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TORSION MOMENT OF INERTIA EFFECT ON RCC T GIRDER SKEW BRIDGES

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ABSTRACT

Generally a bridge is defined as a structure spanning a river, road, valley, depression or any other type of obstruction with a purpose to provide through passage of communication. This project is taken to study the torsion moment of inertia effect on reinforced concrete (RCC) girder super structure for the three lanes and skew angles by 0º, 15º, 30º, 45º, and 60º Degree and compare the results to study the characteristics of skew deck and also to investigate the skew effect if the bridge is subjected to IRC 6-2014 Loading.

The following analysis is going to be made using the software STAAD-PRO.

1. The effect of torsion moment of inertia in RCC T Girder with different skew angels.
2. The Effect of torsion moment due to torsion moment and with skew angles.
3. The effect of Skew angle in RCC girder.

The torsion moment of inertia is calculated based on the Timoshenko and Goodier. As skew increases the longitudinal bending moments are increased and the torsion moments also increased. Torsion moment is more at end girders compared to inner girder. For straight girder bridge no torsion moment is observed.

Key words: *Skew Bridge, Torsion Moment of Inertia, Girder Bridge.*

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1. INTRODUCTION

The continuing expansion of highway network throughout the world is largely the result of great increase in traffic, population and extensive growth of metropolitan urban areas. This expansion has lead to many changes in the use and development of various kinds of bridges. The bridge type is related to providing maximum efficiency of use of material and construction technique, for particular span, and applications.

Bridges are structures which are provided a passage over a gap without closing way beneath. They may be needed for a passage of railway, roadway, and footpath and even for carriage of fluid, bridge site should be so chosen that it gives maximum commercial and social benefits, efficiency, effectiveness and equality. Bridges are nation‟s lifelines and backbones in the event of war. Bridges symbolize ideals and aspirations of humanity. They span barriers that divide, bring people, communities and nations into closer proximity. They shorten distances, speed transportation and facilitate commerce. Bridges are symbols of humanity‟s heroic struggle towards mastery of forces of nature and these are silent monuments of mankind‟s indomitable will to attain it. Bridge construction constitutes an importance element in communication and is an important factor in progress of civilization, bridges stand as tributes to the work of civil engineers.

1.1 CLASSIFICATION OF BRIDGES:

According to the inter-span relations as simple, continuous or cantilever bridges.

• ***Simply supported***

Generally width of bridge is divided into number of individual spans. For each span, the load carrying member is simply supported at both ends. The plate girder and truss girders are used as this type of bridges. They are suitable at places where uneven settlements of foundations are likely to take place.

• ***Continuous***

In continuous bridges spans are continuous over two or more supports. They are statically indeterminate structures. They are useful when uneven settlement of supports does not take place. In continuous bridges the bending moment anywhere in the span is considerably less than that in case of simply supported span. Such reduction of bending moment ultimately results in the economic section for the bridge. In continuous bridges the stresses are reduced due to negative moments developed at pier or supports. Thus continuous span bridges have considerable saving compared to simply supported bridge construction. Following are the advantages of RCC continuous girder bridges over simply supported girder bridges.

1.3. EFFECT OF SKEW:

Skewed bridges are often encountered in highway design when the geometry cannot accommodate straight bridges. 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, as described in Fig. 1.1. Skew bridges have become a necessity due to site considerations such as alignment constraints, land acquisition problems, etc. The presence of skew in a bridge makes the analysis and design of bridge decks intricate. For the Slab bridge decks with small skew angle, it is considered safe to analyze the bridge as a right bridge with a span equal to the skew span.

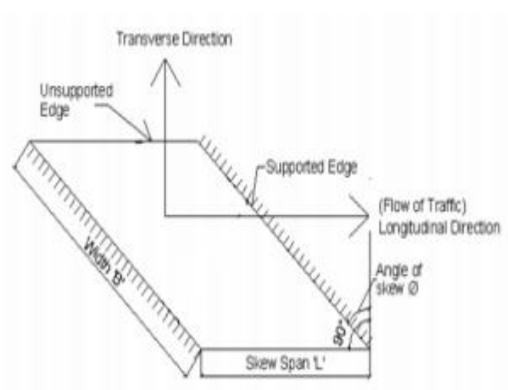

Fig-1.1: Skew Bridge

2. REVIEW OF LITERATURE

The first bridges were made by nature itself — as simple as a log fallen across a stream or stones in the river. The first bridges made by humans were probably spans of cut wooden logs or planks and eventually stones, using a simple support and crossbeam arrangement. Some early Americans used trees or bamboo poles to cross small caverns or wells to get from one place to another. A common form of lashing sticks, logs, and deciduous branches together involved the use of long reeds or other harvested fibres woven together to form a connective rope capable of binding and holding together the materials used in early bridges.

