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"Design and Analysis of River Bridge Deck Slab at Vangani-Karav-Pashane"

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Abstract - *The work on designing of proposed reinforced concrete deck slab of bridge across Ulhas River at vangani-karav-pashane was carried out. A simple reinforced concrete deck slab is analysed using working stress method and results are presented in this paper. The main function of deck slab is to improve the distribution of the traffic loads among the main beams and to increase the lateral stability of the structure. The deck slab is generally designed for two lane of IRC class A loading. The deck slab is proposed as two lanes having clear roadway width between the kerbs as 6.8m. This design of deck slab of riverbridge has been proposed to facilitate ease of commuting.*

***Key Words: Deck slab, class A loading, staad.pro V8i, stresses on* slab*, shear force and moment on slab*.**

1. INTRODUCTION

According to this, the bridge (deck slab) at "ULHAS RIVER" is built for the betterment of the people living at karav-pashane. Because of natural calamities such as rain the deck slab is being deteriorate and it has become dangerous for the local people to go across the river to schools, colleges, offices, etc. this is the initiative to make the deck slab, so the local people to travel safely to near-by areas. As in case of design, span length, live load and impact load are always important factor. The analysis of deck slab of a river bridge is studied analytically by working stress method and by using STAAD.pro software. The analysis is done by IRC class A loading for live loading. The combination of STAAD.pro and STAAD.beava can make bridge design and analysis easier. STAAD.pro is first used to construct the bridge geometry and STAAD.beava is used to find load positions that will create the maximum load response.

1.1 STATEMENT OF PROBLEM

The deck slab of bridge on ulhas river is with rapid increase in vehicle users and decreasing life span of this bridge deck slab is damaged internally and reinforcement steel get corroded. So in order to make the traffic flow continuous and also avoid accidents, a new deck slab should be constructed across the major river. This is the only solution to elimination of such problem. The substructure i.e, piers, abutments, etc due to age of structure and increasing river water pressure become deteriorated, so we are designing deck slab.

1.2 LITERATURE REVIEW

(kushwah kapil, M Nivedhitha, singh. R Robert, 2018) has deck with the comprarative study on behavior of simply supported RC T- beam bridge under IRC AA class loading. The study is based on analytical modeling of RC T- beam bridge by STAAD pro V8i for different spans & also calculated the max shear force, bending moment, deflection in girder & max stresses & support reaction with analytical solution is studied. (Patil sudarshan,2017) this paper studied the analysis of super structure of different sections and spans is carried out by courben's method using MS Excel and load carrying capacity as the T-beam bridge is analysed for both IRC class AA and class A loading.(H Tanushree, 2016) their study stated that simply single spans, two lanes RCC and PSC slab bridge deck are analysed using finite element methods and results are compared to the reference analytic solution for dead load, IRC class AA loading. (E.salakawy, 2015) has conducted study of new highway bridge was constructed using FRP bars as reinforced for concrete deck slab. He work on to overcome related problem, the steel reinforced should be protected from corrosion, or replaced with alternative non-corroding materials.

1.3 OBJECTIVE OF THE WORK

In this paper a comparative study on the behavior of simple deck slab under standard IRC i.e. a class loading. The study is based on analytical calculation of a deck slab and checked by STAAD.pro V8i and calculate maximum shear force, bending moment, deflection and beam stresses in deck slab.

2. PARAMETRIC STUDY

A simply supported, single span, two lanes RCC slab bridge deck is considered. The bridge deck is analysed for the dead load as well as one class of live load i.e. IRC class A tracked loading and also for combination (DL+LL) of loads.

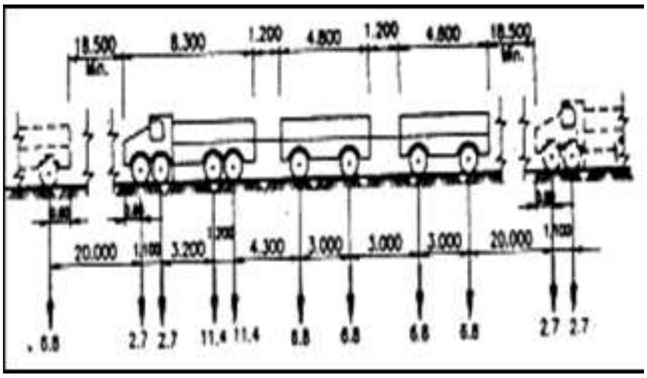


Fig 1 Class a Loading

3. METHODOLOGY

- The bridge deck slab is designed by referring IRC class A loading.
- Working stressed method is used for manually calculation.
- The manual design is then compared with STAAD PRO.V8i result for better results.
- This design of bridge deck slab has been proposed to facilitate ease of commuting.

