Proposal of a new bridge across Pooyamkutty river

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Abstract - *Manikandamchal bridge situated in Pooyamkutty across Periyar river connects Pooyamkutty to Manikandanchal. During monsoon seasons the bridge submerges due to its insufficient height. And also due to its insufficient span large floating bodies cannot pass beneath it which weakens the bridge. This project aims to propose a new bridge parallel to the existing bridge which has sufficient span and height. This includes total station survey, feasibility study, modelling and analysis of the structure using STAAD Pro software and designing the super structure and sub structure.*

1.INTRODUCTION

Pooyamkutty is a small tourism village in Ernakulam district, Kothamangalam taluk and Kuttampuzha panchayat of Kerala state. A place which is blessed with its natural beauty, situated along Pooyamkutty river, a tributary of the Periyar. Manikandamchal bridge (causeway) connects Pooyamkutty to Manikandamchal which was built in 2002, considered as a great blessing to people staying in Manikandamchal, Vellaramkuthu and Kallelumedu. This is the one and only possible way to access the nearest town which used to gets submerged during rainy season.
Monsoon hits Pooyamkutty's tribal hamlets hard as the locality gets cut off from the mainland. On every year the causeway submerges for several weeks since the high flood level is above the bridge road level. In the recent flood in 2018, the flood level was more than 2 meter above the bridge road level. The bridge was submerged for almost 40 days till this year September, leaving the lives of more than 500 families residing at one side of the Pooyamkutty river, in turmoil.
The proposed project is to design a new bridge parallel to existing one which finds a feasible solution to the problem.

2.OBJECTIVE

The project objective is to model analyze and design a two lane bridge to provide an alternative way across the river in Pooyamkutty village in Ernakulam dist. of Kerala for the purpose of safety against over flooding and transportation & communication problems during monsoon season.

Specific objectives of this project includes:

- To design and propose a new two lane bridge parallel to the existing bridge.
- To analyze the design using STAAD Pro software.
- To model the design with STAAD.
- To design the structure manually using suitable standard codes

3.SCOPE

- The foundation design will be done based on the available data.
- The condition of the existing bridge during flood is evaluated by the data collected from the people in that area.
- The design of the bridge will be considered as R.C.C slab beam bridge.

4.METHODOLOGY

4.1. Survey and Data Collection

A study of soil properties, flow data, adverse climatic conditions, environmental hazards, maximum flood level, seismology, traffic data, existing causeway etc and their data will be collected. A suitable site is also selected

Existing bridge data: span-90m, carriage way width-3.75m, RCC slab type-single lane

Maximum flood level: 2m from existing bridge road level(in August 2018)

4.2. Feasibility study of new bridge

The technical, economical and environmental feasibility is considered.

4.3. Study of Loads and Software

The various types of load acting on bridge structure will be studied. STAAD Pro software will be studied for structural modelling and analysis

4.4. Modelling and analysis

Modelling and analysis of the bridge will be done using the software.

4.5. Designing of structure

The detailed designing of the structure is done manually with suitable IS Codes.

5. SURVEY REPORT OF THE SITE

Survey was done on the site using total station for getting the site plan and to select the location for the new bridge.

5.1. RESULTS AND DISCUSSION

Details of existing bridge :
Overall length = 90 m
No. of lanes = 1
Carriage way width = 3.75 m
No. of spans = 13
Reduced level at deck slab = 96.5 m

Summary of survey
From the survey report it is clear that the existing bridge is prone to flood and the span is not sufficient enough for the passage of big trees flowing through the river. So the new bridge should have sufficient height above the high flood level and enough span for the easy movement of obstructions.

6. DESIGN OF SUPER STRCUTURE

From the total station survey an ideal location for the new bridge was obtained by considering width of the bridge, reduced level difference on the two sides of the river etc.

6.1 DETAILS OF THE NEW BRIDGE

Overall length = 108 m
No. of lanes = 2
No. of spans = 6
Span length = 18 m
Reduced level at deck slab = 104 m

6.2 MODELING IN STAAD Pro

Modeling is the input details which gives the basic idea about the dimensioning and material used. It also specifies the load and boundary conditions. The proposed bridge is a RCC T- beam (beam-slab) bridge.

