Economical Design of Bridge Component

Aditya Nanaware[1], Mahesh Nemane[2] Prof. P. Satarkar[3]

[1,2,3]*Savitribai Phule Pune University*

Abstract: Bridges are the lifelines and supporters for the improvisation of the road network. Not only do the bridges help in traffic flow without any interference but also maintain the safety of roads. Due to this reason the bridges design has gained much importance. This paper is basically concerned about the analysis and design of Component Bridge using Staadpro and IRC-6 1966.The focus of this paper is designing the bridge component as per relevant IRC code & comparing Economical of design with software analysis. Factor considered during Economical of design are accuracy and complexity of design. Above key factors should help to propose economical way of design of bridge component.

Keywords:- IRC6-1966, Staad pro V8i

Introduction

(Abdul Rashid and P. Veerabhadra rao, August 2017)

It is found that the load per meter run of IRS loadings is increased by 210% compared to IRC. The Bending Moment due to IRS 25t Loading-2008 load combinations increased on an average of 4.6 times to the Bending Moment due to the IRC loading and Shear force due to IRS 25t Loading-2008 load combinations increased on an average of 3.2 times to the Shear force due to IRC load.

(Amit Saxena and Dr. Savita Maru, 2013)

Compared T-beam girder and Box girder to check which among the two is favorable. The decisions were taken on obvious element of engineering-Safety, serviceability and economy. They had concluded that service load bending moment and shear force for T-beam girder are lesser than box girders which allow the designer to have lesser heavier section for T-beam girder than box girder for span up to 25m.

(A. Patil and Y. Singh, June 2018)

Comparing the behavior of bridge pier designed and detailed using five different national codes, it is observed that AASHTO code [2] provides the highest while CALTRANS code [6] provides the lowest seismic capacity. Short bridge piers, designed and detailed using RDSO code, behave slightly better than piers designed and detailed using the IRC code. On the other hand, the pattern is just opposite for comparatively tall bridge piers.

(Amitkumar. M. Patel 2008)

The analysis and design of well foundation and pile foundation for the provided details have been performed. The software generates the output of result with diagrammatic representation. The output of software is compared with the long hand calculation of problem. Hence it is concluded that the software provides accurate results and within the short period of time. It is possible to develop user friendly, interactive and handy computational tools for the analysis and design of bridges sub-structure sing available software platforms.

(George P. Colman 1993)

Construction of the original 1,143.3 m (3,750 ft.) long bridge structure was completed in 1952, with 1 travel lane in each direction and with twin 150.6 m (494 ft.) long swing spans at the 137.2 m (450 ft.) wide navigation channel.

(Iqura Zaffar and Priyanka Singh, 2016)

Analysis and design of the Deck Slab Bridge as per IRC codes (here IRC 70R loading) can be easily done by STAAD Pro. in connection with STAADbeava mechanism is well understood. The maximum resultant nodal displacement is for node 1529; 0.015mm in x, -51.203mm in y and -.287mm in x.

(Kavita.N et al., 2015)

Article "Analysis and design of flyover" Conducted a traffic survey at four road junction in salem town and designed all the structural parts of grade separator .The grade separator is of 640m length with 21 spans, 20m per span. It consist of deck slab, longitudinal girder, cross girders, deck beam, pier and foundation. Slab is design by working stress method as per recommendation of IRC-21 2000.

(Girish Sawai and Pradeep N Payghan, 2017)

This paper discussed the design and analysis of bridge foundation subjected to Indian Standard code. The study focused on the design and analysis of bridge's foundation using STAAD Pro. In project we create the super structure data required for foundation design. It is possible to analyze and design the bridge substructure with the help of software and time can be saved by avoiding lengthy calculations required for analysis and design of bridge substructure.

(Prof. K C Koradia et al., 2016)

In Bridge foundation, IRC Limit State Method is consuming 23% less Reinforcement in comparing with IRC working stress method. Hong Kong Limit state method and IRC limit state method are comparatively same in Reinforcement detailing for Bridge pile foundation.(4-5% variation) In Indian limit state method and Hong Kong limit state method material utilize up to proper limit. In Indian limit state and Hong Kong limit state, The Hong Kong limit state method is comparatively conservative.

Main goal of this research is design bridge component using revised IRC codes and software. This project gives general idea about design of bridge component by using IRC-6 1966 and SAP software. It also helps to know design parameter and its output. It helps to know economical way to design bridge component by considering accuracy of project, analytical values, difference between stress, pressure or bending moment parameters, use of appropriate material quantity and complexity issues while considering economical aspect and accuracy.

The outline of paper is introduction methodology, Case study, Design, Result, Conclusion, References etc.

After studying this research papers we designed bridge component using IRC6-1966. Similarly we studied staadpro software and designed component using staadpro and finally we concluded.

Problem Statement

Bridges are supporters for improvisation of road network and bridge design has gain much importance. Now days bridge design can done by manual method and by using software analysis. But it is quite be difficult to choose way to design bridge component due to various methods of design and factor affecting on output of design. Affecting factors are such as cost of construction, accuracy of design and complexity of design. This project helps to propose feasible way of design of bridge component as considering above factors.

Aim of Project

To compare design by IRC6-1966, and Staadpro software for economical design.

Objectives of Project

1. The main objective of this project is to design components using revised IRC codes and software.

2. To know design difference between IRC code and software.

3. To identify and analyze more economical design to apply.

Scope of Project

This project gives general idea about design of bridge component by using IRC-6 1966 and SAP software. It also helps to know design parameter and its output. Scope of this project is, it help to know economical way to design bridge component by considering accuracy of project , analytical values, difference between stress, pressure or bending moment parameters, use of appropriate material quantity and complexity issues while considering economical aspect and accuracy.

CASE STUDY

Details of the case study:

Nira is linked by railway to Miraj and

Kolhapur. Long-route trains do not stop there. Roads around Nira are village roads of good quality.

By road, it is well connected to Pune via Jejuri, the famous temple town, and saswad. On the other side, it is also connected to a famous pilgrimage place, Pandharpur via Phaltan. Third major town it connects is Baramati, the emerging industrial town.

