Indian J.Sci.Res. 17(2): 211 - 216, 2018
ISSN: 0976-2876 (Print)
ISSN: 2250-0138(Online)

DESIGN OF RCC T-BEAM BRIDGE CONSIDERING OVERLOADING DUE TO CONGESTION

[1]Nivedhitha M, [2]Gowtham Raja M, [3]Sharu.E
[1]Department of Civil Engineering, VELS University, Chennai
[2]Department of Structural Engineering, Prathyusha Engineering College, Thiruvallur
[3]Department of Structural Engineering, Prathyusha Engineering College, Thiruvallur

Abstract - A bridge is a structure providing passage over an obstacle without closing the way beneath. The required passage may be for a road, a railway, pedestrians, a canal or a pipeline. The obstacle to be crossed may be a river, a road, a railway or a valley. In the world, many of the bridges are failed due to various reasons. But mostly bridge failure occurs due to improper design. Therefore proper designing is required to avoid the failures of bridge. In this Project, We are designed R.C.C T-BEAM Bridge in a proper manner. We referred standard code books, standard procedures, and previous research to make a design in a good manner. The span of the bridge which is being adopted is 20m, with the clear roadway of 10.5m of 3 lanes. The clear cover of the reinforcement is taken as 40mm. The bridge is designed with all the components like Deck, Girders, Bearing, Pier cap, Pier, Pile cap, Pile, Abutment and so on. Each components of bridge is intended based on the configuration by IRC loadings. These components are designed based on IRC loadings and it is being examined with the authentic loading. This bridge design also having a seismic resistance capacity. Finally we are compared designed bridge with the overloading currently due to congestion factor on the bridge and also analysing the structural behaviour and life span of T-beam Bridge.

Keywords– IRC, T-beam Bridge, Structural Capacity

I. Introduction

A bridge is a structure that crosses over a river, bay, or other obstruction, permitting the smooth and safe passage of vehicles, trains, and pedestrians. An elevation view of a typical bridge is a bridge structure is divided into an upper part (the superstructure), which consists of the slab, the floor system, and the main truss or girders, and a lower part (the substructure), which are columns, piers, towers, footings, piles, and abutments. The superstructure provides horizontal spans such as deck and girders and carries traffic loads directly. The substructure supports the horizontal spans, elevating above the ground surface. The first bridge to be documented was described by Herodotus in 484 B.C. It consisted of timbers supported by stone columns, and it had been built across the Euphrates River some 300 years earlier. Most of these early bridges could not support heavy weights or withstand strong currents. It was these in adequacies which led to the development of better bridges. The oldest surviving stone bridge in china is THE ZHAOZHOU BRIDGE, built from 595-605AD during the Sui Dynasty. The bridge is also historically significant as it is the world’s oldest open-spandrel stone segmental arch bridge. The first book on bridge engineering was written by Hubert Gautier in 1716. With the Industrial Revolution in the 19th century, truss systems of wrought iron were developed for larger bridges, but iron didn’t have the tensile strength to support large loads. With the advent of steel, which has a high tensile strength, much larger bridge were built, many using the ideas of Gustave Eiffel.

Figure.1: The Zhaozhou Bridge

II. Classification of Bridges

A. Classification by materials

Steel Bridges: Steel bridge may use a wide variety of structural steel components and systems: girders, frames, trusses, arches, and susp5ension cables.

Concrete Bridges: There are two primary types of concrete bridges: reinforced and pre-stressed.

Timber Bridges: Wooden bridges are used when the span is relatively short.

[1]Corresponding Author

Metal Alloy Bridges: Metal alloys such as aluminium alloy and stainless steel arealso used in bridge construction.

Composite Bridges: Bridges using both steel and concrete as structural materials.

B. Classification by Objectives

Highway Bridges: Bridges on highways.

Railway Bridges: Bridges on railroads.

Combined Bridges: Bridges carrying vehicles and trains.

Pedestrian Bridges: Bridges carrying pedestrian traffic.

Aqueduct Bridges: Bridges supporting pipes with channelled water flow. Bridges can alternatively be classified into movable (for ships to pass the river) or fixed and permanent or temporary categories.

III. Components of Bridge

A. Superstructure

It is the top portion of the bridge. The portion of the bridge that supports the deck and transfer the load to the substructure.

