International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 11 | November - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

A Review on Comparative Analysis and Design of RCC Skew Bridge and Steel Skew Bridge with Variation in Angle

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Abstract - *Bridges form an integral part in a highway or railway network. When the geometry can't accommodate straight bridges, skewed bridges are often encountered in highway design. In spite of the fact that majority of bridges in this country are skewed in plan form few methods of analysis exist for such structure. Skew bridges are required to cross the drains at any angle other than normal. These can be helpful in making straight crossing or utilizing the available land where normal crossing are either impossible or not suitable. The slab bridges are uneconomical for large spans due to excessive design thickness but good for small spans due to its easy execution. The paper aims to adopt an efficient analysis technique for the analysis of various skew decks. To begin with different methods have been explored to determine the exact and approxiearch work has been reported in the literature on the analysis of skew bridges under different load combinations. However less attention have been paid for exploration of suitable analysis technique for highly skewed decks. Since bridges are an important structural element today, efficient methodology to accurately predict the behaviour of skew bridges assume importance. In brief the study includes the behaviour of skew slab bridges with respect support reaction and deflection of the slab under standard IRC 70R wheeled loading is presented. The modeling of the slab is done by using Staad.Pro software. It was found that high –ve reaction occurs at obtuse angled corner for skew angles above 60°, the maximum deflection approaches towards the obtuse angled corner with increase in skew angle and aspect ratio.*

***Key Words*:** Staad-Pro, Baseshare, Base moment, Absolute wall stress, Bending moment, Skew Bridge etc.

1. INTRODUCTION

A bridge is a structure built to span physical obstacles without closing the way underneath such as a body of water, valley, or road, for the purpose of providing passage over the obstacle, usually something that can be detrimental to cross otherwise. There are many different designs that each serve a particular purpose and apply to different situations. Designs of bridges vary depending on the function of the bridge, the nature of the terrain where the bridge is constructed and anchored, the material used to make it, and the funds available to built it. The majority of bridge decks that are constructed now days are often some skewed or curved. Tight geometry is often placed on highway structures due to right of way restrictions in congested urban areas. If a road alignment crosses a river or any other obstruction at an inclination different from 90°, a skew crossing may be necessary. Skewed bridges are one of the most economical and satisfying construction in such conditions. In addition skew bridges are common at highway interchange, river crossing and other extreme grade changes where skew geometry is necessary due to space limitations. In fair meaning, the plan of bridge may appear like parallelogram in plain view. This condition occurs when bridge alignment is not exact perpendicular or making some angle to crossing. The term angle of skew or skew angle is generally applied to the difference between alignments of an intermediate or end support and a line square to the longitudinal axis of the bridge above. Thus, on 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. The simple form of bridge is right deck but demand of skew bridge is increasing due to various factors.

Bridges and culverts form important parts of a rail or road or any other type of communication network and the major part of the project of the cost of the project goes into the construction of these structures. The ideal bridge crossing of any obstacle is a square crossing, which ensures minimum span, deck area and support pier lengths, with attendant economies it also the easiest structure to design and detail. -

In order to cater to high speeds and more safety requirements of the traffic, modern highways are to be straight as far as possible and this has required the provision of increasing number of skew bridges. The inclination of the center line of traffic to the normal to the centre line of the river in case of a river bridge or other corresponding obstruction is called the skew angle. For bridges in which the plan form is a parallelogram. The angle obtained by subtracting the acute angle of the parallelogram from 90º is termed the skew angle of the bridge. The span of a skew bridge measured along an unsupported edge of the bridge in plan is called the skew span, and the perpendicular distance between the two lines of supports is called the right span. The directions parallel and perpendicular to the flow of traffic on the bridge are still called the longitudinal and transverse directions respectively.