To all these places, regular road transport (S. T.) buses are available. Takes around 2–2.5 hours from Pune, 1.5 hours from baramati. Some 2.5 hours from Pandharpur.

Proposed Road Widening Details

Project Name :-Four Laning of Baramati to Phaltan Road SH 10 (Km 42/400 to Km. 64/300) &Phaltan - Lonand to Shirwal Road SH 70 (Km 136/000 to Km 80/000) Pune &Satara District of Maharashtra State.

1) The existing S.H. road requiring widening lies in the village/s Ruhi, Andori in KhandalaTahsil& village Kalaj, Kashidwadi in PhaltonTahsil of dist. Satara

2) Total Length Requiring Widening : 28.488 Km.
   a) Length through Forest area :0.861 Km
   b) Length through non Forest area: 27.627Km.

Additional Land Width proposed: Village-Ruhi, 15 mtr. Village-Andori 30 mtr. Village- Kalaj, 15 mtr. Village- Kashidwadi, 30 mtr

- Carriage way : 2 lane
- Design speed : 40-70 km
- Slab drain : 1 Nos.
- Minor Bridges : 1
- C.D. Drive : 10
- Estimated Cost : Approx.4.90 Crore

Detailed Project Note on Project of Widening of Baramati–Phalton and Shirwal Road S.H.10/70, DIST. PUNE/SATARA

(M.S.) As per the decision taken by the Government of Maharashtra in the meeting held on 18th August 2009 with the Committee of Fundamental Facilities, it is decided to implement the up -gradation of various National Highway carriage-way configuration for capacity augmentation for safe and efficient movement of traffic either through its own budgetary resources or on design built, finance, operate and transfer (DBFOT) basis under National Highway Development Programme. The said, 1980 highway. S.H.-10 connects PhaltanLonand-Shirwal places, which are industrially well developed and generate large amount of vehicular traffic. The existing road is two lane undivided carriageway and is inadequate to widen the exiting road to cope up with the increasing traffic.

Justification, necessity & reasoning for widthwidening of existing alignment.

The existing project road of approx. 7.5 mt. width passes through Forest area of the village Ruhi, Andori in KhandalaTahsil and the village Kalaj&Kashidwadi in Phaltan Tahsil, of dist. Satara. This road was constructed well before 1980 i.e. before F.C. Act-1980. As per Revenue & Forests, Govt. of Maharashtra guidelines letter no. FLD/3902/case-9/F- 10Dt.24/06/2003, for such linear projects requiring widening or improvement in width, area required for widening if passes through Forest attracts the provisions of Forest Conservation Act.Considering this fact, 1.997 ha. Forest area is required for the purpose of widening and strengthening of the existing road. Thus, Total Forest area involved in this widening project is 1.997 ha. falling under Satara Forest Div. bearing its legal status is Reserved Forest. The work of undertaking two/four lane of the SH-10 is totally based on public utility purpose and also other important factors considered wherein to control the rush of traffic from the accident point of view and to safeguard the human life. In view of the above, the proposal initiated by the user agency i.e. P.W. (East) div.

Due to industrial development along the National Highway-10, there is heavy increase in various types of vehicles of heavy load running on the same road in two lanes which is very harmful to the human life as the present situation is always taking dangerous turn of accidents. The widening of S.H.-10 on DBFOT basis from Phaltan to Lonand section will be very convenient to the smoothly running of heavy traffic which is increased now a days on large basis. The forest land as well as acquired land which is going to be involved in the proposal is nearest minimum and very essential for the purpose. Similarly no heavy loss from the environment point of view appears to be seen. The vehicles of the forest department will be asked to be allowed to run free from toll on the same proposed widening 2/4 lanes. This project will be the ideal project of the Maharashtra State was from may benefits available to the vehicle owners as well as to safe guarding of human life. So also saving in consumption of petrol, diesel, oil etc. will be the main factor which will be seen in future.

All other possible alternatives have been examined and explored by this P.W. dept. But, it is impossible to bye-pass this requirement of Forest land for widening of said road is not located deep inside the forest area. The area proposed for diversion is barren and without vegetation.

We aware of the fact that, such Forest land required for the proposed widening comes under the purview of the provisions of the Forest (Conservation) Act-1980, making it incumbent on the State Government to obtain prior approval of the Central Government under the provision of the said Act. The required forest area is the barest minimum and immediate requirement for the proposed project and there is no alternative non forest land available. .

Technical aspects of the project.

The existing S.H. road requiring widening lies in the village/s Ruhi, Andori in KhandalaTahsil& village Kalaj, Kashidwadi in PhaltenTahsil of dist. Satara,with starting point Ch. Km. 98/380 to end point Ch Km.127/170 The grades proposed for these alternatives are well within permissible limits i.e. 1:18 grades of proposed. The elevation between starting point and end point is above 100 meters. The horizontal corves are designed for the apexes having deflection angle of 75 degree.

1) Total Length Requiring Widening : 28.488 Km.

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b) Length through non Forest area : 27.627Km.

2) Additional Land Width proposed : Village-Ruhi, 15 mtr. Village-Andori 30 mtr. Village- Kalaj, 15 mtr. Village- Kashidwadi, 30 mtr.

3) Carriage way : 2 lane

4) Design speed : 40-70 km

5) Slab drain : 1 Nos.

6) Minor Bridges : 1

7) C.D. Drive : 10

8) Estimated Cost : Approx.4.90 Crore

Land acquisition scenario:

The existing Phaltan-Lonad S.H.-10 in the given section where widning on one or both sides proposed passes through village Ruhi, Andori in KhandalaTahsil&Kalaj, Kashidwadi in PhaltanTahsil Dist. Satara and extends up to Baramati in Pune dist. As per indicated on village map enclosed in the proposal the requirement of total land for the proposed width extension on both the sides of the existing route is 1.997 ha. And Non-forest land is approx.41 ha. Thus, total under the jurisdiction of Satara Forest Division.

