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CIV2014-1038

Edathuruthu Bridge: A Novel Art of Concrete

Cini Ambika
Assistant Executive Engineer
Kerala Public Works Department, Bridges Sub Division
Kollam
India

Mohammed Sherin C.P.
Design Engineer, Sree Giri Consultant
India

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This paper should be cited as follows:
Ambika, C. and Sherin C.P., M., (2014) **"Edathuruthu Bridge: A Novel Art of Concrete",** Athens: ATINER'S Conference Paper Series, No: **CIV2014-1038**.

Athens Institute for Education and Research
8 Valaoritou Street, Kolonaki, 10671 Athens, Greece
Tel: + 30 210 3634210 Fax: + 30 210 3634209
Email: info@atiner.gr URL: www.atiner.gr
URL Conference Papers Series: www.atiner.gr/papers.htm
Printed in Athens, Greece by the Athens Institute for Education and Research.

ISSN **2241-2891**
15/07/2014

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Cini Ambika
Assistant Executive Engineer
Kerala Public Works Department, Bridges Sub Division Kollam
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Mohammed Sherin C.P.
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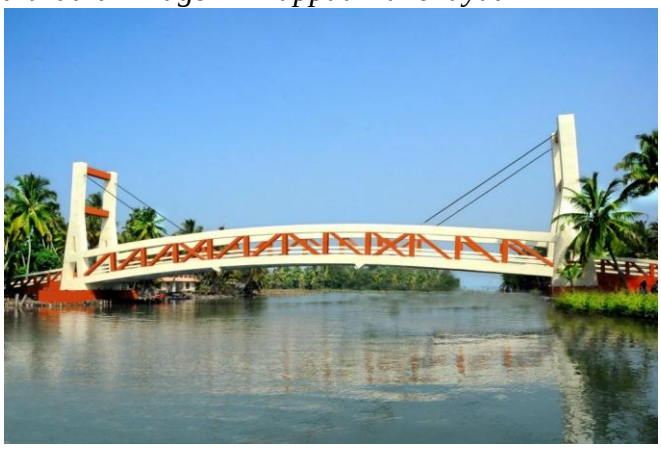
Abstract

The Edathuruthu- Cable stayed Bridge - "A Novel Bridge in Concrete" is located in the Alappad Panchayath of Kollam District in Kerala State of India. The Alappad Panchayath is a narrow strip of land between the Arabian Sea in the West and Thiruvanathapuram-Shornur canal (TS Canal) on the East. This bridge is aesthetically beautiful and structurally durable with single span length of 52.00m and with vertical clearance of 5.00m for facilitating the boat services. This bridge is an arch shaped suspension bridge with pre-stressed cables anchored from the top of pylon of height 16.00m. The accompanying paper is an attempt by the authors to put on record the technical and the constructional aspects, which have resulted in the completion of the Edathuruthu Bridge with very limited facility, a novelty in bridge construction. The construction was completed and opened for traffic in February 2013.

Introduction

Alappad Panchayath of Kollam District in Kerala came to be known to the World after the devastating Tsunami waves hit the West Coast of India on 26th of December 2004. Loss of 145 lives during the devastation of the Tsunami was attributed mainly to the absence of Bridges across TS Canal providing escape routes to secure places. Edathuruthu is an isolated Island in the Alappad Panchayath of Kollam District. Around hundred families are living on this Island. Before the construction of bridge there existed only private ferry service, which is inadequate for the movement of the people for their day to day needs. Hence construction of a bridge at this location is very essential for the safety of the inhabitants. Local self Government Department of Kerala decided to construct a bridge to provide accessibility to the inhabitants of the Edathuruthu Island under the special package of Tsunami Rehabilitation Programme and the work was entrusted to Kerala Public Works Department. Because of various administrative constraints, work was carried out Departmentally. Fig.1 shows the Edathuruthu Bridge which was completed and opened for traffic in February 2013.