The Arkadiko Bridge in Greece (13th century BC), one of the oldest arch bridges in existence. The Arkadiko Bridge is one of four Mycenaean corbel arch bridges part of a former network of roads, designed to accommodate chariots, between Tiryns to Epidaurus in the Peloponnese, in Greece. Dating to the Greek Bronze Age (13th century BC), it is one of the oldest arch bridges still in existence and use. Several intact arched stone bridges from the Hellenistic era can be found in the Peloponnese in southern Greece. The greatest bridge builders of antiquity were the ancient Romans. The Romans built arch bridges and aqueducts that could stand in conditions that would damage or destroy earlier designs. Some stand today. An example is the Alcántara Bridge, built over the river Tagus, in Spain. The Romans also used cement, which reduced the variation of strength found in natural stone. One type of cement, called pozzolana, consisted of water, lime, sand, and volcanic rock. Brick and mortar bridges were built after the Roman era, as the technology. for cement was lost then later rediscovered.

The Arthashastra of Kautilya mentions the construction of dams and bridges. A Mauryan bridge near Girnar was surveyed by James Princep. The bridge was swept away during a flood, and later repaired by Puspagupta, the chief architect of Emperor Chandragupta I. The bridge also fell under the care of the YavanaTushaspa, and the Satrap RudraDaman. The use of stronger bridges using plaited bamboo and iron chain was visible in India by about the 4th century. A number of bridges, both for military and commercial purposes, were constructed by the Mughal administration in India.

Omkar Velhal , J.P. Patankar 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 Tbeam 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 6:2000guidelines. 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.

Mahantesh.S.Kamatagi, Prof. M. Manjunath The present paper describes the analysis and design of longitudinal girder of the T-beam bridge. In this case analysis is done using SAP 2000 software. After analysis design of the longitudinal girders are done by using IRC:21 and IRC:112 codes. The new unified concrete code (IRC:112) represents a significant difference from the previous Indian practice followed through IRC:21 & IRC:18. The code is less prescriptive and offer greater choice of design and detailing methods with scientific reasoning. This paper presents design of T-beam longitudinal girder design by both working stress method and limit state method and result obtained are compared with both methods. T-beam Bridge of 18 m span are designed for class 70R vehicle.

Khaled M. Sennah & John B. Kennedy performed (1) elastic analysis and (2) experimental studies on the elastic response of box girder bridges. In elastic analysis they represent the orthotropic plate theory method, grillage analogy method, folded plate method, finite element method, thin-walled curved beam theory etc. The curvilinear nature of box girder bridges along with their complex deformation patterns and stress fields have led designers to adopt approximate and conservative methods for their analysis and design. Recent literature on traight and curved box girder bridges has dealt with analytical formulations to better understand the behavior of these complex structural systems. Few authors have undertaken experimental studies to investigate the accuracy of existing method.

3. DESCRIPTION OF THE STRUCTURE

The design of the super structure done for the 2 lane loading with footpath & 3 lane loading without footpath loading, critical design values are considered.

3.1 Geometry

a) Carriageway Width 11.0m
b) Overall width 16 m
c) Width of Crash Barrier 0.50m
d) Cross slope 2.50%
e) Thickness of wearing course 65mm (40mm Asphalt wearing with topping of 25mm mastic asphalt).
f) C/C of the Girder 3.25m
g) Dist. between C/L of EJ to C/L of Bearing 0.5m
h) Width of Footway 1.5m
i) Width of RCC Kerb & Railing 0.5

3.2 Dead Load (DL):

Unit weight for Dead loads calculation shall be considered as per IRC: 6-2014

3.3 Carriageway & Footpath Live Load (LL):

1 Lane of Class 70R/ 2 lane of Class A

• 3 Lanes of Class A/1 lane of 70R in combination with 1 lane of class A on third lane

Conforming to IRC 6-2014 shall be considered in analysis and whichever producing severe effect shall be considered in design. Reduction in longitudinal effect for three lane loading shall be considered as per clause 208 of IRC: 6. Pedestrian live load in conformity with clause 209.4 shall be considered over the footpath

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3.4 Method of Analysis for longitudinal Girders

The analysis of the T-Girder for longitudinal flexure shall be carried out using Grillage model on STAAD Pro on the following basis:

- It is proposed to have 4 nos of straight longitudinal beams at 3.0m centre to centre with 1.5m cantilever projection on either side.
- Grillage model has been generated with longitudinal members along the C/L of the I-Girder and with dummy members in between the longitudinal girders and along the outer edges. Suitable transverse members along the cross beams have also been provided.
- Moment and shear force will be calculated separately for inner & outer girders by keeping the loading with minimum eccentricity to crash barrier.
- For the design of the longitudinal Girders stresses and moments shall be determined at End of solid section, End of tapering section and at an every interval of L/8.
- Transverse members of the grillage other than the Cross-diaphragm shall be modelled as slab elements.

