

Study of R.C.C. T-Beam Bridge with Skew Angle

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ABSTRACT: With the increasing rate of urbanization and rapid infrastructure growth, the need for complex transportation systems has also increased. This requirement, along with other requirements for fixing alignment of the bridges, is mainly responsible for provision of increasing number of skew bridges. Skew bridges are often encountered in highway design where geometry cannot accommodate right bridges. In this paper behavioural aspects of skew T-beam bridges are studied and compared those with straight bridges using Finite Element Analysis software. The effect of skew angle is observed on maximum bending moment, maximum shear force and maximum torsional moment, maximum deflection due to dead load and live load at critical locations. Live Load “IRC Class AA Tracked Vehicle” is applied as per IRC 6:2000 guidelines. This study shows that the effect of skew angle on torsional moment of longitudinal girder is considerably high so that, it is important to consider torsional moment while designing skew bridges.

KEYWORDS: skew angle, T-beam Bridge, IRC loading, finite element analysis, torsional moment.

I. INTRODUCTION

A bridge is a structure which facilitates passage over an obstacle without closing the way underneath. The required passage may be for railway track, road, pedestrians etc. The obstacle to be crossed may be deep valley with or without of water, road, railway, river etc. Bridge form an important part of transportation system which contributes to the economic, industrial and cultural development of the country. Bridges are essential transportation links and life lines of our social environment.

T-beam Bridge is a common choice among the designers for small and medium span bridges. The reinforced cement concrete T-beam bridges consist of concrete slabs supported by a series of longitudinal concrete beams. T-beam bridge is commonly adopted type bridge for span range 10m to 25m. The structure is so named because the main longitudinal girders are designed as T-beam integral with part of the deck slab, which is cast monolithically with the girders. Simple supported T-beam span of over 30m are rare as the dead load become too heavy. The number of longitudinal girders depends on the width of the road. The loads on bridge deck and foundations may be both static and dynamic. Static loads are principally the weights of the bridge super structures and substructures. Dynamic loads which occur during the operation of the bridge, resulting from forces generated by inertia of deck parts, during the movement of the traffic, wind and earthquake.

With the increasing rate of urbanization and rapid infrastructure development, the need for complex transportation systems has also increased; often leading to road and bridge geometries with unconventional, non-collinear, configurations. This requirement, along with other requirements for fixing alignment of the bridges, is mainly responsible for provision of increasing number of skew bridges. Skew bridges are often built in highway design due geometrical restrictions; such as obstacles complex intersection, rough terrain or topography and space limitations. The skew angle can be defined as the angle between the normal to the centreline of the bridge and the centreline of the abutment or pier cap. A bridge built at right angle to the abutment is a right bridge whereas a bridge built obliquely to the abutment is a skew bridge. Their Behavioural difference is attributed to, the longitudinal girders that are not orthogonal to the supporting lines. Despite these facts, the design of the skew bridges, for long time, has not treated differently from that of the non-skewed bridges. The presence of skew in a bridge makes the analysis and design of

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bridge complicated. For a T-beam bridge with small skew angle, it is generally considered as safe that of right bridge. But for the larger skew angle alternate configuration of the superstructure should be carried to counteract the forces developed in element of superstructure. In spite of increase in computer power, analysis of skew bridge has not changed to same extent. Therefore, there is a need for more research to study the skew bridges using different computer aided software which are based on finite element method.

