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MANAGE THE TRAFFIC AT CULVERT BY PROVIDING EXTRA WIDENING IN EXISTING PIPE CULVERT

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Abstract: The hydraulic performance of culverts on Indian roads is influenced by backwater conditions. This paper investigates the hydraulic efficiency of rectangular and arch culvers in the specific context of Indian road conditions. The primary objective of the study is to evaluate the performance of widening and enhancing drainage on Indian highways. This study uses numerical simulations to assess the hydraulics of large-diameter and narrow-segment canals. The secondary objective is to investigate how the hydraulic performance is impacted by different backwater environments. The main objective of this paper is to compare the hydraulic performances of rectangular, arch, and narrow canals in the context of the Indian road condition. A case study is presented on the environmental assessment of fish passage through a narrow channel. The results are compared with the results of a case study in which a fish passage is simulated under a wide channel. It is found that a large proportion of the fish passages in a single channel are culverted. The hydraulic efficiency is a function of the backwater condition. The analysis of hydraulic efficiency reveals that the hydraulic characteristics of the narrow channel have a significant impact on flood mitigation. The study provides valuable insights for civil engineers, transportation planners, and policymakers involved in road infrastructure development and management in India. This work contributes to the understanding of how hydraulics can be evaluated for flood mitigation in the Indian context, providing valuable insight for highway engineering, transportation planning, and decision makers involved in flood management efforts in rural areas of India.

Index Terms - hydraulic performance, widening, enhancing drainage, narrow-segment canals, flood mitigation

I. INTRODUCTION

Providing extra widening in pipe culverts involves designing, installing, and maintaining pipe structures to facilitate the passage of water beneath roads, railways, or other structures. The objective of providing extra widening pipe culvert, is to reduce traffic at culvert and to manage the waste water at RTO road Sagar MP. Here's an overview of the process:

Survey and Assessment: Before installing a pipe culvert, engineers conduct a survey of the area to determine factors such as the volume and flow rate of water, soil conditions, topography, and any existing infrastructure. This information helps in selecting the appropriate size, type, and location of the culvert.

Design: Based on the survey data of the filed, engineers design the culvert to meet the specific requirements of the site. This data includes determining the diameter or size of the pipe, the material of construction (such as concrete, steel, or plastic), the shape and other structural details.

Permitting and Approvals: Depending on local regulations and environmental considerations, obtaining permits and approvals may be necessary before construction can begin. This may involve obtaining permits for waterway crossings, environmental impact assessments, and approvals from relevant authorities.

Installation: Once the design is finalized and permits are obtained, the installation process begins. This typically involves excavation of the field where the culvert will be placed, followed by the placement of the pipe and backfilling to secure it in place. Proper alignment, slope, and elevation are critical to ensure efficient water flow and structural integrity.

Bedding and Backfilling: The culvert pipe is typically placed on a stable foundation, which is known as bedding, to support the pipe and distribute the load. After the pipe is installed, the culvert pipe is backfilled with suitable material to cover and protect it. After backfilling proper compaction is essential to prevent settling and ensure the longevity of the culvert.

Headwalls and End Treatments: Headwalls, wing walls, and end treatments may be installed at the inlet and outlet of the culvert to provide additional support and protection against erosion. These structures help to guide the flow of water into and out of the culvert and prevent scouring of the surrounding soil.

Maintenance: Regular inspection and maintenance are essential to ensure the proper functioning of the culvert over time. This may include clearing debris, inspecting for signs of erosion or damage, and repairing any issues that arise.

Overall, providing pipe culverts involves a systematic approach to design, installation, and maintenance to ensure the safe and efficient passage of water beneath transportation infrastructure.

II. RESEARCH METHODOLOGY

A. DATA COLLECTION:

The usefulness of an accurate and comprehensive system of collection of data and recording the problem of removal of waste water. Such data use to identify the problems on the field also identify the basic causes of the problem of removal waste water.

