International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 04 Issue: 09 | Sept -2020 ISSN: 2582-3930

A Review on Stress Distribution and Design of Deck Slab Bridges

Nagesh Balekundri[1], Abhijit Galatage[2]

[1]*P.G Student, Department of civil Engineering, Flora Institute of Technology, Pune, Maharashtra*
[2]*Professor,Department of civil Engineering,Flora Institute of Technology, Pune, Maharashtra*

---***---

Abstract –Bridge is a structure which is importance to facilitate a communication route for carrying road traffic or other moving loads. There are various types of bridges but the simplest type of bridge is single–span deck slab which is supported on its end. Various methods can be used for analysing and designing the superstructure of bridge which is deck.From this study we can conclude that as span of the bridge increases the stresses also increase. In this present study also discussed the effect of grade of concrete on stress distribution, as the grade of concrete increases the stress developed on deck reduces. From this study we can conclude that percentage of steel reduction in limit state method as per IRC-112:2011 compare to working stress method as per IRC-21:2000. So, limit state method as per IRC-112:2011 is economical compare to working stress method as per IRC-21:2000.

.***Key Words***:Deck slab, LSM, WSM, IRC class, Effective Width Method, 70R Tracked Loading, IRC standard

1. INTRODUCTION

1.1 History of Bridges

Bridge is a structure that provided passageway over obstacles such as valleys, rough terrain of water by spanning those obstacles with natural materials. They was begun be used in ancient times when fist modern civilizations started rising in the Mesopotamia, from that point on knowledge , engineering and manufacture of new bridges spread beyond their borders which enabling slow but steady adoption of bridges all across the world.

In the beginning bridges were very simple structure that were built from easily available resource such as wooden logs and stone. Because of that, small span very close distance and the structure integrity was not high because at that time mortar is not invented. Revulsion of bridge construction come in ancient Rome whose engineers found that grinded volcanic rock can provide as excellent material for production mortar. This invention enabled them to build much further sturdier and powerful larger structure than any civilization before them. Roman architects soon spread across the Europe, Asia, and Africa, build the bridges for high quality. The figure1.1 shows the revolution of bridge from B.C to A.C and 20th centuries. The new technologiesthatenabled bridges to become one of the most important structure. Modern bridges are usually made with the combination of concrete, irons and cables, and can be built from very small sizes to incredible lengths that span entire mountains, rough landscapes, lakes and seas. Bridges may be classified by how the forces of tension, compression, bending, torsion and shear are distributed through their structure. Most bridges will employ all of the principal forces to some degree, but only a few will predominate.

Fig-1: Natural Bridge

Fig-2: B.C Romans

Fig-3:Suspension bridges

Fig-4:Pre-stressed concrete

1.2 Importance of Bridges in India

a) Bridges are used in transportation systems such railway track, highway bridges.
b) Bridges are used to avoid the obstacles and providing passage over the obstacle.
c) Bridges are constructed to reduce the travelling time.
d) Bridges connect difficult terrains
e) Bridges are used in militaries

1.3 Deck Slab

The deck slab should be designed as a one way slab to carry the dead load and the prescribed live load with impact and still to have stresses within the permissible limits. For a state highway, the width of the bridge may be adopted as 12 m to permit two-lane
Carriageway. The deck slab should be designed for the worst effect of either one lane of IRC 70R/Class AA tracked vehicle, or one lane of 70R/Class AA wheeled vehicle, or two lanes Class A loads trains. It is necessary to compute the maximum live load bending moment for three different conditions of loadings, and then adopt for design the greatest of the three values.
The ministry of road transport and highway, government of India, referred herein MORTH, has published a set of plans for 3.0 m to 10.0 m span reinforced concrete deck slabs. Grade of concrete M25 (M30 for 10.0 m span) and steel reinforcement to Fe415 grade of IS: 1786 are adopted. Allowing for 'moderate 'conditions of exposure, approach slabs are provided for 3.5 m length on both side approaches.

