Effect of Span Length on RC T- Girder Skew Bridge

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Abstract- *Objective of the study is to understand the impact of span length on skew bridge. A study would be made for varying span length. Skew angle are 0, 10, 20, 30, 40, 50 and 60 respectively. Skewed bridges are widely use to keep the alignment straight, with one prominent application being for high speed railways and highways. The bridge configuration i.e. spans and particularly width would be considered as per IRC-6. A comparison would be made between the results for different skew bridges for different span length. An attempt would be made to formulate an equation though which skew effect on design could be ascertained. This parametric study would be performed by finite element modeling of bridges in CsiBridge Software.*

Keywords- Skewed bridges, Girders, Span length, Skew angle, Vehicle loads.

I. INTRODUCTION

Skew bridges are used generally in railways, waterways and cross roadways which are not perpendicular to the bridges at the intersection. Skew bridges is defines as line of skew which is not straight or right angle to the abutments. Skew bridges are characterized by their skew angle. Highly skewed bridges are typically considered as irregular bridges by the design specifications. Skew bridges not only expand or contract in longitudinal direction but can also move in transverse direction of the bridge. During a seismic event, it is very important to minimize the deck displacement to prevent unseating, especially for skew bridges.

The analysis on skew bridge is done by varying their column heights, skew angle and span arrangement. The small change in the bridge reflects the big change in the behavior of bridge. The analysis of bridge is complicated due to skew in the bridge. Analytical and numerical studies of skew bridge with large skew angle have demonstrates that the static and dynamic responses of these bridges are different from those of their straight counterparts. The grillage and finite element method is use to analyzed the structure. Both the method are different from each other, in grillage analysis the slab is discretized in grid of interconnecting beam and in finite element method the slab is discretized in grid of interconnecting plate. In the Comparison of both the method, grillage method is easy to use and not consuming more time as compare to the FEM and finite element method required more effort and time in modeling than grillage, and give the accurate result.

For design of Highway and Railway Bridge superstructures there are many codes used around the world and most of the countries have their own code depending on the natural conditions and the surrounding environmental factors, such as the seismic effects, heavy rainfall, heavy snowfall, mountainous terrain, different types of vehicle used in country etc. Indian bridge engineers refer IRC (Indian Road Congress) standard for the structural design.

CLASSIFICATION OF BRIDGE

Bridges are classified based on form, type of materials used for construction, Inter span relationship, so on. Some main type of bridges under consideration are.

Steel Bridges: steel bridge may use a wide variety of structural steel components and systems: girders, frames, trusses, arches, and suspension cables.

Concrete Bridges: There are two primary types of concrete bridges: reinforced and pre-stressed.

Timber Bridges: Wooden bridges are used when the span is relatively short.

Metal alloy bridges: Metal alloys such as aluminum alloy and stainless steel are also used in bridge construction.
Bridges using both steel and concrete as structural materials.

Plate Girder Bridges: The main girders consist of a plate assemblage of upper and lower flanges and a web. H or I cross-sections effectively resist bending and shear.

Box Girder Bridges: The single (or multiple) main girder consists of a box beam fabricated from steel plates or formed from concrete, which resists not only bending and shear but also torsion effectively.

Composite Girder Bridges: The concrete deck slab works in conjunction with the steel girders to support loads as a united beam. The steel girder takes mainly tension, while the concrete slab takes the compression component of the bending moment.

Culverts: Bridges having length less than 8 m are called culverts.

II. LITERATURE REVIEW

The analysis on skew bridge is done by varying their abutment skew angle, column height and span arrangement. The small change in the structure reflect the big changes in the result. The skew in the bridge make the analysis and design complicated and time consuming. The behavior of bridge in each skew angle is varies and increase in skew angle increase the complication in design. Analytical and numerical studies of skew bridge with large skew angle have demonstrate that the static and dynamic responses of these bridges are different from those of their straight counterparts. JunyiMeng et.al [1]. Various experimental and analytical test is done on the skew bridge to understand the response of bridge in different condition. The grillage and finite element method is use to analyse the structure. Khaled M et.al [11]. Both the method element method the slab is discretized in are different from each other and not similar for every grid size, in grillage analysis the slab is discretized in grid of interconnecting beam and in finite grid of interconnecting plate. In the Comparison of both the method, grillage method is easy to use and not consuming more time as compare to the FEM and finite element method required more effort and time in modeling than grillage, and give the accurate result.

