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Analysis of Three different types of Culverts for same Loading Conditions as per I.R.C. Loadings using Analysis Tool SAP2000

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Abstract: ***A culvert is a cross-drainage structure having a total length of 6m or less between the inner faces of the dirt wall or extreme vent-way boundaries measured at right angles thereto. Construction of a road embankment unavoidably obstructs and interferes with the natural overland flow and flow through the natural channels e.g. rivers, nallas, canals, drains etc. Suitable bridge / culvert openings under the road should, therefore, be provided across these channels with a view to pass the peak discharge through the channels without causing harmful afflux and disturbing the natural flow regime.***
In this Study we are performing a comparison of three different type of culverts under heavy traffic flow and hydraulic flow as per site using finite element analysis tool SAP2000.
Here we are concluding that box culvert is comparatively more stable, stiffer and economical structure in comparison, As same loading and analysis is applied on all the cases, it is clearly observed that box culvert will be a better option instead of slab culvert.
Keywords: culvert, analysis, hydraulic data, SAP2000, F.E.M. stability, cost analysis.

I. INTRODUCTION

Culverts throughout the country are approaching or are past their original design lives. These `baby boomer' culverts will need to be repaired, rehabilitated, or replaced. Because entire culvert replacement is so expensive and intrusive, alternate measures to extend the culvert project life are growing increasingly popular. One such method is retrofitting, where a `strength developing section' is installed within an existing culvert barrel and stabilized. Footing support and column strengthning are very popular for retrofitting primarily because the material's lower Manning's roughness values allow for the culvert capacity to be maintained despite a reduction in culvert size. Culverts are commonly used both as cross-drains for ditch relief and to pass water under a road at natural drainage and stream crossings. A culvert may be a bridge-like structure designed to allow vehicle or pedestrian traffic to cross over the waterway while allowing adequate passage for the water.

The investigation of the street culvert area superstructure has dissected utilizing examination programming (SAP-2000) which is a customary kind use in culverts. Culvert segments is a basic, simple and quick development kind of structure and overall it has utilizing for traverse length 3 m to 6 m. A writing survey is an evaluative report of concentrates found in writing identified with chose region.

Polra et. al. (2017) [20] 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.

Jing et. al. (2017) [19] Illustrated that Culvert diseases are prevalent in highway engineering. There are many factors involved in the occurrence of the disease, and the problem is complex. However, the design cannot accurately determine the role of the soil pressure on the culvert is the main reason to the disease. Based on the theoretical analysis and field test, this paper studies the characteristics of the stress and deformation of the culvert-soil structure. According to the theory of soil mechanics, the calculation model of vertical soil pressure at the top of culvert is determined, and the formula of vertical soil pressure at the top of culvert is deduced. Through the

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field test of the vertical soil pressure at the top of culvert of several engineering examples, the calculation formula of this paper is verified, which can provide reference for future practical engineering.

Osama et. al. (2018) [18] Box culverts may be constructed in active seismic areas, where ground shaking or ground failures can impose considerable earth pressures on them. In this study, the seismic response of box culverts was investigated experimentally and numerically. A series of scaled centrifuge tests was performed and subjected to three different earthquake signals, with different amplitudes and frequencies. Two values of culvert wall thickness and two values of sand relative density were considered in the experimental program. Experimental results are presented in terms of comparisons of seismic bending moments. These results were used to calibrate and verify two-dimensional numerical models developed using the computer program FLAC. The verified models were then used to investigate the effect of earthquake intensity and frequency, height of soil cover, and culvert thickness on the seismic bending moments for the different culvert sections. Based on the analysis results, charts are presented to aid in the seismic design of box culverts.

II. SCOPE OF WORK

In this study, I will prepare a comparative study based on three different type of culverts i.e. Box type, pipe type and slab type using finite element analysis in SAP 2000, considering same strength in SAP 2000 to analyze. In this study we will prepare a cost analysis of both the structures using S.o.r. C.P.W.D. 2014.