SKEW BRIDGE:

A Bridge built obliquely between abutments is called as Skew Bridge. The angle between the normal to the center line of the bridge and the center line of the abutment is known as Skew Angle. Skew bridges are built where geometry cannot accommodate straight bridge. Highway should be straight as long as possible in provision of high speed and safety requirements of the traffic, this resulted in increase in number of skew bridges.

Generally bridge with a skew angle less than 20° is designed as normal bridge. If it is more than 20° there is change in the behavior of the skew bridge. Thus Geometry and behavior of skew bridge are affected by the presence of skew angle. The Structural response of skewed bridge to stresses in slab and reactions on abutments can be significantly altered by the skew angle of the substructure.

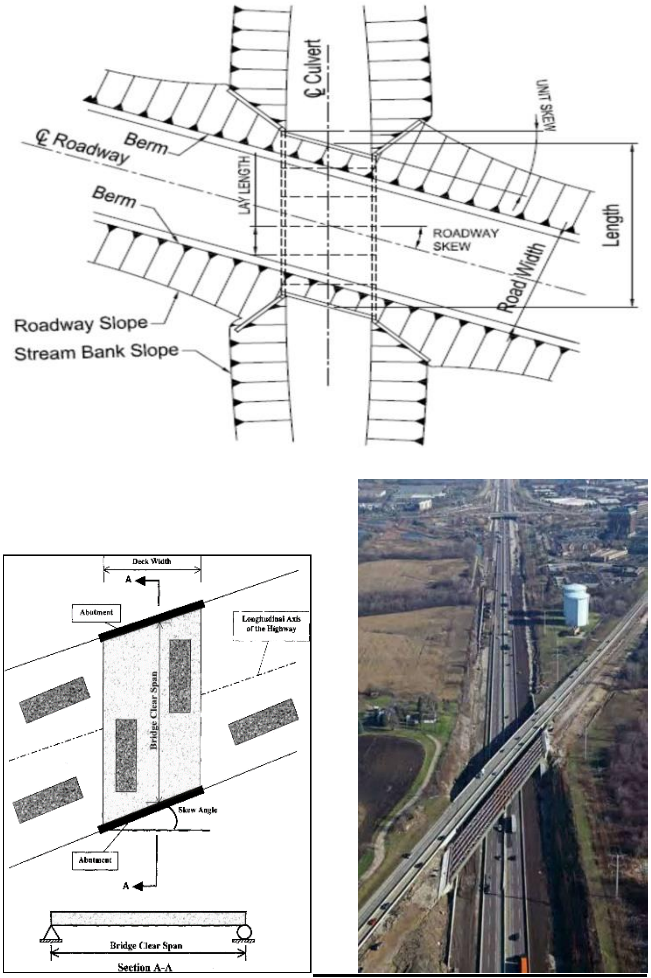

Figure 1: Section of Skew Bridge

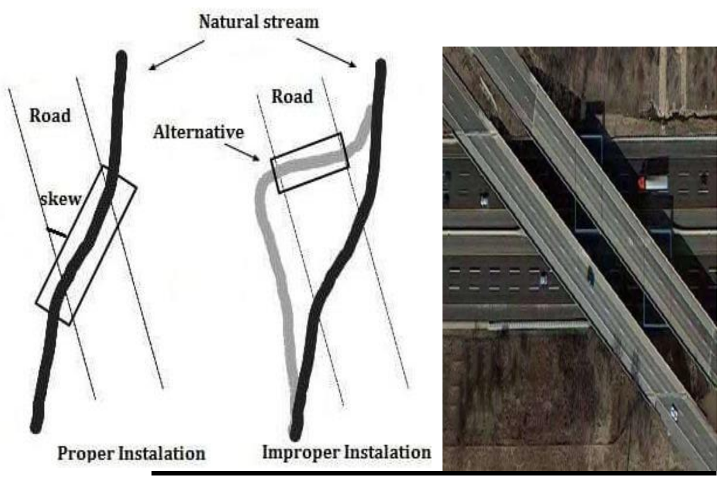

Figure 2: Proper Installation Of Skew Bridge

2. LITERATURE REVIEW

Literature Review for Paper [1] shows the two lanes solid slab and on beam and slab arrangement (composite) on various skew angles. 1tonne/sq m of imposed load is given on each model and comparison of the results is observed to study the characteristics of skew deck and also investigational study on the skew effect if the bridge is subjected to IRC loading is completed. The analysis is done using the software STAAD-PRO t Composite Bridge Deck slab. The effect of Skew angle in Composite Bridge is observed for same model using STAAD-PRO. The critical section in skew angle where behavior is dominant is also found out by this analysis which can be effectively used while designing skew bridge.

The aim of paper [2] a total of nine different grid sizes (4 divisions to 12 divisions) are made using grillage analogy and have been studied on skew angles 30°, 45° and 60° to determine the most effective grid size. It is observed that finite element method (FEM) and Grillage method results are not similar for every grid size. They can be different for each grid size depending on various parameters. It is also observed from the analysis that mostly seven divisions on gridding is appropriate i.e., ratio of transverse grid lines to longitudinal grid lines is 1.8-2.0.