Engineering uses of data:

Data collection is important for future works. In engineering field collected data helps the engineers to assess the problems that come at the time of construction of any structure. With the use of collected data engineers can design the structure accordingly.

- Regular data collection helps engineers anticipate maintenance requirements for culverts.
- Data collected over time allows for the establishment of a comprehensive asset management system for culverts.

- Engineers use collected data to assess the performance of existing culverts.
- By analyzing historical data and monitoring ongoing performance, engineers can identify potential risks associated with culverts, such as inadequate capacity during extreme weather events or structural deterioration due to corrosion.

a.Collection of data:

Data is collected from a field that includes the measurements of the road, culvert, Flow intensity at that place etc.

Measurements of road-

Two way two lane road is going to construct on a selected site. The measurements of the road include, name of road, type of road, width of the road, thickness of the road, slope on the road. Height, width and thickness of the parapet wall. The total width of the road is 18.200 m which include the width of both road i.e. 7m each, both right and left shoulders i.e. 1.5 m each. And the width of parapet walls i.e. 1.2 m. The slope on the road is 1:1000.

b. Measurement of road

Name of road – Rajghat Junction to new RTO road (Sagar)
Types of road - Road is rigid pavement type i.e. Reinforced cement concrete.

Table 1

S. No.	Parameters	Values
1	Road carriage way	5650 mm each way (two way two lane)
2	Total width of parapet walls	1200 mm (Including both wall's thickness)
3	Slope of road	1:1000

Table 2 Measurement of the existing pipe culvert

S. No.	Parameters	Values
1	No. of pipe culvert	10
2	Length of one pipe culvert	2500 mm
3	Diameter of pipe culvert	1000 mm
4	Slope	1:1000

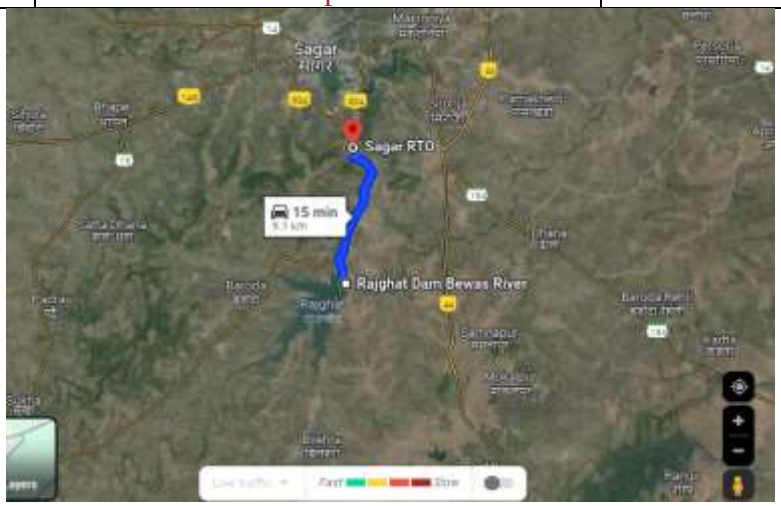

Figure 1 Location of Road

B. STRUCTURAL CONSIDERATIONS:

Analysing the structure of a pipe culvert involves assessing various aspects of its design, materials, dimensions, and functionality. Here's a breakdown of the key components to consider:

a.Material Selection:

Pipe culverts can be made of various materials such as concrete, steel, plastic, or corrugated metal. The choice depends on factors like expected traffic load, soil conditions, water flow, and budget. Here we are using concrete pipe culvert.

b. Dimensions:

Diameter: The diameter of the pipe determines the capacity of the culvert to carry water. It's essential to calculate the diameter based on factors such as expected water flow, hydraulic requirements, and local regulations. Here the inner diameter and outer diameter of pipe culvert is 1000 mm and 1230 mm respectively.