A. Need of study

The primary objectives of our research work is to find the followings:

1) Determine the more effective and efficient use of software Implementation in culvert design and analysis.
2) Compares box culvert, pipe culvert and slab culvert for same hydraulic calculation.
3) Determine the best of both type of culverts in resisting hydraulic flow and vehicle load as per I.R.C. chapter-6.
4) Applying the same on a live project on PMGSY-2 package road in Sehore (Icchawar) at chainage 02+236.

III. METHODOLOGY

1) Step-1 Determine the site condition and position for casting culvert.
2) Step-2 Hydraulic design to determine required culvert length and profile grade using topographical sheet.

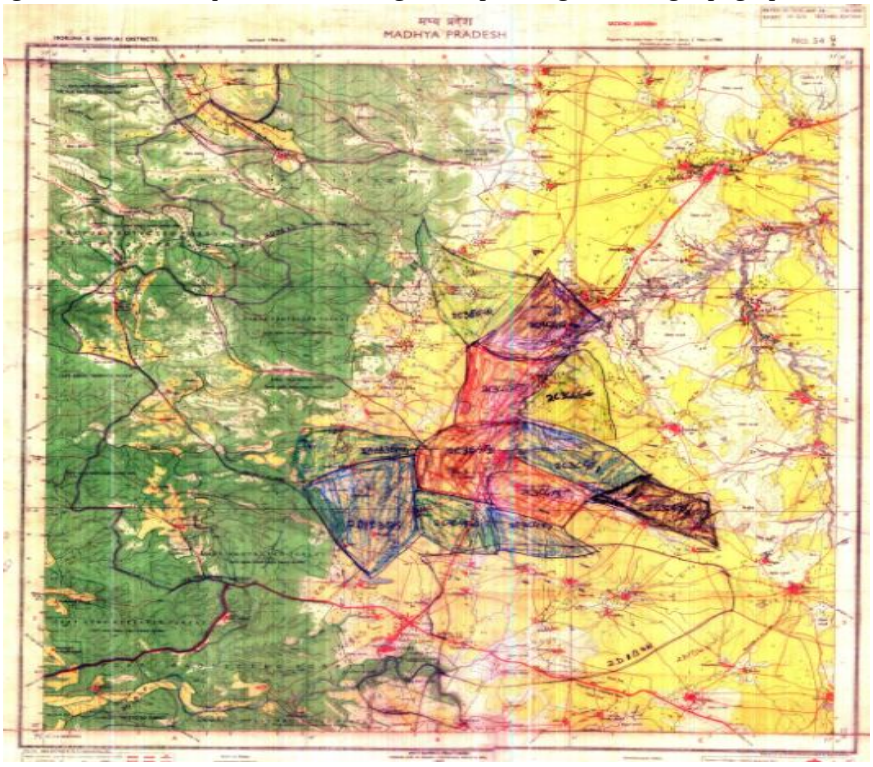


Fig 1: topography sheet

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3) Step-3 Preparation of geometry of culvert in SAP 2000