3.1 METHOD OF ANALYSIS

- Manual Analysis is done by working stress method for IRC class A loading.
- Comparative study is carried out by using STAAD.pro V8i software.

TABLE -1: DESCRIPTION OF DECK SLAB

SR NO	BRIDGE DETAILS	MEASUREMENTS
1	Design loading	Class A loading (2 lane)
2	Type of deck slab	Simple deck
3	Carriage way width	6.8m
4	Effective span	5.87m
4	Clear span	5.5m
5	No of span	21
6	Length of the bridge	117m
7	Wearing coat	80mm

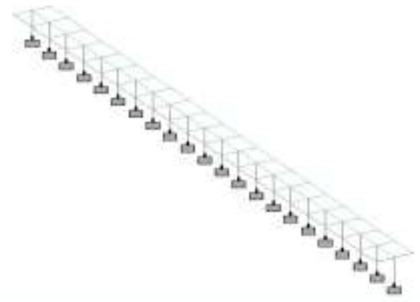


Fig 1.1 perspective view of 5.5m span deck slab

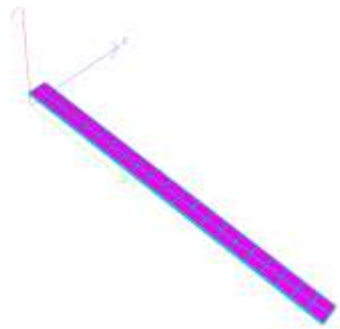


Fig 1.2 Rendering view of 5.5m span deck slab

3.2 DESIGN CONSIDERATION

Design of bridge deck slab consists of determining the following:

1. Stresses on deck slab
2. Maximum shear force
3. Maximum bending moment
4. Maximum deflection

DESIGN:

I. Clear width of carriage way = 6.8 m
II. Live load :IRC Class A loading

Use M20 concrete and Fe 250 steel

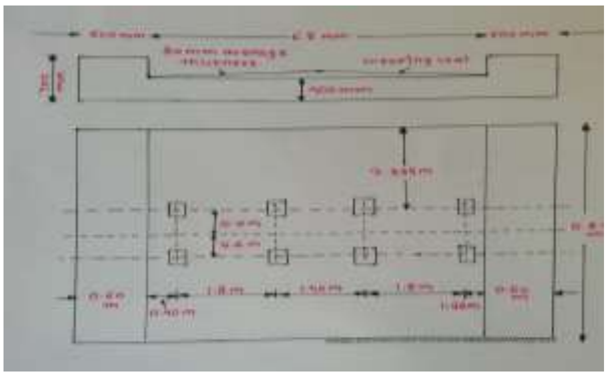


Fig.2

Solution. Let the thickness of the slab be 400 mm.

Allowing an effective cover of 30 mm, effective depth of the slab = 400 – 30 = 370 mm

Effective span = clear span + effective depth = 5.50 + 0.37 = 5.87 m

Let the average thickness of the wearing coat be 80 mm.

Overall width of bridge= 6.80 + 0.60 + 0.60=8.0 m

B. M. Calculations

Dead Loads

Weight of wearing coat = 80 × 23=1840 N/m^2

Weight of slab = 400 × 24= 9600 N/m^2

= 11440 N/m^2

B. M. due to dead load, for a one meter wide strip

= [(11440 × 5.87^2) / 8] = 49270 Nm = 49.27 KNm

Since the clear width of the roadway is 6.8 metres, provision is made for two lanes of traffic.

