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A Study of a Box Culvert for Improvement of its Life Span and Cost Analysis

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***Abstract*: Transportation always plays an important Role in economic growth & globalization for a country. Road transportation is one of the main transporting way in India. Therefore, that required connectivity of cities. Hence bridges & culverts are construct to connect Roads. Box Culvert can be defined as a structure having box shape which is constructed below the Embankment to drain water from one side of the bank to the other side of the bank. Failure reasons of a Box Culverts are maintenance failure, Erosion and increase in Scour depth, and Installation Failures (occurs in Pre Cast Box Culverts). To improve the problems occurring in the Structure are described briefly. Box Culverts are normally constructed without RCC cut off and curtain walls. Due to which structure getting damaged easily. In previous Researches Box Culvert are constructed with PCC cut off & curtain walls while taking various parameters in design. Main objective of the present work is to analysis a Box Culvert with RCC Cut off & curtain walls. RCC cut off & Curtain walls increases strength of a Box Culvert Bridge & gives two times life span to Box Culvert Bridge. Movements of people and transportation will not be affected because structure will not be constructed number of times because life of structure will be very long. Seepage pressure is less in box culvert with RCC Cut off & curtain walls because the gripping in RCC structure is good as compare to PCC Structure, and Seepage pressure is directly proportional to voids that makes PCC structure unstable against seepage pressure. BM of PCC walls is also less than as compare to RCC walls. Life of structure will also increase around two times, & also Government planning will not be affected because project will be for long time period. The study included estimation of PCC & RCC Cut off & Curtain walls through comparative results in SOR 2017.Results re discussed in this thesis.**

***Keywords*: BOX Culvert, CUT OFF Wall, Curtain Wall, Estimation, SSR 2017, Structure, Analysis, & comparative Results, Life span.**

1. Introduction

Culverts – culverts can be defined as a structure which is constructed on obstructions that allows water to flow beneath it. In other words, we can define culverts as a tunnel structure constructed under railways or roadways to supply drainage from one side to another.

Types of Culverts,

- Pipe Culvert
- Pipe Arch Culvert
- Arch Culvert
- Bridge or Slab Culvert
- Box Culvert

- *Pipe culvert:* Pipe culverts are widely used culverts and rounded in shape. The culverts may be of single or multiple in number. If a single pipe culvert is required to construct then larger diameter culvert is installed. It is one of the most common used type of Culverts. Normal diameter used in this type of culverts vary from 1200 to 1500 mm.
- Multiple Pipe Culverts are commonly used when the flow of water is large. Multiple Pipe Culverts are suitable for larger flows very well. The diameter of multiple pipe culverts ranges from 1 meter to 6m. Generally Pipe Culverts are made of Concrete or steel etc.
- *Pipe arch culvert:* Pipe arch culverts looks like half circle shaped culverts. This type of culverts is suitable for large flow of water but the flow of Water should be stable. Due to the arch shape fishes or sewage in the drainage easily carried to the outlet without obstructions at the entrance gate or bottom of channel.
- Pipe Arch culverts can also be provided in multiple numbers based on the requirement or length of obstructions. They also resemble beautiful appearance.
- *Arch culvert:* Arch culvert is just similar to pipe arch culvert but in this case a floor artificially is provided below the arch Culvert.
  - For narrow passages it is widely used.
- *Slab or Bridge culvert:* Slab or Bridge culverts are provided on canals or rivers and also used as road bridges for vehicles.
  - It can be three sided or a deck slab simply constructed in the soil on either side.
- *Box culvert:* Box Culverts – A structure which is in a shape of Box, generally constructed to drain water beneath the Embankment to let flow the water from one side of bank to another side of bank so that the obstruction can be easily crossed and connect to the road of the other side of the bank.

Two types of Box Culvert generally constructed:

- Pre cast Box Culvert
- Cast in site Box Culvert
- Box culverts generally constructed as precast or post cast.

- Box culvert constructed in rectangular shape and generally constructed by concrete. Reinforcement is used in construction of boxes.
- Box Culverts are constructed to flow large amount of water.

Materials used in Construction of Box Culvert:
Concrete
Reinforcement
PVC pipe

Design data required for designing a Box Culvert:
Hydraulic Data
OGL
Scour Depth
SBC

2. Methodology

Two methods are used for designing a Box Culvert:

- WSM method
- LSM or LRFD method
- *WSM method:* WSM indicates working stress method. Working stress method shows the linear relationship between loads & stresses. It's a very old method, in this method concrete is assumed as elastic.
- *LSM Method:* LSM signifies Limit State Method. It is also known load & resistance factor design (LRFD) method. It does not show a linear relationship between load & stresses, it's a new method, it is a Plastic design method.

In this design we are using WSM method & the design is given below of Box Culvert.

A. Experimental work

Cut off Wall Reinforcement: The main requirement of cut off wall (COW) is to flow the water. But due to the hydraulic pressure & scour pressure it gets damaged easily. Hence in this study we are providing reinforcement in Cut off wall as shown in given figure,

The main bar Ring is of 12 mm & distribution bar is of 8 mm. The 2nd figure shows the establishment of reinforcement in COW by which the wall is also capable to bear the tensile load developed due to hydraulic pressure & Scour pressure and gives more strength to Box Culvert to resist the tensile force developed in Cut off Wall.

