PARAMETRIC STUDY AND COMPARISON OF I-GIRDER BRIDGE WITH DIFFERENT SUPPORT CONFIGURATION

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ABSTRACT

A study of I-girder with same cross-section, same number of support and same number of intermediate diaphragm but with 4 different support configurations is done. Commercial available software STAAD PRO has been used to carry out linear analysis of these I-girder bridges. Grillage method of analysis has been used to analyze the bridges. The linear analysis has been carried out for the dead load (self weight) and live load of Indian Road Congress (IRC) class 70R LOADING, CLASS A1 LOADING, CLASS A TWO LANE AND CLASS A FOUR LANE for eccentricity loading as per IRC is done.

The paper presents a parametric study for deflection, bending and shear for different support configuration. It is found that the continuous span with equally spaced support is superior to other three support configuration. It can be stated that the obtained results will provide guidance to bridge designers.

Keywords – I-GIRDERS; diaphragm; bending moment; shear force; support configuration.

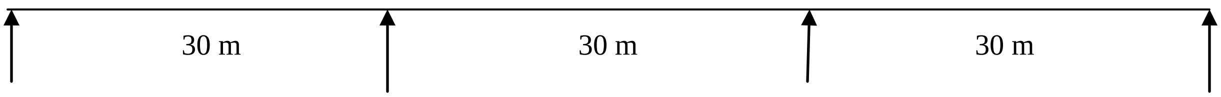
1. INTRODUCTION

I-Girder have gained wide acceptance in freeway and bridge system due to their structural efficiencies, better stability, serviceability, economy of construction and pleasing aesthetics. Analysis of prestress I-girder bridge is very complex because of its three dimensional behavior consisting of torsion, bending and shear. Diaphragms are used to connect all the girders at mid span and on the support to hold all the girders together which also reduces deflection. Greater span will give greater bending moment and thus depth of cross section will also increase and more amount of concrete and prestressing force will be required. While giving support configuration to a bridge one must take care that the difference between sudden changes in bending moment is not too high (that is no shooting moment). Thus the shear force will be less.

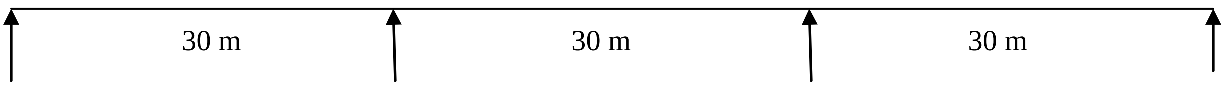
2. PROBLEM DEFINATION

In the present work comparison of I-girder Bridge with four different support configuration namely:

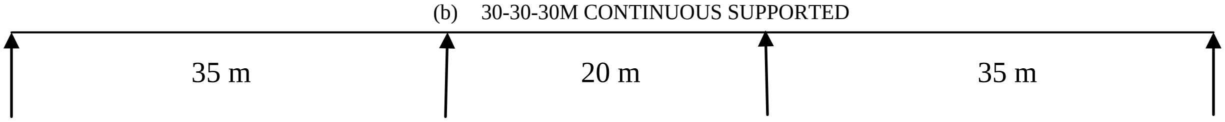
a. 30-30-30m continuous span
b. 30-30-30m simply supported span
c. 25-40-25m continuous span
d. 25-40-25m simply supported span