Figure 1. *Edathuruthu Bridge in Alappad Panchayath*



Design Concept

General

To match with the landscape beauty (Fig.2) and to get a clearance of 5m for navigation and also due to limited stretch of land for approach road, it is decided to adopt two trussed arches on either side of the driveway with deck resting on the bottom chord of the trussed arch to minimize the height of the approach road. Also because of the difficulty in piling due to the minimum construction facility available at the site only single span of 52m with two abutments with pylons on either side of the canal was adopted. Clear roadway width is 5m. All the members were cast-in-situ. Fig.2 shows the location before the construction of bridge.

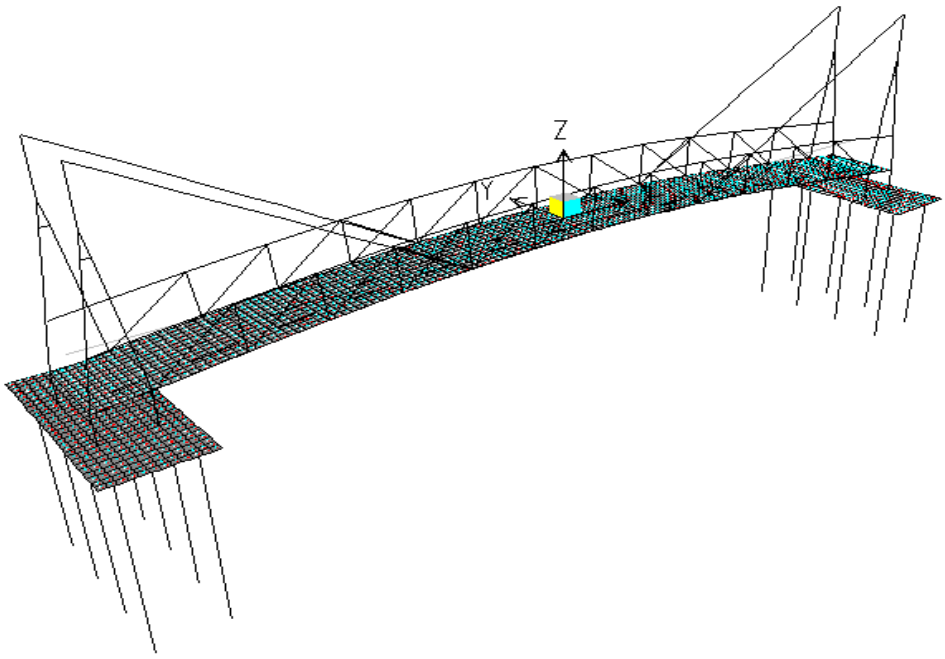
Figure 2. *Location of the Bridge*

On the basis of the soil investigation report, design for the bridge was prepared by M/s Sree Giri Consultant, Kochi. The truss was anchored to the pylon at two points to minimize the bending moment in the trussed arches and the trussed arches also used as hand rails. Anchors are prestressed before deshuttering to minimize the dead load deflection. The bridge is designed for IRC Class A Loading and the design is done by satisfying all relevant IRC specifications. Fig.3 shows the structural model of the bridge.

Materials for Construction

M35 concrete with Ordinary Portland Cement (Fly ash based) conforming to IS: 1489(Part I) and Fe 415 steel conforming to IS: 1786 were adopted. Severe exposure condition as per IS: 456 is assumed for piles and pile caps. M40 concrete is used for Pylons and superstructure.

Figure 3. *Structural Model of the Bridge*



Method of Analysis

The bridge structure as a whole including the piles were modeled and analysed using finite element method for all the loads including dead load, live

load, wind load, seismic load, current forces and prestressing forces. The live load is considered as moving load and the absolute maximum bending moment and shear force are found at various critical sections.

Foundation

According to the local soil conditions, pile foundation was used to support the super structure. Due to heavy loading at the pylon, bored piles of 1200mm diameter and having length of 60m were used.

Pylon

The pylon is modeled as frame element. Due to non prismatic shape of the sections, a fully supported scaffolding system was chosen for concrete pouring on the 16m high pylon (Fig.4). Due to heavy reinforcement in the pylon's section, particularly at the proximity of the stay cable anchors, special care was given to the reinforcement work and effectiveness of concrete compaction.

