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# Analysis and Design of Deck-Bridge using STAAD PRO V8i

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**ABSTRACT:** A bridge is a structure that connects two transportation access points. A movable bridge allows for the passage of two separate modes of transportation through waterways and railways/ roadways. The deck of the movable bridge can be moved vertically. When the deck is lifted it gives passage for boats and at rest give passage for train. In the southern portion of India, Pamban Bridge is the only movable bridge in India that connects Rameshwaram town with Pamban Island. The behavior of the Pamban Bridge is determined using STAAD Pro V8i software and Indian Standard codes for varied loads. On the bridge deck, the software calculates the maximum deflection, Shear force and Bending Moment.

**KEYWORDS:** Movable Bridge, Vertical lifted bridge, Hydraulic action, Bridge Deck, Pamban bridge, STAAD Pro V8i.

## I. INTRODUCTION

Bridge is a structure constructed in passage having obstacles such as river. there are various types of bridges like suspension bridge, movable bridge etc. We are studying on Movable bridge. In India there is only one movable bridge, it's the Pamban bridge located in the southern part of India. The Pamban bridge joins Rameshwaram town with Pamban islands. The purpose of the bridge is to provide passage of train and ships. The length of bridge is of 2.065 kilometres having 143 spans and height of 24 m from foundation. The movable span is of 63m length and width of 10 m. Pamban Bridge is a railway bridge constructed in the year 1914 by German Engineer Scherzer. Earlier, it was used by many pilgrims to travel through bridge to the temple in Pamban island. There are various types of movable bridge like vertical lift bridge, Bascule bridge and Swing Bridge. We have analysed the bridge deck on STAAD pro Software. STAAD Pro stands for Structural Analysis and Design Program. It is of Bentley Systems; it is usually used to analyse and design a structure. The analysis is done considering vehicle load of train engine, Self-weight of the deck, the prototype model of the bridge is prepared using the lift technology of hydraulic jack to lift the bridge deck up to a height of additional 25 meters.

Types of movable bridges.

1. Bascule Bridge
2. Vertical Lift
3. Table Bridge

### 1. Bascule Bridge

The bridge with this movement has single or double flaps without limiting clearance. The connection between the ends of flats transmits shear force only or shear force and bending moment. A counter weight is attached at the other end of the bridge.

## 2. Vertical Lift Bridge

A vertical lift bridge is a type of movable bridge that rises span vertically while remaining parallel with the deck. A lift bridge has clear span between 30m to 50m and free board above water level of about 13m to 15m in service and 25m to 40m respectively when lifted.

## 3. Table Bridge

It is a movable ridge in which deck moves in the vertical axis. Hydraulic jacks are under the bridge rises the bridge deck to allow barge traffic to pass beneath it, in contact to lift bridge.

## II. LITERATURE REVIEW

[1] Bharat Jeswani, and Dilip Budhlani purposed a study on analysis and design of a bridge on STAAD Pro software, they have designed a composite deck slab. They have used IRC Class AA loading and IRC class A loading. A typical Tee Beam is considered having components of continuous deck slab, longitudinal and cross girder. Use of Pigeaud's method is used to find long span and short span bending moment coefficient are read from curve developed, these curves are used for slab support. Design of deck had uniformly distributed load, live load. There are images of Class AA tracked loading, Class A loading in STAAD Pro. The results were shown in graphical chart having dead load and live load in all four corners of the beck slab. They got bending moment, shear force and depth. They concluded with IRC Class AA tracked loading vehicle.

[2] P.K. Sonawane, Rushikesh Shinde, Rahul Shinde, have presented a research paper on design and development of vertical lifting bride. As in Germany, a movable bridge was built in 1972 for waterways transportation, and it was very useful, so it was necessary to build such a bridge in India to keep both types of transportation (railway and waterway) running. They considered the main piece of this bridge to be deck because it raised and settled, therefore they analysed it as such. The project is a prototype or such a bridge and utilizes a chain drive mechanism to lift the middle span of the bridge and this project is a model and a simplified version of Vertical Lifting Bridge and has been made under the constraints of space, time and resources available.

[3] P. V. Kapure, Allan Pereira, Pratik Chikane, proposed a methodology in their paper Innovation of lift bridge by hydraulic action, here they have studied the failure of bascule bridge located at Pamban bridge in India. They have given an innovation to lift bridge by placing a hydraulic jack inside the piers and help the bridge lift vertically. A comparative study of various types of movable bridge is also stated. These movable bridges are bascule bride, Swing Bridge and vertical lift bridge. The space between the piers should be minimum 4 m to 6 m. This method created durable and has more efficiency than bascule bridge.