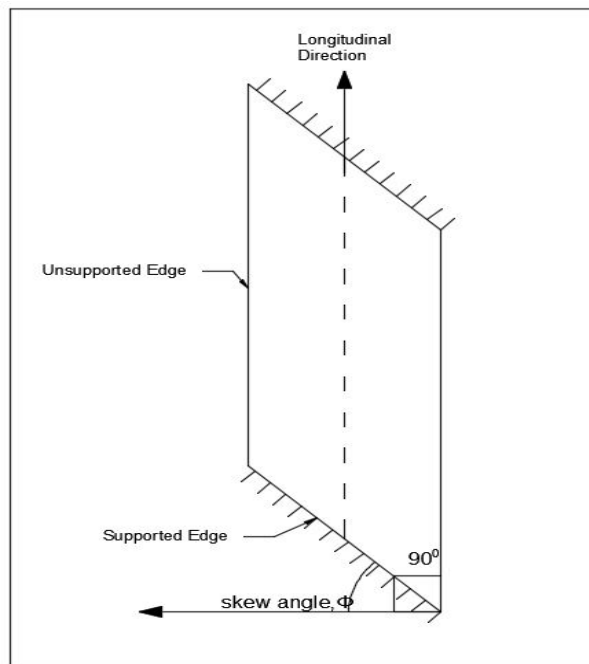


Fig. 1 Typical Sketch of Skew Bridge

II. RELATED WORK

Deepak C and Sabeena MV^[1] The study deals with the finite element modelling of simply supported skew slab with varying skew angles using ANSYS software. In this paper skew angles varying from 0° to 30° were taken for the study. After the nonlinear finite element analysis of all skew slabs it is revealed that when skew angle increases the uplift at both the acute corners also increases. From the result obtained, they said that, the maximum deflection for skew slabs decreases with the increase in skew angle and the load carrying capacity increases with increase in skew angle.

Sindhu B.V et al. ^[2], in this paper effect of a skew angle on single-span reinforced concrete bridges is analyzed using the finite-element method. Investigations are carried out on RC slab bridge decks with and without edge beams. The FEA results of Dead load and Live load bending moments and deflections decreases with increase in skew angle, whereas maximum support reactions increases with increase in skew angle and the maximum torsional moment increases with skew angle up to 45° and there after decreases. The benefit of providing edge beam is reflected in significant decrease in deflection, longitudinal bending moment and torsional moment.

Himanshu Jaggerwal and Yogesh Bajpai ^[3] in this paper an attempt has been made to study the effect of skewness directly on the design parameters i.e. B.M, Shear Force and Maximum Reaction in simply supported RC T-Beam 3 lane bridges. They said that skew bridges designed, ignoring the skew effect is conservative with respect to the bending moment. The effect of skew angle was also studied on the shear coefficients. The shear coefficients as increases almost linearly with skew angle and span. They concluded that proper estimation should be made in the live load shear when designing skew bridges.

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III. PROBLEM FORMULATION

- Clear width of roadway = 7.5 m, total width including parapet = 8.7m
- Span 'L'=16 m, (For comparing results of different skew angles, length of the bridge 'L' is kept constant.)
- 3 main girders, placed @ 2.5 m interval.
- Depth of deck slab = 200mm, with wearing coat=80 mm,
- Kerbs 600 mm wide by 300 mm deep,5 cross girders @ 4m interval.
- Depth of main girder & cross girder =1600 mm at the rate of 10 cm per meter of span. Width of main girders & cross girders =300 mm
- The cross girders are provided perpendicular to the longitudinal girders.
- In addition to dead load, IRC Class AA tracked vehicle load is included as live load.