Paper [3] a simply supported skew slab of varying span length and skew angles are considered. The various span lengths are 10 m, 15 m and 20 m. he carriageway widths are 4.5 m, 7.5 m and 10.5 m and skew angles are 0° ,20° , 40° and 60° . Edge beam is of depth and width 200 mm. the bridge deck is analyzed for two conditions i.e., concentrated load at the centre and knife edge load parallel to the abutment. A total of 36 models are analyzed for different conditions. The results are obtained based on the bending moments, shear forces and torsional moments. From the present study, it is evident that most effective skew angle is 20° skew angle, the increment of torsional moment is larger and so that the failure of bridge will be greater compared to the other skew angles.

In Paper [4] study Analysis and Design of Skew Steel Bridge. Span = 60m, Two Lane width of 3.75m, Foot path = 1m on either side, Height of panel = 5m, No of bays along length = 12 No of bays along width = 2, Grade of concrete = M25, Grade of steel = Fe 415, Loading: IRC class AA tracked vehicle.

They involves the analysis and design of steel bridge with skew angle 300 involves the planning, load calculations, analyzing, design of steel truss, deck slab, pier and design of foundation.

Analysis design has done for various load combinations etc. as per the Indian Standard Code of Practice.

The objective of [5] paper present study is to compare normal and skew bridge of box girder type, with parameter such as displacements, bending moments and shear forces for single, two and three spans deck slab by considering IRC class 70R loading. Detail design and analysis of bridge superstructure for the effect of different skew angles along varying spans has been performed and the results obtained are presented in terms of deflection, bending moment and shear force.

Paper [6] shows the objective of analysis is to study on the behavior on entire bridge section under different loading conditions such as dead load of whole structure, live load of IRC A and IRC 70R loading with the presence of skew angle in bridges section. The objective is to study the structural behavior in each individual girders of a bridge section under the various loading conditions such as IRC A loading and IRC 70R loading with varying in skew angles. This study is conducted by considering single span simply supported Steel I-girder Bridge, further the study can be made on multiple spans using I- girder or U- girder with cast-in-situ deck slab. In this study effect of seismic and wind are not considered, therefore inclusion of seismic and wind effect (Dynamic effect) can be taken up as the research or study topic.

Paper [7] compare and analyze regular and skew bridge with different angles (15º and 30º) for IRC class A loading and 70R loading. To determine deflection, bending moment, absolute plate stress and shear force. Comparison with ordinary bridge and various skew angles is made To evaluate the effectiveness of a skew angle.