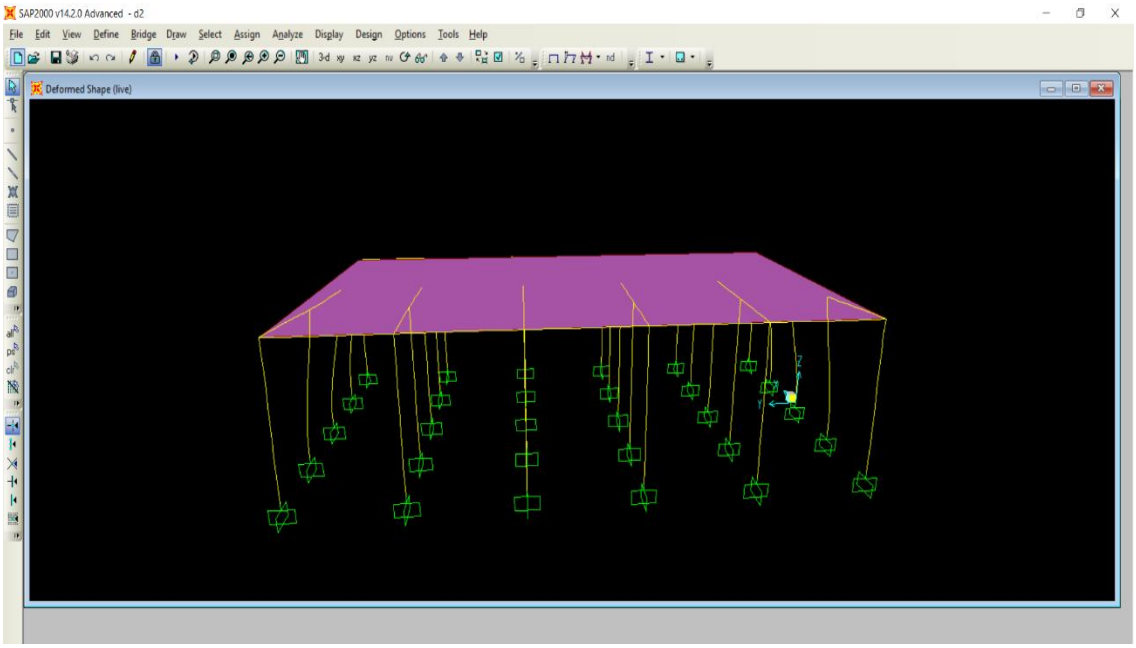


Fig 2: culvert modelling

4) Step-4 Assigning of Loads and section properties with support conditions.
5) Step-5 Assigning hydraulic load and vehicle load as per I.R.C.
6) Step-6 Analysis (finite element)

A. Geometrical Properties

Table 1: geometrical properties

s. no	Description	Values
1	Culvert length	5.5 meter
2	Culvert width	3.75 meter
3	No. of lanes	One
4	Carriageway length	6.25 meter
5	Slab thickness	1.2 meter
6	Pier height	3.5 m
7	Size of beam	300 x 400 mm
8	Support section	Fixed

B. Material Properties

Table 2: material properties

s. no	Description	Values
1	Material property	Values
2	Grade of concrete	M-25
3	Young's modulus of concrete, E_c	$2.17x10^4$ N/mm^2
4	Poisson ratio	0.17
5	Tensile Strength, Ultimate steel	415 MPa
6	Tensile Strength, Yield steel	250 MPa
7	Elongation at Break steel	70 %

