A Review on Effect of Web Inclination on Box Girder Bridges

Akash B. More[1], Shriganesh S. Kadam[2]

[1]Department of Civil Engineering, SKN Sinhgad College of Engineering, Pandharpur, Punyashlok Ahilyadevi Holkar Solapur University

[2]Assistant Professor Department of Civil Engineering, SKN Sinhgad College of Engineering, Pandharpur, Punyashlok Ahilyadevi Holkar Solapur University

---

Abstract – *Bridges are the important assets generally used to connect two communities separated by river, valley etc. Among various types, Box Girder Bridges are gaining popularity in modern highway systems. This paper represents a literature review on the behavioral analysis of box girder under varying conditions. In this study, an attempt was made to analyze behaviour of box girder by changing its web inclination angle to the horizontal using FEM based software CSi Bridge. In this all the other parameters of the box girder like material properties, span length, and boundary conditions are kept constant. For understanding the change in behavior IRC class 70R and IRC class-A loading is used to study and compare the responses in terms of moments, stresses, displacements and support reactions.*

Key Words: Box girder, Web inclination, IRC loading, CSi Bridge, Finite element analysis.

1. INTRODUCTION

Box girder bridge consist closed hallo box shape which constructed from materials such as concrete, steel, composite of steel, reinforced concrete and prestressed concrete. Box girders, have gained wide acceptance in freeway and bridge systems due to their structural efficiency, better stability, serviceability, economy of construction and pleasing aesthetics. Analysis and design of box-girder bridges are very complex because of its three dimensional behaviours consisting of torsion, distortion and bending in longitudinal and transverse directions.

The commonly used box girders may be of two type's rectangular box girder and trapezoidal box girder. Sloping webs of the box girders lead to trapezoidal shape, which is where origin of the commonly used name trapezoidal box girder is derived. While the sloping webs produce a sleek appearance to the girders that enhance the overall aesthetics. There are also practical structural reasons for the inclined webs such as reducing the bottom flange width. In addition to reducing the amount of material required for the bottom flange, also some past researchers propose that the web inclination of the box girder tends to reduce distortional effects induced in the box girders [H. Abbas et al., 2012].

Thus in the present study the effect of the possible web slopes on the overall behaviour of the box girder is investigated. Results from the finite element analysis will be presented to show the effect of web inclination on box girder.

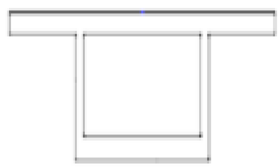

Fig -1: Rectangular cross section

Fig -2: Trapezoidal cross section

2. LITERATURE REVIEW

2.1 Shi-Jun Zhou (2013), "Finite Beam Element Considering Shear-Lag Effect in Box Girder" In this paper the author studied the interaction of the bending and shear-lag deformation of box girder. The finite element method was used to establish the results. In this the shear-lag induced stiffness matrix was defined and the stiffness matrices considering the effect of shear-lag were deduced, at each node of the beam element. For the box girder, two shear-lag degrees of freedom were used as a boundary condition. The author analyses the effect of shear-lag on the deflection, the internal forces, and shear-lag coefficient. The effects were calculated for simply supported cantilever and continuous box beams under uniformly distributed and concentrated loads. The numerical results obtained were compared with those using finite shell element methods, finite stringer method, and the model tests. The author found that the proposed method is reliable and more effective.

2.2 Quang-Viet Vu et al. (2018), "Effect of Intermediate Diaphragms on the Load-Carrying Capacity of Steel-Concrete Composite Box Girder Bridges" In this paper the author investigated the effect of intermediate diaphragms on the load-carrying capacity of steel-concrete composite box girder bridges with open steel box section. A three dimensional FE model of the SCCB girder is developed and analyzed using ABAQUS software. The analysis is carried out using non-linear inelastic behavior in order to accurately capture the actual behavior of box girder. The numerical model is verified with experimental results to ensure the accuracy of the finite element modeling method. A parametric analysis is implemented to study the effect of intermediate diaphragms on the load-carrying capacity of the SCCB girder with a 30-60 m span length. Author considered the four different material models in order to find the most appropriate model. Author concluded that, the combination of the concrete model in compression and in the steel model using a bi-linear stress-strain relationship is the most appropriate for SCCB girders. Author also concluded that, the intermediate diaphragms significantly affect the load carrying capacity of the girder under the strength load combination. Also for SCCB one intermediate diaphragm is recommended to place at the mid-span of the girder to prevent the decrease of load carrying capacity.

2.3 T.H.G.Megson and G.Hallak (1993), "Finite Element Modeling Of Box Girder Diaphragms at Supports" A finite element model for a rectangular, stiffened, load bearing, box girder diaphragm is proposed and used for the prediction of deflections and stress distribution in the elastic range and for prediction of failure modes and collapse loads. Author uses the ABAQUS package to give good agreement with the results obtained from two experimental investigations. Author concluded that, the ABAQUS finite element package is capable of accurately predicting the behavior of a stiffened diaphragm in a length of a box girder, both in elastic range and plastic range, up to failure. Author also concluded that, this package will therefore be sub-sequently used in a parameter study to determine the optimum size and arrangement of stiffeners in load bearing diaphragms.

2.4 Chao Liu et al. (2015), "Behavior of Segmental Box Girder Bridges with Open Webs" In this paper, the Abra Bridge in France was measured and analyzed by using the so called space frame lattice model. The paper discusses the advantages of this bridge type. The paper also presents the use of a space frame lattice computational method for structural analysis. In this the author proposed the calculated results, to reduce the principal stresses in the webs, the shear stresses are reduced by the vertical pre-shear force provided by the external pre-stressed tendons along the whole bridge. The author concluded that the principal tensile stresses mainly exist in the hypotenuse while principal compressive stresses exist in the vertical side in the web.