Table: The total Forest land, required for the project as per F.C.A.-1980 and guidelines issued by Govt. of India, M.O.E.F., New Delhi under the class-Reserved Forests (R.F.), Protected Forest (P.F.) and Private Forests etc.

Division	Total number of villages	Total survey	Forest (Ha)
Satara	5	-	1.997
Total	5	-	1.997

Name of division	Total Forest Area (Ha)	R.F (Ha)	P.F (Ha)	Private forest land	Restored	Enquiry
Satara	1.997	1.997	-	-	-	-

Figure 1.Geographic Location of Phalton Bridge

Figure 2. Map of location site

Financial and Social Solution

1. This existing state highway with congested width connects industrially developed city places like Phaltan-Lonand & Shirwal. Due to generation of large amount of vehicular traffic on existing road formation tends to create accidents hence, it is necessary to widen the existing road for the growing traffic.
2. This road widening project is totally based on public utility purpose and to control the rush of traffic from the accident point of view and to safe guard human life.
3. This widening will not only speed up the traffic and it will also help to increase the level of business, which will speed up their annual income. Hence it would help to achieve the National Productivity.

4. This project shall prove to be boon for the commercial development of the rural, tribal, backward regions in western Maharashtra in particular, marketability and profitability of products at affordable consumer cost as a result of saving in time, fuel and in turn, cost.

ANALYSIS OF DESIGN COMPONENTS OF BRIDGES

Loads and Load Combinations

1 Loads on bridges

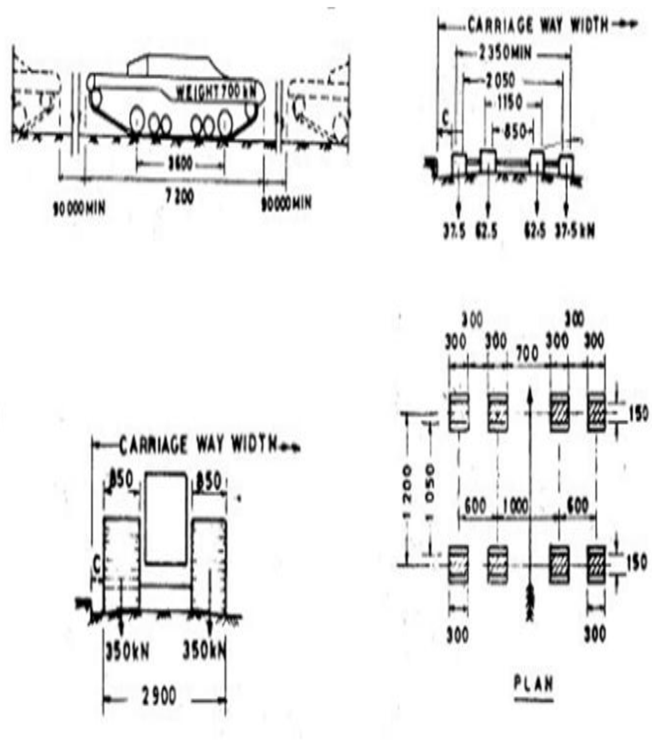
- The following are the various loads to be considered for the purpose of computing stresses, wherever they are applicable.
- Dead load ·
- Live load ·
- Impact load ·
- Longitudinal force ·
- Wind load ·
- Seismic load ·
- Forces due to curvature.
- Forces on parapets ·
- Frictional resistance of expansion bearings.

Dead load– The dead load is the weight of the structure and any permanent load fixed thereon. The dead load is initially assumed and checked after design is completed.

Live load– Bridge design standards specify the design loads, which are meant to reflect the worst loading that can be caused on the bridge by traffic, permitted and expected to pass over it. In India, the Railway Board specifies the standard design loadings for railway bridges in bridge rules. For the highway bridges, the Indian Road Congress has specified standard design loadings in IRC section II.

The following few pages brief about the loadings to be considered. For more details, the reader is referred to the particular standard.

Highway bridges: In India, highway bridges are designed in accordance with IRC bridge code. IRC: 6 - 1966 – Section II gives the specifications for the various loads and stresses to be considered in bridge design. There are three types of standard loadings for which the bridges are designed namely, IRC class AA loading, IRC class A loading and IRC class B loading.



Tracked Vehicle Wheeled Vehicle

Figure 3.IRC class AA Loading

IRC class AA loading consists of either a tracked vehicle of 70 tons or a wheeled vehicle of 40 tons with dimensions as shown in Fig. The units in the figure are mm for length and tons for load. Normally, bridges on national highways and state highways are designed for these loadings. Bridges designed for class AA should be checked for IRC class A loading also, since under certain conditions, larger stresses may be obtained under class A loading. Sometimes class 70 R loading given in the Appendix - I of IRC: 6 - 1966 - Section II can be used for IRC class AA loading.

Class A loading consists of a wheel load train composed of a driving vehicle and two trailers of specified axle spacing's. This loading is normally adopted on all roads on which permanent bridges are constructed. Class B loading is adopted for temporary structures and for bridges in specified areas. For class A and class B loadings, reader is referred to IRC: 6 - 1966.

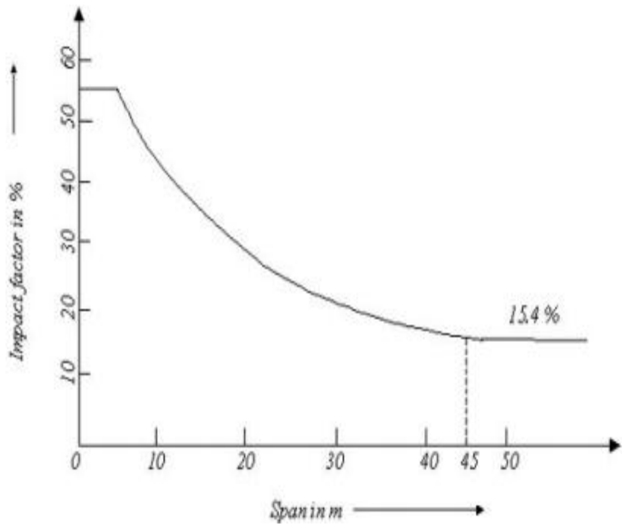


Figure 4: Impact Percentage vs span

Figure 4 shows Impact percentage curve for highway bridges for IRC class A and IRC class B loadings. The dynamic effect caused due to vertical oscillation and periodical shifting of the live load from one wheel to another when the locomotive is moving is known as impact load. The impact load is determined as a product of impact factor, I, and the live load. The impact factors are specified by different authorities for different types of bridges. Figshows impact percentage curve for highway bridges for class AA loading. Note that, in the above table l is loaded length in m and B is spacing of main girders in m.