4. MODELING AND ANALYSIS OF RCC GIRDER

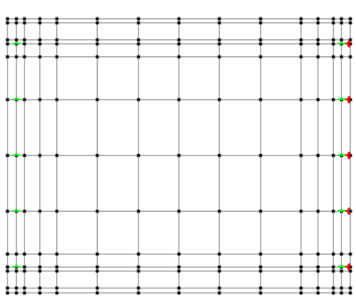

Fig.4.1 Grillage Analysis model of 20m Span RCC T Girder with 0^0 Skew

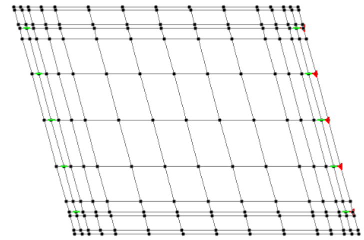

Fig.4.2 Grillage Analysis model of 20m Span RCC T Girder with 15^0 Skew

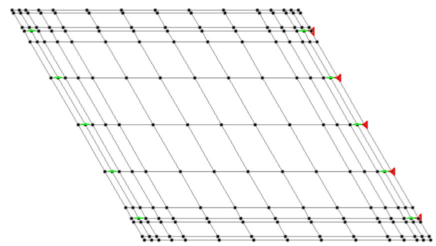

Fig.4.3 Grillage Analysis model of 20m Span RCC T Girder with 30^0 Skew

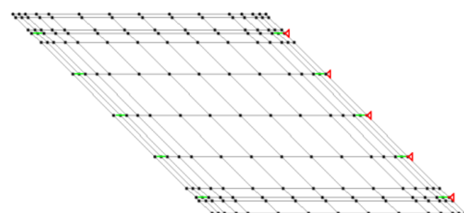

Fig.4.4 Grillage Analysis model of 20m Span RCC T Girder with 45^0 Skew

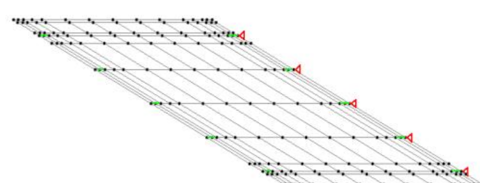

Fig.4.5 Grillage Analysis model of 20m Span RCC T Girder with 60^0 Skew

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4.1 SECTION DIMENSIONS OF RCC I-GIRDER