There are various types of forces are acting on the bridges like wind, seismic, dead, live loads etc. these forces produce different reaction as compare to the normal bridge because in normal bridge load reaction and distribution is uniform and in skew bridge the geometry of the bridges is not straight so the distribution of forces is not uniform, non-uniformity in force distribution it affected the stability of the bridge. The forces acting on the bridge is acting on a particular angle, it affect the stability of the bridge and the maximum reaction is acting at the obtuse corner and lesser on other end. ArindamDhar et.al [10].

The seismic behavior of skewed bridges is affected by a number of factors including bridge skew angle, deck width, deck flexibility, number of span, number of column per bent, column ductility, soil-abutment-superstructure interaction. Berker RM et.al [12]. Also seismic response of bridge is strongly influenced by the column boundary condition. Jun Yi Meng et.al [4]. Due to skewness, the bridge does not only produce response in the direction of applied force but also give response along the other direction. This behavior is due to coupling effect which lead to rotation and finally resulting into an increase in the skew angle. Berker RM et.al [12] The effect of torsion cannot be neglected along with other internal forces as the skew angle increased. The seismic forces affect the strength of the pier-column, shear capacity of the pier-column section is heavily dependent on axial, moment and shear demand. Thomas Wilson et.al[7] The abutment Shear key are designed to support the bridge deck in the transverse direction and act as a fuse in order to protect the abutment piles failure during a seismic activity. PeymanKavianiet.al[2] The dynamic interaction between the abutment backwall and deck in the longitudinal direction and the abutment shear key in the transverse direction is modeled by the gap element between the abutment backfill and bridge deck , gap element between the abutment shear key and bridge deck, nonlinear spring in the transverse direction represent the abutment shear key and nonlinear spring in the longitudinal direction represent the abutment backfill. The abutment of the bridge are constrained in the vertical direction, while free to move in the horizontal longitudinal and transverse direction. Ground motion with asymmetrical high amplitude velocity pulse characteristics have the tendency of producing a biased, one sided response of the bridge structure. Asymmetrical impulsive loading generates larger displacement in one direction leading to a significant rotation and residual displacement on the bridges with skew abutment

III. MODELING AND ANALYSIS

The analysis of bridge can be done using a Grillage analog and finite element method. Grillage analog method is simple method and easy to use, in the grillage method the object is discretized in grid of inter connecting beam. Grillage method take less time and not so complicated as FEM. On the other hand FEM , in the FEM the object is discretized in grid of inter connecting plates. Analysis of the object in FEM takes time and required more work but it give more accurate result.

For the analysis finite element based software CsiBridge is using, Finite element method is a versatile method, It can handle structure of complicated shapes and boundary condition. The analysis is on the single span concrete T-girder bridge, using a same span length with varying skew angle and understand the response of the bridge and load distribution . For the analysis using a skew angle with a interval of 0°,10°, 20°,30°,40°,50° and 60° are the angles for the analysis. Bridge model is analysed for both static and dynamic loads. All the structural data is decided based on the IRC standards, The live load combination is decide on the basis of table(Fig 2) given in the IRC:6-2014 . There are different load combination are given based on their geometrical parameter. In this study, as per IRC, One 70R loading and Class A or 3 class A whichever is maximum, will govern the live loading.