B. Sub-structure

The portion of the bridge that supports the superstructure and distributes all the loads to the footings.

C. Foundation

The bottom most part of the substructure which transmit load of the structure along with its own weight into the soil underneath or surroundings without carrying shear failure or bearing capacity failure and excessive settlement.

IV. Classification by structural system (superstructures)

A. Plate Girder Bridges

The main girders consist of a plate assemblage of upper and lower flanges and a web. H or I-cross-sections effectively resist bending and shear.

B. Box Girder Bridges

The single (or multiple) main girder consists of a box beam fabricated from steel plates or formed from concrete, which resists not only bending and shear but also torsion effectively.

C. T-Beam Bridges

A number of reinforced concrete T-beams are placed side by side to support the live load.

D. Composite Girder Bridges

The concrete deck slab works in conjunction with the steel girders to support loads as a united beam. The steel girder takes mainly tension, while the concrete slab takes the compression component of the bending moment.

E. Grillage Girder Bridges

The main girders are connected transversely by floor beams to form a grid pattern which shares the loads with the main girders.

F. Truss Bridges

Truss bar members are theoretically considered to be connected with pins at their ends to form triangles. Each member resists an axial force, either in compression or tension.

G. Arch Bridges

The arch is a structure that resists load mainly in axial compression. In ancient times stone was the most common material used to construct magnificent arch bridges.

H. Cable-Stayed Bridges

The girders are supported by highly strengthened cables (often composed of tightly bound steel strands) which stem directly from the tower. These are most suited to bridge long distances.

I. Suspension Bridges

The girders are suspended by hangers tied to the main cables which hang from the towers. The load is transmitted mainly by tension in cable.

V. Classification by design life

A. Permanent Bridges

The Bridge which is built permanently for longer duration that has been built by taking care of future traffic conditions is known as permanent bridges.

B. Temporary Bridges

The Bridge which is constructed for short period of time and it can be easily deformed.

VI. Classification by span length

A. Culverts: Bridges having length less than 8m.

B. Minor Bridges: Bridges having length 8-30m.

C. Major bridge5s: Bridges having length greater than 30m.

D. Long span bridges: Bridges having length greater than 120m.

VII. T-Beam Bridges

Beam and slab bridges are probably the most common form of concrete bridge in the UK today, thanks to the success of standard precast Prestressed Concrete beams developed originally by the Prestressed Concrete Development Group (Cement & Concrete Association) supplemented later by alternative designs by others, culminating in the Y-beam introduced by the Prestressed Concrete Association in the late 1980s.

The precast beams can be joined together at the supports to form continuous beams which are structurally more efficient. However, this is not normally done because the costs involved are not justified by the increased efficiency. Simply supported concrete beams and slab bridges are now giving way to integral bridges which offer the advantages of less cost and lower maintenance due to the elimination of expansion joints and bearings.

VIII. Design

Each bridge must be designed individually before it is built. The designer must take into account a number of factors, including the local topography, water currents, river ice formation possibilities, wind patterns, earthquake potential, soil conditions, projected traffic volumes, aesthetics, and cost limitations.

In addition, the bridge must be designed to be structurally sound. This involves analyzing the forces that will act on each component of the completed bridge. Three types of loads contribute to these forces. Dead load refers to the weight of the bridge itself. Live load refers to the weight of the traffic the bridge will carry. Environmental load refers to other external forces such as wind, possible earthquake action, and potential traffic collisions with bridge supports. The analysis is carried out for the static (stationary) forces of the dead load and the dynamic (moving) forces of the live and environmental loads.

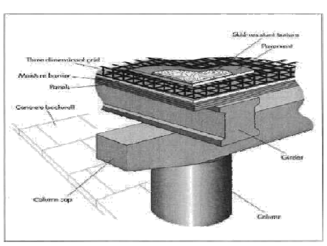

Fig. 2: Cutaway View of a Typical Concrete Beam Bridge

Since the late 1960's, the value of redundancy in design has been widely accepted. This means that a bridge is designed so the failure of any one member will not cause an immediate collapse of the entire structure. This is accomplished by making other members strong enough to compensate for a damaged member.

IX. Aim of the study

To analyze and design the structural behaviour of RCCT-beam bridge under standards of Indian road congress. To study the IRC loading with congestion factor.

