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Static Analysis of SKEW Bridge

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Abstract: - **In bridge construction when the roads cross the streams and canals at angles other than 90 degrees, reinforced concrete skew slabs are widely used. The number of skew bridges increases in modern highways, in order to cater to high speeds and more safety requirements of the traffic. The research deals with the finite element modeling of simply supported skew slab using finite element software ETABS. The simply supported skew slab is analyzed with a concentrated load at the center of deck slab and knife edge load parallel to the abutment. The skew angles considered are 0^0, 20^0, 40^0 and 60^0. The carriageway widths are selected as per IRC 6: 2010. IRC Class A loading is also considered to analyze the skew bridges. With the increase in skew angles, the load carrying capacity also increases. The shear force increases with increase in skew angles and the increment is 76%. For greater span lengths the torsion will be greater and failure occurs near the abutments.**

Keywords: Concentrated Loads, Knife edge Loads, Skew Angles, Skew Bridges

1. INTRODUCTION

Skewed bridges are commonly used to roadways, waterways, or railways that are not perpendicular to the bridge at the intersection [4]. Skewed bridges are characterized by their skew angle, defined as the angle between a line normal to the centerline of the bridge and the centerline of the support [1] which is shown in Fig. 1.

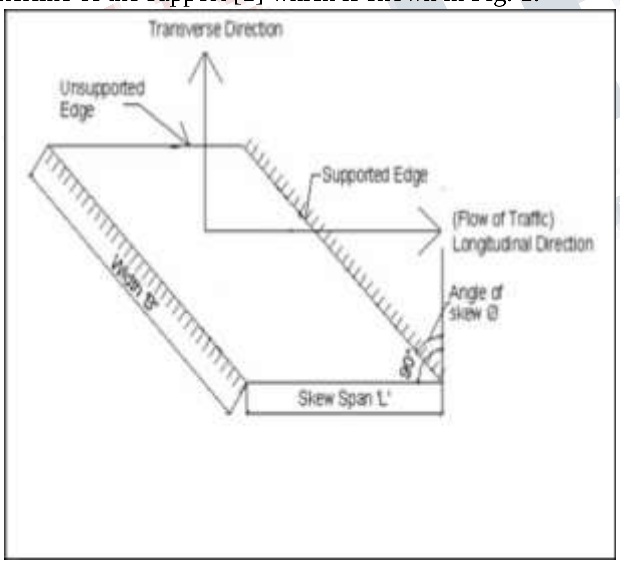

Fig. 1 Plan of a skew deck slab

The load path in skew slabs take a short cut through the strip of area connecting the obtuse - angled corners and the slab initially bends along the line joining corners of obtuse angles [2], [5]. The width of this primary bending strip is a function of aspect ratio (skew span: width of deck) and skew angle. The areas on either side of the strip transfer to the strip as cantilever and do not transfer the load directly to the supports. The load is transferred eventually gets redistributed over the whole length and from the strip to the support over a defined length along support line and then. The fig. 2 shows the load transfer mechanism.

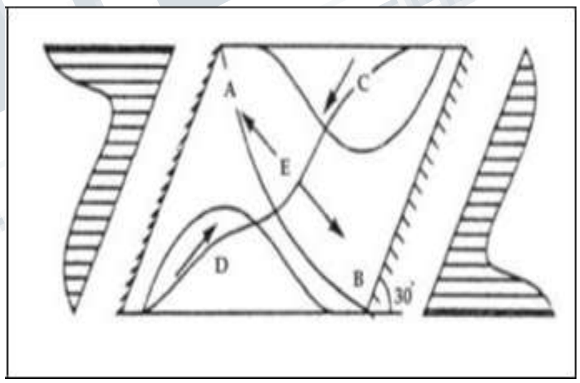

Fig. 2 Load transfer mechanism of skew deck slab

The effects of skew on the completed structures have been well prepared, with effects being shown to be significant for skew angles greater than 30° [6]. Torsional rotations, moments and shears have been shown to be greater for skewed bridges. Skew deck slab is perpendicular to the supports and the load placed on the deck slab is transferred to the supports, these are placed normal to slab. The stresses in the bridge deck, with increase in skew angle and reactions on the abutment vary significantly from those in straight slab. Abozaid et al. (2014) studied a comparison study between results of previous experimental studies and the nonlinear finite element methods of a reinforced concrete skew slab and concluded that the skew angle and concrete grade had a great influence on the behaviour of the slab.