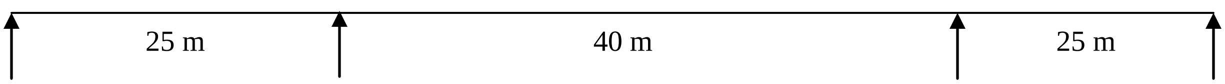
(a) 30M SIMPLY SUPPORTED



(b) 30-30-30M CONTINUOUS SUPPORTED



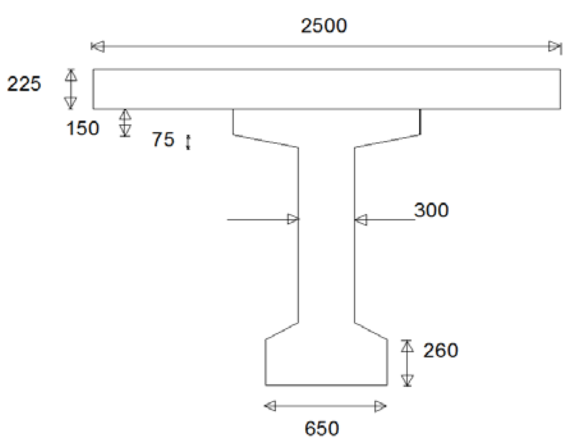
(c) 35-20-35M CONTINUOUS SUPPORTED



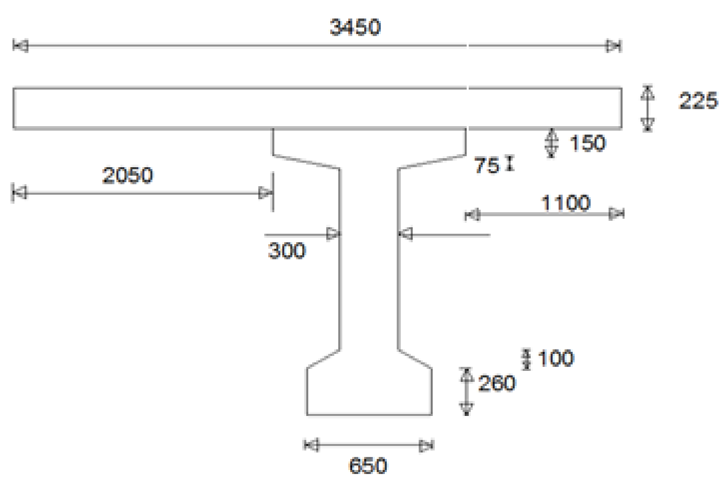
(d) 25-40-25 M CONTINUOUS SUPPORTED

The analysis of the bridge was done taking into consideration same area of cross section of I-girder and same length of bridge, that is 90 m. Also the number of support was kept same, that is four nos. The linear analysis has been carried out for the dead load (self weight) and live load of Indian Road Congress (IRC) class 70R LOADING, CLASS A loading for bridge using STAAD PRO. Deflection, bending moment, shear force was calculated and the comparison of four bridges has been done for various support configuration.

2.1 CROSS SECTION DETAILS



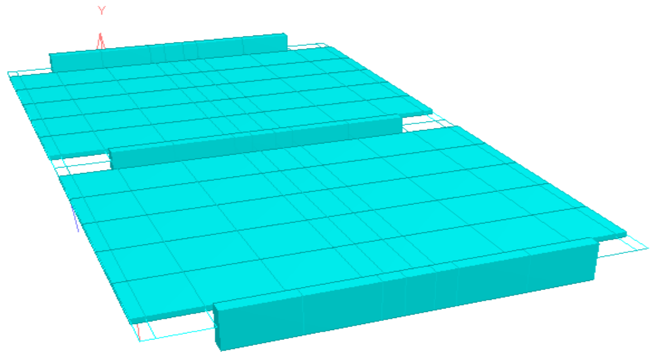
(a) (I-GIRDER WITH DECK)