X. Scope of the study

- Design configuration is being designed.
- Each components of bridge is intended based on the configuration by IRC loadings.
- Condition for various aspects that causes the reduction in life span of bridge.
- To study the results of IRC loadings with congestion factor.
- Precaution to be taken to overcome the d5efects.

XI. Need of the study

- The bridge controls both the volume and the weight of the traffic carried by the transportation system.
- Carry load in shear and flexural bending.
- Stability concerns limits the stresses and associated economy.
- Decks and girder usually act together to support the entire load in highway bridges.

XII. Methodology

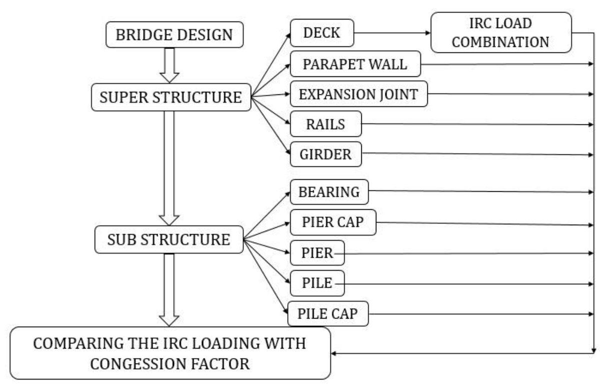

Fig. 3: Methodology of Design

XIII. Design and Reinforcement Details

A. Design of Deck Slab

If the deck slab is spanning in one direction, the bending moment for dead load may be computed as in a continuous slab, continuous over the longitudinal girders. For concentrated loads, the bending moment per unit width of slab may be computed using the effective width formula given in clause 305.16.2 of I.R.C. Bridge code IRC 21-2000 for each concentrated load.

When the slab is supported on four sides, the deck slab may be designed as a two-way slab. The curves are intended for slabs simply supported at the four sides. In order to allow for continuity, the values of maximum positive moments are multiplied by a factor of 0.8. In design computations, the effective span is taken as the clear span.

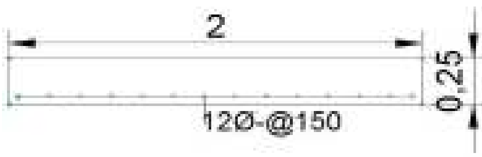

Fig.4: Reinforcement Details for One Panel Deck in Transverse Slab

B. **Design of Cantilever Portion**

The cantilever portion usually carries the kerb, handrails, footpath if provided and a part of the carriageway. The critical section for bending moment is the vertical section at the junction of the cantilever portion and the end longitudinal girder. For the computation of bending moment due to live load, the effective width for cantilever is assessed from the formula given in clause 305.16.2 of the Bridge Code IRC – 21: 2000.The reinforcement should be so detailed that the cranked bars from the deck slab could be used as half of the main reinforcement for the cantilever. The top bars of deck slab may be extended to the cantilever to provide the other half. The distributors for the cantilever portion are computed as corresponding to a moment of 0.2 times dead load moment plus 0.3 times the live load moment.

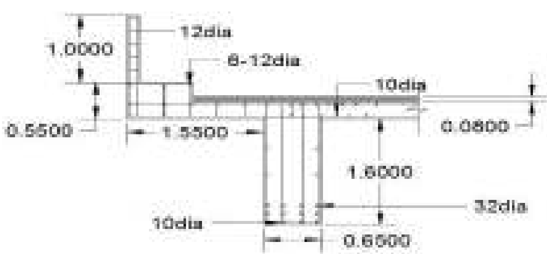

Fig.5: Reinforcement Details for Cantilever Slab

C. Design of Longitudinal Girders

Straight ribs are convenient for cranking of main bars and would facilitate easier formwork. Hence straight ribs are preferred for spans less than 18m.

For the computation of the bending moment due to the live load, the distribution of the live loads between longitudinal has to be determined. When there are only two longitudinal girders, the reactions on the longitudinal can be found by assuming the supports of the deck slab as unyielding. With three or more longitudinal girder, the load distribution is estimated using any one of the rational methods. Three of these are below:

- **Courbon's** method
- **Hendry-Jaegar** method
- **Morice** and Little version of **Guyon** and **Massonnet** method.

By using any one of the above methods, the maximum reaction factor for intermediate and end longitudinal girders are obtained. The bending moments and shears are then computed for these critical values of reaction factors.