2. LITERATURE REVIEW

2.1 Introduction

There is a great deal of literature available on the stress distribution and design of deck slab Many documents are available on seismic evaluation methods. In this chapter some of the literature available on the above has been discussed

2.2 Review of previous studies

Douty and McGuire (1965) performed test on end plate moment connections. They investigated the forces induced in the bolts by the tension flanges. There was good correlation between theoretical and experimental results and an increase in bolt tension in thinner plates was observed. Tests and analytical studies were made of the components and complete assemblies of T-stub moment connections having high strength bolts (A325). In the tests of beams and connections having holes in the beam flanges, the full plastic moment of the beam was developed. In the tests of T-stub flanges the development of prying forces and response of the flange was observed. Semi-empirical formulas for estimating prying were presented and incorporated in a tentative design procedure for the use of connections of this type in plastic design.

Ghobarah et al. (1990) investigated the cyclic behaviour of extended stiffened and unstiffened end plate connections. Five specimens were tested, some with axial load applied to the column to compare the performance of stiffened and unstiffened end plates, stiffened and unstiffened column flanges. They concluded that proper proportioning of the end plate connections could provide sufficient energy dissipation capability without substantial loss of strength. They recommended that for unstiffened connections, the bolts & end plate shall be designed for 1.3 times plastic moment capacity

Borgsmiller (1995) presented a simplified method for the design of four flush and five bolt extended end plate moment connection configurations. The bolt design procedure was a simplified version of the modified Kennedy method to predict the bolt strength including the effects of prying. The end plate strength was determined using yield line analysis. Fifty-two end plates connections were analyzed, and it was concluded that the prying forces in the bolts become significant when ninety percent of end plate strength is achieved. This established a thresh hold for the point at which prying forces in the bolts can be neglected. If the applied load is less than ninety percent of the plate strength, the end plate is considered to be thick and no prying forces are considered. When applied load is greater than ninety percent of the plate strength, the end plate is considered as thin and the prying forces are assumed to be at maximum. This distinct threshold between thick and thin plate behaviour greatly simplified the bolt force determination because only the case of no prying and maximum prying must be determined. Good correlation between past tests results was obtained using the simplified design procedure.

Sumner and Murray (2001) performed six, three row extended end-plate connection tests to investigate the validity of the current design procedures for gravity, wind and low seismic loading. In addition, the tests investigated the effects of standard and large inner pitch distances and the connections utilized both ASTM A325 and ASTM A490 bolts. It was concluded that large inner pitch distance slightly decreases the strength ratio of thick plate end-plate connections. Good correlation between the experimental and analytical results was observed.

Sumner and Murray (2001) investigated extended endplate connections with four high strength bolts per row instead of the traditional two bolts per row. The eight-bolt extended, four-bolts wide and three rows extended, four bolts wide end-plate moment connections were investigated. Seven end-plate connection tests were performed and a modified design procedure, similar to the procedure presented by Borgsmiller (1995) was proposed. It was concluded that the modified design procedure conservatively predicts the strength of the two connection configurations.

Shoemaker and Murray (2002) presented a guide for the design and analysis of flush and extended end-plate moment connections. The guide includes provisions for the design of four flush and five extended end-plate connection configurations. The design provisions are limited to connections subject to gravity, wind and low-seismic forces; moderate and high seismic applications are not included. A unified design procedure based on the simplified method presented by Borgsmiller (1995) was employed. It is based on yield line analysis for the determination of the end plate thickness and the modified Kennedy method for determination of the bolt forces. A stiffness criterion for flush end plate moment connection was also included in the procedure.

Sumner and Murray (2003) presented a unified method for the design of eight extended end-plate moment connection configurations subject to cyclic/seismic loading. They investigated suitability of end plate moment connections for seismic loadings. They also developed end plate & connection bolt design procedure when subjected to cyclic loading. The research also identified & developed appropriate detailing & fabrication practice for extended end plate bolted moment connections.

Ryan, Jr. (2009) investigated the behavior of extended moment end plate connections under quasi-static cyclic loading. Seven full scale, single-sided beam to column tests were conducted, using built-up beams and columns. Three extended end plate configurations were used: four bolt extended stiffened, multiple row 1/3 extended, and four bolt extended unstiffened. The inelastic rotational capacity of each configuration was found. Also design procedures utilizing yield-line analysis, and bolt force predictions with prying action, were checked against test results.