Length: The length of the culvert depends on the width of the roadway or the span it needs to cover. Here's the length of the culvert is 22500 mm including extra widening of 5000 mm both sides.

Bedding and Backfill:

Proper bedding and backfill are crucial for the stability and performance of the culvert. The bedding material should be well-compacted to provide adequate support and prevent settling. Backfill material should be properly graded and compacted to prevent erosion and maintain structural integrity.

Inlets and Outlets:

Inlet and outlet structures are designed to control the flow of water into and out of the culvert. They prevent erosion and manage water velocity to prevent flooding or damage.

Headwalls, wing walls, and aprons are often constructed at the inlet and outlet to guide the flow and protect the culvert from scouring.

c.DESIGN OF CULVERT –

The design of pipe culvert is done using the AutoCAD software which has been designed by M/s. Structure and Highway Engineering Consultant, Bhopal using collected data from site. The drawing is mentioned below.

The drawing gives all the information that will required in installation of the pipe culvert at the site. Engineer can easily understand the drawing and can capable to do work on it. ANALYSIS OF DATA –

Table 3 Calculation for head wall

HEAD WALL					
Item description	Nos	Length (m)	Breadth (m)	Depth (m)	Qty (cu.m.)
Head wall excavation	2	7.66	1.4	1.22	26.17
Head wall PCC	2	7.66	1.4	0.15	3.22
Head wall 1st lift	2	7.36	1.14	0.65	10.91
Head wall 2nd lift	2	7.36	0.835	1.23	15.12
Head wall 3rd lift	2	7.36	0.52	0.6	4.6

Table 4 Calculation for quadrant pitching -

QUADRANT PITCHING					
Item description	Nos	Length (m)	Breadth (m)	Depth (m)	Qty (cu.m.)
Quadrant stone pitching	4	3.69		0.3	4.43
Granular below quadrant pitching	4	2.61		0.15	1.56
Soil in quadrant portion	4	0.63		0.78	1.97

Table 5 Calculation for floor apron

FLOOR APRON					
Item description	Nos	Length (m)	Breadth (m)	Depth (m)	Qty (cu.m.)
Floor apron (downstream)	1	7.36	3	0.3	4.43
Deduction floor apron (downstream)	-2	0.785	4	0.3	-6.28
Floor apron (upstream)	1	4.93	1.5	0.3	2.23

Table 6 Calculation for number of pipes required for extra widening –

PIPE CALCULATION					
Item description	Nos	Length (m)	Length of 1 pipe (m)	Depth (m)	Qty
No. of pipes required	2	10	2.5		8

Table 7 Calculation for concrete work

CONCRETE WORK					
Item description	Nos	Length (m)	Breadth (m)	Depth (m)	Qty (cu.m)
Bedding with PCC M-15	1	7.86	3.36	0.3	7.92
Encasing concrete of M-20	1	8.37	3.36	1.23	34.6
Deduction for pipe portion	-2	1.18		8.37	-19.89
PCC work on pipe with M-15	1	8.805	3.36	0.05	1.48
PCC work on to with M-20	1	8.9	3.36	0.25	7.48

C. INSTLLATION –

The installation of pipe culvert includes various steps. They are –

a. Layout of pipe culvert –

Creating a layout of a pipe culvert for extra widening involves drafting a plan view that shows the alignment, dimensions, and details of the culvert within its surrounding environment. The layout is done using the data, taken from drawing.

b. Excavation –

The excavation is the next process after the layout. The excavation is done according to the data, taken from the drawing. Some factors are mentioned below that are considered in excavation work:

Table 8 Parameter

S. No.	Parameters	Values
1	Depth of head wall	2630 mm
2	Length of head wall	7360 mm
3	Width of head wall	1400 mm
4	Length of extra widening	5600 mm
5	Width of extra widening	3360 mm

D. DLC above the PCC layer –

After the laying of Plain Cement Concrete (PCC), the next step is often the application of a Dry Lean Concrete (DLC) layer. DLC serves as a base or sub-base for further construction activities, providing a stable and level surface for the placement of structures, pavements, or utilities. Before applying DLC over the PCC layer, ensure that the surface is clean, free from any debris, and adequately cured. Prepare the DLC mix according to the specified proportions and mix design requirements. Place the DLC mix over the cured PCC layer using suitable equipment. Spread the DLC evenly to achieve the thickness of 250 mm.