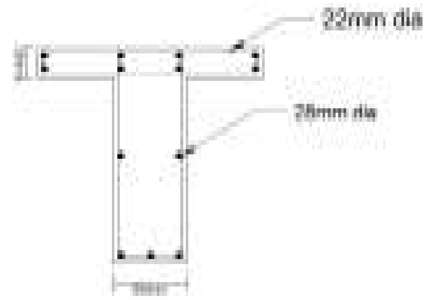

Fig.6: Reinforcement Details for Intermediate Longitudinal Grider

D. Design of Cross Beams

Dead load B.M. is computed considering a trapezoidal distribution of the weight of deck slab and wearing course, besides including the self-weight. The cross beam is considered continuous over two span. Suitable weighted moment factors may be computed, considering different dispositions of the standard loading over the cross beams. Similarly, shears may also be computed. Reinforcements may then be provided to suit the values of moment and shear. Additional cranked bars (usually two bars of 20ϕ or 22ϕ) may be provided to cater to diagonal tension.

Using the approximate method, the depth of the intermediate cross beam may be arranged such that bottom of the cross beam is at the top of the bottom flange of the longitudinal beam when a bulb is provided or to a depth of at least 0.75 of overall depth when straight T-ribs are adopted. Width of cross beam may be adopted nominally as 250mm. The reinforcements may be provided at 0.5% of gross area at bottom and 0.25%of gross area at top. The same reinforcements may also be used for the end cross beam. Nominal shear reinforcement consisting of 12ϕ two-legged stirrups or 10ϕ four-legged stirrups at 150mm centers will usually be adequate.

The design of the end cross beam may be performed on the same lines as for the intermediate cross beam. In earlier days, the depth of the end cross beam had been reduced to about 0.6 of that for intermediate beam. With the use of elastomeric bearing, provision has to be made for the possibility of lifting the deck to replace the bearings. Hence the present practice is to keep the depth of the end cross beam the same as for the intermediate cross beam. The bottom reinforcement may be taken as half the bottom reinforcement for the corresponding intermediate cross beam. The top reinforcement is kept the same. In addition, two bars of 20ϕ or 22ϕ are provided at top as cracked bars to cater to diagonal tension occurring during the lifting operation.

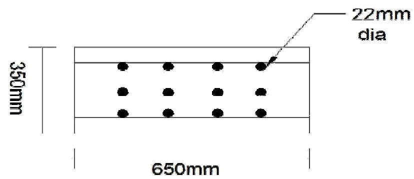

Fig.7: Reinforcement Details for Cross Beams

E. Design Of Abutment

In abutment design, the forces to be considered are:

- Dead load due to superstructure.
- Live load on the superstructure.
- Self-weight of the abutment.

Longitudinal forces due to tractive effort and braking and due to temperature variation and concrete shrinkage.

Thrust on the abutment due to retained earth and effect of live loads on the fill at the rear of the abutment. The latter effect is considered in design as an equivalent surcharge. The bridge code (clause 714.4) requires all abutment to be designed for a live load surcharge of 1.2m height of earth fill.

All the above forces, the earth pressure is the most difficult to complete correctly.

The magnitude of earth pressure varies with the character of the material used for back fill and the moisture content. It is important in abutment construction to place the fill material carefully and to arrange for its proper drainage. The design of an abutment is performed by assuming preliminary dimension of the abutment section depending on the type of superstructure, substructure and foundation, and checking for stability against overturning, base pressures and sliding. The factor of safety against overturning should be greater than 2.0. Further, the eccentricity of the resultant of all forces on the abutment should lie within one sixth of the base width so that there is no tension at the base. The maximum stress should be less than the safe bearing capacity of the soil. The factor of safety against sliding should be more than 1.5.

For masonry abutments, it is usual to provide a batter of about 1 in 25 to 1 in 12 for the front face of the breast wall. The rear batter is adjusted to get the width required to restrict the net pressure within the prescribed limits. When reinforced concrete abutments are adopted, it would be permissible to have vertical faces both in front and rear faces of the breast wall. The toe and the heel portions of the base slab are so proportioned that the eccentricity of the resultant is limited to on sixth of the base width.