Arthur G.A. (2010) investigated the failure mechanism and predicted moment capacity in ten bolt flush end plate moment connection. Research identified possible failure modes that could result due to a certain number of failed bolts, analyzing the failure mechanisms with the yield line method in evaluating end plate yielding and the prediction of the bolt forces using a modified form of the Kennedy method. He accessed the effect of the various components of the connection on the overall structural capacity including moment capacity and rotational stiffness, after a certain number of failed bolts. Finite Element Analysis (ABAQUS Standard) was carried out to predict the moment capacity of the ten bolt Flush End plate Connection and observation of various levels of failure. Design methodology was developed for the prediction of the moment capacity for a ten-bolt unstiffened flush end plate connection with a predetermined number of failed bolts.

Sudip Jha and Cherukupally Rajesh [2015]in this paper focuses on the methodology of design and analysis of Slab Bridge by WSM and LSM. Two models of deck slab bridges with different carriageway width are analysed using STAAD PRO v8i as per Indian standard IRC. Grillage analogy is adopted for the structural analysis of the models which compares the change in economy by varying the carriageway widths.In this study by observe that maximum bending moment is obtained at the middle of the span and maximum shear force is obtained at the end support. Class AA tracked vehicle gives maximum live load shear force for two models as in chart 9 and chart 12 respectively. It is due to maximum UDL load with less contact length. In 3rd,6th,9th , and 12th charts the variation in WSM and LSM is not only due to different loading cases but also due to change in impact factor for different live loads. The thickness of deck slab was 500 mm for WSM which has been reduced to 400 mm for both carriageways still there is about 20% saving in amount of concrete and 5-10% saving in amount of reinforcement for LSM that is LSM is considerably economical design compared to WSM.

Sumner and Murray (2015) presented a design guide for extended end plate moment connections for wind & seismic applications. This guide consists of design procedure for four bolts unstiffened extended (4E) end plate connections, four bolts stiffened extended (4ES) end plate connections & eight bolts stiffened extended (4ES) end plate connections. They also developed preliminary design tables for various American standard hot rolled sections for different values of applied moments.

Shrikant D. bobade and Dr.valsson Varghese (2016) in this paper box girder bridge deck, the span in direction of the roadway and connect across their top and bottoms by thin continuous structural slab, the longitudinal box girder can be made of concrete or steel. In this paper they used simply supported single span concrete bridge deck. This paper more concentrated on skew angle and their effects on bridges. The comparative study was conducted based on the analytical modelling of simply supported RC box Girder Bridge for various Skew angle using Staad Pro. Based on this study deflection occurs for live load combination case-II of different skew angle s result is increase by 1.75% with increase in skew angle are compared. Bending moment increase with increase in skew angle at the rate of 1.525%. As similarly shear force at the 1.376%.Torsional moment occur for live load combination case-II of different skew angles results is increase by 135.36% with increase in skew angle are compared.

Miss.mohini Dhande and prof.M.M chaudhari [2017] in this paper the comparative analysis is make for different span with different load condition for analysis and design of the deck slab. Bridges are designed in WSM in past days, but now a day’s according to govt of India the bridges should be design on the basis of LSM. For structural analysis purpose of bridge deck the effective width method of IRC 112:2011 is used and FEM is used which is software basis. They used IRC method for design for minor deck Slab Bridge they make two models first of plate elements and second one is beam element. For plate element we have to make grid frame and for beam element 3-nodel and 4-nodel element. The conclusion obtained from this paper is the effective width method specified in IRC is time consuming method as for each wheel we have to calculate area and for longer vehicle with number of axles it is more lengthy process, so it is better to go for alternate method which will give similar results with less effort and time.FEM are suitable for a long span design of deck a bridge. It gives quick results as compared to analytical methods.