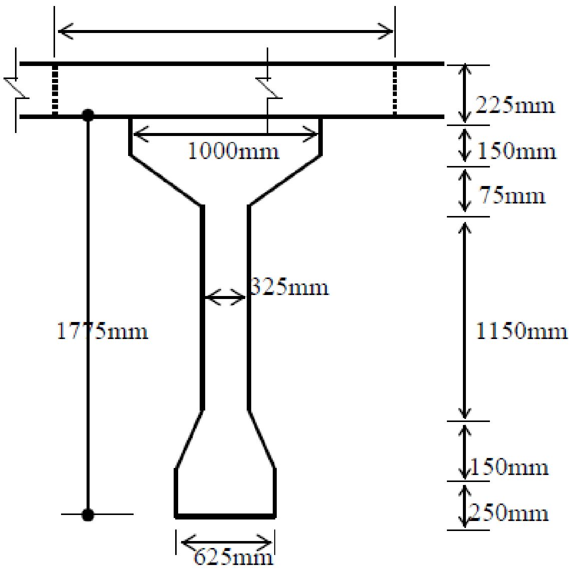

Fig.4.6. Mid-Section Dimensions of RCC I Girder

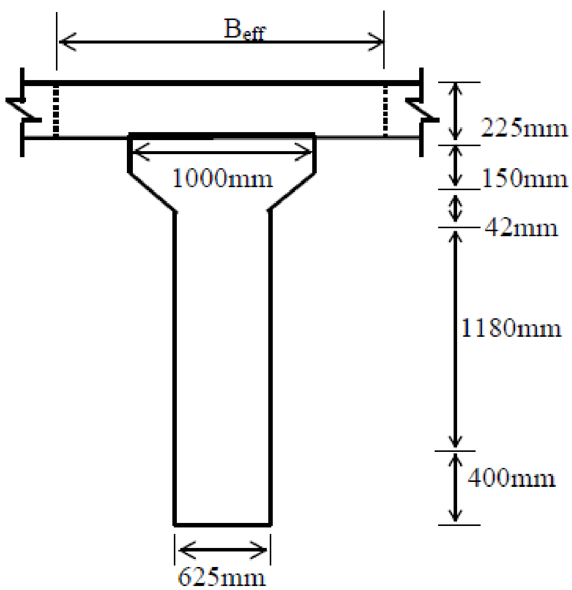

Fig.4.7. End-Section Dimensions of RCC I Girder

5. ANALYSIS RESULTS

5.1 Bending Moment & Shear Force Results:

From the analysis of grillage model the bending moment and shear force results for different girders are given in following table. We consider the maximum bending moment for internal and external girders.

Table 5.1 Bending Moment and Shear Force for 1st Girder with different skew angels

Section	Without Skew		With 15 Deg Skew		With 30 Deg Skew		With 45 Deg Skew		With 60 Deg Skew	
	BM 'kN-m'	SF 'kN'	BM 'kN-m'	SF 'kN'	BM 'kN-m'	SF 'kN'	BM 'kN-m'	SF 'kN'	BM 'kN-m'	SF 'kN'
@End of solid sec	47.901	9.769	78.759	11.046	694.162	487.084	2627.627	1052.145	4720.688	1151.572
@ End of tap. Sec	131.148	9.539	149.619	10.403	262.958	322.842	1580.684	637.726	3726.5	513.907
@ 2L/8	395.785	8.01	482.399	5.369	730.853	91.241	1041.674	219.383	1622.917	241.559
@ 3L/8	501.781	5.518	613.003	2.305	769.468	77.185	1389.105	119.24	822.994	64.142
@ 4L/8	544.482	3.037	676.756	2.435	664.512	77.809	1331.327	170.404	604.738	150.679
@ 5L/8	499.014	5.35	629.819	6.096	629.923	81.005	1042.678	198.813	587.769	208.383
@ 6L/8	381.95	7.966	494.427	9.565	540.273	89.75	631.38	209.981	610.453	243.776
@ End of tap. Sec	125.784	10.274	341.684	11.331	325.599	149.145	272.498	211.373	1042.088	259.145
@End of solid sec	129.546	23.088	282.37	24.732	211.547	149.145	270.459	211.127	1251.724	260.276

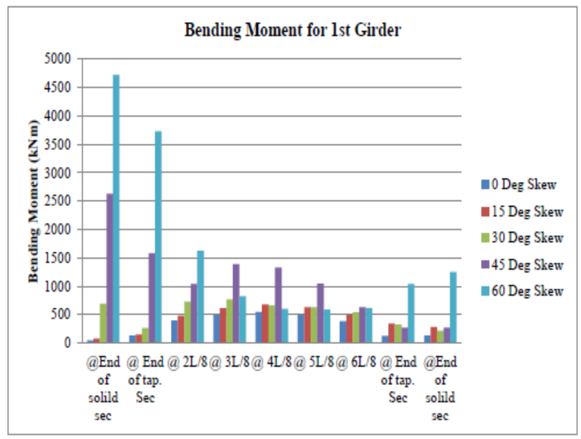

Fig 5.1 Bending moment graph for 1st Girder

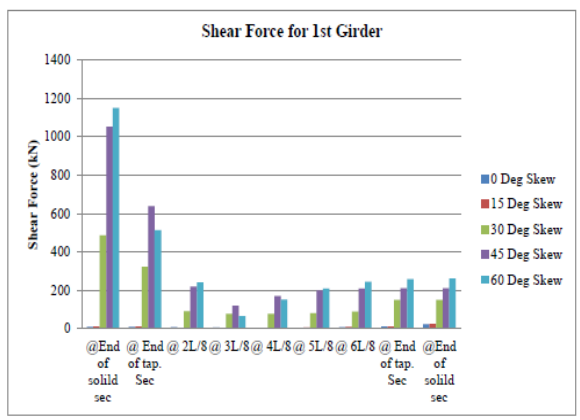

Fig 5.2 Shear Force graph for 1st Girder

Table 5.2 Bending Moment and Shear Force for 5th Girder with different skew angels