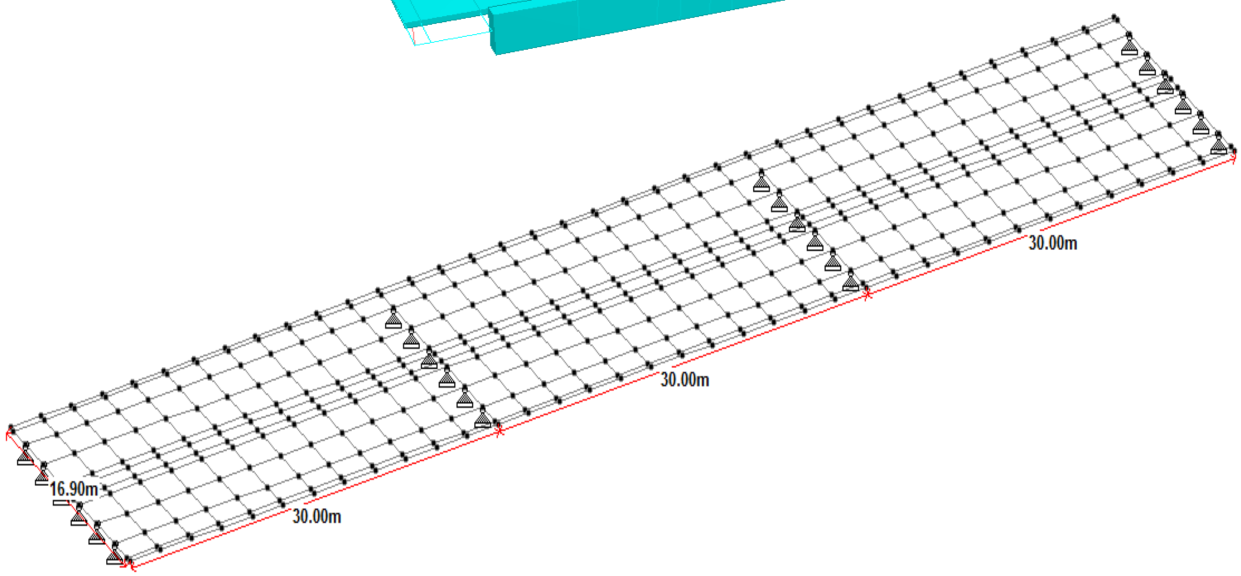


(b) (END DECK)

3. STAAD MODELLING AND DESCRIPTION

STAAD PRO is a commercially available analysis and design software also used for analysis of bridge including moving loads. The grillage modeling was done for the analysis of I-girder bridge.





Section property to the girders was give by conducting the Ixx, Iyy and area of the section including the deck.

Gross section property to the end girder was given by calculating the Ixx, Iyy and area of the figure (a). And gross section property to the intermediate girder was given by calculating Ixx, Iyy and area of the figure (b).

Material property was given to the girder such as density, poisons ratio, damping etc. This modeling gives stiffness to the bridge in the direction of the girder (i.e. x direction). To give stiffness in z direction. Dummy cross beams were provided at a distance of 2.1 m. stiffness was given to the dummy cross beams but no density was given so that there is no overlapping of self weight. Diaphragms were provided on the support and also on the mid span of all the four bridges.

