Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 07, July-2016

Comparative Study on Fatigue Behaviour of Integral and Conventional Bridges

Aparna Prasad [1]
P.G Student,
Department of Civil Engineering,
Amal Jyothi College of Engineering, Kerala, India

Jiji Thomas [2]
Assistant Professor,
Department of Civil Engineering,
Amal Jyothi College of Engineering, Kerala, India

Abstract— **In Conventional construction of bridge, the superstructure typically consists of a series of simply supported spans. These structures are separated by expansion joints and resting on bearings at the abutments and piers. In integral construction of bridge, the superstructure and abutments are constructed as continuous structure. Thus the maintenance cost and construction cost is lesser for integral bridges. In integral bridges, joints and bearings are eliminated as it is made integral with intermediate pier. Response of the structure depends on the geometry, material, configuration, soil interaction and construction details of the system. Fatigue evaluation of integral bridges is studied by using deflection characteristics and based on S-N curve. In this paper, finite element tool ANSYS Workbench is used for the study of fatigue behavior of integral and conventional bridge.**

Keywords—Bearings, Conventional bridges, Fatigue behaviour, Integral bridges, Joints

I. INTRODUCTION

Bridges are structures that is used to cross rivers, bay, mountains or other obstructions for the passage of vehicle, trains and pedestrians. Bridges have two part with upper part called superstructures and lower part called substructures. Superstructures consists of floor slab, main truss or girders and substructures consists of Piers or columns, abutments ,footing or piles etc. Bearings and joints are provided in bridge for the free expansion of superstructure and abutments. And these joints and bearings are the sources of weakness in bridges. The type of bridge without these joints and bearings or any of them are called Integral bridges. In this bridge deck and abutments are constructed monolithically. The mode of movement of integral and conventional bridge is different .In case of Integral bridges movement is accommodated by flexible foundation and in case of conventional bridges movement is accommodated by movement of sliding of bearing surfaces. During earthquakes major problem occurs in conventional bridge is the unseating of superstructures from the support bearings. Integral bridge overcomes this disadvantage of conventional bridge. Integral bridges are of two types, Semi Integral bridge and Full integral bridge.

Usually Semi Integral bridge or Integral Abutment bridges are widely used. In Integral Abutment Bridges, expansion joints are avoided and deck or girder are constructed continuous with abutment .

Since bridge is an unavoidable structure in our day to day life during travel, its periodic inspection is an important thing. The bridge assessment can be done using laboratory experiments, field test and by analytical methods. Fatigue is the damaging of the structure due to growth of crack in concrete. This is caused due to the variation of stress, as cyclic in nature by the traffic loads. The deck slabs transfer these loads to the supporting elements below it. Fatigue failures are classified into low cycle and high cycle fatigue failures. This classification is based on the number of cycles caused for rupture. For the materials experiencing plastic deformations, low cycle fatigue failure occurs. Structures such as Bridges, Cranes, Offshore structures and slender towers are more prone to fatigue failures since they are prone to cyclic loadings. Figure 1 shows the integral and conventional construction.

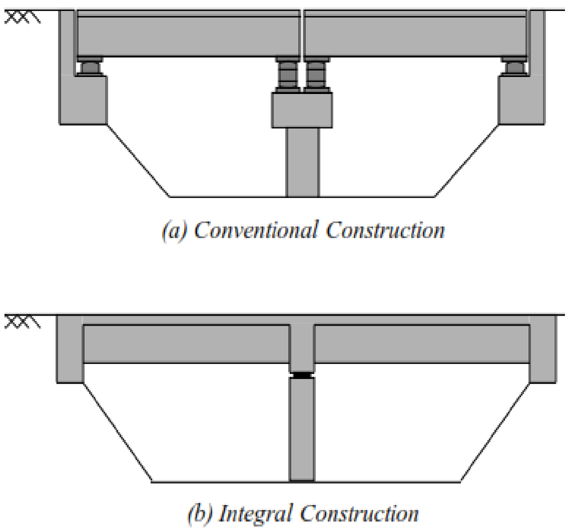

Fig. 1. Conventional and integral bridge

Lowell F. Greimann et al (1986) [1] developed a nonlinear finite element algorithm and it was used for the study of pilling stresses and pile and soil interactions in integral abutment bridges. Jonathan Kunin et al (2000) [2] studied reduced initial cost and maintenance cost, seismic resistance and serviceability of integral bridges. Murat Dicleli (2000) [3] presents a computer-aided approach. This is for the design of integral-abutment bridges. He proposed procedure for analysis and simplified structure model. This is for the design of integral abutment bridges. Murat Dicleli et al (2003) [4] presents design recommendations for the maximum length of integral bridges which is built on sand. The maximum length of integral bridge is determined as the function of abutment

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 07, July-2016

supporting steel H-piles's ability to sustain cyclic lateral displacements and flexural capacity of abutment due to thermal action. Jimin Huang et al (2008) [5] conducted a study to widen the results of an experimental program on a concrete integral abutment bridge situated in Rochester.