6.3 LOADING CONDITIONS

The dead loads considered includes self-weight of the deck slab, girder, cross beam, wearing coat, footpath and hand rail and the live loads given are IRC Class A wheeled vehicle, load due to crashing and live load on footpath.

- Self-weight
- Live loads- IRC Class A wheeled vehicle(According to IRC:6-2014 (table 2), for a carriage way width 5.3 m to 9.6 m, two lane of IRC class A loading is specified
  - Live load on footpath = 400 kg/m² (IRC: 6 c.206.1)
  - Horizontal load on kerb due to crashing = 750 kg/m (IRC: 6 c.206.2)

6.4. DESIGN OF DECK SLAB

1.**Bending moment due to dead load -**

Consider a section of 3.5m x 4.5m
Dead load = self-weight of slab + self-weight of wearing coat
Dead load = (24 x 0.25) + (22 x 0.08) = 7.76 kN/m
2.Bending moment due to live load-

Final live load bending moment:
M_1 = 49.305 kNm (short span)
M_2 = 45.654 kNm (long span)
Dead load bending moment:
M1 = 1.1875 x 49.305 = 58.55 kNm
M2 = 1.1875 x 45.65 = 54.20 kN
Design bending moment:
Design bending moment = (1.35 M_{DL} + 1.5 M_{LL}) x 0.8
M1 = (1.35 x 5.836 + 1.5 x 8.55) x 0.8 = 76.56 kNm
M2 = (1.35 x 3.86 + 1.5 x 54.2) x 0.8 = 69.2 kNm

Reinforcement:
Short span Ast -
Provide 16mm dia bars @ 160mm c/c

Long span Ast:
Provide 16mm dia bars @ 160mm c/c spacing

6.5.DESIGN OF LONGITUDINAL GIRDER

Data from STAAD:
Dead load bending moment = 2090 kNm
Live load bending moment = 926.5 kNm (without impact factor)
Live load bending moment with impact factor = 1100.2 kNm
Design ultimate bending moment = 4471.8 kNm