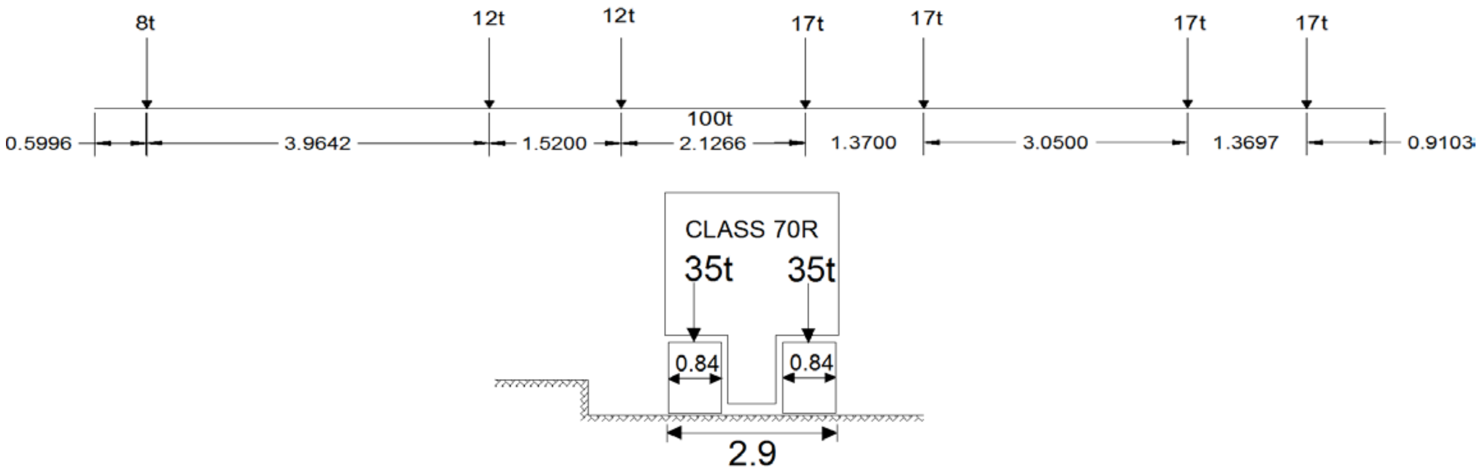
3.1 LOADING PLACEMENT

IRC class 70R load was first applied and checked for deflection and bending moment and similarly class A 1 LANE, class A 2 LANE and class A 4 LANE loading was applied and checked for deflection and bending moment. The loading was placed as moving load which was at a distance of 2.5 m.

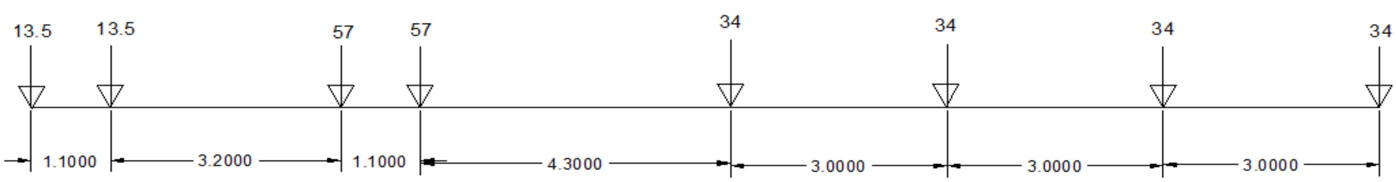
4. TRANSVERSE LOADING PLACEMENT

4.1 70R LOADING

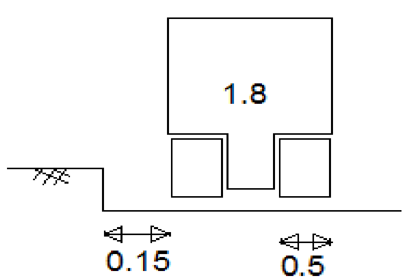
a. CASE 1



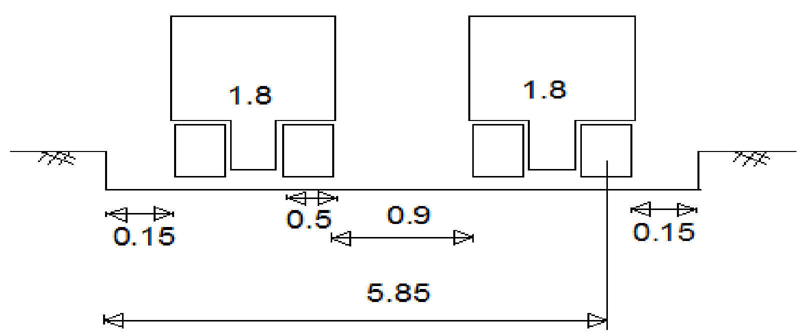
4.2 CLASS A LOADING



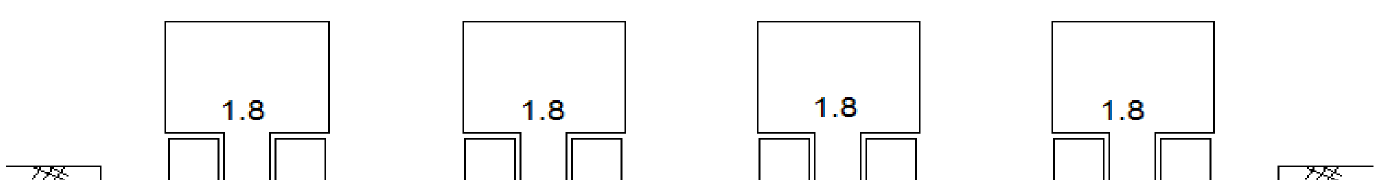
a. CASE 1



b. CASE 2



b. CASE 3



5. RESULTS AND COMPARISON

(Due to the limitation of space the results like BM, SF and Deflection of dead load at a particular section (L/2,L/4,L) bridge are represented graphically).