Section	Without Skew		With 15 Deg Skew		With 30 Deg Skew		With 45 Deg Skew		With 60 Deg Skew	
	BM 'kN-m'	SF 'kN'	BM 'kN-m'	SF 'kN'	BM 'kN-m'	SF 'kN'	BM 'kN-m'	SF 'kN'	BM 'kN-m'	SF 'kN'
@End of solid sec	13.078	2.667	10.103	0.968	13.792	10.582	295.54	269.86	1448.266	298.311
@ End of tap. Sec	36.497	2.653	18.436	0.966	20.193	10.7	61.981	269.719	1205.454	297.129
@ 2L/8	111.953	2.253	47.264	0.641	44.91	9.901	818.181	266.892	532.433	279.274
@ 3L/8	146.317	1.648	63.437	0.164	61.524	6.909	1333.839	250.91	286.678	238.483
@ 4L/8	161.546	0.748	69.811	0.291	68.457	3.998	1689.829	213.152	341.806	172.052
@ 5L/8	156.501	1.507	64.804	0.696	64.146	6.92	1752.745	135.573	812.703	76.666
@ 6L/8	127.115	2.189	50.373	1.019	50.377	9.609	1290.027	279.423	1866.767	281.423
@ End of tap. Sec	68.732	2.564	17.732	1.02	19.525	10.181	2012.086	810.396	4341.104	597.561
@End of solid sec	70.998	2.598	8.981	0.938	13.792	9.976	3307.79	1316.792	5521.34	1280.071

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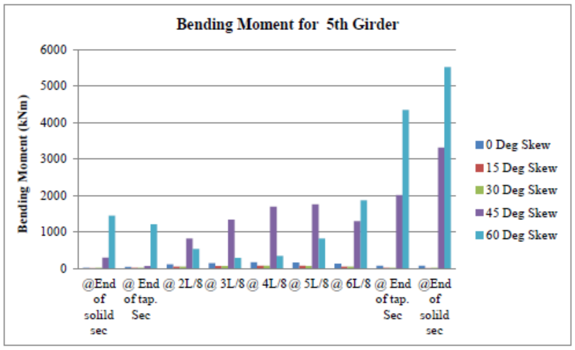

Fig 5.3 Bending moment graph for 5th Girder

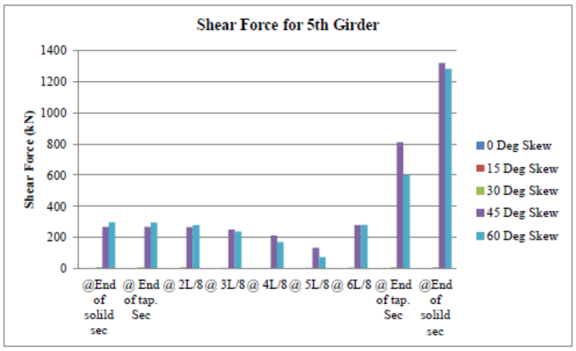

Fig 5.4 Shear Force graph for 5th Girder

Table 5.3 Bending Moment and Shear Force for 2nd Girder with different skew angels

Section	Without Skew		With 15 Deg Skew		With 30 Deg Skew		With 45 Deg Skew		With 60 Deg Skew	
	BM 'kN-m'	SF 'kN'	BM 'kN-m'	SF 'kN'	BM 'kN-m'	SF 'kN'	BM 'kN-m'	SF 'kN'	BM 'kN-m'	SF 'kN'
@End of solid sec	297.596	60.693	271.161	44.784	266.438	805.17	443.02	1278.726	262.609	980.964
@ End of tap. Sec	746.147	54.379	687.317	49.004	848.671	695.255	1434.679	1103.583	1070.254	943.88
@ 2L/8	1852.433	38.26	1736.46	32.867	1883.438	357.176	3091.848	410.404	2480.809	413.579
@ 3L/8	2262.615	30.148	2109.147	0.21	2145.789	272.745	3182.596	253.414	2647.205	256.61
@ 4L/8	2421.856	22.952	2268.03	9.685	2314.594	207.53	2804.502	268.487	2435.156	220.094
@ 5L/8	2295.861	27.847	2142.068	19.977	2156.594	255.307	2162.234	322.535	2281.819	295.891
@ 6L/8	1822.646	35.565	1723.268	30.462	1720.607	335.725	1730.564	324.896	1816.669	340.53
@ End of tap. Sec	694.992	50.845	636.694	47.424	628.244	454.64	631.476	447.473	656.974	473.623
@End of solid sec	280.14	57.119	249.5	48.425	348.962	486.897	292.593	450.481	333.248	509.026