Figure 2 DLC Above the PCC

E. Preparation of Subgrade:

The first step involves preparing the subgrade, which is the native soil on which the road will be constructed. This may involve excavation, compaction, and grading to achieve the desired slope and strength.

F. Base Course Preparation:

Depending on the design specifications, a base course layer may be added on top of the subgrade to provide additional support and stability. This base course could be made of materials like crushed stone, gravel, or recycled concrete.

G. Construction of PQC:

The PQC layer is typically constructed in several steps:

a. **Formwork Installation**: Formwork is set up along the edges of the road to define the shape and dimensions of the PQC slab.

b. **Reinforcement Placement**: In some cases, steel reinforcement such as welded wire mesh or steel bars may be placed within the PQC slab to enhance its tensile strength and prevent cracking. Here we are providing 12 mm diameter of rod with C/C spacing of 150 mm.

c. **Batching and Mixing**: Concrete materials including cement, aggregates, water, and admixtures are batched and mixed thoroughly to achieve the desired consistency and strength.

d. **Transportation and Placement**: The mixed concrete is transported to the site using transit mixers and then placed onto the prepared base course using dump trucks or concrete pumps.

e. **Compaction and Finishing**: Specialized equipment such as rollers and screeds are used to compact and level the concrete surface. This ensures uniform thickness and smoothness across the road.

Curing: After the PQC is laid, it needs to be cured properly to prevent drying shrinkage and ensure strength development. This may involve methods such as water curing, curing compounds, or covering with wet burlap or plastic sheets.

III. RESULTS AND DISCUSSION

Providing extra widening in pipe culverts offers numerous benefits, including increased hydraulic capacity, improved conveyance efficiency, enhanced resilience to extreme events, reduced maintenance requirements, extended service life, enhanced safety, compliance with design standards, and optimized environmental performance. These advantages underscore the importance of incorporating extra widening into culvert design and infrastructure planning processes to enhance the functionality, durability, and sustainability of transportation networks.

a.Increased Capacity

Widening the pipe culvert allows for greater flow capacity, enabling it to accommodate higher volumes of water during peak flow conditions. This helps prevent overflow and reduces the risk of flooding, particularly in areas prone to heavy rainfall or flash floods.

To calculate the flow rate of pipe culvert, select an appropriate flow equation or formula to calculate the hydraulic capacity of the culvert.

Here we are using Manning's equation to calculate the flow rate of pipe culvert.

Manning's Equation $Q = 1/n.\ A.\ R^{(2/3).}\ S^{(1/2)}$

Q = 8.28 cubic metre per sec.

Volume of water V = A×L

Volume of water of existing pipe culvert = A×L

= 3.142×12.5

= 39.28 Cubic meter

Volume of water after providing extra widening = A × L

= 3.142×22.5

= 70.70 Cubic meter

Increment in volume = 70.70-39.28 = 31.42 Cubic metre

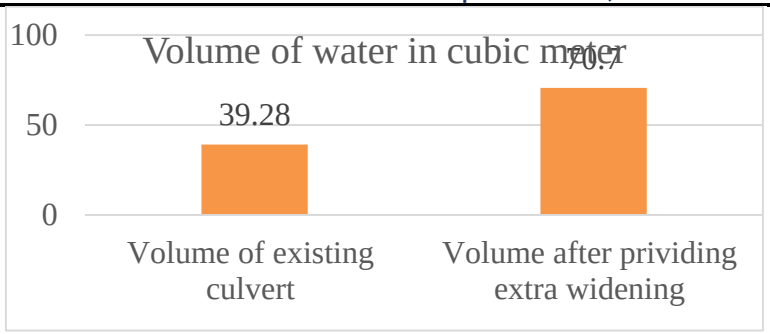

Figure 3 Graph of volume of water

The above graph is showing the volume of existing culvert and the volume after provide extra widening. Graph A is showing the volume of existing culvert and graph B is showing the volume after providing extra widening.