[4] Akshay Bharadwaj Krishna proposed a study of bascule bridge on ANSYS software and prepared a detailed study on Pamban Bridge old structure of double leaf bascule bridge. The calculation of loads was dynamic load included weight of passenger train, dead load included self-weight of deck, and sleepers. A comparative study was done on stainless steel and structural steel used in the movable deck. They have presented comparative study between stainless steel and structural steel. From this paper it can be observed that maximum stress, strain and deformation occurs on the cage of the bridge structure which includes the base and truss.

## III.SCOPE

The deck of bridge is to be constructed using Prestressed concrete. The comparative study of changing deck from bascule to vertical lift movable action. To get maximum free board to pass the barrages and ship under the deck. To focus on transportation through sea ways.

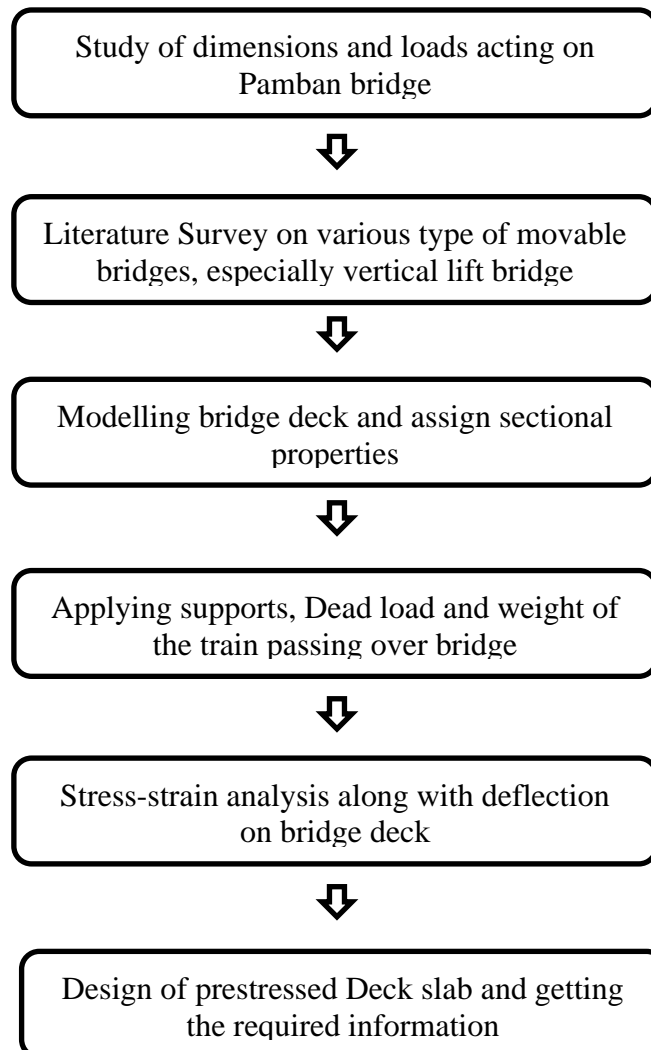
#### IV. AIM

‘To analyze and design of bridge deck on STAAD Pro V8i software, and propose modification of Pamban Bridge deck from double bascule to vertical lift using hydraulic action’

#### V. OBJECTIVE

- 1) To study and calculated Vehicle moving capacity at Pamban Bridge.
- 2) To know the effect of different load types taken considering Indian codes as reference.
- 3) To find the maximum load capacity of the Bridge deck.
- 4) Analysis of bridge deck on STAAD Pro V8i
- 5) To find the effect of design parameters on the structure i.e., bending moment, Shear force and Nodal Displacement.
- 6) Design of deck using Post tensioning considering One-way Slab.
- 7) To find wires diameter, number of wires and pacing required in bridge deck.