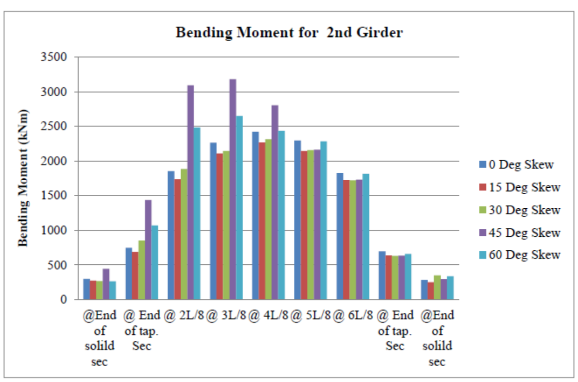

Fig 5.5 Bending moment graph for 2nd Girder

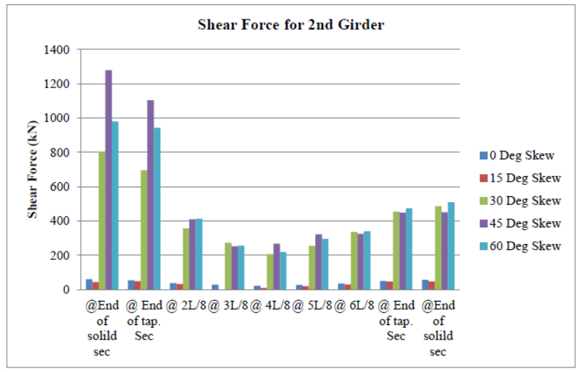

Fig 5.6 Shear Force graph for 2nd Girder

Table 5.4 Bending Moment and Shear Force for 3rd Girder with different skew angels

Section	Without Skew		With 15 Deg Skew		With 30 Deg Skew		With 45 Deg Skew		With 60 Deg Skew	
	BM 'kN-m'	SF 'kN'	BM 'kN-m'	SF 'kN'	BM 'kN-m'	SF 'kN'	BM 'kN-m'	SF 'kN'	BM 'kN-m'	SF 'kN'
@End of solid sec	285.829	58.293	264.005	45.613	268.531	524.345	258.074	511.63	271.168	515.503
@ End of tap. Sec	714.122	52.049	676.548	37.713	682.454	481.818	660.556	460.611	635.432	483.989
@ 2L/8	1745.237	36.098	1673.535	32.205	1729.676	344.008	1759.024	334.184	1826.317	349.756
@ 3L/8	2116.621	28.825	2029.838	0.584	2096.897	263.772	2141.045	250.21	2287.58	254.178
@ 4L/8	2244.372	22.118	2150.374	9.908	2245.028	205.242	2291.889	186.991	2418.271	179.398
@ 5L/8	2124.57	26.686	2009.184	18.523	2082.916	251.159	2084.607	234.906	2279.567	244.36
@ 6L/8	1703.366	33.018	1627.335	8.594	1671.342	325.117	1653.711	312.706	1795.16	345.99
@ End of tap. Sec	661.588	48.222	627.434	44.323	601.082	445.893	603.848	436.004	574.005	474.446
@End of solid sec	260.416	53.11	239.384	41.876	253.012	489.436	238.408	483.699	304.234	520.842

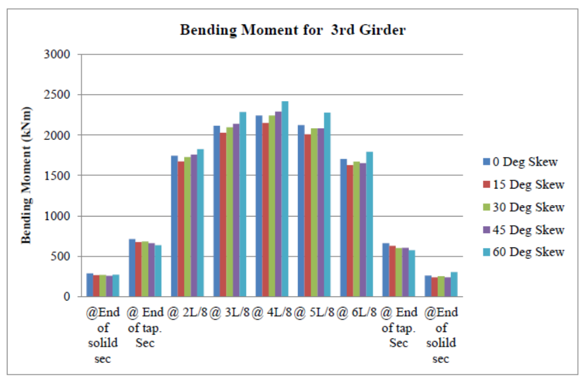

Fig 5.7 Bending moment graph for 3rd Girder

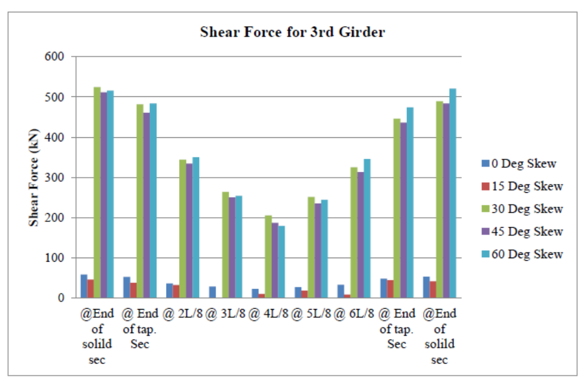

Fig 5.8 Shear Force graph for 3rd Girder

Table 5.5 Bending Moment and Shear Force for 4th Girder with different skew angels