5.1 30-30-30M SIMPLY SUPPORTED

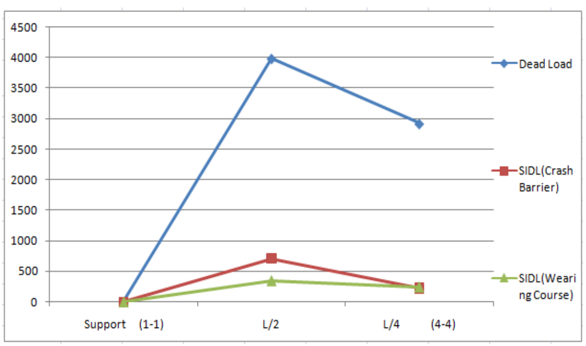
COMPARISON OF EXSTERNAL AND INTERNAL GIRDER FOR DEAD LOAD

PARAMETERS	EXSTERNAL GIRDER (max.)	INTERNAL GIRDER (max.)
Deflection (mm)	28.45	28.43
Bending Moment (kN.m)	5268.73	5023.82
Shear Force (kN)	168	126

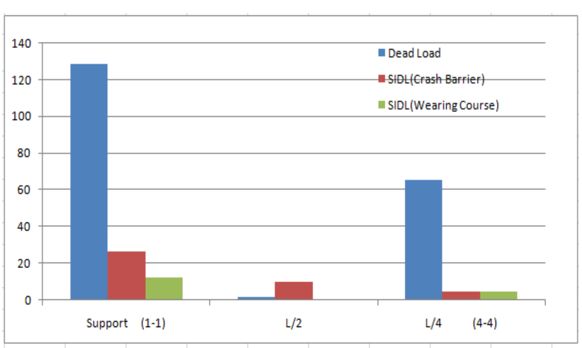
COMPARISON OF EXSTERNAL AND INTERNAL GIRDER FOR LIVE LOAD

PARAMETERS	EXSTERNAL GIRDER	INTERNAL GIRDER
Deflection	18.89	12.62
Bending Moment	3488.4	2085.2
Shear Force	120	62.3

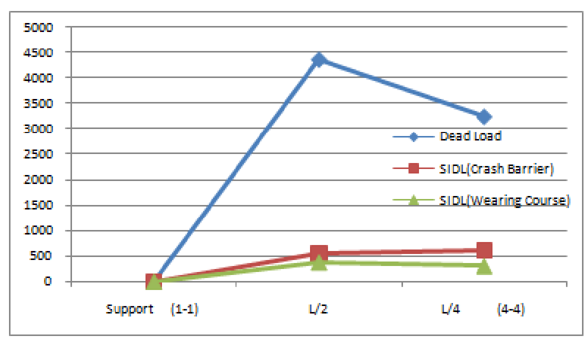
EXTERNAL GIRDER:



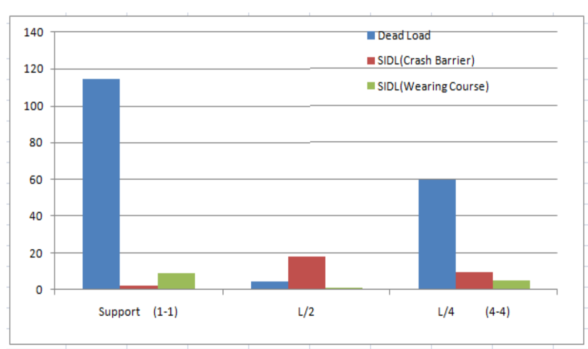
LONGITUDINAL BENDING MOMENT



INTERNAL GIRDER:



LONGITUDINAL BENDING MOMENT



SHEAR FORCE SHEAR FORCE

From the above table & graphs it is observed that the difference between B.M & Deflection is quite less in both the cases i.e. dead load and live load. In case of dead load the S.F in external girder is moderately higher than the internal girder but in case of moving load the S.F in external girder is twice as that of internal girder.