Sl. No.	Carriageway Width (CW)	Number of Lanes for Design Purposes	Load Combination
1)	Less than 5.3	1	One lane of Class A considered to occupy 2.3 m. The remaining width of carriageway shall be loaded with 500 kg/m^2
2)	5.3 m and above but less than 9.6 m	2	One lane of Class 70R OR two lanes for Class A
3)	9.6 m and above but less than 13.1	3	One lane of Class 70R for every two lanes with one lanes of Class A on the remaining lane OR 3 lanes of Class A
4)	13.1 m and above but less than 16.6 m	4	One lane of Class 70R for every two lanes with one lane of Class A for the remaining lanes, if any, OR one lane of Class A for each lane.
5)	16.6 m and above but less than 20.1	5	
6)	20.1 m and above but less than 23.6	6	

Fig. 2 Live load combination

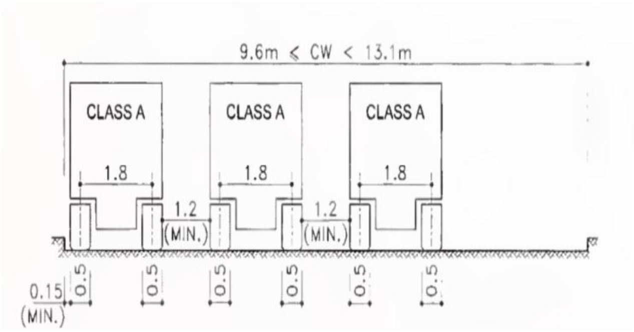

Fig. 3 Class A - 3 Lanes

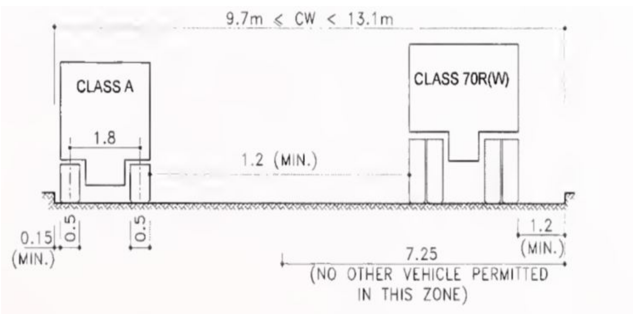

Fig. 4 Class A - 1 Lanes + Class 70R (W)

Bridge Data –

Support	Simply supported
Length of bridge	30 m& 25
No of lane	3
Wearing coat	80mm
Grade of concrete	M 25
Grade of steel	Fe-415
Width of carriageway	10.5m
Total width	11.7m
Diaphragms	At 5m interval
Slab thickness	0.2m
Load	IRC Class AA OR A

Bending moment

The bending moment of D.L.inner girder decreases suddenly at 40° skew angle and decreases gradually after that. Dead load bending moment for both 30m & 25m span deck are decreases in aproximate same manner. For the inner girder live load bending moment there is a sudden decrement after 20° skew angle.

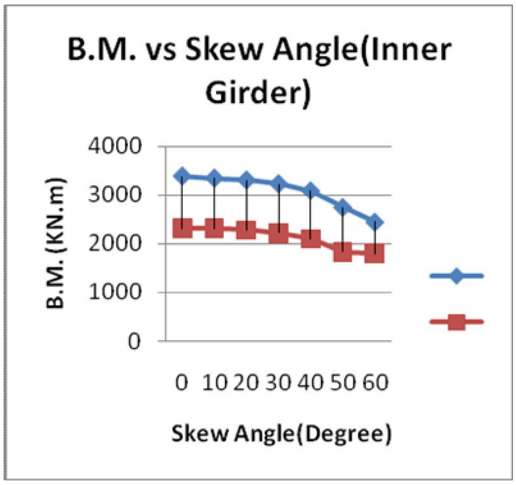

Fig 4.41 B.M. vs Skew angle (Inner girder)