Longitudinal forces :

Longitudinal forces are set up between vehicles and bridge deck when the former accelerate or brake. The magnitude of the force F, is given by

$$\mathbf{F} = \left(\frac{\mathbf{W}}{\mathbf{g}}\right)\left(\frac{\Delta \mathbf{V}}{\Delta \mathbf{t}}\right) \mathbf{KN}$$

Where,

W –weight of the vehicle

g –acceleration due to gravity

δV– change in velocity in time d t

This loading is taken to act at a level 1.20 m above the road surface. No increase in vertical force for dynamic effect should be made along with longitudinal forces. The possibility of more than one vehicle braking at the same time on a multi-lane bridge should also be considered.

Seismic load – If a bridge is situated in an earthquake prone region, the earthquake or seismic forces are given due consideration in structural design. Earthquakes cause vertical and horizontal forces in the structure that will be proportional to the weight of the structure. Both horizontal and vertical components have to be taken into account for design of bridge structures. IS:1893– 1984 may be referred to for the actual design loads. Forces due to curvature - When a track or traffic lane on a bridge is curved allowance for centrifugal action of the moving load should be made in designing the members of the bridge. All the tracks and lanes on the structure being considered are assumed as occupied by the moving load. This force is given by the following formula:

$$C = \frac{wv^2}{12.7R}$$

Where,

C - Centrifugal force in kN/m

W - Equivalent distributed live load in kN/m

V - Maximum speed in km/hour R - Radius of curvature in m Erection forces – There are different techniques that are used for construction of railway bridges, such as launching, pushing, cantilever method, lift and place. In composite construction the composite action is mobilized only after concrete hardens and prior to that steel section has to carry dead and construction live loads. Depending upon the technique adopted the stresses in the members of the bridge structure would vary. Such erection stresses should accounted for in design. This may be critical, especially in the case of erection technologies used in large span bridges. Load combinations Stresses for design should be calculated for the most sever combinations of loads and forces. Four load combinations are generally considered important for checking for adequacy of the bridge.

Sr.No.	Load Combinations	Loads
1	Stress due to normal loads	Dead Load, Live Load, Impact Load and Centrifugal Force.
2	Stress due to normal loads + occasional loads.	Normal Load as in 1 + Wind Loads, other Lateral Load, Longitudinal Forces and Temperature Stresses
3	Stresses due to loads during erections	---
4	Stress due to normal loads + occasional loads + extraordinary loads like seismic excluding wind loads	Loads as in 2 + with seismic loads instead of Wind Loads.

Table1 : Load Combinations

Design of Deck Slab

Effective span $= 12.2$ m

Clear width $= 4.175$ m

Effective width $=$

$4.175 - 0.285$

$= 3.89$ m

Depth of slab $= 680$ mm

Effective depth $= 630$ mm

Thickness of wearing coat $= 75$ mm

M25, Fe500

Step1.Design coefficient as per IRC21 − 2000

$\varsigma cb = 8.33\ N/mm^2$

$\varsigma st = 200\ N/mm^2$

$m = 10$

$Q = 1.1$

$j = 0.9$

Deal Load Bending moment

Dead weight of slab $= 0.68 * 24$

$= 16.32\ KN/m^2$

Dead weight of wearing coat $= 0.075 * 22$

$= 1.65\ KN/m^2$

Total Dead Load $= 18\ KN/m^2$

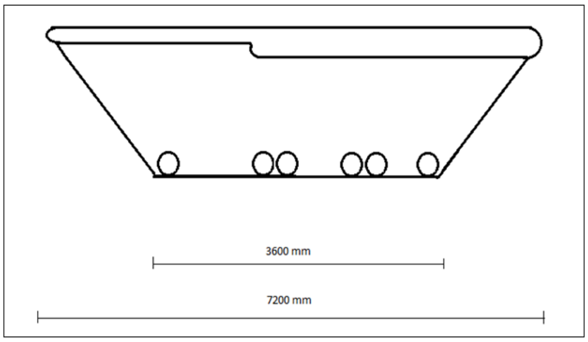
Bending moment $= WL^2/8$

$= 18 * 12.2^2/8$

$= 334.89$ KNm

1) **Live Load Bending Moment**

Generally bending moment due to Live Load will be maximum for IRC class AA.



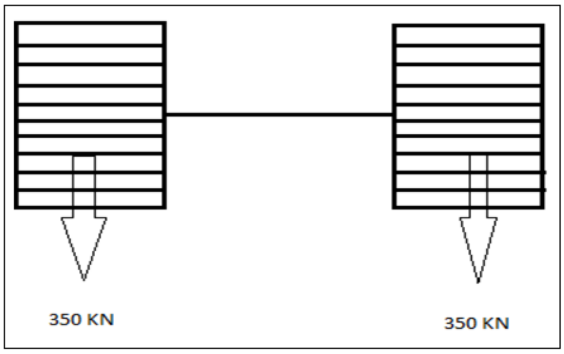


Figure No 5: Tracked Wheeled Load.

