EFFECT OF SKEW ANGLE IN U-GIRDER METRO

KARTHIKA K A , Dr.LAJU KOTTALIL

Abstract— The concept of U-shaped bridge girder is now being increasingly adopted in urban metro rail projects and for replacing old bridges where there is a constraint on vertical clearance. This requirement, along with other requirements for fixing alignment of the bridges, is mainly responsible for provision of increasing number of skew bridges. The presence of skew in a bridge makes the analysis and design of bridge decks intricate. For the U girder rail bridges with small skew angle, it is frequently considered safe to ignore the angle of skew and analyze the bridge as a right bridge with a span equal to the skew span. However, U girder bridges with large angle of skew can have a considerable effect on the behavior of the bridge especially in the short to medium range of spans. In this paper an analytical study using three dimensional finite element methods was performed to investigate the effect of skew angle on behavior of Kochi Metro U girder bridge decks. The parameter investigated is deformaton . The finite element analysis (FEA) results for skewed bridges were compared to the reference straight bridges (nonskewed). The geometric dimensions of the U girder railway bridge decks and the loading used are in compliance with Kochi Metro rail project standard specifications. . This paper presents the behavioural aspects of a skew bridge with skewness of 30° , 45° and 60° and compares them with the real structure by using a 3D Bridge model in Finite Element Analysis software – ANSYS.

Keywords— U-Girder;Skew angle;deformation

Introduction

A metro system is an electric passenger railway transport system in an urban area with a high capacity, frequency and the grade separation from other traffic. Metro System is used in cities, agglomerations, and metropolitan areas to transport large numbers of people at high frequency. The grade separation allows the metro to move freely, with fewer interruptions and at higher overall speeds. Metro systems are typically located in underground tunnels, elevated viaducts above street level or grade separated at ground level. An elevated metro structural system is more preferred one due to ease of construction and also it makes urban areas more accessible without any construction difficulty.

Raju et.al (2011) , attempted to assess the extent of error in the simplified analysis, by compared the results with a more rigorous three-dimensional finite element analysis (3DFEA). The results of the 3DFEA, in terms of load-deflection plots, have been validated by field testing. The deflections in the bridge girder, as predicted by 3DFEA, under various stages of loading, validated against field test results on a typical prototype U-girder railway bridge. However, the use of 3DFEA is recommended in cases where eccentric loading occurs on the U-girder, as in double track railway and highway bridges, because the effects of torsion and distortion (not accounted for in simplified analysis) can be significant.

*Harba (2011),*studied the effect of skew angle on behavior of simply supported R. C. T-beam bridge decks. The results of a parametric study which evaluated the effect of skew angle on the behavior of simply supported R.C. T-beam bridge decks. The effects of skewness of T-Beam deck models on the maximums live load bending moments, shear, torsions, deflections and supports reactions were also evaluated. Thus, the finite element results for skewed models with skew angles 15°, 30° and 45° are compared to their corresponding FEA values for straight bridges (skew angle = 0°). The max. Live load bending moment in T-beams Bridge decks decrease for skewed bridges. The max. Live load deflections in T-beams bridge decks decrease for skewed bridges. The maximum Live load torsions in T-beams bridge decks increases for skewed bridges.

As box girder bridge skew angles increase, vertical bending moments and deformations decrease. However, torsional stresses and deformations increase as well as differential reaction levels. *He et.al (2012)*

Dhar et.al (2013), studied the behavioural aspects of a skew bridge and compares them with those of the straight counterparts using a 3D Bridge model in Finite Element Analysis software To understand the trend clearly, a simply supported RC Bridge was adopted. The results of the bridge model in ABAQUS show that with the increase in the skew angle, the support girders increase while these parameters decrease in the corresponding acute longitudinal girders. Most importantly, the increasing skew angle rapidly increases the torsional moment in the obtuse angled girder. Such changes in the moment are generally not considered while designing a straight bridge. With increasing skew angle, the slab showed asymmetric bending with increasing deflection at obtuse corner and decreasing deflection at the acute corner.

U-Girder

ISSN 2229-5518

The U-shaped girder bridge (also called 'channel bridge') is a relatively new and innovative concept in bridge deck design. U-shaped girder is appropriate when a new or modified alignment structure requires an increase in the vertical clearance beneath the bridge. The bridge deck, made of prestressed concrete (PSC), has other important advantages, such as protection against traffic noise pollution, aesthetic appearance, reduced construction time, durability and economy. This concept can be used for overpasses, under-crossings, viaducts, etc. The concept of U-shaped bridge girder is now being increasingly adopted in urban metro rail projects and for replacing old bridges where there is a constraint on vertical clearance.