Section	Without Skew		With 15 Deg Skew		With 30 Deg Skew		With 45 Deg Skew		With 60 Deg Skew	
	BM 'kN-m'	SF 'kN'	BM 'kN-m'	SF 'kN'	BM 'kN-m'	SF 'kN'	BM kN-m'	SF 'kN'	BM 'kN-m'	SF 'kN'
@End of solid Sec	115.115	23.477	123.431	21.914	137.375	209.603	180.107	316.031	360.421	390.759
@ End of tap. Sec	294.399	21.44	285.109	20.454	307.266	198.279	352.415	317.773	368.982	388.923
@ 2L/8	732.508	14.512	739.037	14.602	730.409	138.29	1399.523	319.509	1274.795	367.852
@ 3L/8	891.63	10.306	876.385	9.786	858.493	93.851	2101.46	304.013	2017.516	317.082
@ 4L/8	893.701	7.103	857.724	3.855	845.364	61.522	2657.726	253.892	2525.722	217.569
@ 5L/8	780.999	9.689	746.515	1.515	718.339	86.242	2941.834	152.945	2714.615	192.4
@ 6L/8	600.76	12.06	559.645	2.798	531.14	111.867	2661.048	371.386	2363.064	456.295
@ End of tap. Sec	219.515	15.985	199.513	11.35	172.384	144.144	1313.502	984.763	866.505	865.523
@End of solid Sec	85.055	17.346	68.141	13.438	60.516	158.501	483.977	1156.696	326.653	913

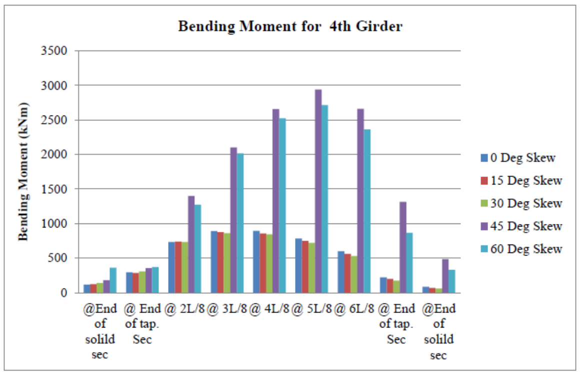

Fig 5.9 Bending moment graph for 4th Girder

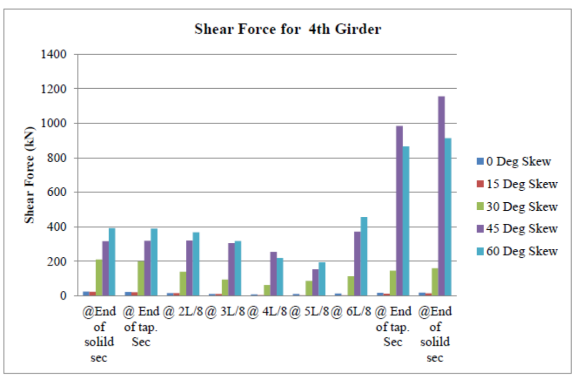

Fig 5.10 Shear Force graph for 4th Girder

Table 5.6 Maximum Torsion Moment for External Girders with Different Skew Angels

Section	EXTERNAL GIRDER MAXIMUM				
	With Out Skew	With 15 Deg Skew	With 30 Deg Skew	With 45 Deg Skew	With 60 Deg Skew
	Mx(kN-m)	Mx(kN-m)	Mx(kN-m)	Mx(kN-m)	Mx(kN-m)
@End of solid sec	0	631.45	1632.913	3184.05	3066.418
@ End of tap. Sec	0	503.933	1338.252	2708.34	2758.335
@ 2L/8	0	225.53	669.98	1650.846	2084.602
@ 3L/8	0	117.074	381.25	1089.761	1645.484
@ 4L/8	0	64.802	232.635	945.728	1521.243
@ 5L/8	0	102.042	165.124	1378.375	1888.182
@ 6L/8	0	198.645	171.776	2086.402	2392.895
@ End of tap. Sec	0	444.932	351.403	3420.75	3168.448
@End of solid sec	0	592.845	351.403	3989.896	3540.143