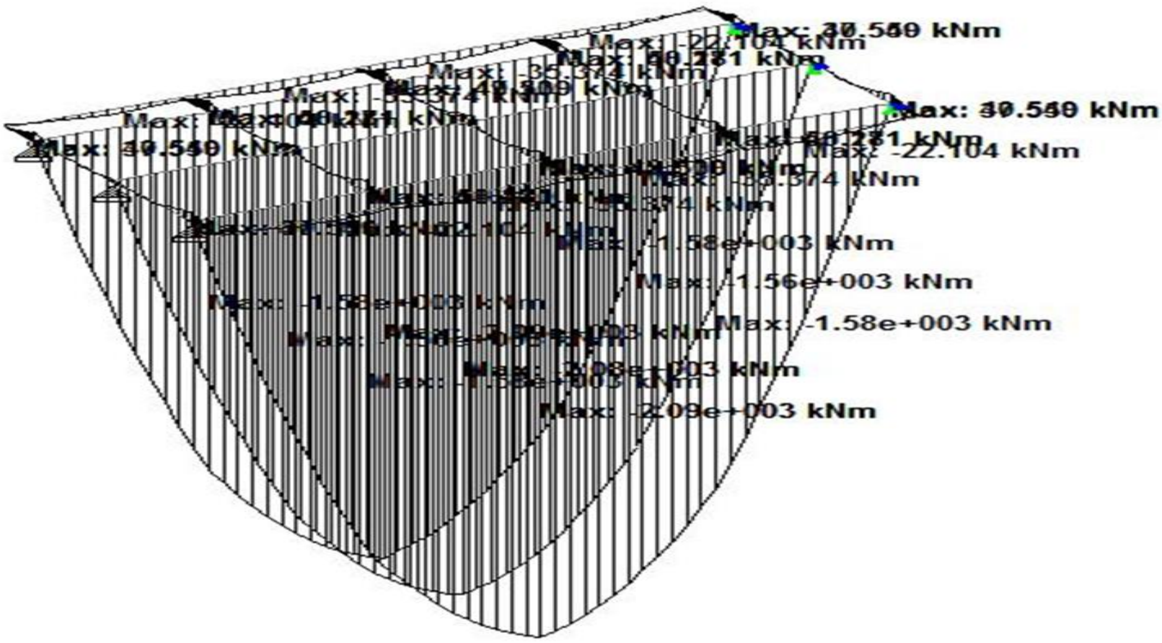

Fig -1: Maximum DL bending moment

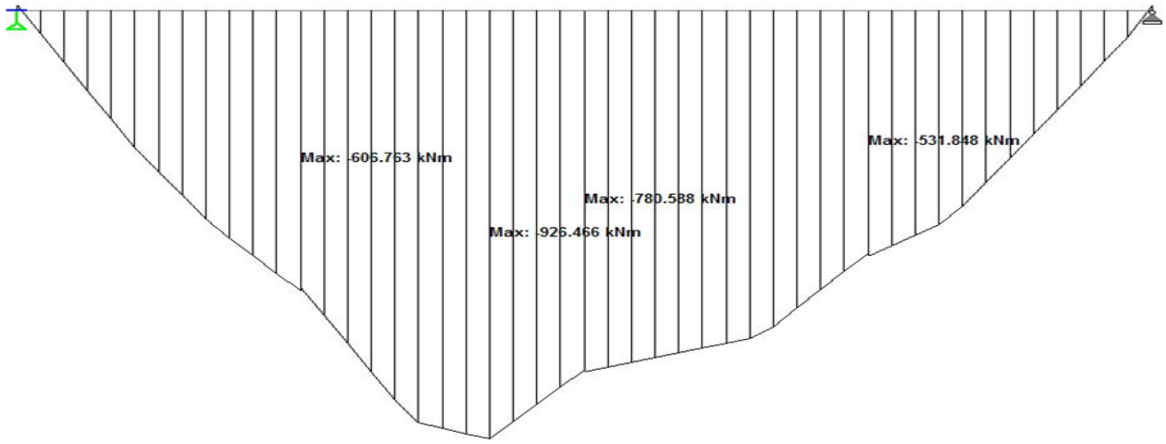

Fig -2: Maximum live load bending moment

Reinforcement:

- Main reinforcement:
  - Tension reinforcement

Provide reinforcement as 4 layers with bottom two layers containing 6 bars and other two containing 5 bars.

  - Compression reinforcement

Provide 4 no. of 25mm dia bar at compression side

  - Side face reinforcement

Provide 3- 25 mm dia bars on both side @ 300 mm c/c spacing

  - Transverse reinforcement

Provide 12 mm dia bar spacing be 250 mm

6.6 DESIGN OF BEARING

Loads on bearing

Maximum DL reaction per bearing = 491.4 kN
Maximum LL reaction per bearing = 337.7 kN
Longitudinal force per bearing due to friction = 97/3 = 32.33 kN
Maximum vertical load on bearing = N_{max} =1243.65 kN
Minimum vertical load on bearing = N_{min} =737 kN
select plan dimension of bearing pad of size = 320x500mm
Thickness of individual elastomer layer, h_i = 10mm
Thickness of outer layer, h_c = 5mm
Thickness of steel laminate, h_s =3mm
Side covering, C = 6mm
Adopt 3 laminate with 2 internal layers
Total thickness of elastomeric pad, h_o =
= 39mm

Dimensions of bearing:

Hence adopt an elastomeric pad of overall dimensions 320 mm x 500mm with a total thickness of 39 mm having two internal elastomeric layers of 10 mm thickness and three steel laminates of thickness 3 mm each having bottom and top covers 5 mm**.**

