Structural Analysis and Design of Culverts Using Standard Specification Drawings

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Abstract- *This research paper presents a systematic methodology for the hydraulic design and optimization of culverts, with a focus on evaluating erosion potential and control at inlet and outlet structures. The methodology is based on a comprehensive review of existing literature and design guidelines, as well as the results of numerical simulations and case studies.*

The paper presents a detailed analysis of the hydraulic design of culverts, including the evaluation of flow characteristics, hydraulic loading, and erosion potential. The results of the analysis are used to develop a set of design guidelines and recommendations for the hydraulic design and optimization of culverts.

A case study is presented to demonstrate the application of the proposed methodology, highlighting the importance of iterative design and computer-aided simulation in achieving optimal culvert design. The case study involves the design of a culvert for a major highway project, and demonstrates the effectiveness of the proposed methodology in reducing erosion risks and improving water management.

The findings of this research contribute to the development of best practices in culvert design, with implications for improving water management, reducing erosion risks, and enhancing the overall sustainability of transportation infrastructure. The results of this research are expected to be of interest to transportation engineers, hydraulic engineers, and environmental scientists, and are expected to contribute to the development of more sustainable and resilient transportation infrastructure.

Keywords: culvert design, hydraulic engineering, erosion control, structural optimization, water management.

I. INTRODUCTION

When planning ducts, development and future upkeep necessities must be considered with fitting medications consolidated into the structure. Some direction as for development prerequisites and techniques can be found inside different departmental standard drawings and particulars. Nonetheless, this must not keep all water powered and natural necessities from being fulfilled.

Loads on Culverts include:

a) Fill over the structure, which is a component of:
   - Height of fill
   - Type of fill material
   - Installation conditions, (for example, 'channel' or 'bank')

b) Design traffic loads

c) Construction traffic loads

d) Other or irregular burden conditions.

   The heap bearing limit of a duct is an element of:
   - Unit quality (for instance, pipe class)
   - Type of sheet material and refill material
   - Pipe measurement (barring box ducts)

II. METHODOLOGY

Construction of Piped Culvert Design aspects:

General:

The required formation width for rural roads [Other District Road (ODR) and Village Road (VR)] is 7.5m. The design life for all culvert types is 100 years.

Codes

The pipes shall be conform to IS:458-1989 (Specification for concrete pipes) and shall be laid as per relevant IS:783-1985 (laying of concrete pipes).

Hydraulic& Field Data

The following data needs to be collected for the design of a culvert after detailed survey and from field visit:

(i) Catchment area of the stream in hectares.

(ii) Traverse the stream 100M either side of culvert to ascertain the actual flow details like velocity, width & depth of flow in the clear banking reaches.

Selection of Type of Pipe, Diameter & No. of rows

The quantity of funnels, length and channel measurement ought to be chosen dependent on the investigation of catchment territory, stream width and profundity of water, stream arrangement, gulf and outlet conditions. Since the catchment zone shifts broadly, it is proposed to assess release of a characteristic stream by direct estimation. On the off chance that it is beyond the realm of imagination to expect to gauge, a portion of the exact formulae (like, Dicken's and Inglis) recorded in IRC:SP:13 might be alluded to fix the release.

The example configuration on low profile is as per the following.

I) Approximate catchment territory of the stream-"M" Acres
ii) Using Dickens equation, Max. Release Q = C(M) ¾ (Where C=11-14 , where yearly downpour fall is 60-120 Cm/s).
iii) Assume Velocity of Flow dependent on incline conditions= V m/sec
iv) Arrive Vent age territory A=Q/V sqm.
v) Assume dia. of funnels and No. of lines dependent available condition and check for vent age gave.

Table 1 The pipes for culverts shall to IS: 458.1989 the shell thickness is as follows

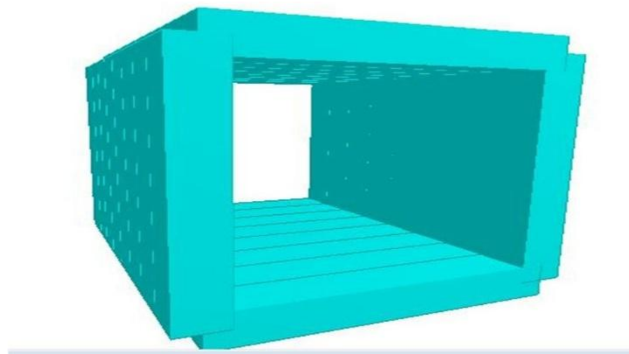
NP4 Pipes Dia.	Shell thickness
300MM	40mm
600MM	85mm
900MM	100mm
1000MM	115mm
1200MM	125mm

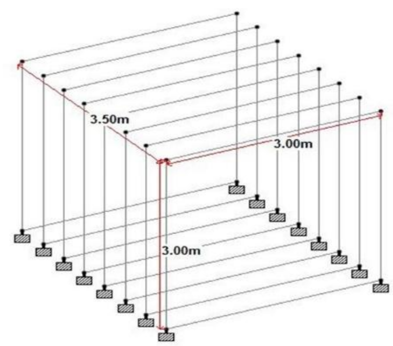
1.1 The minimum vertical clearance shall be provided as per table