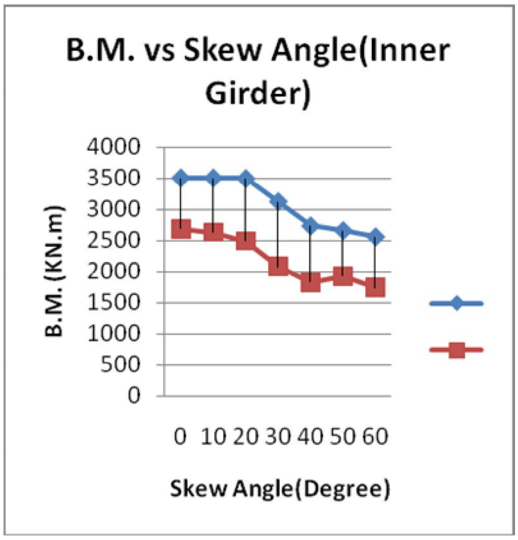

Fig 4.42 B.M. vs Skew angle (Inner girder)

D.L. Bending moment of 30m span deck increases slightly at 0°angle after that decreases gradually. There is a large difference in magnitude of values of 25m and 30m span deck at all the skew angle.

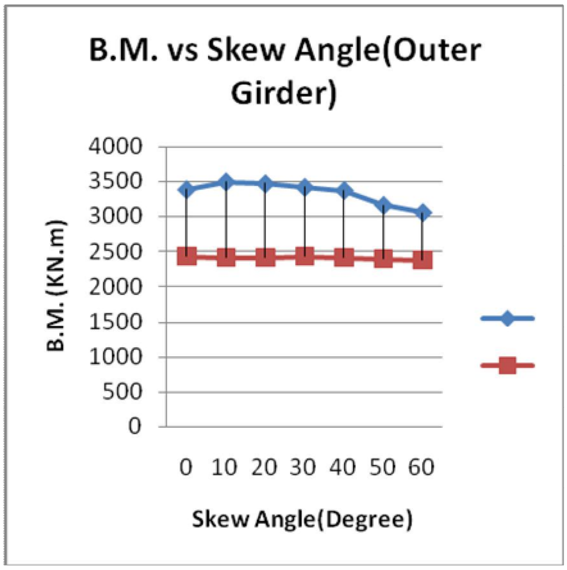

Fig 4.43 B.M. vs Skew angle (Outer girder)

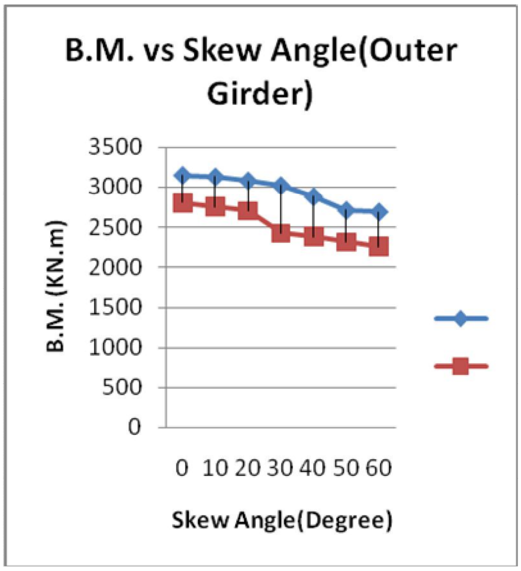

Fig 4.44 B.M. vs Skew angle (Outer girder)

Shear force

Shearforce of inner girder for both dead load and live load have the approximate same increment pattern which show increase in skew angle increases the shear force in girder. Live load shear force increases rapidly as compare to the dead load shear force with increase in skew angle.

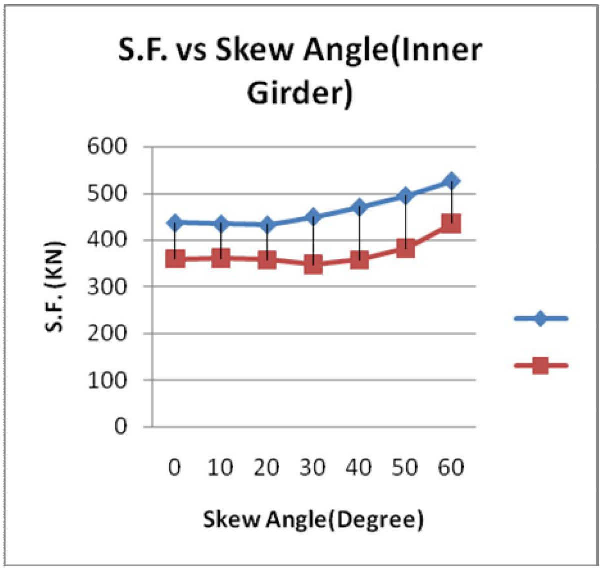

Fig 4.45 S.F. vs Skew angle (Inner girder)