Effectve Length of Load

$= 3.6 + 2 * (0.68 * 0.075)$

$= 5.11$m

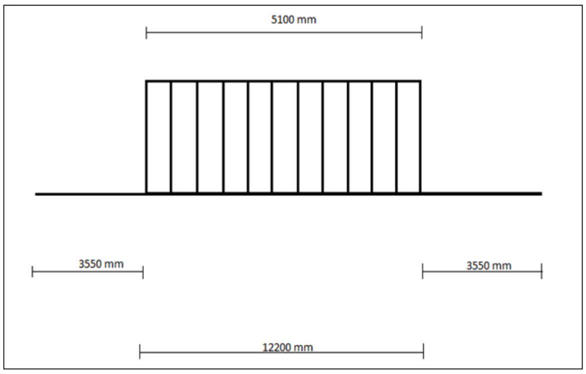


Figure No 6: Effective Width of the Load (cross section of road)

Effective width of Load

$$Be = K * x(1 - x/L) + bw$$

$$B/L = 4.175/12.2 = 0.34$$

$K = 1.288$

$X =$ Distance of C.G of Load from nearest support $= 6m$

$Bw =$ Track contact area over the road surface $+ 2 * w.c$

$$= 0.85 + 2 * 0.075 = 1$$

$$Be = [1.288 * 6.1(1 - 6.1/12.2)] + 1$$

$$= 4.93 \text{ m}$$

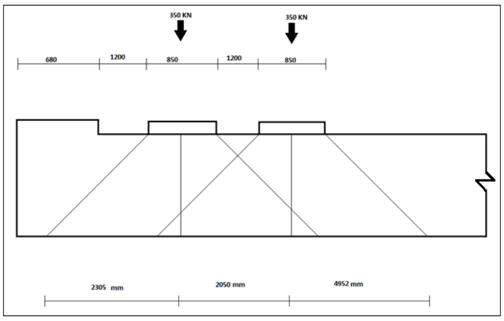


Figure 7: Effective Width of Wheel Load Dispersion

Net effective width of dispersion $= 8.637$

Impact factor $= 25\%$

Total Load of 2 tracks with impact $= 700 \text{ KN} * 1.25$

$$= 875 \text{ KN}$$

Average intensity of Load $= 875/5.11 * 6.82$

$$= 25.11 \text{ KN/m2}$$

Maximum Bending Moment due to LiveLoad

$$Mmax = [(\text{Average Intensity of Load} * \text{Effective length of load})/2 * \text{effective span}/2] - [(\text{Average intensity} * \text{Effective length of Load})/2 * \text{Effective Length of Load}/4]$$

$$= [(25.15 * 5.11)/2 * 12.2/2] - [(25.11 * 5.112/8)]$$

$$= 309.39 \text{ KNm}$$

Total design Bending Moment

$$= \text{Live Load Bending Moment} + \text{Dead Load Bending Moment}$$

= 334.89+309.39 = 644.28KN.m

Step2. Effective width of dispersion is given by :

$$Be = k * x [1 - X/L] + bw$$

$$X = 2.555$$

$$K = 1.288$$

$$Bw = 1$$

$$Be = 1.288 * 2.55 [1 - 2.555/12.2] + 1$$

$$= 3.6 \text{ m}$$

Therefore width of dispersion

$$= 2305 + 2050 + 1800$$

$$= 6155 \text{ mm}$$

$$\text{Average intensity of load} = 875/5.11 * 6.15$$

$$= 27.84 \text{ KN/m2}$$

$$\text{Shear force} = 27.84 * 5.11 * 9.645/12.2$$

$$= 112.5 \text{ KN}$$

Step3. Dead Load shear = WL/2

$$= 18 * 12.2/2$$

$$= 109.8 \text{ KN}$$

Total Design Shear Force

$$= 222.3 \text{ KN}$$

Step 4.Design of DeckSlab

$$D = (M/Q * b)1/2$$

$$= (644.28 * 10\char`^6/1.1 * 1000)\char`^(1/2)$$

$$= 765.32 \text{ mm}$$

Take eff. depth =765 mm

Overall depth = 800 mm

Step 5.Reinforcement

a) Main reinforcement

Ast = $\frac{M}{\sigma^{2*j*d}} = \frac{644.28*10^6}{200*0.9\ 765}$

= 4678.86 mm^2

Spacing = $\frac{1000*491}{4678.86}$

= 105 mm

Provide 25 mm bars @ 105 mm c/c

b) Distribution reinforcement

BM = 0.3 M_l+0.2M_d

= 0.3 * 309.39 + 0.2 * 334.89

= 159.8 KN-m

Ast = $\frac{M}{\sigma^{2*j*d}} = \frac{159*10^6}{200*0.9\ 765}$

= 1154.68 mm^2

Provide 20 mm dia bars @ 272 mm c/c spacing.

Kerb design

Kerb is designed for a live load of 4 KN/ and horizontal load of 7.5KN

$$\text{Assume wt of railing} = 0.6 \text{ KN/m run}$$

$$\text{LL/m run} = 0.68 \text{ X } 0.98 \text{ X } 24 = 15.9 \text{ KN}$$

$$\text{Total load /m run} = 0.6 + 7.5 + 15.9$$
$$= 24.09 \text{ KN}$$

$$\text{BM} = 448.26 \text{ KN} - \text{m}$$

Live load moment of class AA loading is taken half.

$$\text{LL} = 0.5 \text{ X } 309.39 = 154.69 \text{ KN} - \text{m}$$

$$\text{Total BM} = 448.26 + 154.69 = 602.95 \text{ KN} - \text{m}$$

$$\text{Ast} = 3418.08$$

Provide 8 nos. of 20 mm diameter bars.

Provide 2 legged stirrups of 16 mm @ 150 mm C /C spacing.