#### VI. METHODOLOGY





VII. RESULTS

Load Calculations

Load Type	Load Intensity
Self-Weight and weight of train engine	6750 kN
Weight of train	1346.45 kN

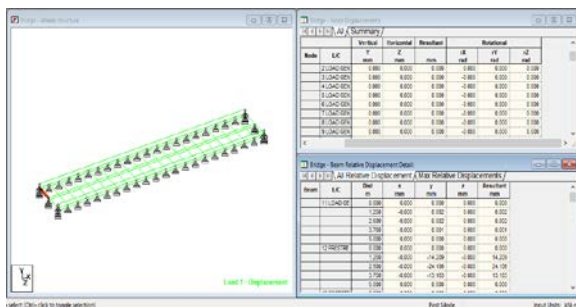


Figure 1. Maximum

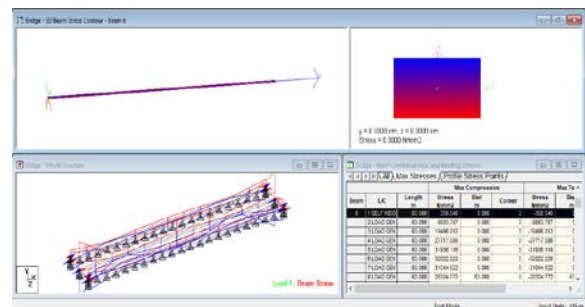


Figure 2. Maximum Stress

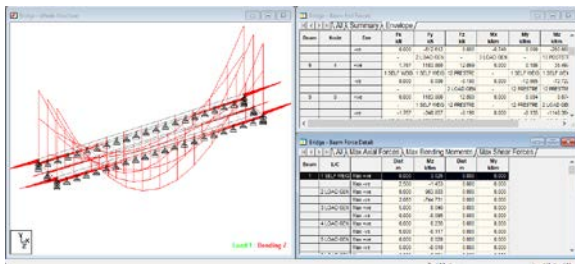


Figure 3. Bending Moment

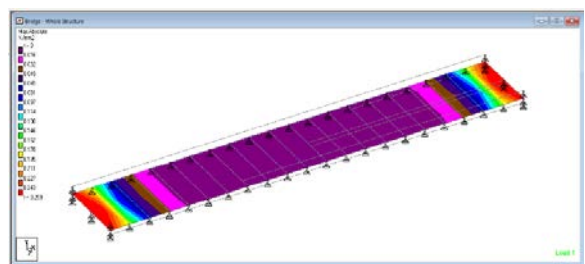


Figure 4. Plate Stress contour

Design of Deck Materials

- Grade of concrete = M 60
- Steel is H. T. steel
- Data Span = 10 m
- Imposed load = 6750 kN/m<sup>2</sup>
- Nominal diameter of strand = 15.20 mm
- Nominal area of strand = 139.4 mm<sup>2</sup>
- Strength of Strand = 250 kN
- Loss Ratio ( $\eta$ ) = 0.8

1. Bending moment/ due to DL and LL

b = Unit width of slab = 1.0 m;

D = Overall depth of slab

M<sub>z</sub> = Bending moment due to dead load

$$M_z = \frac{[(b \times h \times 25) (10^2)]}{8} = 312.5 \text{ bh kN.m}$$

M<sub>q</sub> = Bending moment due to imposed load

$$M_q = \frac{[6750 \times (10)^2]}{8} = 84375 \text{ kN.m}$$

## 2. Permissible stresses

Fig. 7 and 8 of IS 1343-2012

$$f_{ct} = f_{cw} > 8 \text{ N/mm}^2;$$

$$f_{it} = f_{tw} = 0 \text{ (Assuming type 1 member)}$$

$$f_{br} = 0.8 \times 6750 = 5400 \text{ N/mm}^2$$

## 3. Minimum section modulus

Using the governing inequalities to calculate minimum section moduli for the expected moments.

$$\frac{(bD^2)}{6} = \frac{[Mq + (1-h) Mg]}{f_{tr}}$$

$$\frac{(1000 \times h^2)}{6} = \frac{[84375 \times 106 + (1 - 0.8) \times 312.5 \times 1000 \times h]}{(0.8 \times 8)}$$

$166.67 h^2 - 11.57 h - 15.625 \times 10^6 = 0$ , on solving for h

$$h = 190 \text{ mm} = 200 \text{ mm}$$

Plugging  $h = 200 \text{ mm}$ ,  $b = 1000 \text{ mm}$

$$A = (1000 \times 200) = 2,00,000 \text{ mm}^2;$$

$$Z_b = \frac{(bD^2)}{6} = 6.67 \times 10^6 \text{ mm}^3$$

$$Mg = \frac{[(1.0 \times 0.20 \times 25) (10^2)]}{8} = 62.50 \text{ kN.m}$$

## 4. Check for stresses

Stress in top fiber

$$f_t = \frac{P}{A} - \frac{Mg}{Z_b} = 0 - \frac{62.50 \times 10^6}{6.67 \times 10^6} = -9.37 \text{ N/mm}^2$$

$$f_b = \frac{P}{A} - \frac{Mg+Mq}{n \cdot Z_b} = 0 - \frac{62.50 \times 10^6 + 84375 \times 10^6}{0.8 \times 6.67 \times 10^6} = -15824.119 \text{ N/mm}^2$$