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Mallikarjun et al. (2015) analysed the effect of a skew angle on single-span reinforced concrete bridges and PSC bridges are analyzed using the finite-element method to study the influence of skew angle and type of load and reached the conclusion in significant decrease in longitudinal bending moment.

Deepak and Sabeena (2015) studied the effect of skew angle on uplift and deflection of R. C. C. Skew slab and concluded that as skew angle increases at both the acute corners also increases the uplift. And suggests that the load carrying capacity increases with increase in skew angle. Sindhu et al. (2013) studied the effect of a skew angle on single-span reinforced concrete bridges which reflected in significant decrease in deflection, longitudinal bending moment and torsional moment.

II. SCOPE OF WORK

Skew bridges are very common at highways; the analysis and design of skew bridges are much more complicated than those for a right bridgeThere are no guidelines addressing the performance of skewed highway bridges. So, no need to study the effect of skew angles of highway bridges.

III. OBJECTIVE OF THE WORK

The objective of the work is to analyse the effect of skew angle on varying carriageway width and span length. The parameters considered are:

a) Skew angles as 00, 200, 400 and 600.
b) Carriageway width as 4.5 m, 7.5 m and 10.5 m.
c) Span length as 10 m, 15 m and 20 m.

IV. PARAMETRIC STUDY

A skew slab of simply supported varying span length and skew angles are considered. The span lengths are 10 m, 15 m and 20 m. The various carriageway widths are 4.5 m, 7.5 m and 10.5 m and various skew angles are 00, 200, 400 and 600. The bridge deck is analyzed for two conditions i.e., at the center, concentrated load and knife edge load parallel to the abutment. A total of 52 models are analyzed for different conditions.

V. MODELLING OF BRIDGE

The analysis is carried out in ETABS software. The concrete skew slabs are of 200 mm thickness. The edge beams provided are of concrete section. Table 1 shows the properties of concrete.

Table 1. Properties of concrete

Elastic modulus	*2500 N/mm^2*
Value of Poisson's ratio	0.21
Density of concrete	25 kN/m$_2$

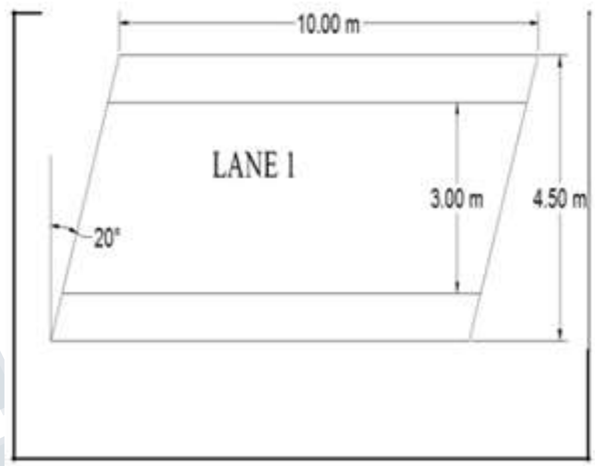

Fig. 3 One lane bridge

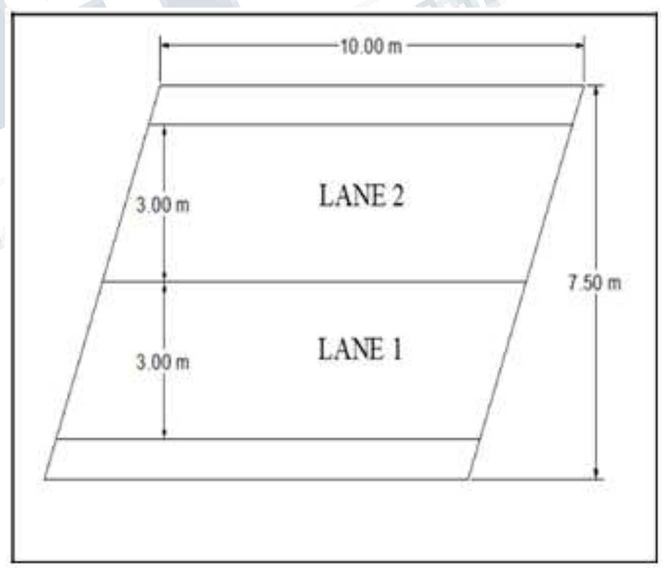

Fig. 4 Two lane bridge

The effect of carriageway width on the behavior of skew bridge is analyzed. Fig. 3 and 4 shows One Lane Bridge and Two Lane Bridge and Three Lane Bridge respectively.

