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EVALUATION OF THE STRUCTURAL BEHAVIOUR OF GIRDER BRIDGE DECK WITH SKEW ANGLE

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Abstract: Bridges with Skew are very common at highway, river passage and other extreme grade changes, due to restrictions in space skewed geometry is necessary. Due to the needs for complex intersection and the troubles with space constraint in urban and metro city areas there is a growing demand for skewed RC girder bridges. There are many reasons such as when roadway alignment changes are not feasible or due to the topography of the site to maintain economic and as well at particular areas someplace environmental impact is an issue then the Skewed bridges are useful. A skew crossing may be essential if a road alignment crosses a river or other obstruction at an inclination different from 90°. The inclination of the centre line of Roadway to the centre line of river in case of a river bridge or other obstruction is called the skew angle. The analysis and design of a skew bridge are much more complicated than those for a Normal bridge. Bridges with large angle of skew can have a considerable effect on the behavior of the bridge especially in the various ranges of spans. A lot of research studies have been made to examine the performance of skewed highway bridges. However, there are no detailed guidelines addressing the performance of skewed highway bridges. There are many parameters which affect the response of skewed bridges which make their behavior intricate. Therefore, there is a need for additional research to work the effect of skew angle on the performance of RC girder bridges. As the Bridge plays a major part in Road Network since the Bridge Structure is affected by various parameters. The Skew angle is one of the major factor which is taken under consideration while Design and Analysis of Bridge. As the perpendicular crossing or right angle crossing of bridge is not possible due to site condition or due to the proposed alignment, the effect of skew angle of the bridge deck is finalized by modeling the bridge and the comparison of various skew angle effects. This will be done considering Bending Moment, Shear Force, Bending Stress, and Tensile Stress.

***KEYWORDS*– Skewed Bridge, Stress Distribution, Bending moment, Shear force**

I. INTRODUCTION

Bridge is a structure which covers a gap, generally these structures will carry a road or railway over an obstacles such as natural or artificial obstacles like a canal, river, or roadway or railway. It is the most significant component of a transporting system and it is corresponding to the responsibilities in carrying a force flow of transport. These structures are classified on the basis of distribution of forces in the structure such as shear, compression, tension and moment. The presence of skew angle in the bridge plays an important role. All the times it is not possible to have 0 degree skew bridge or straight bridge, therefore at certain situation it is necessary to provide certain amount of skew to the bridge. The skew angle is defined as the angle of inclination between the centre line of bridge and abutment. As the span and skew angle increases, the design parameters like maximum B.M., S.F. and Torsion is also increases.

II. REVIEW OF LITERATURE

These literature reviews are experimental work carried out by researchers on skew angles.

Manjunath K , H.R. Prabakara, Mahadev M. Achar(Sep.-2016) In this project work carried out to determine the skew effect on the design of composite super structure of a bridge. Total six models were modelled, bridge of span 3.565m, 7.130m, 10.695m and 14.260m were analysed for skew angles of 0^o, 10^o, 20^o, 30^o, 40^o, and 50^o. **(1)**

Nagashekhar J, Dr.Ramesh Manoli, Dr. Mahadev M Achar, Shiva Kumar KS (July-2016) In this chapter analysis is performed to evaluate the effect of skew on the behaviour of precast I girder bridges, from the analysis the results are obtained and presented in terms of structural parameters such as bending moment, shear force and torsion. These parameters occur in the girder bridges due to applied dead load and live load. Bridges of span 25m and 12m wide were analysed for skew angles of 0 degree, 15degree, 30degree, 45degree and 60degree.**(2)**

Shruti G. Kulkarni, Pradeep A R, Guruprasad T N (May-2017) This study had come to know the joint reactions is found to be higher in case of vertical loads. The joint reactions are found to be least in case of parapet wall. For the varying load cases, as the skew angle increases, base reactions also increases.**(3)**

Srivasta M S, Dr.Mahadev M Achar, Dr. Ramesh S Manoli, Deeplav Kumar (June-2018) This study primarily concentrated on appraisal of ultimate values of bending moment, shear force and torsion in bridges of varying skew angles at critical sections.**(4)**

Santhosh Kumar R, Dr. Mahadev Achar M, Dr. H Eramma (Jan-2019) this paper present that the effect of skew angle on the behaviour of Bowstring girder-bridge is briefly described in this project. The behaviour include predominant axial force in bottom chords, top arches, hangers and top bracings is considered and predominant bending moment and shear force is considered in bottom cross beams. The skew angles considered for study is 0 degree, 30 degree, 45 degree and 60 degree.**(5)**