Description Of U-Girder Bridge Concept

Structurally, the U-shaped girder bridge can be viewed as the conventional 'single-cell box girder' with its top flange removed, as shown in Fig.1.1 . The two webs are configured as beams positioned above and on either side of the deck surface. The webs and the deck slab are post tensioned with longitudinal tendons anchored at the two ends of the bridge deck (with suitable 'end blocks'). The longitudinal stiffness and strength are obtained from the two webs as well as the connecting passageway slab spans between the webs. The resulting requirement for the depth of girder section below the passageway level is very less than that required for convectional beam-and slab type designs, as shown in Fig. 1.2, and herein lies its main functional advantage. The U-girder is essentially a 'through' type girder where the train passage occurs on the soffit slab; the side cantilev-

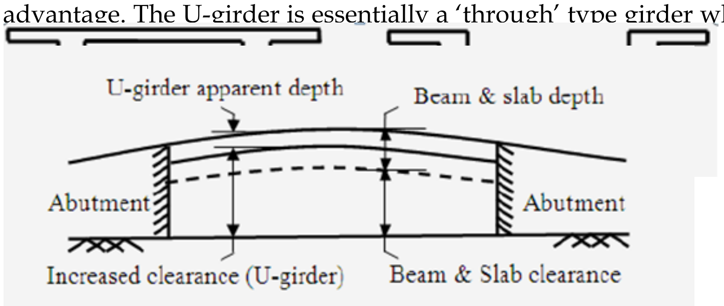


Fig.2 Requirement for the depth of girder section below the passageway level

Skew Angle In Briges

The concept of U-shaped bridge girder is now being increasingly adopted in urban metro rail projects and for replacing old bridges where there is a constraint on vertical clearance. This requirement, along with other requirements for fixing alignment of the bridges, is mainly responsible for provision of increasing number of skew bridges. The term 'angle of skew' or 'skew angle is generally applied to the difference between the alignment of an intermediate or end support and a line square to the longitudinal axis of the bridge above. Thus, on a straight bridge, the skew angle at all supports would normally be the same and the term skew angle can be applied to the bridge as a whole. On a curved bridge, the skew angle is different at each support.

FE Modeling

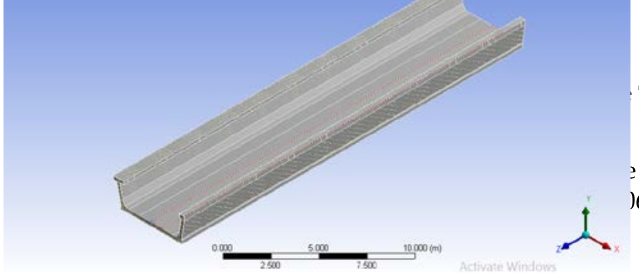
The FE modeling is conducted on ANSYS Workbench. The U-Girder taken for this study is the bridge pier of Kochi metro rail which is an under-construction metro rail system for the city of Kochi in Kerala, India. The 25.65km metro line with 22 stations will run from Aluva to Petta. A single span U-Girder with a span of 25m is taken for the study. Different skew angles say 30^o,45^o and 60^o are provided for this girder and analysed.

Geometry and Loading

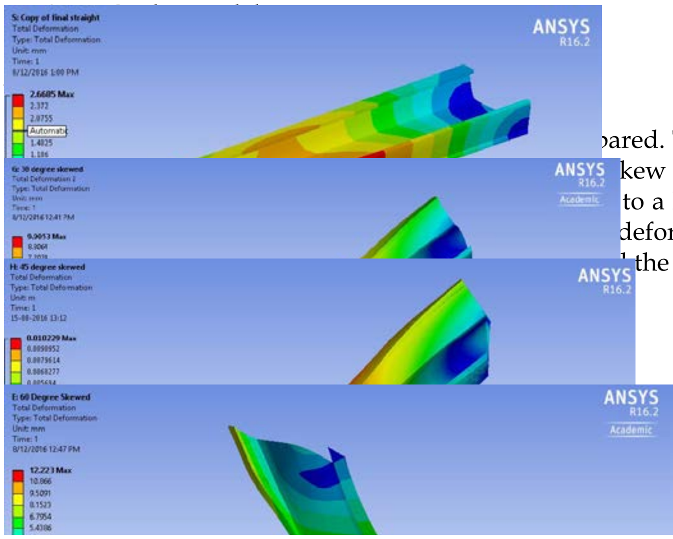
Each girde has a span of 25m and has a width of 5.2 m. The track has a width of 1.626m. A maximum 75mm cover is provided for the reinforcement. The model with different skew angle is modeled in the similar way.