H. White II et al (2010) [6] studied the European way of construction of integral bridge. At the time of the study Integral abutment bridges were becoming popular in Europe, but the traditions differs from country to country. Jafar Razmi et al (2013) [7] noticed that piles in integral-abutment bridges (IABs) may affect plastic deformation and fatigue as a result of cyclic loading occurs due to daily and seasonal temperature variations. Habeeba A et al (2015) [8] found that, if the ability of the tool to identify the problem is good then the analytical assessment of bridge will be accurate. Necessary of this assessment is due to the increase in traffic, ageing of material, cracking of components of bridge, physical damage in concrete, reinforcement corrosion and inadequate maintenance. Shahanas P et al (2015) [9] compared the seismic performance of integral and conventional bridge. For this study, one eleven span existing conventional bridge was selected. By analyzing inner span bending moments, it was found that positive bending moment is more for conventional bridges. Since the positive bending moment is low for integral bridges, it can reduce cross section of members with economy.

II. VALIDATION

Validation is done by using the journal "Experimental study on fatigue behavior of Steel Reinforced Concrete (SRC) beams", written by Lewei Tong Bo Liu , Qingjun Xian and Xiao-Ling Zhao[10]. This paper presents the fatigue behavior of SRC beams under high cycle fatigue loading using experiment.. SRC beam is of size 220mm width, 400mm depth and 2.9 m length. This beam is simply supported at two ends. The beam is reinforced with H-steel and longitudinal reinforcements. Constant amplitude fatigue loading of 400kN is applied. The fatigue analysis was done using ANSYS software.

TABLE 1. Fatigue results of validation model

	ANSYS	Experiment
Fatigue life(cycles)	4.9007×10^{6}	4.9×10^{6}
Deformation(mm)	7.1525	7.72

III. FATIGUE BEHAVIOUR OF INTEGRAL AND CONVENTIONAL BRIDGES

A. *Modelling and loading of conventional bridge*

This is a RCC bridge at Kazhuthurutthy in Kollam district It is a single span roadway bridge of 21.56m length. It has four longitudinal girders and five cross girders. Deck slab consists of 7.5m width and 240mm thickness. Footpath of 1.5m is provided on one side. Longitudinal girders are provided at a spacing of 2.3m c/c distance. Material used are M25 grade concrete and Fe415 grade steel. Live load is provided as per IRC-Class A train of vehicles as per IRC 6-2000[11]. For conventional bridge bearing support is given under the longitudinal girders using ANSYS.

Concrete is modelled as solid 65 element in ANSYS Workbench. It is a three dimensional eight nodded solid isoperimetric element. This solid has the capacity of crushing in compression and cracking in tension. And also it has special features like plasticity, creep, cracking, crushing, large deflection and large strain. Reinforcements are given as smeared. Bearing support is provided for the conventional bridge.

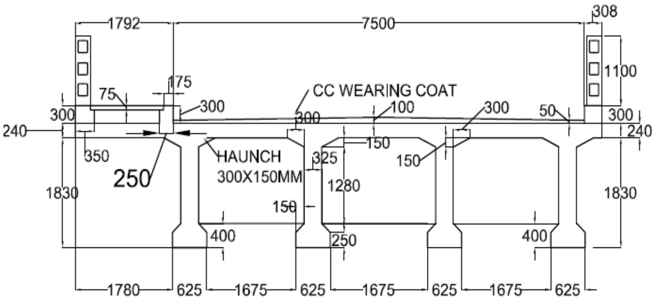

Fig 2. Cross section of deck (all dimensions are in mm)

TABLE 2. Material properties of Concrete and steel

SL.NO	Material	Elastic modulus (N/mm^2)	Poisson's ratio	Density (N/mm^3)
1	Concrete	25000	0.2	2.4×10^{-6}
2	Steel	2×10^{5}	0.3	7.85×10^{-6}

B. *Modelling and loading of integral bridge*

Geometry and loading of integral bridge is same as that of conventional bridge. Only the difference is that fixed support is provided at the ends of the deck so as to make it as an integral support.