Design of Pier:

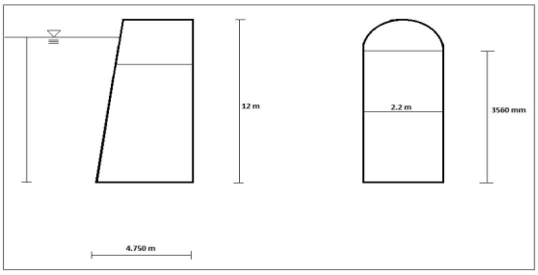


Figure 8 Elevation and Plan of proposed Pier

Step1. Design computation

$$2 * 334.89 = 669.78$$

$$\text{Dead Load} = 669.78 * 4.17 = 2792.98 \text{ KN}$$

Self weight of pier

$$= 0.5(4.17 + 4.75) * 3.56 * 12 * 24 = 4572.74 \text{ KN}$$

$$\text{Total} = 2792.98 + 4572.74 = 7365.72 \text{ KN}$$

Compressive stress at base of pier

$$= 7365.72/\ (3.56 \text{ x } 2.2)$$

$$= 940.116 \text{KN/m}^2$$

Step2. Effect of Buoyancy

Width of pier at HFL $= 1.2\text{m}$

Submerged weight

$$= 3.56 * 0.5\ (1.2 + 4.7) * 11.38$$

$$= 119.51 \text{ m3}$$

Reduction in weight of pier due to buoyancy

$$= 119.51 * 12$$

$$= 1434.15 \text{ KN}$$

Stress at base due to buoyancy

$$= -\ (1434.15/(3.59 * 2.2)$$

$$= -173.68$$

Step3. Stress due to eccentricity of LiveLoad

Reaction from one span 222.3 KN acting at eccentricity $= 0.15$

$$\text{Moment about base} = 222.3 * 0.5 = 111.15$$

$$\text{Section modulus} = 3.59 * 2.22\ /\ 6$$

$$= 3.16$$

Stress developed at base of pier due to eccentricity

$$= 222.3/\ (3.59 * 2.2) \pm 111.51\ /\ 2.89$$

$$\varsigma \text{ max} = 65.38 \text{ KN/m2}$$

$$\varsigma \text{ min} = 10.32 \text{ KN/m2}$$

Step4. Stress due to load longitudinal braking forces

Braking force at bearing level $= 140$ KN

Moment about base of pier $= 140 * 12.38$

$= 1733.2$ KNm

Stress at base $= \pm M/Z = \pm 1733.2/2.89$

$= 59.7$ KN/m2

Step 5. StressesduetoWindPressure

Total Wind Pressure on pier

$=$ Area x wind intensity

$$= \frac{4.17 + 4.75}{2} * 12.38 * 2.4$$

$= 138.45$ KN

Assume,

the wind to act at mid of pier

Moment about base of pier $= 138.45 * 6.19$

$= 857$ KNm

Modulus of section of base (z)

$= 2.2 * (3.59)^2$

$= 4.94$ m3

Stress developed at base due to wind load

$\pm M/Z$

$(857)/4.72$

$= 181.35$ KN/m2

1) **Stressduetowatercurrent**

Intensity of pressure $= 0.5\ kv^2$

$= 0.5 * 0.66 * 3^2$

$= 2.97$ KN/m2

Force due to water current

$$= \frac{4.17 + 4.75}{2} * 12.38 * 2.97$$

$= 163.98$ KN

This Force acts at height of $2/3 * 11.38$

$= 7.58$m

Moment at base (m) $= 163.98 * 7.58$

$= 1244.06$ KNm

Stress at base $= \pm M/Z = \pm 1244.06/4.72$

$= 263.54$

$$1687.23 = 939.31 + 66.6 - 181.95 + 599.7 + 263.57 + 181.17$$

$$116.23 = 939.31 - 10.32 - 181.95 - 599.17 - 265.57 - 181$$

(DL − LL − Buoyancy − Braking − Watercurrent − Wind)

The grade of concrete is M20 and combination of both loads is within permissible compressive stress in concrete.

8. Analysis and Design of Bridge Component by Using Staadpro

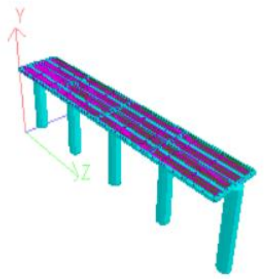


Figure 9.

Material and Properties

Materials

Mat	Name	E (kip/in^2)	ν	Density (kip/in^3)	α (/°F)
1	STEEL	29E+3	0.300	0.000	6E -6
2	STAINLESSSTEEL	28E+3	0.300	0.000	10E -6
3	ALUMINUM	10E+3	0.330	0.000	13E -6
4	CONCRETE	3.15E+3	0.170	0.000	5E -6

Supports

Node	X (kip/in)	Y (kip/in)	Z (kip/in)	rX (kip˙ft/deg)	rY (kip˙ft/deg)	rZ (kip˙ft/deg)
4	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
10	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
16	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
22	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
28	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed

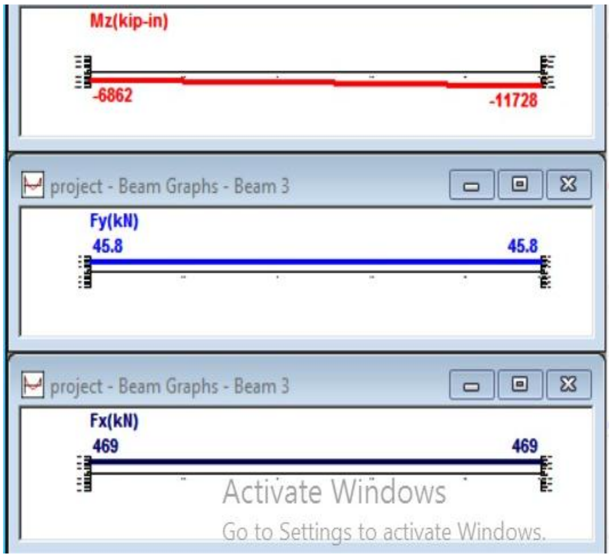
Loads and Combination

Primary Load Cases

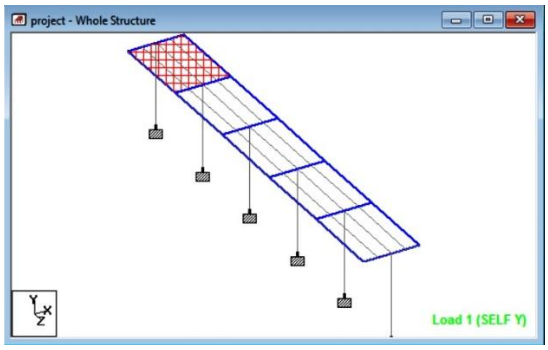
Number	Name	Type
1	DL	Dead
3	WL	Wind
2	LOAD CASE 2	Live