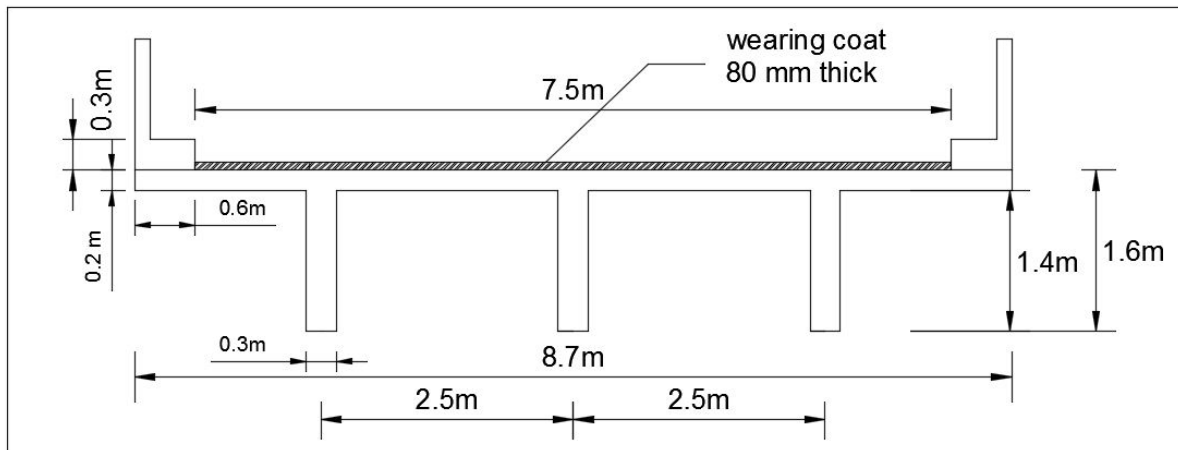


Fig. 2 R.C.C. T-beam Bridge Cross Section

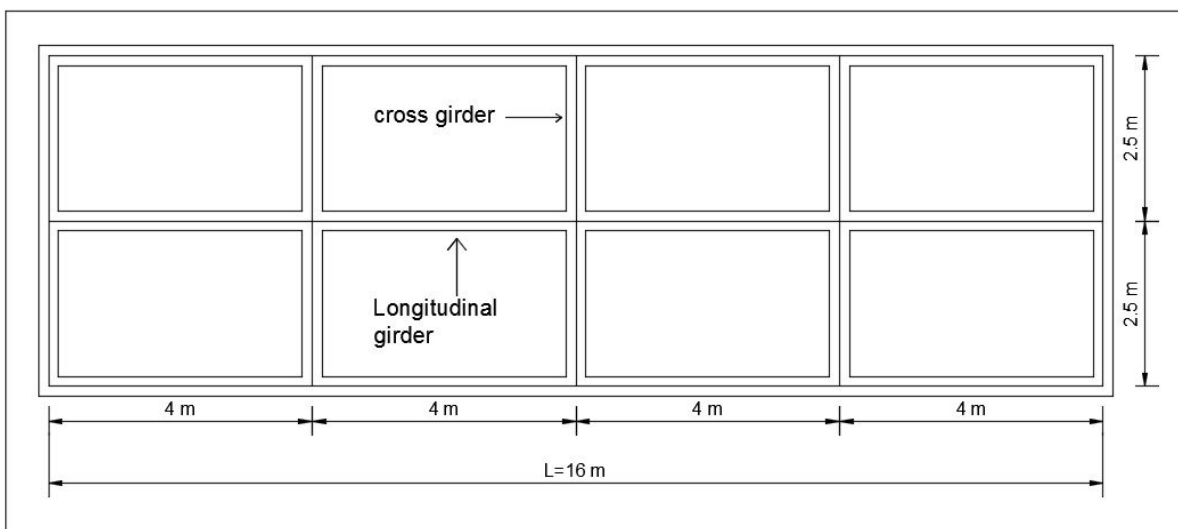


Fig. 3 T-beam Bridge Plan

IV. MODELLING

To facilitate a detailed comparative parametric study of the skewed highway T-beam bridges, a number of detailed three dimensional (3D) finite element (FE) models were developed using CSi Bridge (2015). In all of the models, the superstructure was assumed to be linear-elastic. The benchmark bridge was altered to produce models with different skew angles, but with the same overall dimensions. Skew angle of 0⁰, 15⁰, 30⁰, 45⁰ and 60⁰ were adopted.