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VI. RESULTS AND DISCUSSIONS

The results are obtained based on the shear forces , bending moments and torsional moments. The critical structural responses are shown in various graphs.

A Bending Moment

In Knife Edge Load condition and Concentrated Load condition compared to that of straight deck slab decreases the Bending moment for skewed slabs with the increase in skew angle for all carriageway widths and it is shown in Fig. 6 and 7 respectively. The load is transferred at the obtuse corners through the strip area at the ends .

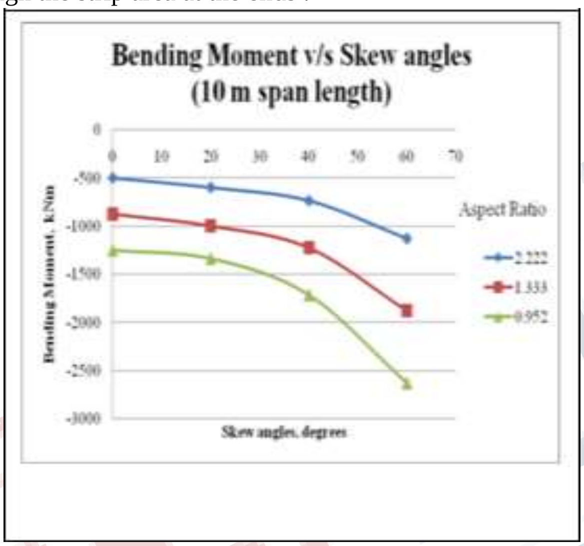

Fig. 6 Bending moment for knife edge load condition (10m span length)

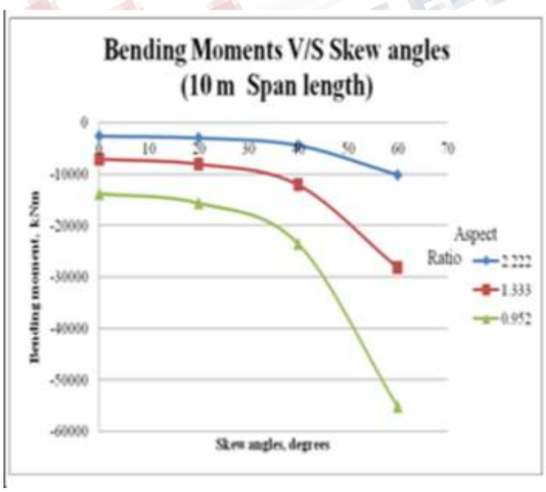

Fig. 7 Bending moment for concentrated load at the center (10m span length)

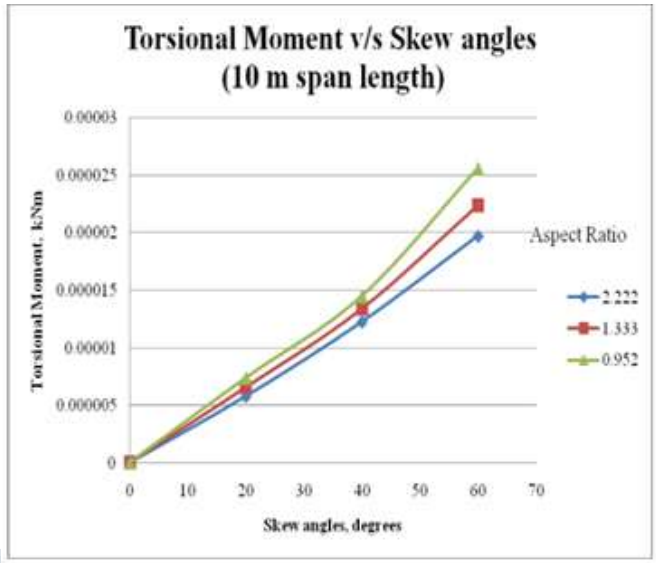

Fig. 9 Skew angles on torsional moments in the concentrated load condition (10 m span length)