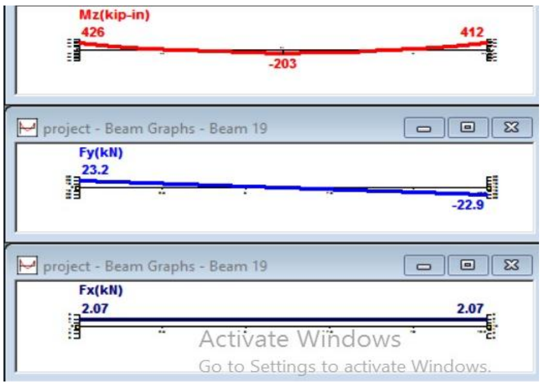
Combination Load Cases

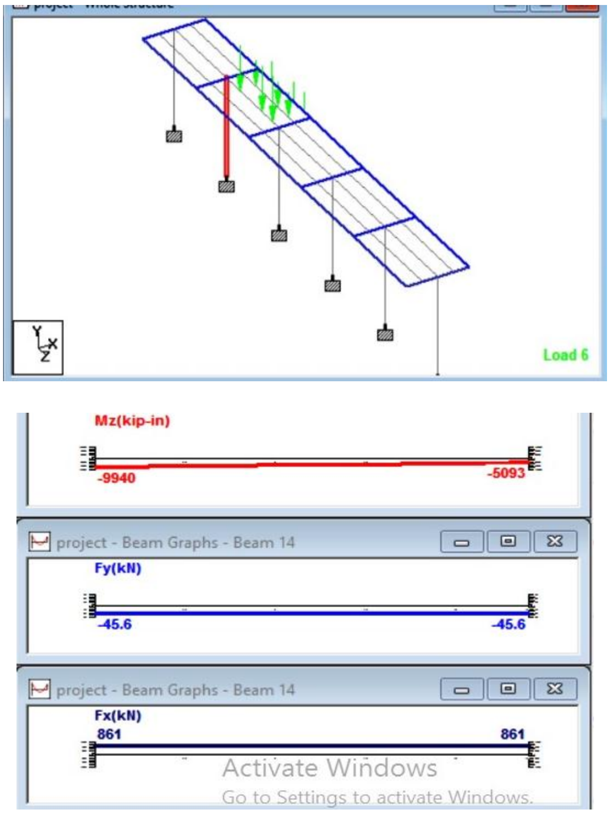
Comb.	Combination L/C Name	Primary	Primary L/C Name	Factor
8	GENERATED INDIAN CODE GENRAL_S	1	DL	1.50
		2	LOAD CASE 2	1.50
9	GENERATED INDIAN CODE GENRAL_S	1	DL	1.20
		2	LOAD CASE 2	1.20
		3	WL	1.20



Graphs

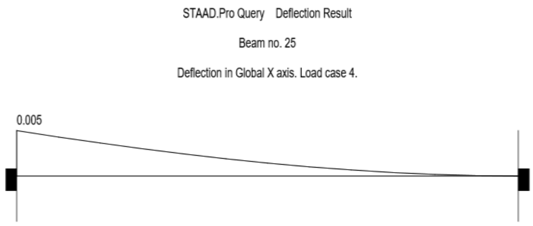




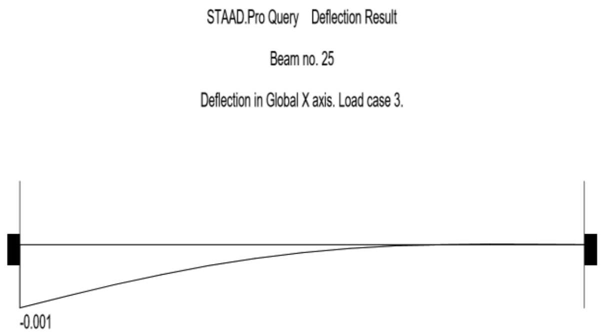


Loading Diagram and Graph

Analysis



Dist.m	X(in)	Y(in)	Z(in)
0.000000	0.0052	0.0002	0.0189
0.999998	0.0045	0.0002	0.0162
1.999996	0.0038	0.0002	0.0137
2.999994	0.0031	0.0002	0.0114
3.999992	0.0025	0.0001	0.0092
4.999990	0.0020	0.0001	0.0072
5.999988	0.0015	0.0001	0.0054
6.999986	0.0011	0.0001	0.0038
7.999984	0.0007	0.0001	0.0025
8.999982	0.0004	0.0001	0.0015
9.999980	0.0002	0.0000	0.0007
10.999978	0.0000	0.0000	0.0002
11.999976	0.0000	0.0000	0.0000



Dist.m	X(in)	Y(in)	Z(in)
0.000000	-0.0013	0.0000	0.0000
0.999998	-0.0011	0.0000	-0.0000
1.999996	-0.0009	0.0000	-0.0000
2.999994	-0.0006	0.0000	-0.0000
3.999992	-0.0005	0.0000	-0.0000
4.999990	-0.0003	0.0000	-0.0000
5.999988	-0.0002	0.0000	-0.0000
6.999986	-0.0001	0.0000	-0.0000
7.999984	-0.0000	0.0000	-0.0000
8.999982	0.0000	0.0000	-0.0000
9.999980	0.0000	0.0000	-0.0000
10.999978	0.0000	0.0000	-0.0000
11.999976	0.0000	0.0000	0.0000

