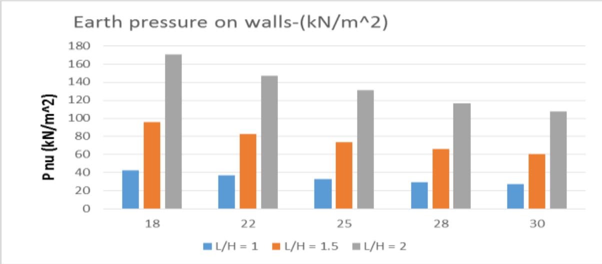

Figure 5.2: Earth pressure on walls - Pnu (kN/m^2)

Table 5.3 : Deck slab Axial forces - Pd (kN)			
Angle of internal friction Φ	**L/H Ratio**		
	L/H = 1	L/H = 1.5	L/H = 2
18	55.265	127.071	300.66
22	33.626	109.504	259.039
25	30.114	97.736	230.989
28	27.09	86.984	205.321
30	24.956	80.345	189.52

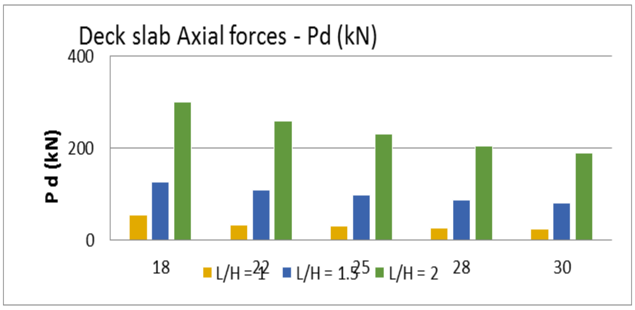

Figure 5.3: Deck slab Axial forces - Pd (kN)

Table 5.4 : Side Wall Axial forces - Pd (kN)			
Angle of internal friction Φ	**L/H Ratio**		
	L/H = 1	L/H = 1.5	L/H = 2
18	281.558	292.161	302.764
22	281.558	292.161	302.783
25	281.558	292.161	361.934
28	281.558	292.161	302.764
30	281.558	292.161	302.764

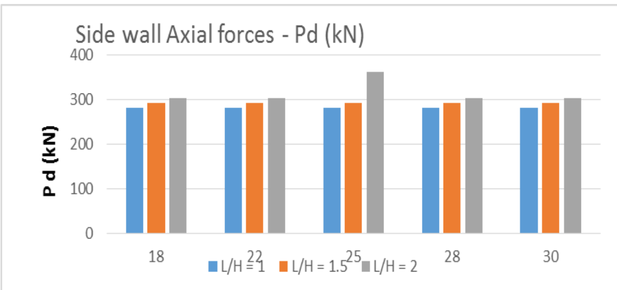

Figure 5.4: Side Wall Axial forces - Pd (kN)

Table 5.5 : Deck slab Shear forces -Vd (kN)			
Angle of internal friction Φ	**L/H Ratio**		
	L/H = 1	L/H = 1.5	L/H = 2
18	260.353	260.353	260.353
22	260.353	260.353	260.373
25	260.353	260.353	319.523
28	260.353	260.353	260.353
30	260.353	260.353	260.353

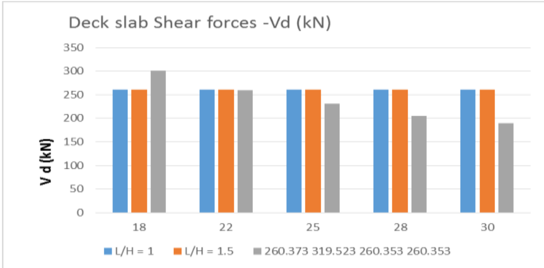

Figure5.5: Deck slab Shear forces -Vd (kN)

Table 5.6 : Side wall Shear forces -Vd (kN)			
Angle of internal friction Φ	**L/H Ratio**		
	L/H = 1	L/H = 1.5	L/H = 2
18	66.418	163.437	385.032
22	43.277	141.112	332.199
25	38.824	126.162	318.096
28	34.794	112.432	264.07
30	32.282	103.941	244.041

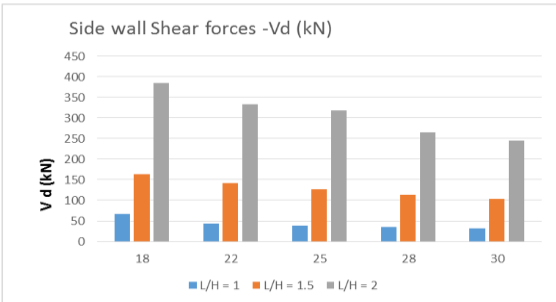

Figure 5.6: Side wall Shear forces -Vd (kN)

Table 5.7 : Base slab Shear forces -Vd (kN)			
Angle of internal friction Φ	**L/H Ratio**		
	L/H = 1	L/H = 1.5	L/H = 2
18	230.206	239.046	248.895
22	229.938	239.003	249.058
25	229.93	238.411	297.27
28	229.265	237.897	249.04
30	229.919	237.52	248.866