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IV. RESULTS & DISCUSSION

A. *F.E.M. analysis*

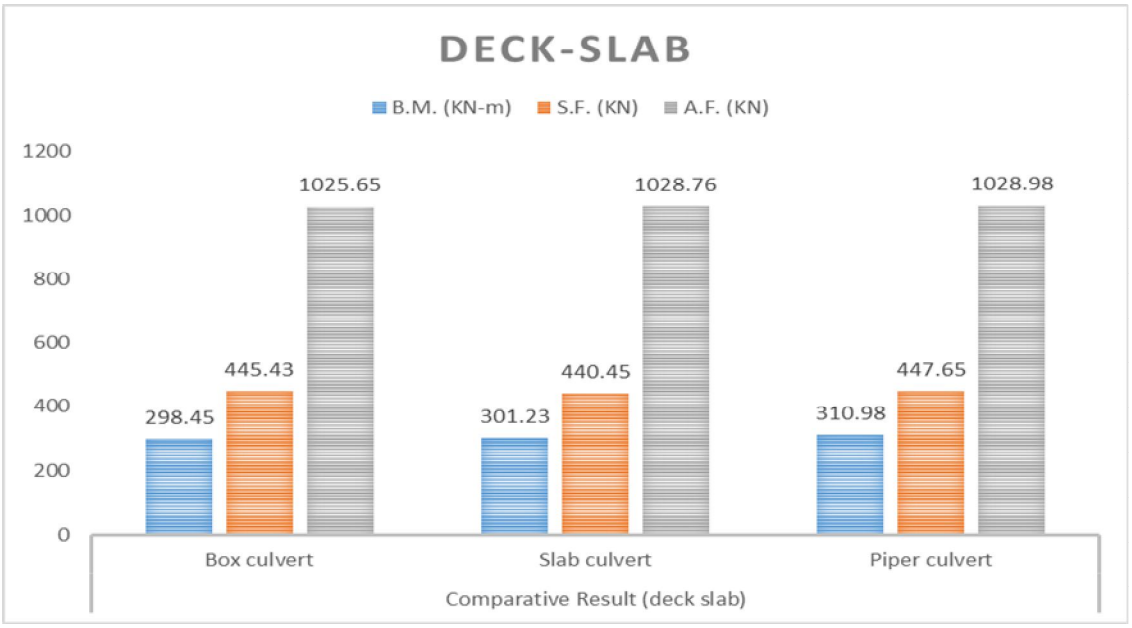


Fig 3: Deck analysis

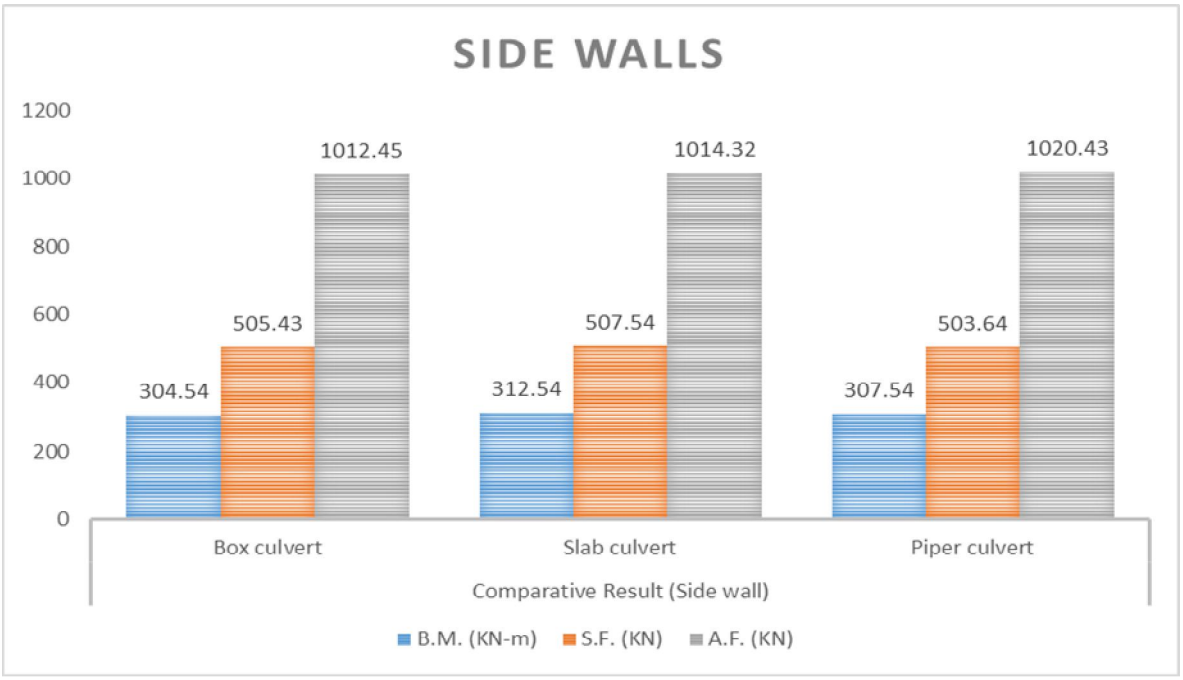


Fig 4: side walls analysis

B. *Cost Analysis*

Table 3: Cost estimation

Cost estimation of Box culvert					
concrete (cu.m)	Rebar (kg)	S.O.R. rate concrete	S.O.R. rate rebar	total concrete	total rebar
210	22128	4500	24	9,45,000	531072

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Cost estimation of Box culvert					
concrete (cu.m)	Rebar (kg)	S.O.R. rate concrete	S.O.R. rate rebar	total concrete	total rebar
207	22130	4500	24	9,31,500	531120
Cost estimation of Pipe culvert					
concrete (cu.m)	Rebar (kg)	S.O.R. rate concrete	S.O.R. rate rebar	total concrete	total rebar
203	22140	4500	24	9,13,500	531360