Clear distance g between two trains. This distance is to be determined as follows:

For a clear width of roadway of 5.5 m,

g = 0.4 m

For a clear width of roadway of 7.5 m,

g = 1.2 m

For a clear width of roadway of 6.8 m

g = 0.4 + [(1.2 – 0.4)/ (7.5 – 5.5)] × (6.8 – 5.5) m

= 0.92 m

Minimum clearance f between the outer edge of the wheel and the roadway face of the curb = 150 mm

Ground contact area

Width of contact area = W = 500 mm

Length of contact area = B = 250 mm

Distance between centres of wheels of two trains

= 0.92 + 0.50 = 1.42 m

Distance between roadway face of kerb and centre of wheels

= 0.15 + (0.50/2) m = 0.40 m

For the maximum bending moment condition the heavy loads namely axle loads of 114 KN will be placed symmetrically with respect to the span. For this position of the heavy axle loads, the other wheel loads are off the span. Fig. 3 shows the position of the heavy loads.

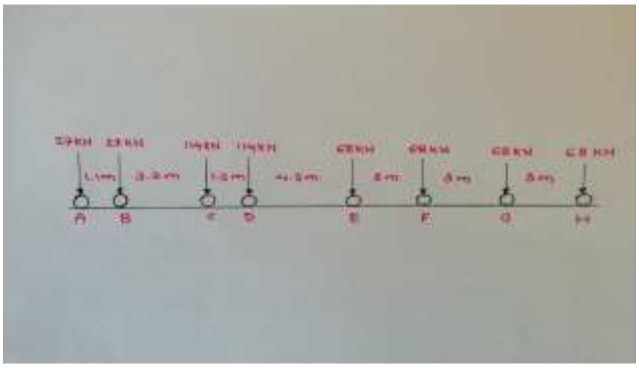


Fig.3

Impact factor = (4.5 / 6.0 + L) = (4.50 / 6.0 + 5.87) = 0.38

Distribution of concentrated load on slab

For a single concentrated load, the effective width shall be taken equal to

e = k x [l – (x/ l)] + W

In our case l = effective span = 5.87 m

x = Distance of load from the nearer support

= 2.335 m

k = constant depending on the ratio (l^* / l)

l^* = width of slab = 8 m

(l^* / l) = (8 / 5.87) = 1.36

Referring to Table on page 1296

For (l^*/ l) = 1.3 k = 2.72

For (l^*/ l) = 1.4 k = 2.80

For (l^*/ l) = 3.36

k = 2.72 + [(2.80 – 2.72) / (1.4 – 1.3)] × (1.36 – 1.30) = 2.768

W = breath of concentration area

= width of type + 2 x thickness of wearing coat

= 0.50 + [2 × (8/100)] = 0.66 m

Effective width = e = 2.768 × 2.335 [1 – (2.335/5.87)] + 0.66 m = 4.55 m

This means the effective widths for heavy loads will overlap.

Effective width for all the heavy loads

= (0.6 + 0.4) + 1.8 + 1.42 + 1.80 + 1.38 + 0.60 m

= 8 m

Load to be considered per m width

= [(2 × 1.114) / 8] = 28.5 KN

When the bridge is subjected to only one train of loads the corresponding effective width

= 0.60 + 0.40 + 1.80 + (4.55 / 2) m = 5.075 m

Since the effective width is more, the critical condition is therefore the previous case viz. when both the train of loads are present.

Dispersion of load along the span

Effective length of slab on which the wheel load acts shall be taken as equal to the dimension of tyre contact area over the wearing surface of the span plus twice the overall depth of the slab inclusive of the thickness of the wearing surface.

In our case the effective length on which the wheel load is applied

= 250 + 2 × (400 + 80) = 1210 mm

= 1.21 m

But distance between wheels

= 1.20 m

The effective length of dispersion is almost equal to wheel space.