The maximum deflection for skewed deck slabs decreases with the increase in skew angle for all aspect ratios and at 30 degree there was a reduction of 70 percentage is observed. The longitudinal bending moment shows a similar pattern of reduction with increase in skew angle. As the skew angle increases, maximum longitudinal moments gradually shifts towards the obtuse angle The load-carrying capacity of the skew Slab significantly depends on the skew angle. Based on this study the skew angle with 30° improved the overall behavior of the bridge compared to standard bridge.

Paper [8] describes the analysis and behaviour of skew bridges with different skew angle. Many highway bridges are skewed and their behavior and corresponding design analysis need to be furthered to fully accomplish design objectives. The research deals with the finite element modeling of simply supported skew slab with varying skew angles using ETABS 2013 software. The behavior of the simply supported skew slab under point load applied at the center depends on the ratio of short diagonal to its span. In the theoretical study, the skew angle and the concrete grade had a significant influence on the overall behavior of the slab. The simply supported skew slab is analyzed with a concentrated load at the center and knife edge load. The analysis is done on the varying span length and the skew angles. Moment, shear force and Torsional variations are analyzed. The research deals with the design of skew bridge with suitable skew angle. The bending moments in the concentrated load condition and the knife edge load condition are decrease up to 65% and 75% respectively as the skew angle increases to 600. The increment of torsional moments is of 60% in both the conditions.

Reinforced concrete bridge model with mesh slab Under Dead load, Live load and combination of Dead + Live load, results obtained for all 26 models with skew angle 0o to 60o are axial Force, shear, torsion and moment. These parameters are further interpreted to get maximum bending moment, maximum Shear force, Bending Moment due to Torsion, Design Equivalent Bending Moment, Shear Force due to Torsion, and Design Equivalent Bending Moment.

In paper [9] shows the modelling of the Slab Bridge in Staad Pro.V8i Positioning of Vehicles on the Skew Slab Bridge in Staad Pro.V8i. For a smaller ratio of the amplitude to the width, the inclination has a marginal effect at the moment of deign. With the increase of this ratio, the effect of the inclination increases. For a lower tilt angle of up to 15 degrees, the tilt effect is minimal, while with the tilt angle increase the tilt effect is compounded. For a smaller tilt angle of up to 15 degrees, the Mx value is small, while with the increase of the tilt angle the value Mx increases exponentially.

Paper [10] Study of R.C.C. T- Beam Bridge with Skew Angle. The effect of skewness directly on the design parameters i.e. B.M, Shear Force and Maximum Reaction in simply supported RC TBeam 3 lane bridges. 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. It is also observed that, skew angle up to 150do not affect the design values considerably for skew bridges. For higher skew angles, analysis results must be taken into account while designing skew bridges.

3. OBJECTIVE OF RESEARCH WORK

The objective of this research work is to investigate the effect of skew angle on varying carriageway width and span length. The parameters of RCC skew bridge and steel skew bridge considered are:

1. Variation of skew angles as 300, 500 and 700.
2. Variation of carriageway width as 6m, 9m and 12m.
3. Variation of span length as 25m, 35m, and 45m.

Table 4.1: Angle, Span and carriageway of the skew bridge

SR. NO.	Angle(degree)	Span(m)	Carriageway width
1	30	25	6
2	50	35	9
3	70	45	12

4. PROBLEM STATEMENT

1. Skewed bridges are irregular structures due to the geometry of the deck and bents. Past earthquakes indicate that skewed bridges with seat type abutments exhibit greater damage than non-skewed bridges with similar seat type abutments. These bridges have become unusable due to damage at the piers and/or by unseating of the deck.
2. This reports the behaviour of skew bridges analyzed and tabulated using STAADPRO software. Three different cases of models with skew angles 30, 50, 70 degree and span of 25m, 35m, and 45m width and carriage width is 6m, 9m, and 12m are considered
3. These forces and restraint of movement can cause cracking in the concrete integral end diaphragms and bridge deck, leading to serviceability problems. Therefore, integral abutments are typically not used on moderately or severely skewed plate girder bridges.
4. In skew bridge the force flow is much more complicated as compared to normal straight bridges
5. Under service load and seismic load skew bridges makes their behaviour more complex.