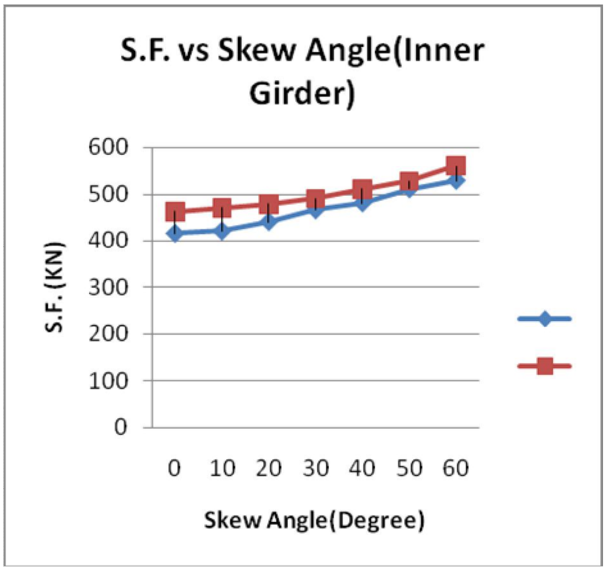

Fig 4.46 S.F. vs Skew angle (Inner girder)

Shear forces of dead and live load of outer girder initially have a large gap in value but after 10°skew angle the difference reduces and show a increment with increase in skew angle.

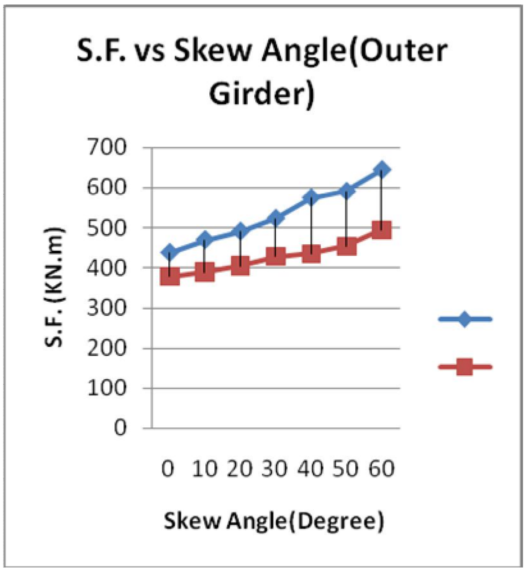

Fig 4.47 S.F. vs Skew angle (Outer girder)

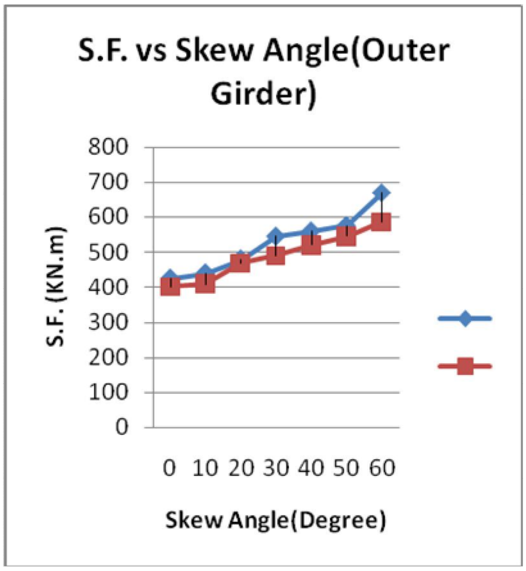

Fig 4.48 S.F. vs Skew angle (Outer girder)

Torsion

Torsion vs skew angle figure of inner girder shows that the initially magnitude of torsion at 0° is very less for both 30m and 25m span deck but with increase in angle magnitude of torsion increases suddenly. The magnitude of inner girder live load increases suddenly after 40° skew angle.