5.2 30-30-30M CONTINUOUS SUPPORTED SPAN

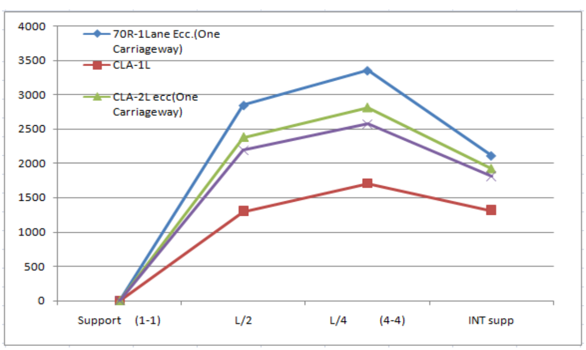
COMPARISON OF EXSTERNAL AND INTERNAL GIRDER FOR DEAD LOAD

PARAMETERS	EXSTERNAL GIRDER (max.)	INTERNAL GIRDER (max.)
Deflection (mm)	20.627	24.64
Bending Moment (kN.m)	5618.75	2789.78
Shear Force (kN)	215.2	129.96

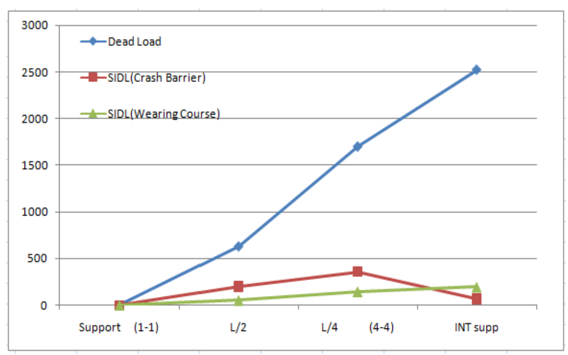
COMPARISON OF EXSTERNAL AND INTERNAL GIRDER FOR LIVE LOAD

PARAMETERS	EXSTERNAL GIRDER	INTERNAL GIRDER
Deflection	18.89	12.94
Bending Moment	3350.2	1030
Shear Force	140	58

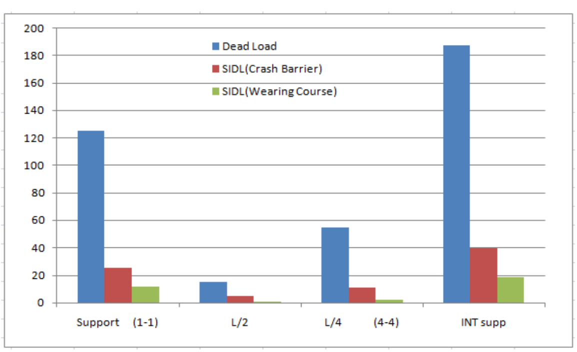
EXTERNAL GIRDER

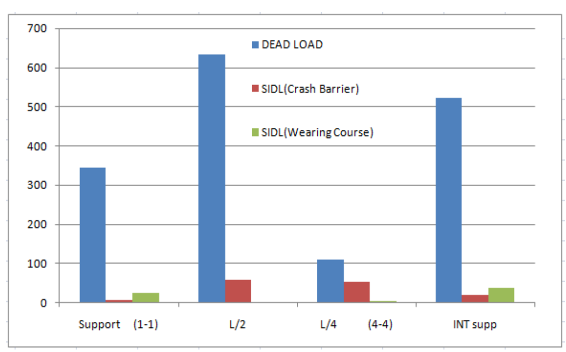


INTERNAL GIRDER



LONGITUDINAL BENDING MOMENT LONGITUDINAL BENDING MOMENT





SHEAR FORCE SHEAR FORCE

From the above table & graphs it can be observer that the B.M & S.F in the external girder is almost twice as that of internal girder. Whereas there is no great difference in deflection on the girders. In case of moving load the S.F, Deflection & B.M value of internal girder is less than the half of that of the external girder.