C. *Results and discussion*

Life of integral and conventional bridge can be determined by taking the number of cycles for failure from ANSYS. The value of average daily traffic (ADTT) was assumed as 5228 trucks/day. Each truck is assumed as each cycle for loading.

Therefore, Life of bridge in years = $\frac{\text{Number of cycles for failure}}{\text{ADTT}\times365}$

Fatigue damage indicates the ratio of design life to available life. If its value is greater than one. Then the failure occurs before the design life. Partial safety factor (PSF) indicates the factor of safety with respect to fatigue failure for a given design life. If the partial safety factor is less than one then it indicates the failure before design life is reached. Partial usage factor (PUF) for fatigue analysis indicates the ratio of used life to available life of the structure.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 07, July-2016

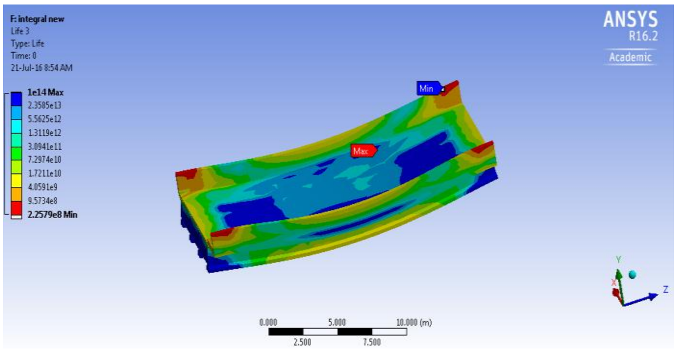

Fig 3. Life of Integral bridge (in number of cycles)

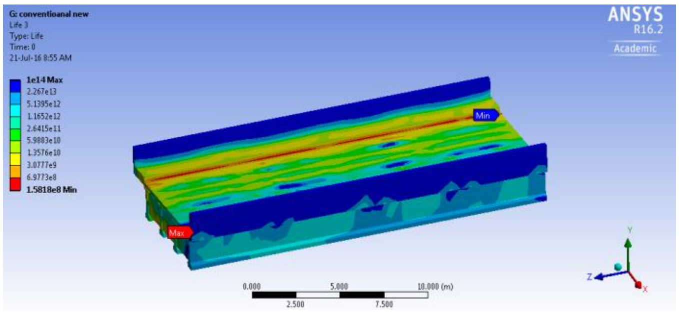

Fig 4. Life of Conventional bridge (in number of cycles)

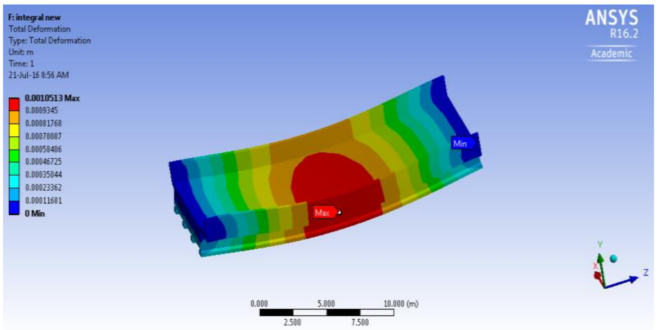

Fig 5. Total deformation of Integral bridge (in m)

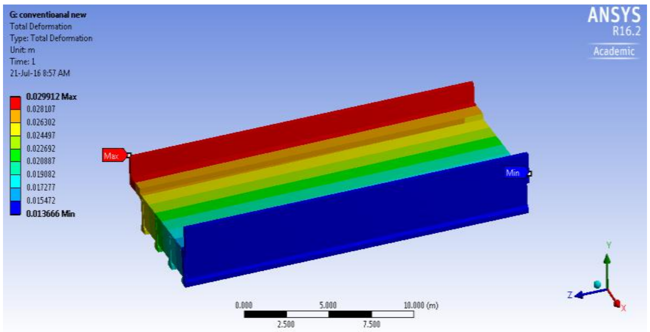

Fig 6. Total deformation of Conventional bridge (in m)