P.M. Kulkarni, P.M. mohite (Aug-2019) This paper is present that There are insignificant changes in parameters like stresses at top and bottom, longitudinal moment,torsional moment, deflection and required prestressing force for small skew angles i.e. up to10 degree. For higher skew angles there is great alteration in behavior. As skew angle increases from 0^o to 60^o, torsional moment is observed to be increased by 1000%.**(6)**

Ajay D. Shahu, S.V. Joshi, P. D. Pachpor(Oct.2016) Torsional moment plays a major role for both equivalent bending moment and equivalent shear force observed during the analysis and design for varying skew angle both for the dead load and live load. As the skew angle increases, torsion moment increases.**(7)**

Patrick Theoret, Bruno Massicotte, David Conciatori (2012) The paper presented the resultsof an investigation aimed at determining the bending moments and shear forces requird to design skewed concrete slab bridges using equivalent beam method. Straightand skewed slab bridge were modeled using grillage and finite element model to characterize their behaviour under uniform and moving loads.**(8)**

Madhu Sharma, Naveen Kwatra, Harvinder Singh(2017) Elastic solution for Skew slab bridges are available in the published literature as observed. The bending moment and deflection expression determined by various researchers for standard skew angle i.e. 0degree to 60 degree with specific load cases. These final expression neither are used in routine practices for design calculations nor used in finite element based software in design offices. It is suggested prepare a bending moment coefficient for angle 0 degree to 90 degree for the ready reference for designer to design a skew slabs.**(9)**

Muhammad Hasan S, Sakthieswaran N(April 2016) In this paper A ground motion, compatible with design acceleration spectrum is applied in the longitudinal direction and transverse direction of the bridge. The maximum skew angle of 60° as recommended in codes and specification (e.g., AASHTO, 2000) is considered in the analysis.**(10)**

Anusreebai S.K , Krishnachandran V.N.(Aug 2016) The general behavior of the finite element models represented by the load-deflection curves show good agreement with the experimental data. It is verified that the finite element analysis can accurately predict the load deformation similar to the experiment.**(11)**

Abhishek Gaur, Ankit Pal (May2019) From this paper presents the contribution of different researches in the field of the deck slab structure system, a gap in the research and objective of the research to be conducted. These contributions help to visualize the problem faced by RC deck slab from a new perspective. By evaluating the performance of deck slab bridge with different thicknesses its enhanced economic aspect may be achieved, which shall lead to the direction of the design of safe stronger and more economical bridge.**(12)**

Nikhil V. Deshmukh, dr. U. P. Waghe (April 2015) In this paper article For class A loading the increase in shear force for low skew angle (<15°) the shear force increases linearly. The pattern of increase of shear force with respect to span is straight in nature. There is about 20% increase in shear force when span increases from 4m to 6m. As the skew angle is increase, shear force is decreased about 30% when span change to 6m from 4m from thereon, hear force for each span increase.**(13)**

Dhiraj patil, popat kumbhar (july 2016) This study had come to know During the comprehensive parametric study for skewed and curved box girder bridges, point out that the combine effect of skew angle and radius of curvature cannot be neglected for design consideration. Shear stress for skewed and curved box girder bridges is directly proportional to the skew angle while inversely proportional to radius of curvature. The effect of skew angle can be minimize by increased the radius of curvature.**(14)**

Sujith P S , dr. Jiji anna varughese , tennu syriac (september 2015) In the skew angle,With increase in the skew angle, the stresses in the slab differ significantly from those in a straight slab reaction increased with increasing skew angle finite element method gives more economical design and accurate when compared with the grillage analysis. Uplift or negative reaction at the acute corner. Maximum or high reaction at the obtuse corner.**(15)**

III. CONCLUSION

The following conclusions were carried out by researchers

1) For Class A Loading the increase in shear force for low skew angle (<15°) the shear force increases linearly. The pattern of increase of shear force with respect to span is straight in nature
2) By evaluating the performance of deck slab bridge with different thicknesses its enhanced economic aspect may be achieved, which shall lead to the direction of the design of safe stronger and more economical bridge.
3) The bending moment and deflection expression determined by various researchers for standard skew angle
4) The maximum skew angle of 60° as recommended in codes and specification (e.g., AASHTO, 2000) is considered in the analysis.
5) The joint reactions is found to be higher in case of vertical loads.
6) The joint reactions is found to be least in case of parapet wall. For the varying load cases, as the skew angle increases, base reactions also increases.
7) Few studies shows that up to 20 degree skew angle the behavior of the bridge is similar to the straight bridge, but beyond 20 degree the behaviour is quite different.
8) As skew angle increases from 0^o to 60^o, torsional moment is observed to be increased by 1000%.

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