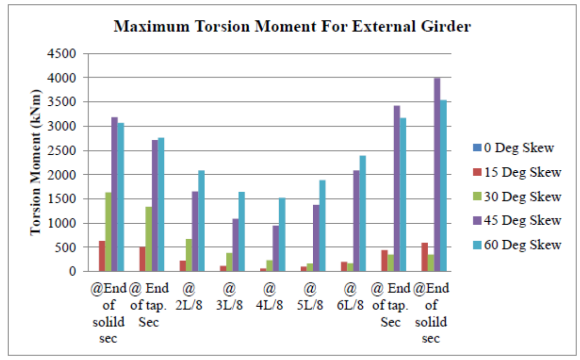

Fig 5.11 Maximum Torsion Moment graph for External Girders

Table 5.7 Maximum Torsion Moment for Internal Girders with Different Skew Angels

Section	INTERNAL GIRDER MAXIMUM				
	With Out Skew	With 15 Deg Skew	With 30 Deg Skew	With 45 Deg Skew	With 60 Deg Skew
	Mx(kN-m)	Mx(kN-m)	Mx(kN-m)	Mx(kN-m)	Mx(kN-m)
@End of solid sec	0	113.27	120.345	162.459	301.598
@ End of tap. Sec	0	100.993	104.933	179.198	303.158
@ 2L/8	0	65.751	125.403	244.988	314.052
@ 3L/8	0	52.673	111.444	240.86	318.145
@ 4L/8	0	38.829	80.503	260.18	318.145
@ 5L/8	0	44.231	54.748	292.098	313.175
@ 6L/8	0	56.705	61.837	292.098	309.741
@ End of tap. Sec	0	85.998	86	168.295	269.726
@End of solid sec	0	99.471	101.231	130.85	268.045

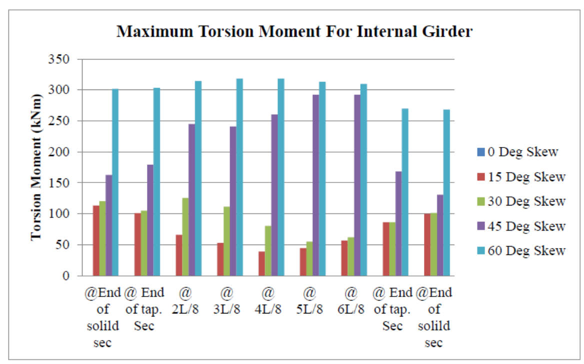

Fig 5.12 Maximum Torsion Moment graph for Internal Girders

CONCLUSION

Torsion moment of inertia effect on the RCC I-girder bridge with different skew angels i.e. 0o, 15o, 30o, 45o, and 60o were studied in this research.

- Torsion moment of inertia is calculated based on Timoshenko and Goodier asdescribed in chapter 4.

- All the properties of girder sections are inserted in the grillage model.
- Bending moment, shear force and torsion moments are getting from the STAADgrillage analysis results.
- As skew increases the longitudinal bending moments are increased and the torsion moments also increased.
- The results tables show that bending moment, shear force and torsion moment at different sections of each girder.
- Torsion moment is more at end girders compared to inner girder.
- For straight girder bridge no torsion moment is observed.
- Hence it is concluded that, without torsion moment of inertia property there is no torsion moment is occurred.
- As skew changes the center of gravity of bridge also changes so maximum moment does not occurs at center of the girder for skew brides.

REFERENCE

[1]. IRC:6-2000; Standard Specifications and code of practice for road bridges; Section II: Loads and Stresses (4th revision); The Indian Roads Congress (New Delhi, 2000).

[2]. IRC:21-2000; Standard Specifications and code of practice for road bridges; Section III: Cement Concrete (Plain and Reinforced, 3rd revision); The Indian Roads Congress (New Delhi, 2000).

[3]. IRC:112-2011; Code of practice for concrete road bridges; The Indian Roads Congress 2011 (New Delhi, 2011).

[4]. IRC 83 part II (1987), "Standard Specifications and Code of Practice for Road Bridges Section IX, Elastomeric Bearings", The Indian Road of Congress, New Delhi, India

[5]. RajaGopalan K.S (1969), "Comparison of Loads around the world for design of highway brides". Paper sp 26-2.

[6]. Victor D. Johnson (1980), Essentials of Bridge Engineering, Third Edition, Oxford and IBH Publishing Co. Pvt. Ltd., India.

[7]. Raina V.K (1994), "Concrete Bridge Practice, Analysis Design and Economics", 2nd edition, Tata McGraw-hill publishing company limited, New Delhi.