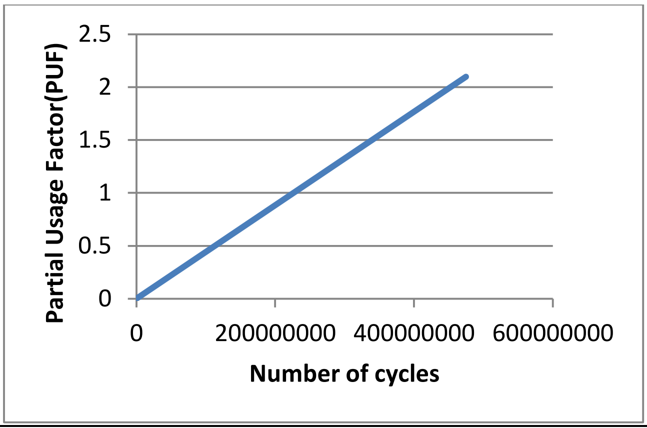

Fig 7. Numer of cycles VS PUF graph of Integral bridge

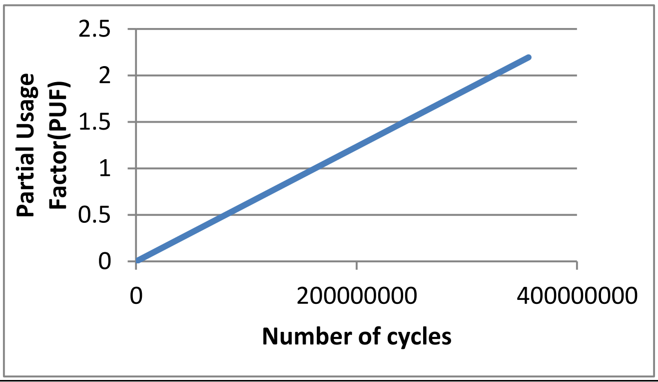

Fig 8. Number of cycles VS PUF graph of Conventional bridge

TABLE 3. Results of fatigue analysis of integral and conventional bridge

	Integral bridge	Conventional bridge
Life (Years)	118	83
Damage	4.429	6.322
Partial Safety Factor	0.66452	0.60216
Total deformation(mm)	1.0513	29.912

IV. CONCLUSION

The action of repeated action of moving loads on bridges has significant effect on the life of the bridge. From the fatigue analysis, it has been seen that for the integral bridge, life is 118 years. For the conventional bridge it is about 83 years. Total deformation and damage of conventional bridge is much greater than integral bridge. Partial safety factor for integral bridge is more. Due to the increased stiffness of integral bridge, it shows lower deflections. From the fatigue analysis it can be seen that integral bridges have promising solution for better fatigue behavior with maximum life than that of conventional bridge.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 07, July-2016

REFERENCES

[1] Lowell F. Greimann,Pe-Shen Yang and M. Wolde-Tinsae, Nonlinear Analysis Of Integral Abutment Bridges, Journal of structural engineering(ASCE), 112(10)(1986), 2263-2280.

[2] Jonathan Kunin and Sreenivas Alampalli , Integral Abutment Bridges Current Practice In United States and Canada, Journal of performance of constructed facilities(ASCE), 14(3)(2000), 104-111.

[3] Murat Dicleli, Simplified Model for Computer-Aided Analysis Of Integral Bridge, *Journal* of bridge engineering(ASCE), 5(3)(2000),240-248.

[4] Murat Dicleli and Suhail M. Albhaisi, Maximum length of integral bridges supported on steel H-piles driven in sand, Journal on engineering structures, Volume 3,Issue 25(2003),1491–1504.

[5] Jimin Huang,Carol K. Shield and Catherine E. W. French , Parametric Study of Concrete Integral Abutment Bridges, Journal of bridge engineering(ASCE), 13(5)(2008), 511-526.

[6] H. White II, H. Petursson and P. Collin, Integral Abutment Bridges: The European Way, Practice periodical on structural design and construction (ASCE), 15(3)(2010), 201-208.

[7] Jafar Razmi,Leila Ladani and M. Sherif Aggour, Fatigue Life of Piles in Integral-Abutment Bridges: Case Study , Journal of bridge engineering(ASCE), 18(10)(2013), 1105-1117.

[8] Habeeba A, Sabeena M.V and Anjusha R, Fatigue Evaluation of Reinforced Concrete Highway Bridge, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 4, Issue 4(2015).

[9] Shahanas P and Dr. Sabeena M.V, Comparative Study on the Seismic Performance of Integral and Conventional Bridges, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 4, Issue 6(2015).

[10] Lewi Tong, Bo Liu, Qingjun Xian and Xiao-Ling Zhao, Experimental study of fatigue behavior of Steel Reinforced Concrete (SRC) beams, Journal of engineering structures(Elsevier), 123(2016), 247-262.

[11] IRC 6-2000,"Standard specifications and code of practice for Road bridges

[12]]IRC 37-2001,"Guidlines for the design of flexible pavements".

[13] AASTO LRFD 2007,"Bridge design specifications".