RESEARCH ARTICLE OPEN ACCESS

Minimum requirement of steel in Designing of the Approach Bridge- Deck Slab.

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ABSTRACT
It is important to reinforce the bridge elements in such a way that they can carry sustained load and do not fail suddenly without adequate warning. The Indian Road Congress has drafted the specifications resulting in simplified approach of design of deck slab bridges. To begin with 3m width, deck Slab Bridge was design as per specifications and it is found that following parameter are significant in the analysis and designing of deck slab bridge depth of slab, DLBM, LLBM at mid span. Using the WSM method the whole components are designed and analyzed using Staad.Pro software. According to different width the minimum requirement of steel is calculated.

Keywords: Span length, depth of slab, DLBM, LLBM at mid span, Steel requirement, STAAD.Pro Vi8

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I. INTRODUCTION

Bridge is a structure constructed to provide a passage over the obstacle such as river crossing, railway crossing, valley etc. Design of bridge structure is depending upon the use of bridge or function of the bridge. It also depends upon the nature of the region where bridge to be constructed. It depends upon the site conditions, construction material used in the bridge construction, construction methods and financial conditions etc. Due to so speedy growth and development of the technology, the traditional bridges are replaced by the cost effective and new designer bridges. There structure designs are designed so that they have a new look or appearance and there cost of the structure is also economical.

There are various types of bridges are built now a days.

1) Deck slab bridge
2) Deck girder bridge
3) Balanced cantilever beam
4) Rigid frame culvert or bridge
5) Arch bridge
6) Continuous girder or arch bridge

In present project our main concern is with

Deck slab or solid slab bridge

The solid slab bridge is the simplest type of construction, used mostly for the culverts or small bridges with a span not exceeding 8 m. Approach Bridge is the deck slab bridge which is constructed on dam or river for the easy access to any intake structure. As it is providing the access to structure, we called it as a "Approach Bridge".

II. OBJECTIVE

The objectives of the present study are shortening as follows:

- To study the site conditions.
- To study the various forces acting on Approach Bridge.
- Design of the Approach Bridge by WSM method.
- 3D analysis of Approach Bridge using Staad.Pro Software.
- To Study Criteria for Earthquake Resistant Design of Structures.

LOAD CONSIDERATION:-

1. Dead Load

The dead load is nothing but a self-weight of the bridge elements. The different elements of bridge are deck slab, wearing coat, railings, parapet, stiffeners and other utilities. It is the first design load to be calculated in the design of bridge.

2. Live Load

The live load on the bridge, is moving load on the bridge throughout its length. The moving loads are vehicles, Pedestrians etc. but it is difficult to select one vehicle or a group of vehicles to design a safe bridge.

So, IRC recommended some imaginary vehicles as live loads which will give safe results against the any type of vehicle moving on the bridge. The vehicle loadings are categorized in to three types and they are

- IRC class AA loading
- IRC class A loading
- IRC class B loading

IRC Class AA Loading

This type of loading is considered for the design of new bridge especially heavy loading bridges like bridges on highways, in cities, industrial areas etc. In class AA loading generally two types of vehicles considered, and they are

- Tracked type
- Wheeled type

3. Impact Loads

The Impact load on bridge is due to sudden loads which are caused when the vehicle is moving on the bridge. When the wheel is in movement, the live load will change periodically from one wheel to another which results the impact load on bridge.

To consider impact loads on bridges, an impact factor is used. Impact factor is a multiplying factor which depends upon many factors such as weight of vehicle, span of bridge, velocity of vehicle etc. The impact factors for different IRC loadings are given below.

For IRC Class AA Loading and 70R Loading

For IRC Class AA Loading and 70R Loading

Span	Vehicle type	Impact factor
Less than 9 meters	Tracked vehicle	25% up to 5m and linearly reducing to 10% from 5 to 9 m.
	Wheeled vehicle	25% up to 9 m
Greater than 9 meters	Tracked vehicle (RCC bridge)	10% up to 40 m
	Wheeled vehicle (RCC bridge)	25% up to 12m
	Tracked vehicle (steel bridge)	10% for all spans
	Wheeled vehicle (steel bridge)	25% up to 23 m

For IRC class A and class B loadings

Impact factor $I_f = A/(B+L)$
Where L = span in meters
A and B are constants

Bridge type	**A**	**B**
RCC	4.5	6.0
Steel	9.0	13.50

Apart from the super structure impact factor is also considered for substructures
For bed blocks, If = 0.5
For substructure up to the depth of 3 meters $I_f = 0.5$ to 0
For substructure greater than 3 m depth $I_f = 0$

4. Combination of Live load

This shall be read in conjunction with clause 112.1 of IRC:5-1998. The carriageway live load combination shall be considered for the design as shown in table below.