In these models, the support given is hinge support.The different loads to be considered include the self weight of 'U' girder,track rail, track slab and live load of the train.The load is given as static load for analysis. Therefore, total load on pier is taken as 520kN.

The concrete used is M45 concrete with RHT concrete properties with 45MPa compressive strength. The tensile failure stress is



e steel material used for HC-FCS with elastic modulus of 200GPa, yield
06.



pared. The girder without skew angle is compared with girder models with
kew angle increases.
to a large extends. When a skew angle of 30° is provides increase of 78%
deformation is shifted from the centre the skewed corner. Maximum de-
the maximum deformation is found at the corner position.

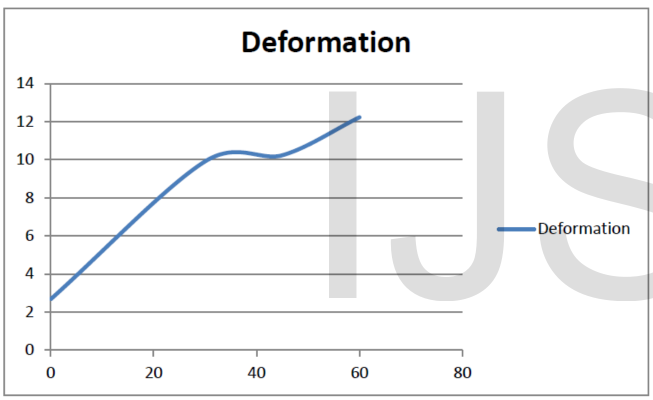


Fig 8: Deformation V/S Skew Angle graph

Conclusion

The behaviour of an hinge supported U-Girder bridge was studied by increasing the skew angle. The parameter investigated is deformation. The deformation increase as the skew angle increases. As skew angle increases the deformation is shifted from the centre the skewed corner. Maximum deformation is showed by the 60° skew angled bridge and the maximum deformation is found at the corner position.Up to 45° the deformation is uniform in the structure..But further increase in skew angle leads to the formation of maximum deformation to the skewed corners. Increase in skew angle reduce the stability of the structure. Up to 45° skew angle the structure can withstand the changes. But the increase in the skew angle above 45° will leads to collapse of the structure.

References

[1] Michal Majka , Michael Hartnett. "*Dynamic response of bridges to moving trains: A study on effects of random track irregularities and bridge skewness*",2009

[2] Carlos Sousa , João Francisco Rocha , Rui Calçada , Afonso Serra Neves. "*Fatigue analysis of box-girder webs subjected to in-plane shear and transverse bending induced by railway traffic*", Engineering Structures,2013

[3] X.H. He , X.W. Sheng , A. Scanlon , D.G. Linzell , X.D. Yu . "*Skewed concrete box girder bridge static and dynamic testing and anal-*

ysis", Engineering Structures,2011.
[4] G. Kaliyaperumal , B. Imam, T. Righiniotis , "*Advanced dynamic finite element analysis of a skew steel railway bridge*" , Engineering Structures,2011
[5] Alok Singh, Abhishek Kumar, Mohd. Afaque Khan, "*Effect of Skew Angle on Static Behavior Of Reinforced Concrete Slab Bridge Decks: A Review*",2016
[6] Ibrahim S. I. Harba, "*Effect Of Skew Angle On Behavior Of Simply Supported R. C. TBeam Bridge Decks*" , ARPN Journal of Engineering and Applied Sciences , 2011.
[7] Nikhil V. Deshmukh, Dr. U. P. Waghe , "*Analysis and Design of Skew Bridges*",2013.
[8] V Raju1, Devdas Menon, "*Analysis of Behaviour of U-Girder Bridge Decks*", 2011.
[9] Xia H, Zhang N. "*Dynamic analysis of railway bridge under high-speed trains*". Comput Struct 2005;
[10] Menassa C, Mabscout M, Tarhini K, Frederick G. " *Influence of skew angle on reinforced concrete slab bridges*". J Bridge Eng 2007. Effect Of Skew Angle In U – Girder Metro Rail Bridges 59
[11] Scordelis AC, Wasti ST, Seible F. " *Structural response of skew RC box girder bridge*". J Struct Eng 1982.
[12] Kalantari A, Amjadian M. " *An approximate method for dynamic analysis of skewed highway bridges with continuous rigid deck* ". Eng Struct ,2010.
[13] Meng JY, Ghasemi H, Lui EM. "*Analytical and experimental study of a skew bridge model*". Eng Struct 2004.
[14] Matsumoto Y. "Study *on reinforced concrete skew girder for railway bridges. Tokyo*". Y Tech Res Inst – Quart Rep 1966.