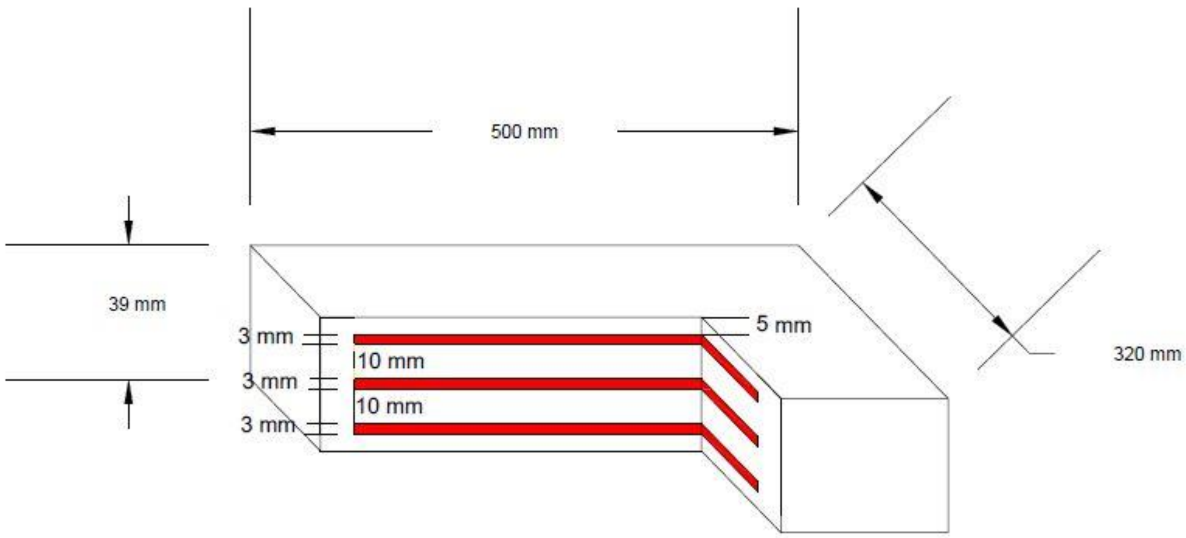

Fig -3: Elastomeric pad bearing

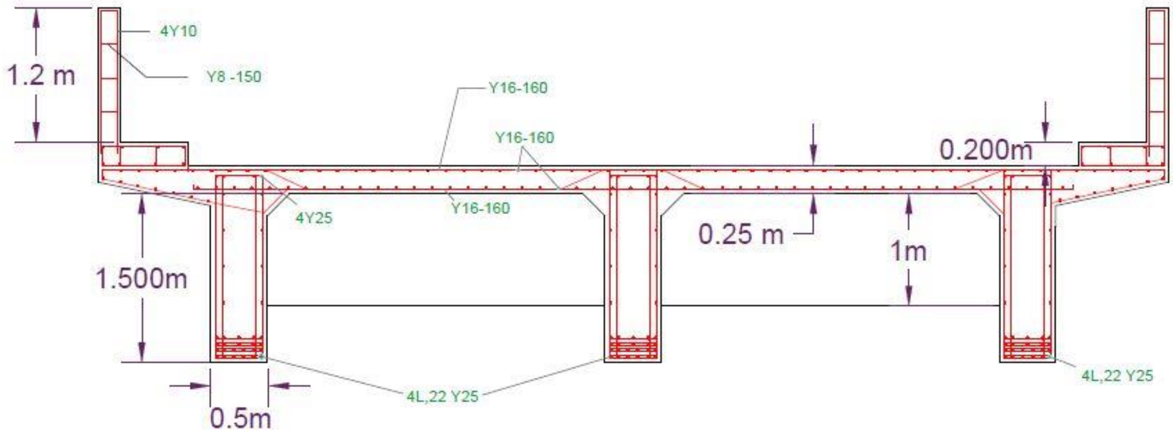

Fig -4: Detailing of the super structure

7.DESIGN OF SUB STRUCTURE

7.1 MODELLING IN STAAD Pro

Pier and pier cap is modelled in STAAD by giving preliminary dimensions.
Preliminary dimensions
Dimensions of pier cap :
Width = 1.5 m, Length = 8.5 m
Depth is taken as 1 m at end and 1.5 m at centre (tapered).
Dimension of pier :
A circular section of 1.3 m dia is assumed is taken as trial