Carriageway width	Number of lanes for design purpose	Load combination
1. Less than 5.3m	1	One lane of class a considered to occupy 2.3m.the remaining width of carriageway shall be loaded with 500Kg/m^2.
2. 5.3m and above but less than 9.6m	2	One lane of class 70R or two lanes of class A
3. 9.6m and above but less than 13.1m	3	One lane of class 70R for every two lanes with one lane of class A on the remaining lane or 3 lanes of class A.
		One lane of class 70R for every two lanes with

4. 13.1m and above but less than 16.6m	4	one lane of class A for remaining lanes, if any, or one lane of class A for each lane.
5. 16.6m and above but less than 20.1m	5	--
6. 20.1m and above but less than 23 6m	6	--

5. Seismic Loads

When the bridge is to be built in seismic zone or earthquake zone, earthquake loads must be considered. They induce both vertical and horizontal forces during earthquake. The amount of forces exerted is mainly depends on the self-weight of the structure. If weight of structure is more, larger forces will be exerted.

III. METHODOLOGY

In this present study, deck slab Approach Bridge for Bhivapur Water Storage and Supply under Nogrotthan Programme Dist- Nagpur, Maharashtra. is considered having width 3 m and height of nearly 7 m from ground and is analyzed in standard software Staad pro Vi8 using various conditions.

WORKING STRESS METHOD

Working Stress Design Method Definition:

Working Stress Design Method is a method used for the reinforced concrete design where concrete is assumed as elastic, steel and concrete act together elastically where the relationship between loads and stresses is linear.

Assumptions of Working Stress Design Method

i. Plane Section before bending will remain plane after bending
ii. Bond between steel and concrete is perfect with in elastic limit of steel
iii. The steel and concrete behave as linear elastic material
iv. All tensile stresses are taken by reinforcement and none by concrete
v. The stresses in steel and concrete are related by a factor known as "modular ratio".
vi. The Stress-strain relationship of steel and concrete is a Straight line under working load

Deck slab Approach Bridge is designed by using the Working Stress Method.

Various types of loads are considered for design of bridge structures. These loads and their combinations decide the safety of the bridge construction during its use under all circumstances. The design loads should be considered properly for perfect design of bridge.

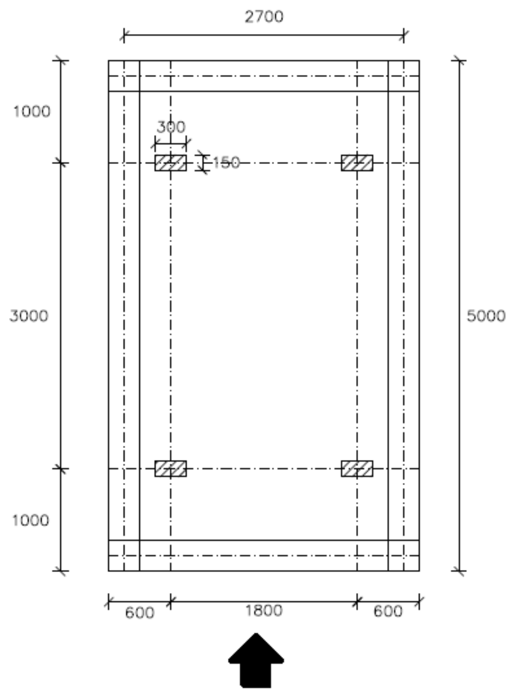


Fig 1: Position of Wheel on Deck Slab

IV. STRUCTURAL COMPONENTS

Scheme aspects of structural design are as follows:

- Deck Slab
- Longitudinal and transverse Beam
- Longitudinal and transverse Brace
- Column
- Footing