V. CONCLUSION

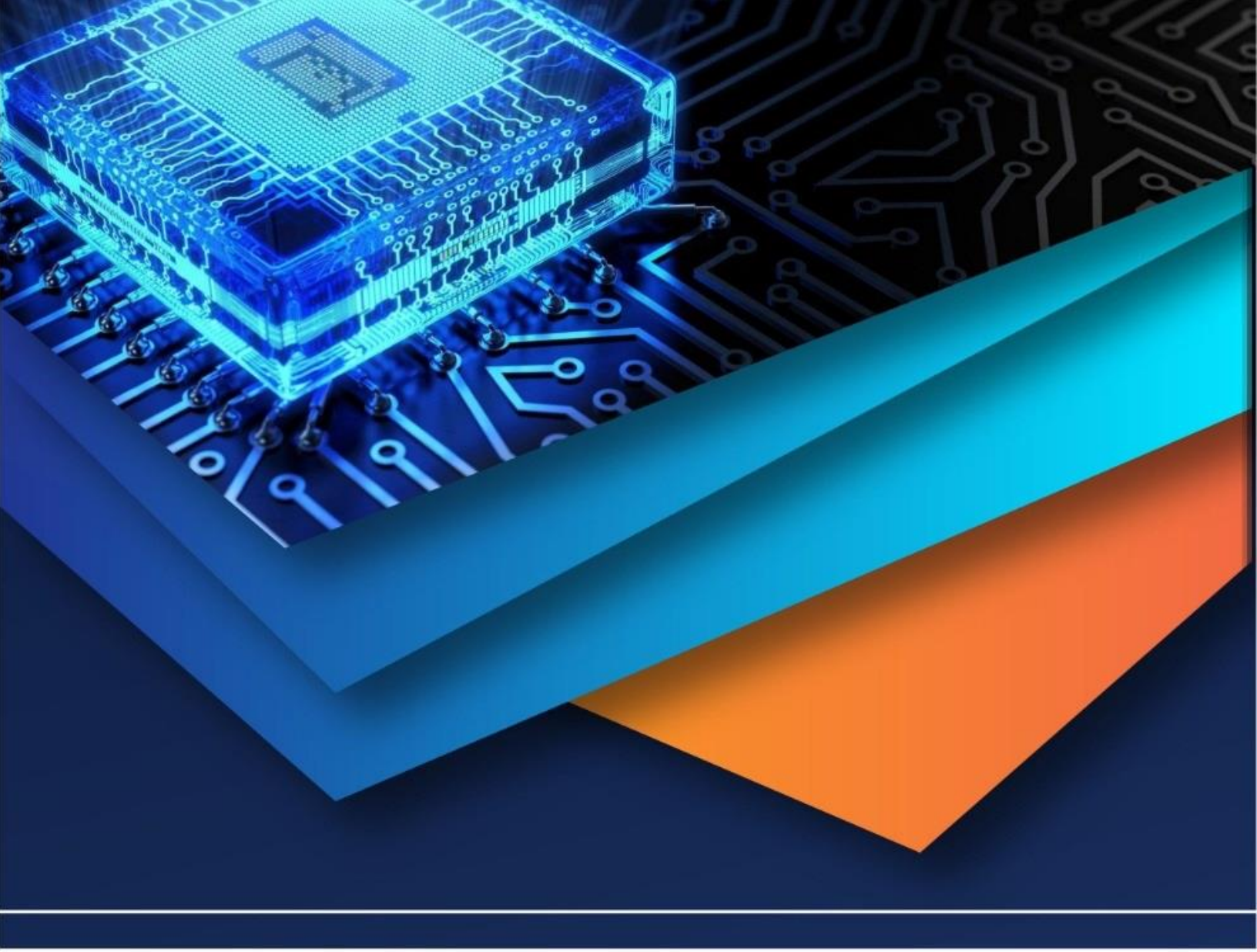
Following are the main Conclusions of our study are as follows:

A. In this comparative analysis it is clearly stated that box culvert is more stable in resisting load.
B. In this study Hydraulic calculation is determined using topography sheet available as per Indian standard using dickens formulae.
C. In this study we manually calculate the total discharge and assigned it in software.
D. It is concluded that in terms of cost Pipe & Slab culvert is comparatively more costlier than Box culvert.
E. Here vehicle load using I.R.C. loading is applied to justify its implementation using SAP-2000

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