Raj KK and phani RG(2017) in this paper deals with the behaviour of simply supported skew deck slab bridges with different skew angels 0°,15°,30°,45°,60°. For in this project structural analytical software STAAD PRO, and analysis is done as per provisions of Indian codes IRC6:2014. Modelling is done using node element. This paper is gives conclusion on basis of previous experimental results with the increase of the angle of inclination. The reaction at the obtuse inclined end of the deck slab supports is larger than the other two ends. The maximum deflection occurs closer to the oblique angled corner, but as the angle of inclination is greater; it approaches more towards centre of the span. In this study, the behaviour of concrete reinforced concrete deck slab with different angle of inclination under static load has been investigated. The general behaviour of the FEM represented by the load-deflection curves show a good agreement with the experimental data. From this study we can predict that FEM results gives similar to the experiment. The maximum deviation of the inclination slabs decreases with the increase of the inclined angle, the load capacity of the tilting deck slab increase as the tilting angle increases, up to the angle of inclination 15° the behaviour of the slanted slab is almost similar to the rectangular deck slab.

Kapil Kushwah and Anshuman nimade [2018] from this paper the analysis of a three span two lane T-beam bridge is carried out by varying the span of 10m,15m,18m, and number of longitudinal and cross girders using software Staad ProV8i.in order to obtain maximum bending moment shear force in girder , maximum stresses in deck slab. The bridge models are subjected to the IRC class AA Tracked loading system.Centre shear stresses in deck slab increases 52% and 83% in 15m and 18m span bridges respectively when it compares with 10m span bridge. The principal top stresses in deck slab increases 53% and 79% in 15m and 18m span bridges respectively when it compares with10 m span bridge. The principal bottom stresses in deck slab increases 26%and 41% when it compares with 10m span bridge. From this paper it concludes that the principal top and bottom stresses in deck slab more increases with increasing span length.

3. SUMMARY AND CONCLUSION

From above literature study it can be concluded that:

- the effective width method specified in IRC is time consuming method as for each wheel we have to calculate area and for longer vehicle with number of axles it is more lengthy process, so it is better to go for alternate method which will give similar results with less effort and time
- FEM are suitable for a long span design of deck a bridge. It gives quick results as compared to analytical methods
- The maximum deviation of the inclination slabs decreases with the increase of the inclined angle, the load capacity of the tilting deck slab increase as the tilting angle increases, up to the angle of inclination 15° the behaviour of the slanted slab is almost similar to the rectangular deck slab.
- Maximum bending moment is obtained at the middle of the span and maximum shear force is obtained at the end support.

REFERENCES

1) IRC: 5-1998 “Standard specification and code of practice for road bridges” SECTION-I General features of design.
2) IRC: 6-2014 “Standard specification and code of practice for road bridges” SECTION-II Loads and Stresses
3) IRC: 112-211 “Code of practice for concrete road bridges”
4) IRC: 21-2000 “Standard specification and code of practice for road bridges” SECTION-III cement concrete
5) IS: 456-2000, Indian Standard Plain and Reinforced Concrete-Code of Practice (Fourth Revision), Bureau of Indian Standards, New Delhi.
6)] N. Krishna Raju (2010) “Design of bridges”, Fourth edition, Oxford & IBH Publishing Company Pvt. Ltd., New Delhi, India.
7) D.JOHNSON VICTORE “ESSENTIALS OF BRIDGE ENGINEERING”, sixth edition , Oxford & IBH Publishing Company Pvt. Ltd., New Delhi, India
8) B.H.Solanki & Prof.M.D.Vakil “Comparative study for Flexure design using IRC 112:2011 & IRC 21:2000”, Published in International Journal of Scientic & Engineering Research, Volume 4, Issue 6 June 2013
9)] “Sudip Jha and Cherukupally Rajesh [2015]” by Comparative study of RCC slab bridge by Working stress (IRC: 21-2000) and Limit state (IRC: 112-2011).
10) Raj KK And Phani RG (2017) Design and study on behaviour of skew slab bridges with various skew angles
11) Shrikant D. Bobade and Dr.Valsson Varghese (2016) parametric study on skew angle on box girder bridge deck.
12) [12] Kapil Kushwah And Anshuman Nimade [2018] analysis of RC deck slab bridge for varying span
13) [13] “Miss .Mohini Dhande” comparative analysis and design for deck slab of minor bridge by effective width method and finite element method