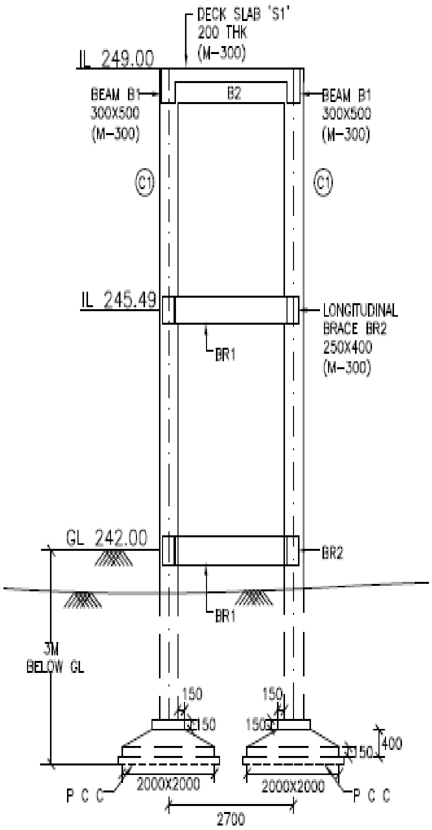


Fig 2: Section at GL 242 m

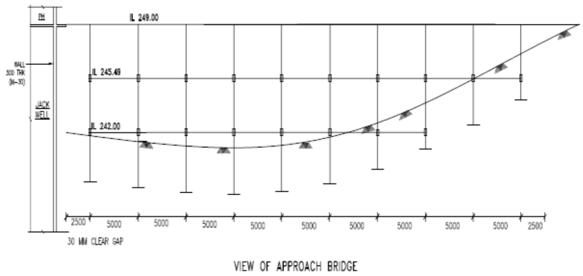


Fig 3: Approach Bridge side view

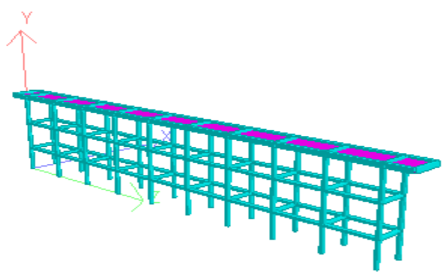


Fig 4: Approach Bridge Model

V. ANALYSIS & DESIGN OF BRIDGES

On 50 m span bridge is analyzed and designed as per specifications. The details are presented below.

Data:
Span = 50 m
Road width = 3 m
Wearing coat = 20 mm

Sr. No	Member	Dimensions
1.	Total length	50 m
2.	Span length	5 m
3.	Width	3 m
4.	Slab	3 m x 5 m
5.	Depth of Slab	200 mm
6.	Top IL	249 m
7.	Bottom IL	241.48 m
8.	HFL/FSL	248 m
9.	SBC	10 t/m^2
10.	Foundation Level	3 m below ground
11.	Seismic Zone	III
12.	Slab level	249 m
13.	Longitudinal Beam	300 x 500 mm
14.	Transverse Beam	300 x 500 mm
15.	Longitudinal Brace	250 x 400 mm
16.	Transverse Brace	250 x 400 mm
17.	Column	400 mm dia
18.	Footing	2 x 2 m isolated sloped
19.	Depth of footing	400 mm
20.	Steel	Fe 415
21.	Concrete	M 30

Table 1

Preliminary Data considered for the Analysis

Weight of Structure		
Slab	8250	kg
Beam	2925	kg
Brace	6500	kg
Column	6606.56	kg
Truck	10000	kg
total	34281.56	kg

Table 2

VI. RESULTS AND DISCUSSION

After preparation of an excel sheets for the width of 3, 3.5, 4, 4.5 and 5 m, we are finding the results are as follows.
Thickness of Slab: 200 mm
Span length: 5 m

Fe 415

SR. NO	Concrete Grade	Road Width	DLBM (Kg.m)	LLBM (Kg.m)	TOTAL BM
1	M30	3	334.13	1287.55	1621.68
2	M30	3.5	469.34	1448.53	1917.87
3	M30	4	627.46	1576.91	2204.37
4	M30	4.5	808.5	1682.97	2491.47
5	M30	5	1012.46	1772.53	2784.99

Table 3

Variations in the DLBM and LLBM for M30 grades of concrete for Fe415 grade of steel with different width for deck slab

Fe 415

SR. NO	Concrete Grade	Road Width (m)	Depth Required (mm)
1	M30	3	104.62508
2	M30	3.5	113.77883
3	M30	4	121.98155
4	M30	4.5	129.68201
5	M30	5	137.10829

Table 4

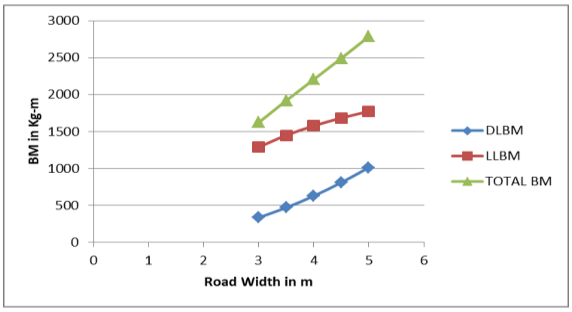
Variations in the Depth required for M30 grades of concrete for Fe415 grade of steel with different width for deck slab

Fe 415

SR. NO	Concrete Grade	Road Width (m)	Min Area of steel (mm^2)
1	M30	3	588.51653
2	M30	3.5	696.00121
3	M30	4	799.97298
4	M30	4.5	904.1625
5	M30	5	1010.6819

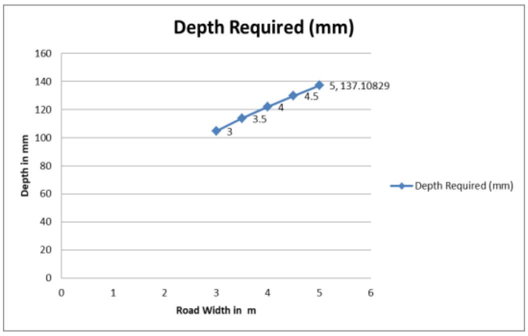
Table 5

Variations in the Area of Steel for M30 grades of concrete for Fe415 grade of steel with different width for deck slab