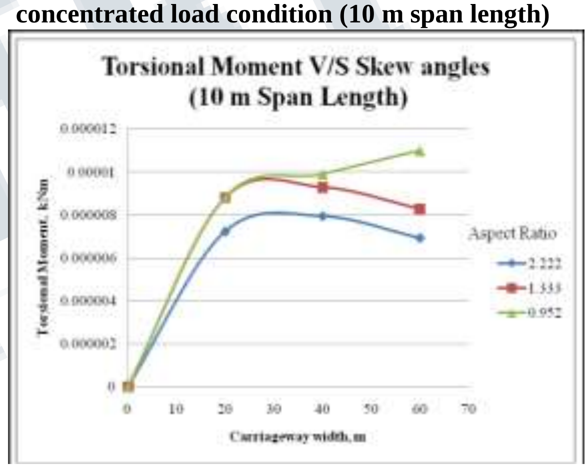

Fig. 8 Torsional moment v/s skew angles (10 m span length)

B Torsional Moment

The maximum torsion in beam bridge decks for skewed bridges compared to that of straight bridges increases with increase of skew angle up to 400 for considered the various span lengths 10 m, 15 m and 20 m. Beyond 400, a decrement occurs as skew increases. The torsional values are considered based on (span: width). Around 60 % increment in the torsional moments. Fig. 8 shows the torsional variation of span lengths.

In concentrated load at the center, when skew angle increases from 200 to 600, the increments of torsional moment for aspect ratios 2.222, 1.333 and 0.952 are 70.66%, 70.71% and 71.18% respectively. Around 70% increment in torsional moment as skew angle reaches to 600. Fig. 9, 10

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and 11 shows the graphical representation of the torsional variation in concentrated load condition.

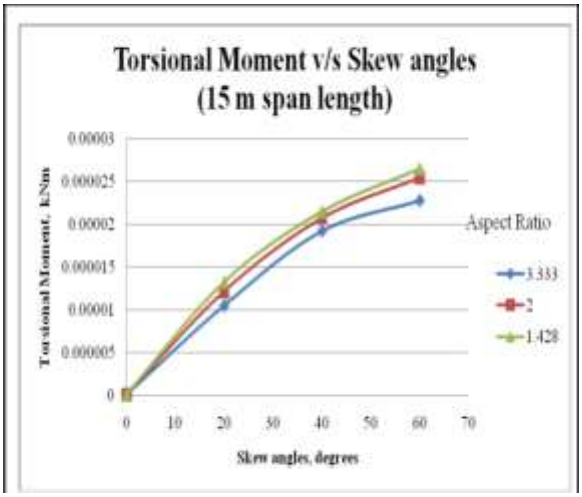

Fig. 10 Representation of skew angles on torsional moments in the concentrated load condition (15 m span length)

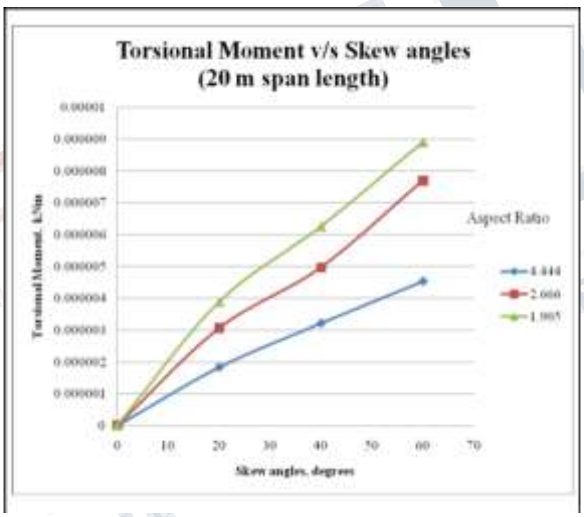

Fig. 11 Representation of skew angles on torsional moments in the concentrated load condition (20 m span length)

CONCLUSIONS

According to the investigation on skew bridge with Varying skew angles and also with varying carriageway widths, the following conclusions are arrived.

1) The shear force in the knife edge condition is increasing gradually and the increment is nearly 30%.

2) The bending moments in the concentrated load condition and knife edge load condition are decrease up to 65% and 75% respectively as the skew angle increases to 600.

3) The increment of torsional moments are of 60% in both the loading conditions.

4) From this study, it is evident that most effective skew angle is 200 skew angle, so that compared to the other skew angles, the failure of bridge will be greater.

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