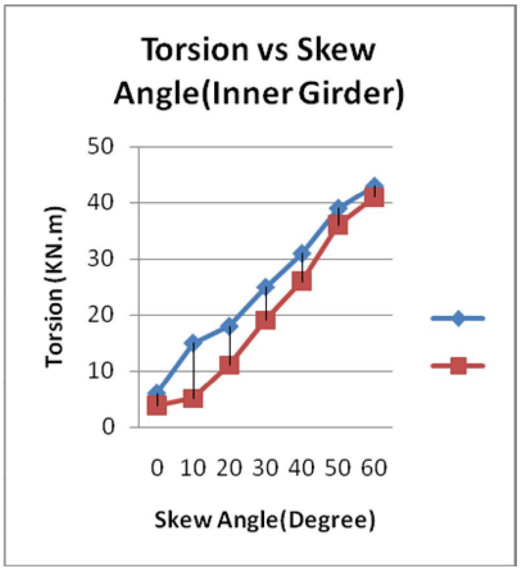

Fig 4.49 Torsion. Vs Skew angle (Inner girder)

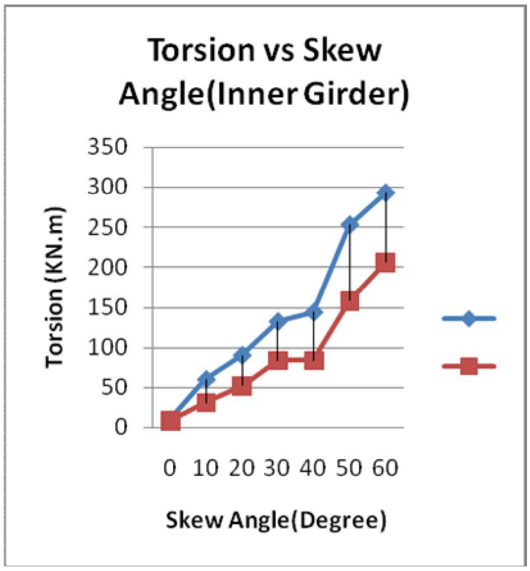

Fig 4.50 Torsion. Vs Skew angle (Inner girder)

Torsion vs skew angle figure of outer girder shows that the initial value of dead and live load torsion at 0° is approximate equal but with increase in angle torsion value increases. The live load increment is higher than the dead load. The magnitude of outer girder live load increases suddenly after 30° skew angle and increases upto 60° in a same way.

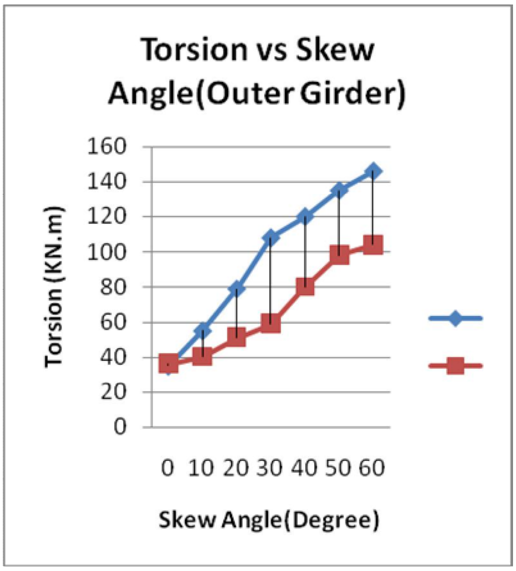

Fig 4.51 Torsion. vs Skew angle (Outer girder)