F. Design Of Pier Cap

The minimum cap dimension to be used is 3’ deep by 2’-6” wide, with the exception that a 2’-6” deep section may be used for caps under slab structures. If a larger cap is needed, use 6”increments to increase the size. The multi-column cap width shall be a minimum of 1 1/2"wider than the column on each side to facilitate construction forming. The pier cap length shall extend a minimum of 2’ transversely beyond the centreline of bearing and centreline of girder intersection.

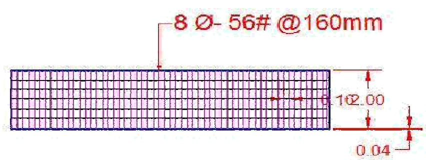

Fig.8: Reinforcement Details for Pier Cap

G. Design Of Pier

Cellular, trestle, hammerhead and single column type use reinforced concrete and are suitable for heights above 6m and spans over 20m. The cellular type permits saving in the quantity of concrete, but usually requires difficult shuttering and additional labour in placing reinforcements. The thickness of the wall should not be less than 300mm. The lateral reinforcement of the wall should be more than 0.3 percent of the sectional area of the wall of the pier, and the quantity should be distributed as 60 per cent on the outer face and 40 per cent on the inner face.. It is usually kept at a minimum of 600mm more than the out-to-out dimension of the bearing plates, measured along the longitudinal axis of the superstructure.

Fig.9: Reinforcement Details for Pier

The length of the pier at the top should not be not less than 1.2m in excess of the out-to-out dimension of the bearing plates measured perpendicular to the axis of the superstructure. The bearing plates are so dimensioned that the bearing stress due to dead and live loads does not exceed 4.2MPa.

H. Design Of Pile

Piles transmit the load of a structure to competent sub-surface strata by the resistance developed from bearing at the toe or skin friction along the surface or both. The construction of pile foundation requires a careful choice of piling system depending upon subsoil conditions and load characteristics of structures.

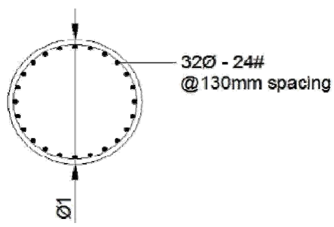

Fig.10: Reinforcement Details for Pile

XIV. Conclusion

The structural design of the bridge having components of deck slab, longitudinal girder, cross girder, bearing, pier cap, pier, pile cap, pile and abutment was completed using IRC loading. The designed bridge is compared with the overloading currently due to congestion factor on the bridge. The bridge comparing with the actual loading from IRCis not safe when 15% over loading occurs. The failure due to over loading has been identified as flexural failure. So, this failure can be avoided by various methods like eternal bond reinforcement, Carbon fibre wrap, CFRP sheet, CFRP laminates, Jacketing for the beam and pre-stressing the tendons.

References

[1] IRC: 5 – 1998, "Standard specification and code of practice for road bridges, Section I – General features of design", The Indian Road congress.

[2] IRC: 6 – 2014, "Standard specification and code of practice for road bridges, Section II – Loads and Stresses", The Indian Road congress.

[3] IRC: 78 – 2014, "Standard specification and code of practice for road bridges, Section VII – Foundation and substructure", The Indian road congress.

[4] IRC: 112 – 2011, "Code of practice for concrete road bridges", The Indian road congress. IS: 456 – 2000, "Plain and Reinforcement concrete – Code of practice", Bureau of Indian standards, New Delhi, 2000.

[5] Victor, D.J., "Essential of Bridge Engineering".

[6] S.V.V. Prasad (2015), "Design and Estimation of concrete girder bridge on Road curve"

[7] Sachin Kulkarni (2014), "Case study of RC slab bridge using Nonlinear analysis"

[8] Jasmin (2014), " Comparative study of Analysis and Design of T-beam girder and Box girder super structure"

[9] M. Ameerutheen (2014), "Study of Skew bridges over a normal bridge"

[10] Mohammad Adil Dar,(2013), "A study on Earthquake resistance construction techniques"

[11] AmitSaxena (2013), "Comparison between Pushover and Upper bond Pushover analysis of RC bridge"

[12] SupriyaMadda (2013), "Dynamic analysis of T-beam bridge structure"

[13] VikashKhatri (2012), "Comparative study of PS steel concrete composite bridges of different span length and girder spacing"

[14] S.R. Debbarma (2011), "Behavior of PSC bridge girder due to time dependent and temperature effect".