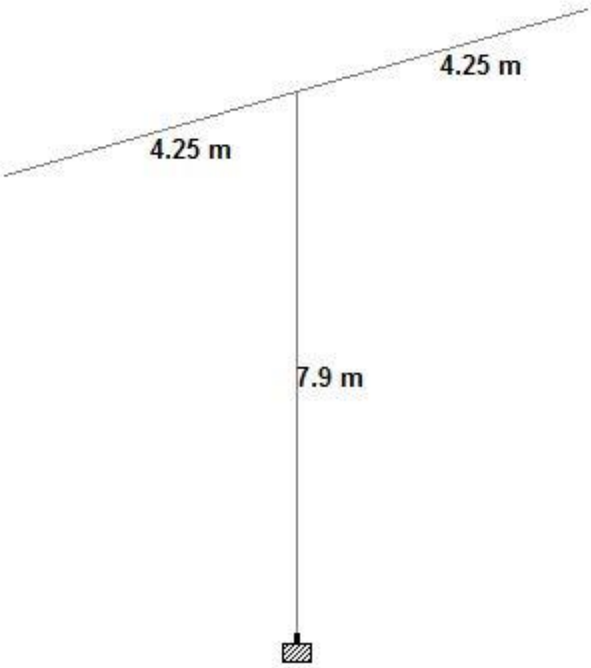

Fig -5: Pier STAAD model

7.2 LOADING CONDITIONS

Loads considered are :
1.Braking load
2.Wind load
3.Horizontal force due to water current
4.Load from superstructure

1.Braking load (IRC 6-2014 c. 211.2) -
It is taken as 20% of the first train load + 10% of the succeeding trains
= 97.2 KN (acting at 1.2 m above deck slab)
2.Wind load (IRC 6- 2014 c. 209.3.3) -
Transverse wind force $F_{T,}$
$F_T = P_Z \times A_1 \times G \times C_D == 8.1$ kN
3.Horizontal force due to water current (IRC 6 – 2014 c.210) -
Intensity of pressure, $P = 52\ KV^2$
Force = 0.34 x 1.5 = 0.51 kN/m (acting at 5 m above bed level)
4. Loads from superstructure -
Vehicle loads can be placed in two ways.
One, the vehicles can be placed at permissible distance from the footpath.
Second, the vehicles can be arranged centrally .And first one is the worst.
Live load reactions: F_1 = 337.769 kN
F_2 = 255.721 kN
F_3 = 121.874 kN
Dead load reactions: F_1 = 491.426 kN
F_2 = 463.371 kN
F_3 = 491.426 kN
Design ultimate load : F_1 = 1170 kN
F_2 = 1009 kN
F_3 = 846 kN

7.3.DESIGN OF PIER

Data from STAAD :
P_u = 3846.211 kN
M_{ux} = 766.3 kNm
M_{uy} = 1159.03 kNm
M_u = 1597.86 kNm
Assume d' = 75 mm
$P_u / f_{ck}bd$ = 0.091
$Mu / f_{ck}bD^2$ = 0.03
Referring to the chart,
P = 0.5%
Taking 1% steel (for safety)
Providing 25 mm dia bars
No. of bars = ≈ 28 bars
Check for safety against biaxial loading:

$[M_{ux}/M_{ux1}]^{\alpha n} + [M_{uy}/M_{uy1}]^{\alpha n} = (766.3/2197)^1 + (1159.03/2197)^1$
$= 0.87 < 1$. Hence the section is safe under applied loading

Transverse reinforcement:

- Pitch ≯ least of lateral dimensions = 1300 mm
  ≯ 16 times smallest dia of longitudinal reinforcement = 16x 25 = 400mm
  ≯ 300 mm

Hence pitch can be taken as 300 mm
(Diameter of lateral ties can be chosen accordingly
ϕ≮ ¼ x diameter of the largest longitudinal bar = ¼ x 25 = 6.25mm
≮6 mm . So diameter can be taken as 12 mm)