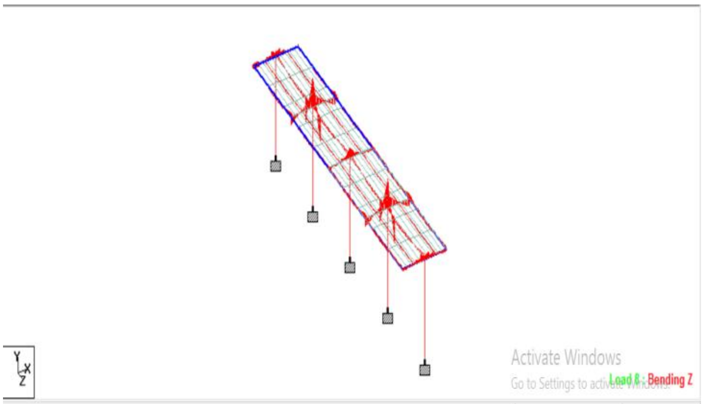
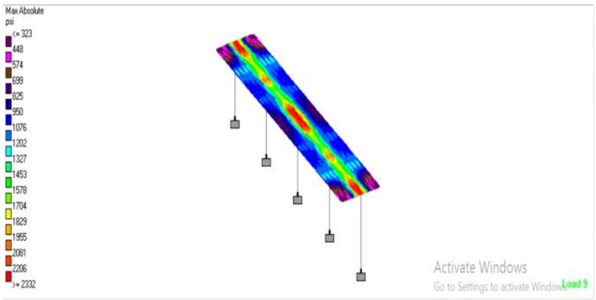
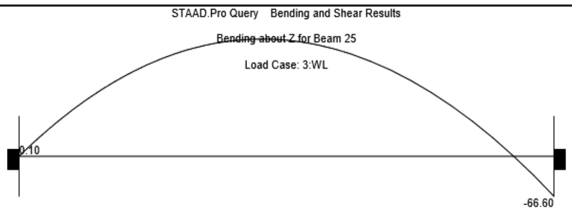


Fig: Bending moment profile along Z



Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kip-in	My kip-in	Mz kip-in
25	1 DL	14	855.815	0.000	-0.001	0.000	0.104	0.016
		16	-1933.072	-0.000	0.001	-0.000	0.041	-0.006
	2 LOAD CAS	14	2789.950	0.000	-0.004	0.000	0.334	0.038
		16	-2789.950	-0.000	0.004	-0.000	0.140	-0.015
	3 WL	14	-0.000	-8.200	0.000	-0.000	-0.000	0.099
		16	0.000	-8.951	-0.000	0.000	-0.000	66.604
	8 GENERATE	14	5468.648	0.000	-0.009	0.000	0.657	0.081
		16	-7084.533	-0.000	0.009	-0.000	0.271	-0.031
	9 GENERATE	14	4374.918	-9.840	-0.007	0.000	0.525	0.184
		16	-5667.626	-10.741	0.007	-0.000	0.217	79.899



Dist.m	Fy(kN)	Mz(kip-in)
0.000000	-8.2002	0.0994
0.999998	-6.6426	65.7706
1.999996	-5.1079	117.7568
2.999994	-3.5960	156.2547
3.999992	-2.1081	181.4773
4.999990	-0.6477	193.6545
5.999988	0.7824	193.0341
6.999986	2.1806	179.8925
7.999984	3.5425	154.5408
8.999982	4.8945	117.2041
9.999980	6.2465	67.9011
10.999978	7.5985	6.6317
11.999976	8.9505	-66.6040

Bending Moment Profile

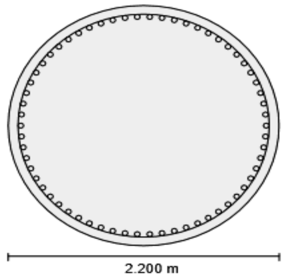
Design of Pier

```
=========================================================================


=========================================================================

        C O L U M N   N O.    36  D E S I G N   R E S U L T S

     M30                    Fe415 (Main)              Fe415 (Sec.)

LENGTH: 12000.0 mm   CROSS SECTION: 2200.0 mm dia.  COVER: 40.0 mm

** GUIDING LOAD CASE:    8 END JOINT:    22  SHORT COLUMN


REQD. STEEL AREA   :     3775.86 Sq.mm.
REQD. CONCRETE AREA:   471981.94 Sq.mm.
MAIN REINFORCEMENT : Provide  34 - 12 dia. (0.10%,   3845.31 Sq.mm.)
                     (Equally distributed)
TIE REINFORCEMENT  : Provide  8 mm dia. circular ties @ 190 mm c/c

SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)
----------------------------------------------------------
Puz :  52442.18   Muz1 :    6479.96   Muy1 :   6479.96

INTERACTION RATIO: 0.19 (as per Cl. 39.6, IS456:2000)

SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)
----------------------------------------------------------
WORST LOAD CASE:     8
END JOINT:     22 Puz :  52462.86    Muz :    6499.16    Muy :    6498.78    IR: 0.19
=========================================================================
```

STAAD.Pro Query Concrete Design

Beam no. 25

Design Code: IS-456



Design Load

Load	3
Location	End 1
Pu(Kns)	-0.000000
Mz(Kns-Mt)	0.010000
My(Kns-Mt)	0.000000

Design Results

Fy(Mpa)	415
Fc(Mpa)	30
As Reqd(mm²)	30411.000000
As (%)	0.801000
Bar Size	25
Bar No	62

	IRC 6 : 1966	Staadpro
B.M. due to D.L.	334.89 KN.m	403.016 KN.m
B.M. due to L.L	309.39 KN.m	319.29 KN.m
Design B.M (Deck slab)	644.28 KN.m	722.306 KN.m
Compressive stresses at base of pier	940.116 KN/m²	1150.87 KN/m²
Accuracy of design	Lengthy calculations Less accuracy	Easy analysis than IRC Less calculations
	We can provide steel as per requirement.	Provide excess steel and concrete

Results and Conclusions :-

As per design analysis done by both codes IRC 6; 1966, IS 112; 2011 shows same results but this process is time consuming , contains lengthy calculations and person to person results may change. On the other hand while designing on staadpro , the analysis and design of bridge components can be easily done. Drawback of software is it considers excess amount of steel and concrete than actual requirement and it will affect economical aspect.

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