b. Improved Conveyance Efficiency:

The extra widening facilitates smoother flow through the culvert, reducing the likelihood of sediment deposition, debris build up, and flow constriction. This enhances conveyance efficiency, ensuring more effective drainage and minimizing the risk of culvert blockages or obstructions.

c.Reduced Maintenance Requirements:

Widening the pipe culvert can decrease the frequency and intensity of maintenance activities required to maintain proper functionality. With improved flow conditions and reduced risk of blockages, the need for costly and labour-intensive maintenance, such as debris removal or sediment dredging, is minimized.

d.**Extended Service Life**:

By accommodating higher flow rates and reducing the risk of sedimentation and debris accumulation, extra widening helps preserve the structural integrity and longevity of the culvert. This contributes to the prolonged service life of the culvert and reduces the frequency of repair or replacement, resulting in cost savings over time.

e.Improved Traffic Volume –

After providing extra widening at a pipe culvert, the result typically includes improved traffic flow and safety. This reduction in potential disruptions leads to smoother traffic operations and fewer delays for commuters and transportation networks. Additionally, the widened culvert helps prevent water pooling on roads, reducing the risk of accidents caused by hydroplaning and improving overall road safety. Overall, integrating traffic reduction considerations into culvert widening projects results in more resilient infrastructure and safer transportation routes for communities.

Total width of existing road = 12500 mm

Total width of roadway width after providing extra widening = 22500 mm

Increment in width = 22500-12500 = 10000 mm

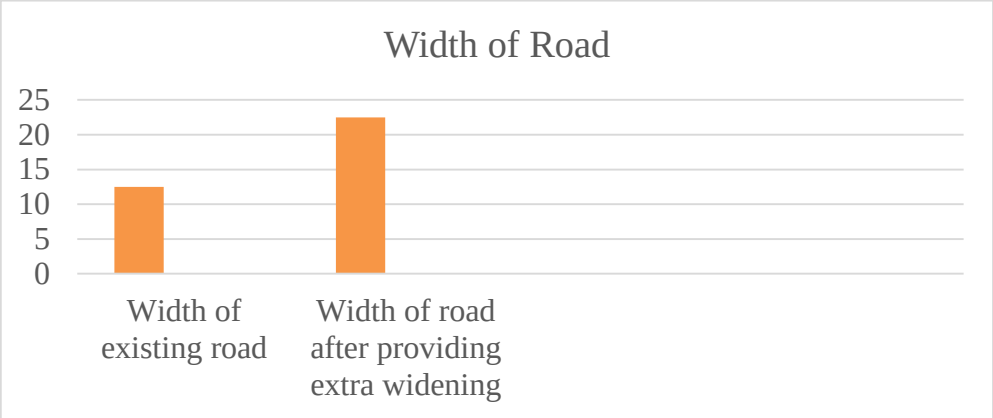

Figure 4 Graph of volume of water

The above graph is showing breadths of road. Graph A is showing the width of existing road and graph B is showing the width of road after providing the extra widening. The total width of extra widening is 10000 mm (including both sides). The difference between the width of existing road and the width of road after providing the extra widening is 10000 mm.

f. Enhanced Safety:

Improved flow capacity and reduced risk of flooding contribute to enhanced safety for road users and surrounding communities. By minimizing the potential for roadway inundation and associated hazards, such as hydroplaning or structural damage, extra widening enhances overall road safety and reduces the risk of accidents or disruptions.

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