The loading for a 1 m wide strip is therefore taken as shown in Fig.4

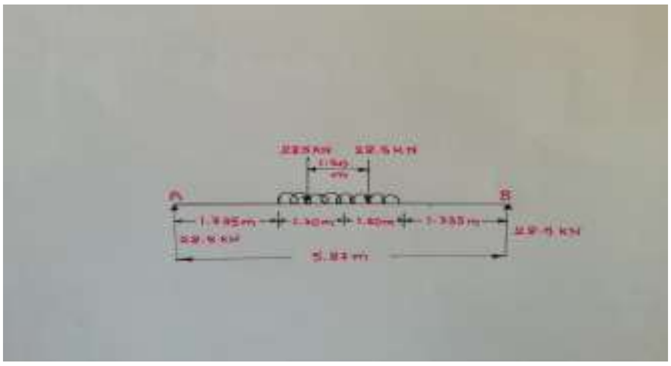


Fig.4

Max bending moment = 28.5 × (5.87 / 2) – 28.5 × (1.2 / 2) m = 66.50 KNm

B.M. due to impact = 0.38 × 66.5 = 25.27 KNm

Total B.M per m width

= 49.27 + 66.5 + 25.27 = 141.04 KN-m

Equating the moment of resistance to the bending moment,

$1.213\ bd^2 = 1.213 \times 1000\ d^2 = 141.04 \times 10^8$

∴ d = 341 mm

Providing 18 mm Φ bars at a clear cover of 25 mm

Effective depth available

= 400 – 25 – 9 = 366 mm

$A_{st} = [(141.40 \times 10^6) / (140 \times 0.87 \times 366)$

$= 3164\ mm^2$

Spacing of 18 mm Φ bars = [(254 × 1000) / 3164] = 80.2 mm

Provide 18 mm Φ bars @ 80 mm c/c

Distribution of steel

Distribution steel should be computed for resisting 0.3 times the live load bending moment and 0.2 times the dead load moment

∴ B.M. for which the distribution steel should be calculated

= 0.3 × (66.5 + 25.27) + 0.2 × (49.27)

= 37.385 KN m

If 12mm diameter bar be used, the effective depth to the centre of these bars.

= 400 – 25 – 18 – 6 = 351 mm

A_{st} = [(37.385 × 10^6) / (140×0.87×351)] = 875 mm^2

 spacing of 12 mm Φ bars = [(113×1000) / (875)] = 129 mm

Provide 12 mm ƒ bars @ 125 mm c/c

Shear

The greatest shear force will occur when the loads are closest to the support.

Effective width of slab for load near the support

e = k x [1 – (x/l)] + W

= 2.768 × 0.6 [1 – (0.6/5.87)] + 0.66 m =2.15 m

Now also the effective widths will overlap. When both trains are present, the effective width

= 0.6 + 0.4 + 1.8 + 1.42 + 1.8 + (2.15/2) m

= 7.095 m

 load to be considered perm width

= [(2×114) / 7.095] = 32.1 KN

When the bridge is subjected to only one train of loads the corresponding effective width

= 0.60 + 0.40 + 1.80 + (2.15 / 2) = 3.875 m

(This is more than for the case when both the trains are present)

Effective width of slab for the second load

= e = k x [1 – (x/l)] + W = 2.768 × 1.8 × [1 – (1.8/5.87)] + 0.66 = 4.12 m

This shows that the effective widths of the two trains will overlap.

 Effective width when both trains are present

= 0.6 + 0.40 + 1.80 + 1.42 + 1.80 + 1.38 + 0.60

= 8 m

 load per metre width

= [(2×114) / 8] = 28.5 KN

When the bridge carries only one train of loads, the effective width will be still greater and this condition that will not be considered.

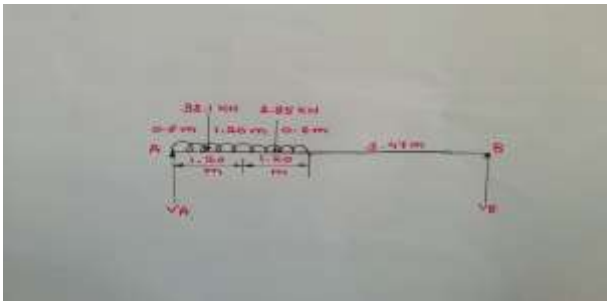


Fig.5

Fig.5 shows the loading for which S.F is to be computed.

Vertical reaction at A = V_a = [(28.5 × 4.07 + 32.1 × 5.27) / 5.87] = 48.6 KN

S.F. due to L.L. = 48.6 KN

S.F. due to impact = 0.38 × 48.6 = 18.5 KN

S.F. due to DL = 1.44 × (5.87/ 2) = <u>33.6 KN</u>

Max S.F. = <u>100.7 KN</u>

Nominal shear stress τ_v= (S / b d) = [(100.7 × 10^3) / (1000 × 366)] = 0.28 N/mm^2