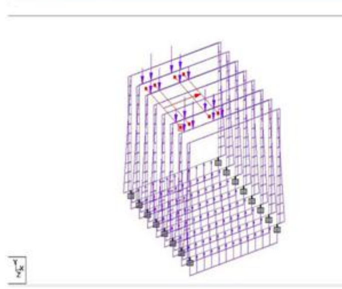
Discharge in M3/sec	Minimum
Upto0.30	150
Above 0.3 and up to 3.0	450
Above 3 and up to 30	600
Above 30 and up to 300	900
Above 300 and up to 3000	1200
Above 3000	1500

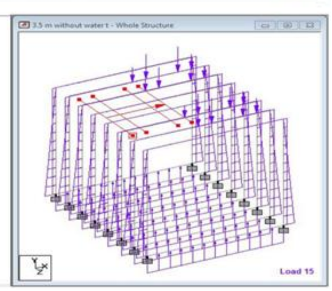
COMPUTER AIDED ANALYSIS OF BOX CULVERT

The most extreme twisting and subsequently the general financial matters of the Box Culvert relies on the dividing of the longitudinal supports to land at an ideal separating manual investigation of various Box Culvert with various longitudinal brace dispersing is a period accepting errand as well as a technique that welcomes human mistakes with advert of PCs numerous such issues have been tackled effectively by embracing applicable programming. The Box Culvert with similar information was upgraded in STAAD Pro and the outcomes are thought about.









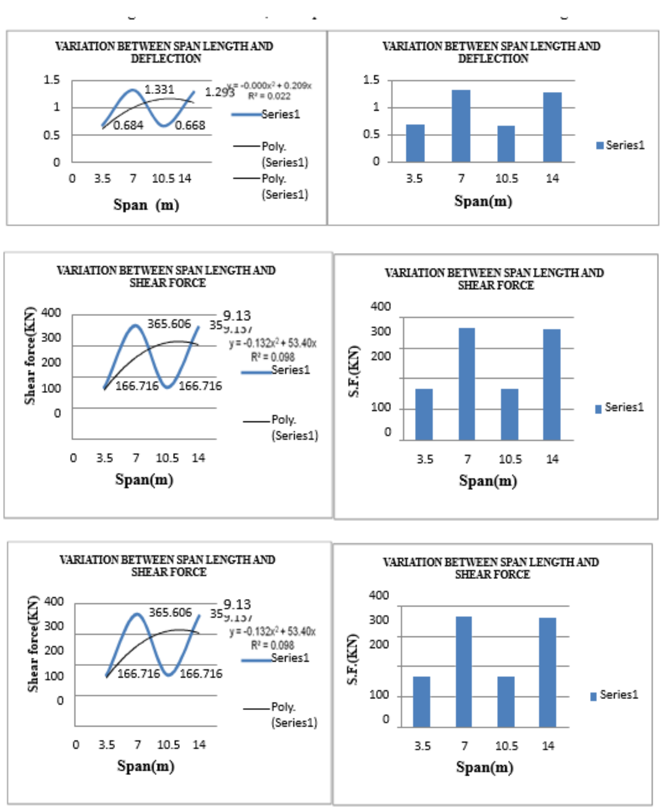
III. RESULTS AND OBSERVATIOBS

Since right now work of mine I have thought about the physically configuration structures and STAAD PRO in different plates in codes just to examine that structure that is planned physically considering different variables of security like factor of wellbeing against sliding and factor of wellbeing against sliding and structures structured from standard determination drawings and the parameters that will contrasted are connected with security, quality parameters and furthermore from the efficient perspective.

Table 5.13. STAAD PRO results for IRC class AA wheeled loading for 3.5 m width

S. No.	Span(m)	Maximum Deflection(mm)	Maximum Bending Moment(KN-m)	Maximum Shear Force(KN)
1	3.5	0.842	140.503	337.808
2	7	1.017	224.187	523.175
3	10.5	0.750	145.561	340.115
4	14	1.019	224.409	523.472

Figure: 5.1 Graphical portrayals of results for Max. Diversion, range length oppressed to IRC Class 70R stacking for box is unfilled, earth pressure with live burden extra charge on both side fills.



IV. CONCLUSION

This study examines the design and analysis of culverts using standard specification drawings. The manual count and outcome section of the theory are presented, and the manual structure and plan by STADD Pro are evaluated.

The standard specification drawings referenced in this study provide a framework for the design and analysis of culverts. The drawings are used to plan and design interstate structures, and the benefits and drawbacks of physically structured structures and plans by STADD Pro are discussed.

The structural analysis of reinforced box culverts requires the consideration of bending moment and shear force in longitudinal boards. This is a tedious process that involves a significant amount of time. This study developed numerical models for these parameters, and the results showed that the models accurately predicted the bending moment and shear force.

However, the study also found that the models overestimated the shear force, and the positive and negative errors for all parameters were under 10%. This can be taken into consideration by adopting a reasonable factor of safety while designing structures based on these drawings.

The study concludes that the standard specification drawings are more efficient than physically planned structures. The drawings provide a framework for the design and analysis of culverts, and the use of numerical models can accurately predict the structural behavior of reinforced box culverts.

V. RECOMMENDATIONS:

1. The standard specification drawings should be used as a framework for the design and analysis of culverts.
2. Numerical models should be used to predict the structural behavior of reinforced box culverts.
3. A reasonable factor of safety should be adopted while designing structures based on these drawings.

VI. LIMITATIONS

1. The study only examined the design and analysis of culverts using standard specification drawings.
2. The study did not consider other factors that may affect the structural behavior of culverts.

V. FUTURE SCOPE

1. Further studies can be conducted to examine the design and analysis of culverts using other methods.
2. The study can be extended to consider other factors that may affect the structural behavior of culverts.

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