## 5. To find prestressing force 'P' and eccentricity 'e'

To determine what combination of prestressing force, P and eccentricity, e will satisfy: Tensile and compressive stresses at transfer and at service.

$$P = \frac{[A (f_b Z_b + f_t Z_t) (Z+Z_i)]}{[Z_b + Z_t]} = \frac{[200 \times 10^3 (15824.119 \times 6.67 \times 10^6 - 9.37 \times 6.67 \times 10^6)]}{(6.67 \times 10^6 + 6.67 \times 10^6)} = 1581.47 \text{ kN}$$

$$e = \frac{[Z_t Z_b (f_b - f_t)]}{A [f_t Z_t + f_b Z_t]} = \frac{[6.67 \times 10^6 \times 6.67 \times 10^6 (10.48 - (-3.67))]}{250 \times 10^3 (-3.67 \times 6.67 \times 10^6)} = 55.83 \text{ mm}$$



**6. Number of strands**

Prestressing force, P = 1581.47 kN  
 Eccentricity, e = 55.83 mm  
 HT steel - 15.20 mm strand  
 Nominal area of strand - 139.4 mm<sup>2</sup>

∴ The number of strands required

$$N = \frac{P}{A_o} = \frac{1581.47}{250} = 6.32 \sim 7 \text{ Nos}$$

Total area of HT steel, A<sub>p</sub> = 7 (139.4) = 975.8 mm<sup>2</sup>

$$\text{Spacing between strands} = \frac{1000}{7} = 142.85 \text{ mm} \sim 140 \text{ mm}$$

∴ Provide High Tensile 7 Nos of 15.2 mm strands @ 140 mm

**7. Secondary reinforcement**

Un-stressed steel reinforcement @ 0.12 % is to be provided.

∴ Provide # 16 mm ∅ @ 300 mm c/c on both sides,

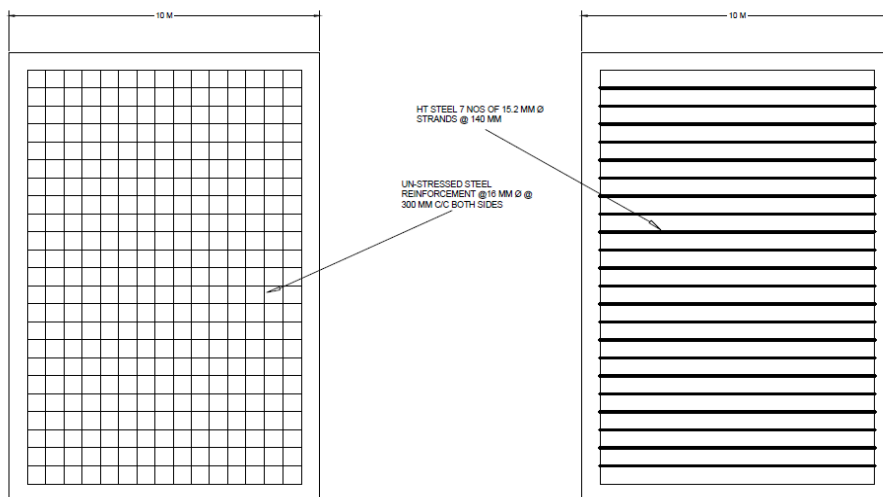


Figure 5. Steel Detailing

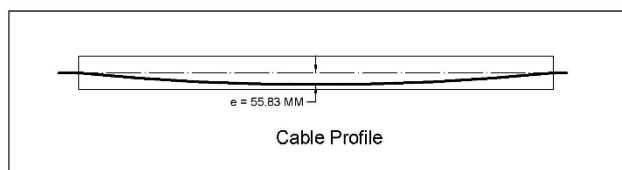


Figure 6. Cable Profile



### VIII.CONCLUSION

Design and analysis of vertical lifted bridge deck on STAAD Pro V8i is safe using Prestressed Concrete of M60 grade and providing 7 Strands of 15.20 mm each having spacing of 140 mm and which can be lifted with the hydraulic action considering combination of loads.

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