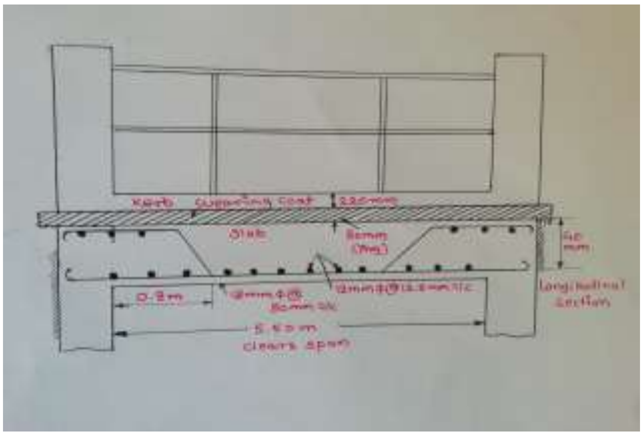
Percentage of steel = [31.64 / (1000 × 366)] × 100 = 0.86 %

For 0.86% steel, τ_c = 3.37 N/ mm^2

Thickness of slab = 400 mm, k = 1

 Permissible nominal shear stress

= k τ_c = 1 × 0.37 = 3.37 N/mm^2



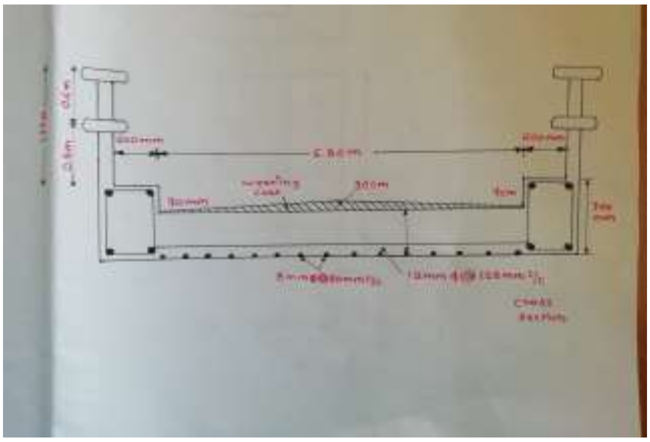


Fig.6

Kerb

kerbs 0.6 metre or more in width shall be designed for a live load of 4000 N / m and also a horizontal load of 7500 N/m run.

Design for vertical loads

D.L. of kerb = 0.6 × 0.7 × 24000 = 10080 N/m

Railing (assumed) = 600 N/m

Live load = 4000 × 0.6 × 1 = 2400 N/m

= 13080 N/m

Max B.M. = $[(13080 \times 5.87^2) / 8]$ = 56337 N/m

Effective depth available

= 700 – 25 – 9 (18 mm Φ bars) = 666 cm

$A_{st} = [(56337 \times 10^3) / (140 \times 0.87 \times 666)]$

= 695 mm^2

Provide 3 bars of 18 mm Φ

Design for horizontal loads

Horizontal load per metre run = 7500 N/m

B.M. due to horizontal load

= 7500 × (700 – 400) = 2250000 N mm

Effective depth = 600 – 30 = 570 mm
$A_{st} = [2250000 / (140 \times 0.87 \times 570)]$

= 32.4 mm^2 (very small quantity)

Provide nominal 8 mm Φ vertical links at 250 mm c/c.

4. RESULTS

TABLE NO - 2 COMPARISON OF MANUALLY AND STAAD.pro RESULTS

OUTPUT PARAMETER	MANUALLY	STAAD.pro
Shear force	100.2KN	131.72KN
Bending moment	141.04KN.m	149.9KN.m
Deflection	0	0
Beam stresses	48.6KN	60.45KN

5. SCOPE FOR FUTURE

The current status of the Vangani-Karav-Pashane river bridge, it being deteriorated i.e. damaged due to the age of structure and it is not safe in present. It was built 10 years ago but a special team alloted for its construction and design so its design is not available. So we are designing these bridge by working stress method as simply supported bridge, and is going to implement the design in future.

6. CONCLUSIONS

- Analysis and design of the deck slab bridge as per IRC codes can be easily done by STAAD.PRO in connection with STAAD.beava. mechanism is well understood.
- The designing by the software saves the design time and by this way we can check the safety of the structure very easily.
- It conclude that the principle top and bottom stresses in deck slab more increses with incresing span length.

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