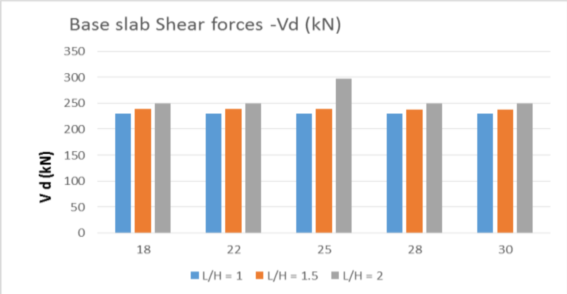

Figure 5.7: Base slab Shear forces -Vd (kN)

Table 5.8 : Deck slab Bending moments –Mz (sagg) (kNm)			
Angle of internal friction Φ	L/H Ratio		
	L/H = 1	L/H = 1.5	L/H = 2
18	-123.309	-135.665	-143.93
22	-123.447	-135.665	-143.865
25	-124.113	-135.552	-143.805
28	-124.646	-135.474	-143.697
30	-125.095	-135.422	-143.627

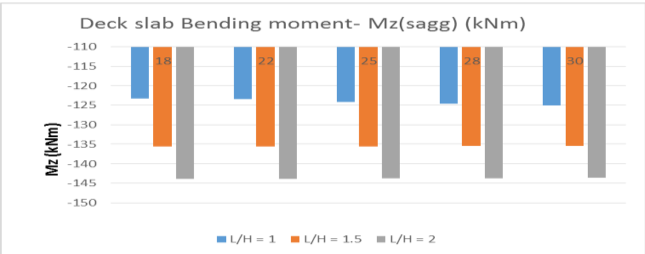

Figure 5.8: Deck slab Bending moments -Mz(sagg) (kNm)

Table 5.9 :Side wall Bending moments -Mz(sagg) (kNm)			
Angle of internal friction Φ	L/H Ratio		
	L/H = 1	L/H = 1.5	L/H = 2
18	-79.965	-119.87	-284.67
22	-74.481	-110.52	-251.01
25	-73.526	-103.95	-348.26
28	-72.737	-97.953	-208.64
30	-72.124	-94.216	-196.13

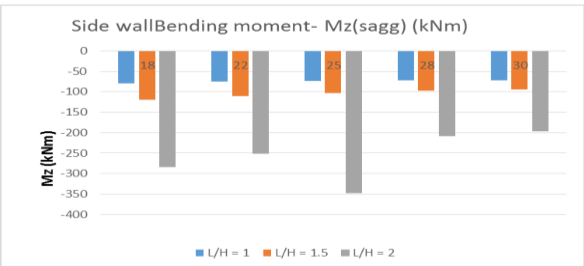

Figure 5.9: Side wall Bending moments -Mz(sagg) (kNm)

Table 5.10 : Base slab Bending moments - Mz(Hogg) (kNm)			
Angle of internal friction Φ	L/H Ratio		
	L/H = 1	L/H = 1.5	L/H = 2
18	119.38	126.486	133.443
22	120.325	126.486	132.809
25	121.145	125.42	164.099
28	121.177	124.679	131.144
30	122.355	124.19	130.443

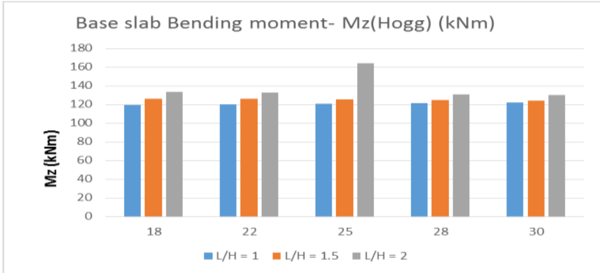

Figure 5.10 : Base slab Bending moments -Mz(Hogg) (kNm)

6. CONCLUSIONS

1. Net ultimate bearing capacity –Qnu of box culvert is increased by 25%as angle of internal friction and L/H ratio are increased.
2. Earth pressure on walls –Pnu of box culvert is decreased by 15% as angle of internal friction is increased but it is increased by 50% as L/H ratio is increased.
3. Deck slab Axial forces –Pd of box culvert is increased by 15% as angle of internal friction is increased but it is increased by 50% as L/H ratio is increased.
4. Side Wall Axial forces –Pd of box culvert is found to be same as angle of internal friction is increased but it is increased by 10% as L/H ratio is increased.
5. Deck slab Shear forces –Vd of box culvert is found to be same for all models.
6. Side wall Shear forces –Vd of box culvert is decreased by 15% as angle of internal friction is increased but it is increased by 50% as L/H ratio is increased.
7. Base slab Shear forces –Vd of box culvert is found to be same as angle of internal friction is increased but it is increased by 10% as L/H ratio is increased.
8. Deck slab Bending moments -Mz(sagg) of box culvert is decreased by 15% as angle of internal friction is increased but it is increased by 50% as L/H ratio is increased.

9. Side wall Bending moments -Mz(sagg) of box culvert is decreased by 15% as angle of internal friction is increased but it is increased by 50% as L/H ratio is increased.

10. Base slab Bending moments -Mz(Hogg) of box culvert is found to be same as angle of internal friction is increased but it is increased by 10% as L/H ratio is increased.

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