Fig. 1. Casting of Reinforcement in Cut off wall

Curtain Wall Reinforcement: The wall which is constructed below the box in a Box Culvert is called as Curtain wall or pin wall. This wall provides stability to the box. In previous studies curtain wall is constructed of normal P.C.C on both beneath end side of Boxes which get affected due to loading and get damaged easily. To avoid this damage we are providing reinforcement in this wall. The main bar is of 8 mm and distribution bar is also of 8mm. Figure shows the reinforcement images and the casting images of reinforcement in Curtain wall or pin wall. The tensile force which is developing in the Curtain wall due to reinforcement Curtain walls can bear it easily and the box culvert cannot get damaged soon. & it provides more stability to the base of the boxes. Sometimes Scour depth increased due to the excavation nearby the box culverts which affects the Cut off Wall and at that time Hydraulic Pressure directly affects Curtain Wall but by providing reinforcement it can bear that tensile force and the structures remain safe for long time interval.

Fig. 2. Casting of Reinforcement in Curtain Wall

Why do we need cut off wall with RCC?

As we know that PCC Cut off wall is unable to bear the tensile force developed due to the hydraulic pressure and Seepage pressure. Which increases requirement of reinforcement in Cut off walls. Addition of Reinforcement in Cut off wall makes the C.O.W more Resistible against Tensile force developed due to the hydraulic Pressure and Seepage pressure which results in more life span of structure.

B. Reasons of RCC in cut off Wall

It Provides stability to the Structure. As well as it gives stability to the structure against tensile force. And also increases life span of the structure which won't affect the government's planning more often.

C. Materials used in cut off wall

Concrete- M15 grade concrete is used in the construction of Cut off wall. Concrete helps the structure in resisting compressive force to the structure.

Reinforcement- Reinforcement of 8mm as main bar ring and 10mm as distribution rings are used in it of fe-500d. Which increase the strength of structure 3 times more, as we know the Reinforcement increase the tensile strength of the structure because the concrete is a brittle material in tensile force.

D. Dead load and live load in RCC cut off wall

W (dead load) = β (density) x V (volume)
= β x A x L
= 25 x ((1.50 + 0.30)/2) x 2.70
= 60.75 KN/m

$BM = \frac{WL^2}{12}$

$= \frac{60.75 \times 10^3 \times (71.90^2)}{12}$

BM (RCC C.O.W) = 26171.1 x 10^6 N-mm
BM (PCC C.O.W) = 25124.3 x 10^6 N-mm

1. BM (RCC) > BM (PCC)

E. Properties of concrete

1) Color/Grayscale figures

W (dead load) = β (density) x V (volume)
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BM (RCC C.O.W) = 26171.1 x 10^6 N-mm
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BM (RCC) > BM (PCC)

F. Properties of concrete

1. GRADE OF CONCRETE IN BOX CELL: M – 30
2. PERMISSIBLE FLEXURE COMPRESSIVE STRESS (fcb): 10. N/mm^2 = 101.94 Kg/cm^2
3. PERMISSIBLE DIRECT COMPRESSIVE STRESS (fcc): 7.5 N/mm^2 = 76.50 Kg/cm^2
4. MAXIMUM PERMISSIBLE SHEAR STRESS: 2.3 N/mm^2 = 23.4 Kg/cm^2
5. E OF CONCRETE : 27.39 KN/mm^2
6. MODULAR RATIO : 10
7. FOR M-30 CONCRETE:
   a) n: 0.238
   b) j: 0.902
   c) Q: 11.20

PROPEUSE OF STEEL

1. GRADE OF STEEL : Fe – 500
2. PERMISSIBLE TENSION IN FLEXURE, SHEAR (fstb) 240 mm^2 = 2447 Kg/cm^2

241 CLEAR COVER BELOW GROUND LEVEL: 75
242 CLEAR COV ER ABOVE GROUND LEVEL: 40

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3. Results & Discussions

A. Result

1) Reinforcement comparison of pcc and rcc cut off and curtain walls

Reinforcement is able to bear the tensile forces developed due to the Hydraulic Pressure which makes the structure more stable & capable to resist the tensile force. The table given below shows the total reinforcement used in Cut off & Curtain Walls which gives enough strength to the COW and Curtain Walls. Firstly, M15 concrete were used in COW and Curtain walls. We are using Reinforcement of Fe-500 which makes the structure more resistible and stable. Because the strength is increasing around 33 times.

Table 1
Reinforcement Comparison

Items	Box Culvert with P.C.C Cut off & Curtain wall	Box Culvert with R.C.C Cut off & Curtain wall
	Reinforcements(in tone)	Reinforcements(in tone)
Cut off Wall	0.00	1.80
Curtain Wall	0.00	1.53
	total reinforcement addition =3.33 tone	

4. Conclusion

The main objective of this study is to determine the most stable and load resisting structure. To determine the costing of RCC& PCC cutoff and curtain wall .To compare PCC and RCC Cutoff and Curtain wall in terms of Life span Stability and costing.

- Life of structure is increased two times.
- Movements of people and transportation will not be affected because structure will not be constructed number of times because life of structure will be very long.
- Seepage pressure is less in box culvert with RCC cutoff & curtain walls.
- Money Manpower and resources will be used less times.
- Government planning will not be affected because project will be for life time period.

5. Future scope

- Filling material can be replaced.
- Various grade of concrete can be used for bridge work.
- An application should be made up to check the seepage pressure of PCC & RCC Cut off wall or Curtain walls.

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