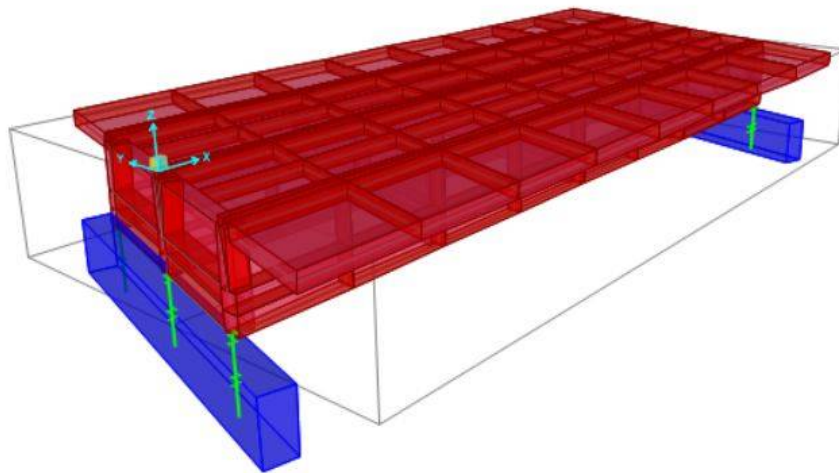


Fig. 4 3-D model of R.C.C. T-beam Bridge

V. RESULTS AND DISCUSSIONS

➤ **Bending Moment in Longitudinal Girder**

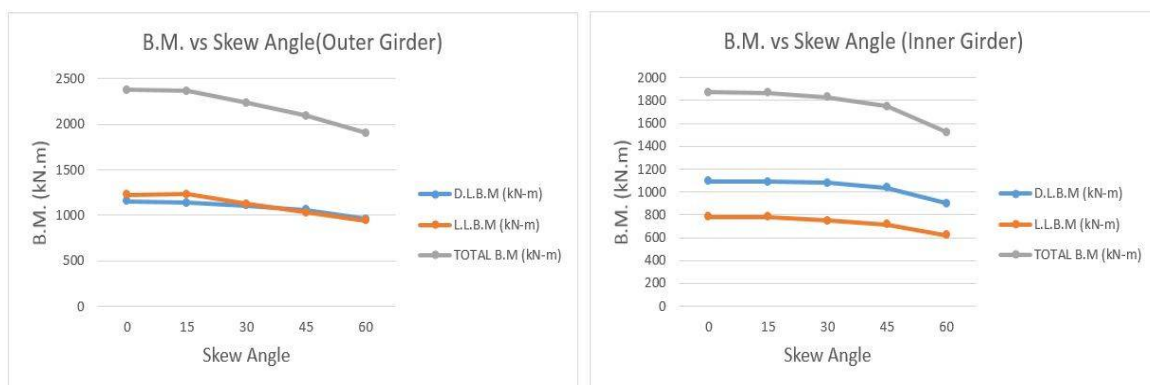


Fig. 5 Maximum Bending Moment in Longitudinal Girder for Different Loading

This figures show that, the bending moment for outer girders decreases rapidly when skew angle increases more than 15⁰. 30 % decrease in bending moment from skew angle 15⁰ to 60⁰. Decrease in the live load bending moment is more than the dead load bending moment. Bending moment due to dead load decreases steady for all skew angles. For the inner girder, bending moment decreases steadily for skew angle 15⁰ to 45⁰. But from skew angle 45⁰ to 60⁰ sudden decrease is observed. Trend in change in dead load bending moment and live load bending moment is almost same.

➤ **Shear Force in Longitudinal Girder**

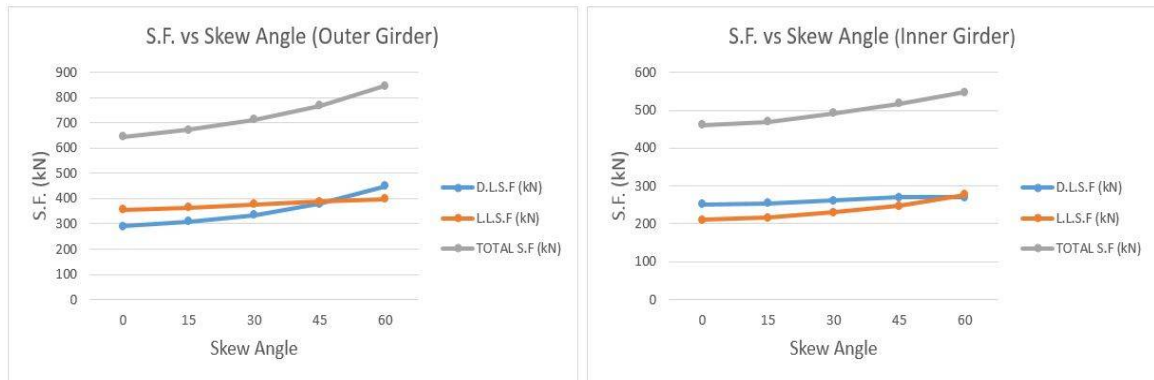


Fig. 6 Maximum Shear force in Longitudinal Girder for Different Loading

This figures show that, for the outer girder increase in dead load shear force is more than that of increase in the live load shear force when skew angle is increases. Dead load shear force increases more after 30° skew angle. Almost 30 % increase in total shear force in outer girder as skew angle becomes 60°. For the inner girder, increase in live load shear is more as compare to increase in dead load shear force for higher skew angle. Increase in total shear force is approximately 20% for inner girder.