Refer Table 3

Fe 415



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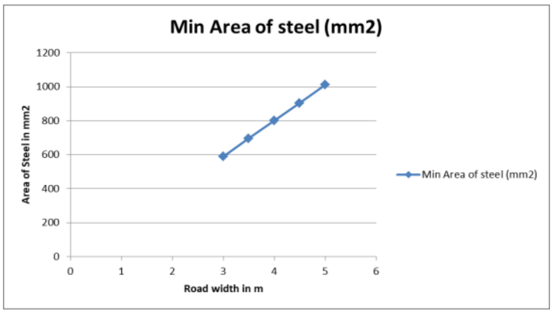
Fe 415



Refer Table 5
Fe 415

Fe500

SR. NO	Concrete Grade	Road Width	DLBM (Kg.m)	LLBM (Kg.m)	TOTAL BM
1	M30	3	334.13	1287.55	1621.69
2	M30	3.5	469.34	1448.53	1917.87
3	M30	4	627.46	1576.91	2204.37
4	M30	4.5	808.5	1682.97	2491.47
5	M30	5	1012.46	1772.53	2784.99

Table 6

Variations in the DLBM and LLBM for M30 grades of concrete for Fe500 grade of steel with different width for deck slab

Fe 500

SR. NO	Concrete Grade	Road Width (m)	Depth Required (mm)
1	M30	3	118.23988
2	M30	3.5	128.5848
3	M30	4	137.85493
4	M30	4.5	146.55745
5	M30	5	154.95011

Table 7

Variations in the Depth required for M30 grades of concrete for Fe500 grade of steel with different width for deck slab

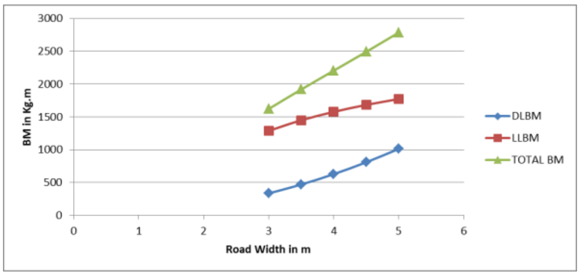
Fe 500

SR. NO	Concrete Grade	Road Width (m)	Min Area of steel (mm^2)
1	M30	3	415.55468
2	M30	3.5	491.45019
3	M30	4	564.86521
4	M30	4.5	638.43399
5	M30	5	713.64788

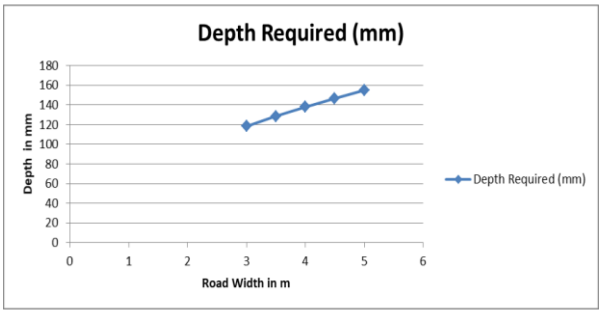
Table 8
Variations in the Area of Steel for M30 grades of concrete for Fe415 grade of steel with different width for deck slab

VII. CONCLUSION

- Approach Bridge undergoes under different actions; hence it is necessary to design accurately.
- The depth of slab increases with increasing road width.
- The steel requirement is also depending on the depth of slab.
- By changing the Grade of steel, we can reduce the amount of steel but it significantly increases the depth.
- The Variations the grade of concrete with load, moment is decrease with increase in the grade of concrete in RCC Bridges.
- Excel sheets developed can give design output for any length of deck slab bridge
- The design of Approach Bridge for 3 to 5 m width can be obtained from the mathematical modelling without doing lengthy calculations.



Refer Table 6 Fe 500



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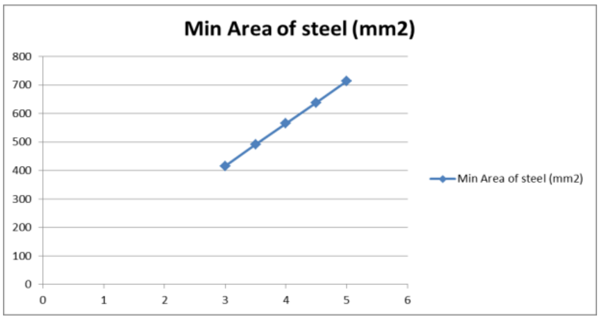

Refer Table 8
Fe 500

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