2.5 Harish M.K. et al. (2017), "Analysis of Box Girder Bridges under IRC Loading" This paper discusses the analysis of box girder bridges under IRC loading of two different type's single cell and Multi cell. The analysis is done for dead load and its heavy vehicles loading. To know its structural behavior author uses CSi Bridge software to decide which standard code is better. In this paper IRC class AA loading conditions are applied and corresponding bending moments and object responses stress values were compared for single and multi-cell box girder bridges. The author concluded that the single cell girder bridges is economical than four cell girder bridges.

2.6 Ricardo Gaspar (2013), "Web Design of Box Girders Concrete Bridges" The purpose of this paper is to introduce a new design approach including the Ultimate Limit State (ULS) due to fatigue. To identify the most realistic one different criterion for the design of those webs are compared by means of shear bending moment interaction diagram. For validation of the newly developed approach an experimental investigation was undertaken. The author considered the following failure models: excessive plastic deformation of the stirrups, crushing of the compressed struts and failure of the stirrups due to fatigue.

2.7 Zhan CHEN et al. (2013), "Seismic Response Analysis of Multi-span Bridge Using FEM" The simply supported bridges are common bridges which have exhibited considerable vulnerabilities in past earthquake events. This paper takes a bridge in China as a case study, by means of the FEM software MIDAS/Civil. The author conducts the elastic response spectrum analysis for this bridge with different span lengths, number of spans and pier height. This paper takes a combination of seismic response spectrum analysis for bridges dynamic properties and seismic response by means of FEM software. The author concluded that, the entire bridges displacements and stresses calculation results shows that this law has good precision and effect in the bridge seismic analysis.

2.8 Cheung et al. (1988), "Curved Box Girder Bridges" The authors studied box girder bridges with circular and non-circular sections. The finite strip method had been used to analyze the bridge deck. The homogeneous differential equations in curvilinear coordinate system were used to derive the stiffness and mass matrix for every element. Each node of strip consists four degree of freedom. The top and bottom flanges are treated as flat plates in which the membrane and bending action will be uncoupled. Authors investigated three examples of curved box girder bridges to demonstrate the accuracy and versatility of finite strip method the results are compared with those obtained by exact solution. Author concluded that, there is a significant reduction in the total number of variables involved in the analysis and thus savings in the computer time and effort as compared to the other methods of analysis.

2.9 Sali and Mohan (2017), "Parametric Study Of single Cell Box Girder Bridge under Different Radii of Curvature" This paper looked at straight and horizontally box girder bridges with trapezoidal cross sections. Dead load, superimposed dead load, live load of IRC class-A tracked vehicle and pre-stressed loads were examined. The span, cross sectional shape and material properties were unaltered. The point of the examination was to explore the behavior of the box girder by changing the radius of curvature. Five models were researched one straight and four horizontally curved and the correlation were made in deflection, torsion and longitudinal stresses. The outcomes demonstrated that expanded the radius of curvature will diminish deflection, torsion and longitudinal stresses.

3. CONCLUSIONS

It can be concluded from the present study that some researchers have focused on parametric study of behaviour of single cell box girder. However, there is limited study on effect of changing web inclination on behaviour of single cell box girder. Therefore, it is proposed to study structural behaviour of single cell box girder under changing web inclination. It can also be believed that the results presented in this paper will be of valuable guidance to the designers. The further study focus on the analysis and behavior investigation of box girder bridges with the help of 3D modelling using FE analysis on CSi Bridge software.

ACKNOWLEDGEMENT

The author is grateful to Dr. C. P. Pise, Head of Department of Civil Engineering, SKN Sinhgad College of engineering; Pandharpur and project guide Dr. S. S. Kadam, for providing all the facilities for carrying out the experimentation.

REFERENCES

[1] Shi-Jun Zhou, "Finite Beam Element Considering Shear-Lag Effect In Box Girder", ASCE, J. Structural Engineering, (2013), pp-1115-1122.
[2] Quang-Viet Vu, Duc-Kien Thai, "Effect of Intermediate Diaphragms on the Load-Carrying Capacity of Steel-Concrete Box Girder Bridges", Elsevier Journal of Engineering Structures, (2018), pp- 230-241.
[3] T.H.G.Megson and G Hallak, "Finite Element Modelling of Box Girder Diaphragms at Supports", Elsevier Journal of Engineering Structures, (1993), pp-25-37.
[4] Chau Liu and Dong Xu, "Behaviour of Concrete Segmental Box Girder Bridges with Open Webs", ASCE, J. Structural Engineering, (2015), pp-15003-1-15003-10.
[5] Harish M.K., "Analysis of Box Girder Bridges under IRC Loading", IJSDR, Vol-2, Issue-9, (2017).
[6] Ricardo Gaspar, "Web Design of Box Girders Concrete Bridges", Elsevier Journal of Engineering Structures, (2013).
[7] Zhan CHEN, "Seismic Response Analysis of Multi-span Bridge using FEM", ASCE, J. Structural Engineering, (2013), pp-3102-3109.
[8] Cheung, W. Y. Li, Tham, "Curved Box Girder Bridges", ASCE, J. Structural Engineering, (1998), Vol. 114, pp-1324-1338.
[9] Sali J., Mohan R. P., "Parametric Study of Single Cell Box Girder Bridge under Different Radii of Curvature", Applied Mechanics and Materials (2017), Vol. 857, pp-165-170.