5. METHODOLOGY

1. The maximum bending moment is observed during increment in skew angle. Also increase in span length will cause effect of bending moment on bridges. Torsional moment occurs due to effect of cantilever load transfer in skew slab. The increase of torsional moment is observed with increase in span length and skew angle.

2. This reports the behaviour of skew bridges analyzed and tabulated using STAADPRO software. Three different cases of models with skew angles 30, 50, 70 degree and span of 25m, 35m, and 45m width are considered.

3. Analysis is performed for dead load and live load on skew bridges. The results have contributed to understanding the behaviour of skew bridges based on the maximum loads. The results are extracted in excel and further used for plotting the graph such as skew angle versus bending moment, shear force and torsion. Comparison is made for all the models and a comprehensive conclusion is drawn.

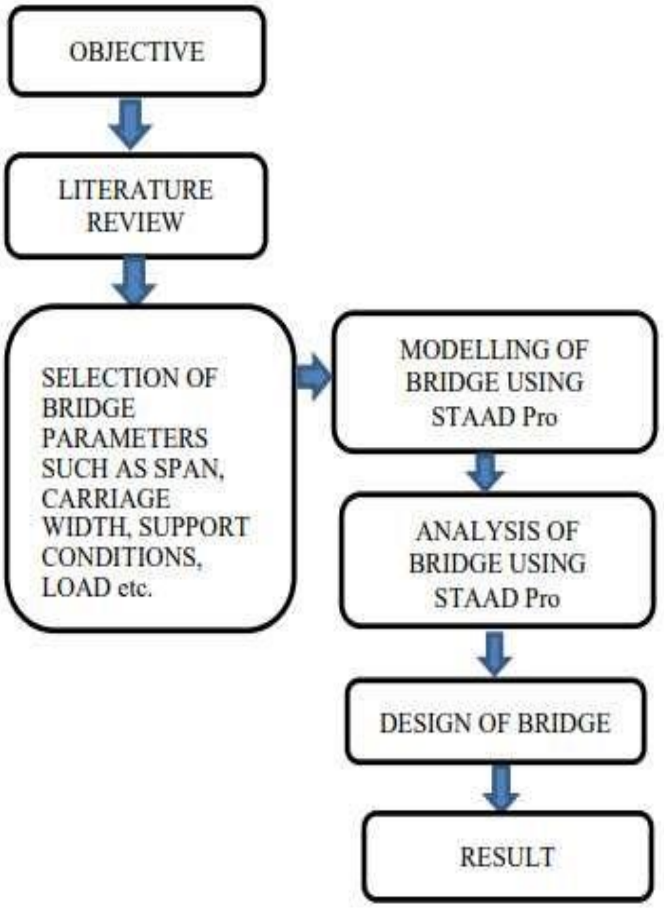

Figure 3: Modelling and Analysis Process

6. CONCLUSION

This paper has to study the behaviour of the RCC and steel skew bridge. The effect of Skew angle in Composite Bridge is observed for same model using STAADPRO. The critical section in skew angle where behavior is dominant is also found out by this analysis which can be effectively used while designing skew bridge. 20° skew angle, the increment of torsional moment is larger and so that the failure of bridge will be greater compared to the other skew angles. Detail design and Analysis of bridge superstructure for the effect of different skew Angles along varying spans has been performed and the results obtained are presented in terms of deflection, bending moment and shear force.

ACKNOWLEDGEMENT

We would like to thank the researchers as well as publishers for making their resources available and teachers for their guidance. The authors would like to thank the Department of Civil Engineering of BIT Bamni, Maharashtra, India for their generous support. We would also thank to all Staff Members of Civil Engineering department for their valuable guidance. We are also thankful to reviewer for their valuable suggestions and also thank the college authorities for providing the required infrastructure and support.

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