➤ **Torsional Moment in Longitudinal Girder**

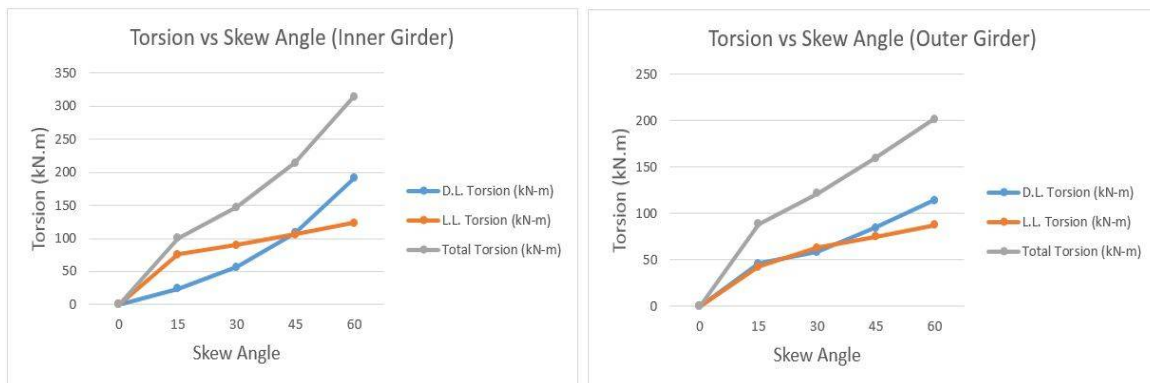


Fig. 7 Maximum torsional Moment in Longitudinal Girder for Different Loading

Torsional moment for straight bridge or Right Angle Bridge is absent or can said that it zero. From the above figures, it can say that live load torsional moment in both outer and inner girder, is increases rapidly upto 15° skew angle, after that linear increase is observed. But dead load torsional moment is increases rapidly for higher skew angle. Increase in torsional moment in both outer and inner girder is considerably high, so that it should not be neglected while designing the skew angle.

➤ **Maximum Deflection in Longitudinal Girder**

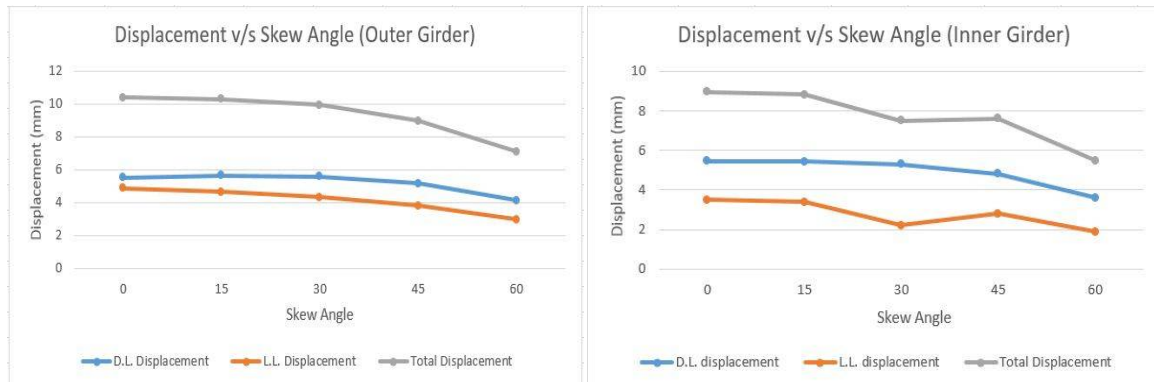


Fig. 8 Maximum Deflection in Longitudinal Girder for Different Loading

Above figures show the change in maximum deflection in outer and inner girder with increase in skew angle. For outer and inner girder deflection decreases as skew angle increases. In outer girder trend is linear or steady. For inner girder, change deflection due to live load is uneven or not steady as skew angle increase.

VI. CONCLUSIONS

The behaviour of an RC simply supported bridge of constant length is analysed and studied for different skew angles. Parameters like Shear force at support, longitudinal and torsional moments in longitudinal girders along with deflections are investigated.

Results show that, the maximum value of shear force of longitudinal girder increases at obtuse corner with increase in skew angle. Maximum value of bending moment in longitudinal girder decreases with increase in skew angle. Maximum value of torsional moment also increases with increase in skew angle. Rate of increase in torsional moment increases with increase in skew angle. Value of maximum deflection in the longitudinal girder decreases with increase in skew angle. Considerable variations are observed in results for skew angles more than 30°.

It is also observed that, skew angle up to 15° do not affect the design values considerably for skew bridges. For higher skew angles, analysis results must be taken into account while designing skew bridges.

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