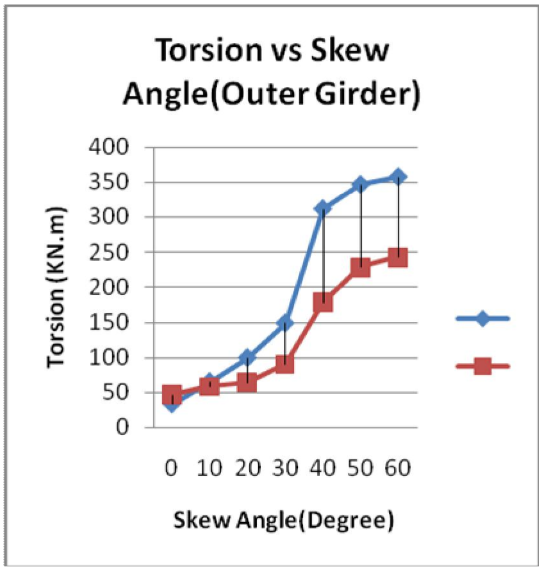

Fig 4.52 Torsion. vs Skew angle (Outer girder)

III. CONCLUSION

Single span 3 lane bridge is studied with varying skew angle and span length and understanding the behavior of bridge with change in skew angle, results shows that the increase the skew angle decreases the bending moments. Skew angle also affect the shear force and torsion. Stress flow in the deck of the bridge shows that the with increases skew angle more stress are at the obtuse corner of the deck and less at acute corner as compare to the obtuse corner. This may increases the chances of the overturning so we have to provide extra thickness of the deck or reinforcement to make the obtuse corner stronger to resist more stress. The above study shows a results in interior and exterior girder separately and it shows a large magnitude in a outer girder as compare to the inner girder. This un equal stress in the members make the skew bridge more complicated.

REFERENCES

[1] X.H. He, X.W. Sheng, A. Scanlon, D.G. Linzell, X.D. Yu, “Skewed concrete box girder bridge static and dynamic testing and analysis, Engineering Structure, 2012.
[2] Jun Yi Meng, Eric M.Lui, “Seismic analysis and assessment of a skew highway bridge.” J StructEngng. 1994, 120, 238-334.
[3] Helba A, Kennedy JB, “Parametric study of collapse load of skew composite bridge.” Engineering Structure .2000, 22, 1433-1452.
[4] Vikas Khatri, P.R. Maiti,P. K. Singh &AnsumanKar, “Analysis of skew bridges using computation method.”

International Journal of computation engineering research .2012, 628-636.
[5] M.S. Qaqish, “Effect of skew angle on distribution of bending moment in bridge slab.” Journal of applied science. 2006, 6(2), 366-372.
[6] ArindhamDhar, MithilMujumdaar, MandakiniChowdhary, SomnathKarmakar, “Effect of skew angle on longitudinal girder (Support shear, Moment, Torsion) and deck slab of an irc skew bridge.” The Indian concrete journal .2013, 47-52.
[7] HimanshuJaggerwal, Yogesh Bajpai, “Effect of skewness on three span reinforced concrete T Girder Bridges.” International Journal of Computation Engineering Research.2014, 2250-3005.
[8] Nikhil V. Deshmukh, Dr. U. P. Waghe, “Analytical and Design of skew bridges.” International Journal of science and research .2003, 2319-7064.
[9] Hamid Ghasemi Eric M Lui, JunyiMeng, “Analytical and experimental study of skew bridge model.” Engineering Structure .2004, 26, 1127-1142.
[10] PeymanKaviani, FarzinZareian, rtugrulTaciroglu, “Seismic behavior of reinforced concrete bridge with skew angled seat type abutments.” Engineering Structure .2012, 45, 137-150.
[11] Shrikant D. Bobade, Dr. Valsson Varghese, “Parametric study of skew angle on box girder bridge deck.” International Journal of science and research .2016, 2277-9655.

IS CODE

[1] IRC 6-2014, “Standard specification and code of practice for road bridges”, Section II “ Load And Stress”, India Road congress , New Delhi.
[2] IRC 21-2000, “Standard specification and code of design of practice for road bridges”, Section III “Cement Concrete (plain & reinforced)”,India Road congress , New Delhi.
[3] IRC 5-1998, “Standard specification and code of design of practice for road bridges”, Section I “ General feature of design”, India Road congress , New Delhi.