Figure 4. *Shuttering System for Pylon*

Girders and Slab

The deck system was designed as trussed arch shaped structure on either side of the roadway. Deck slab was supported by the bottom chord of the trussed arches and cross girders connecting the bottom chords of the trussed arches. Concrete web members between the top and bottom chord are designed as a part of hand rails of the bridge. Top chord is fixed to the Pylon on either side. It is modeled as a frame element. It is designed as a compression element with bending. It is assumed that the top chord is prevented from lateral buckling by the vertical posts. Because of the curved shape of the deck slab over the water stream without any intermediate support special care was taken for the design and erection of formwork for getting the accurate alignment of the deck slab. Fig.5 shows the scaffolding system used for the construction of deck slab and girders and Fig.6 shows the reinforcement of the girders and web members.

Figure 5. *Shuttering System for Deck Slab and Bottom Chord of the Trussed Arch*

Figure 6. *Reinforcement Work for Longitudinal and Cross Beams*

Stay Cables and Pre-Stressing

There are four cables supporting the deck and anchored to the Pylons. After the completion of the casting of the members these cables are stressed and after the stressing, the shutters are removed. Post tensioning method is adopted for prestressing. 12.7 mm nominal diameter strands of low relaxation type conforming to IS:14268-1995 are used for stay cables. Based on the analysis, one 19 T13 cable is proposed to be used, with 18 strands in the cable and protected by HDPE pipes against corrosion. All strands shall be stressed in one stage. As per the requirement of IRC spare strands to the extend of 4% of total Prestress are provided. The cable has linear profile and inclined.

Construction Sequence

- Piling.
- Pile Cap.
- Pylon and side walls up to the bottom Level of the bottom chord.
- Cast the bottom chord after placing the precast web members in the exact location.
- Cast the bottom cross beams and longitudinal beam and the deck slab.
- Cast the pylon Upto the bottom of the Top chord.
- Cast the Top chord.
- Cast remaining portion of Pylon.
- Do the stressing of the cable to an initial prestress load of 1666 kN.
- Remove the shuttering for the deck.

Conclusion

The Edathuruthu bridge is not a large span cable stayed bridge. However it has many special features:

- it requires high precision for anchoring of cables through the inclined web element of the trussed arch
- fixing stressing cone in an inclined plane from the top of pylon of height 16m needed highly skilled labours.

The execution was done directly through the Department. Even though the construction involved high technical complexities requiring highly skilled labour the work could be successfully completed within the stipulated time without using any sophisticated machineries and equipments. This was the real merit of this construction. Technical and Administrative decisions should be taken on merit and based on the available technology after proper analysis. By taking bold decisions by the Higher officials of the department this bridge has seen the light of the day. In the state of Kerala this is the first concrete cable stayed suspension bridge. The bridge has been successfully completed without conflicts and maintaining perfect 'Harmony' during the execution. As a time bound projects, team of officers who start the project should be made to complete the same to ensure continuity of command, accountability, efficiency and satisfaction of the team. The adoption and adaption of the latest technology will definitely expedite completion as achieved in Edathuruthu Bridge.

References and Acknowledgment

a) All relevant IRC and IS codes for Bridge construction
b) Feedback and guidance from the Design Consultant

Prof. Dr.P.K.Aravindan, Former Professor of IIT Madras

The authors also express their gratitude to Er. C.Baburaj, retired Chief Engineer, Roads and Bridges, Er.P.K.satheesan, Chief Engineer, Roads and Bridges, Er. Jaick Joseph, Superintending Engineer, Roads and Bridges, Er.Thomas Mathew, Superintending Engineer, National Highway, Er.Sobha Unnithan, Assistant Executive Engineer and brilliant team of Engineering officers of Kerala Public Works Department for their bold and Dynamic decisions for the completion of the project. The authors also express their sincere gratitude to the Design consultant. Dr.P.K.Aravindan, former Professor of IIT Madras and his team of Engineers for their guidance for the entire execution of the work. Lastly but not the least the authors gratitude to, Sri. Salim, Sri. V.A.Nissam and Sri.Neelalohidadas, the sub contractors, and labours for their untiring efforts for the timely completion of the bridge.