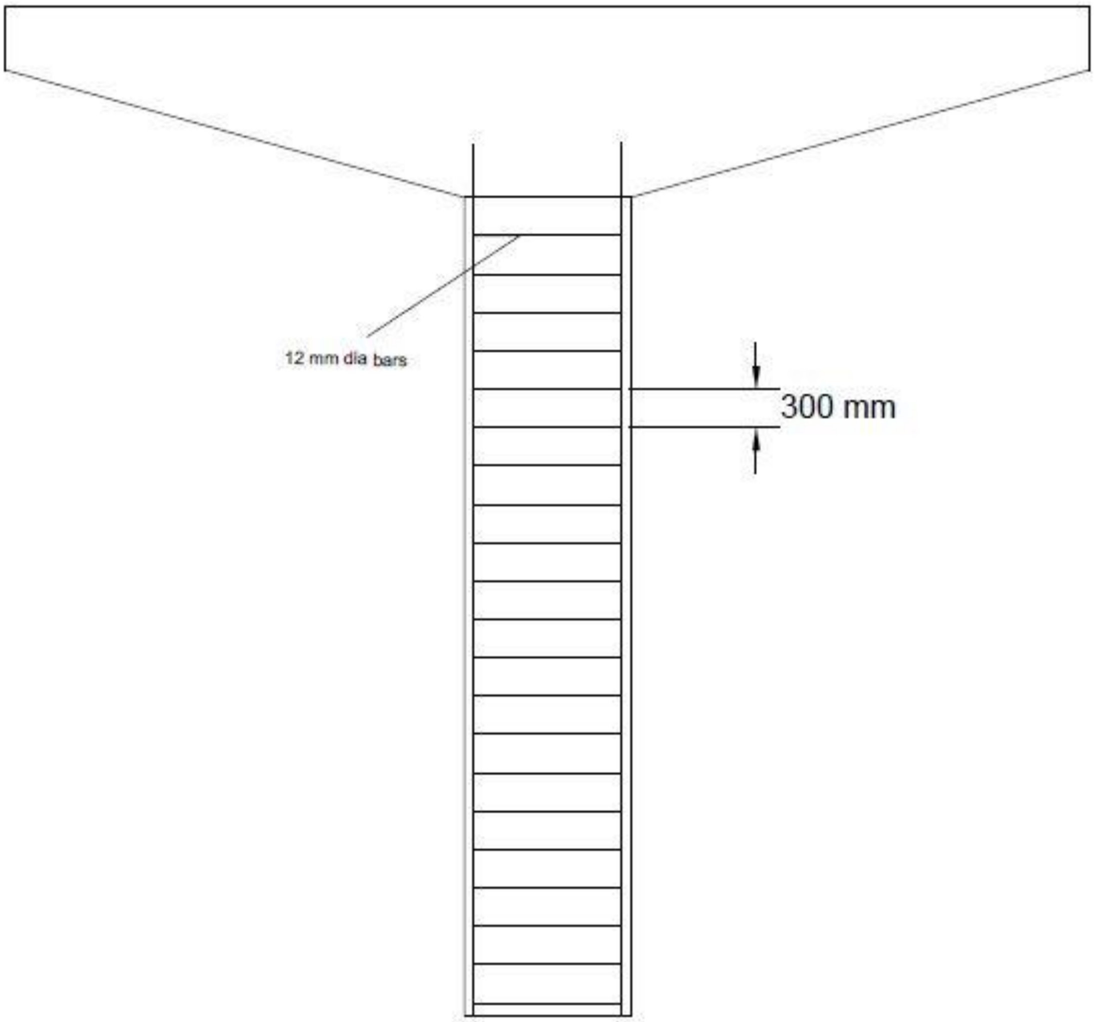

Fig -6: Pier detailing

7.4 DESIGN OF FOUNDATION

- Type: Isolated reinforced concrete footing
- Column: Circular ,1.3m diameter.
- Factored axial load, P_u = 3846 kN.
- Factored uniaxial moment, M_u = 1500kNm at column base.
- Safe bearing capacity of soil, Qu = 250kN/m^2

Area of footing:
$(1.1\times P_u)/\text{Area} = Q_u$

A = 16.92 m^2
Assume square footing ,
Provide 4.5 m × 4.5 m footing
Depth of footing: Considering one way shear**,**

Larger portion = (4500 – 1300)/2 + 390

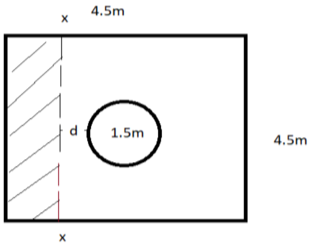

Fig -7: One way shear diagram

= 1990m
Sum of forces to left of xx = Sum of forces to the right of xx
(4500 × (1990 - d) × 0.313) = 4500 × depth × τ_v
τ_v = 0.36N/mm^2 (for M25 concrete with Percentage of steel, Pt = 0.25)
So, depth d = 925.6 mm
Provide, depth of 1.5 m

8.CONCLUSION

The super structure and sub structure of the new bridge is designed by modelling and analyzing in STAAD software and designed it manually according to Indian standards. The proposed bridge meets the requirements found out from the survey and can be adopted safely for the construction.

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