5.3 35-20-35 M CONTINUOUS SUPPORTED SPAN

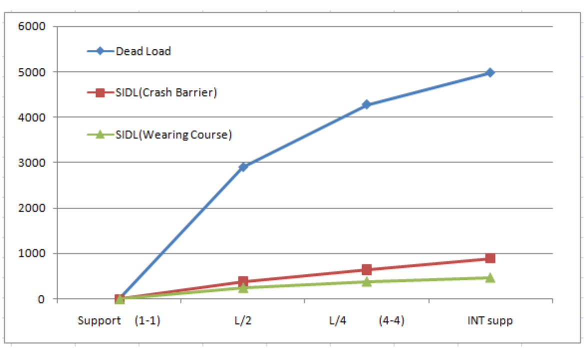
COMPARISON OF EXSTERNAL AND INTERNAL GIRDER FOR DEAD LOAD

PARAMETERS	EXSTERNAL GIRDER (max.)	INTERNAL GIRDER (max.)
Deflection (mm)	39.18	43.85
Bending Moment (kN.m)	6332.03	3002.145
Shear Force (kN)	283.19	139.6

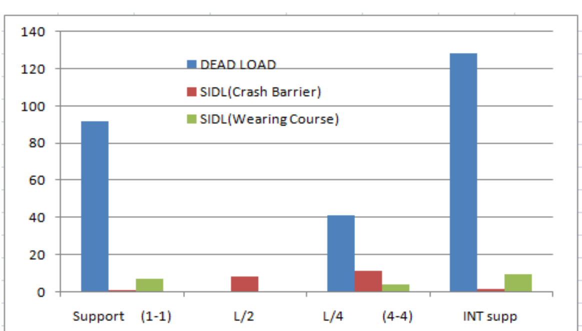
COMPARISON OF EXSTERNAL AND INTERNAL GIRDER FOR LIVE LOAD

PARAMETERS	EXSTERNAL GIRDER	INTERNAL GIRDER
Deflection	19.31	16.22
Bending Moment	3119.4	998
Shear Force	146	65.3

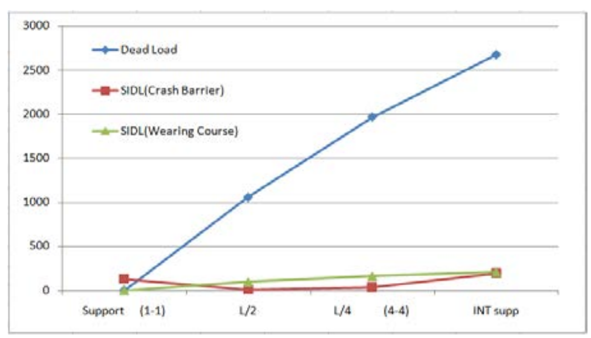
EXTERNAL GIRDER



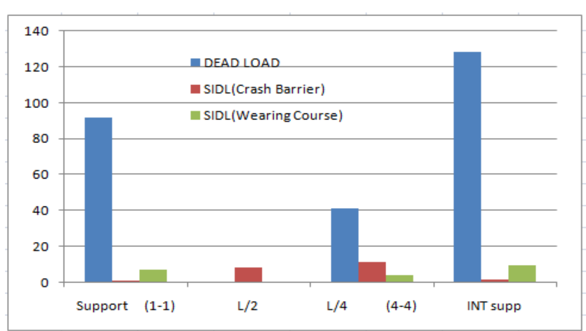
LONGITUDINAL BENDING MOMENT



INTERNAL GIRDER



LONGITUDINAL BENDING MOMENT



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5.4 25-40-25 M CONTINUOUS SUPPORTED SPAN

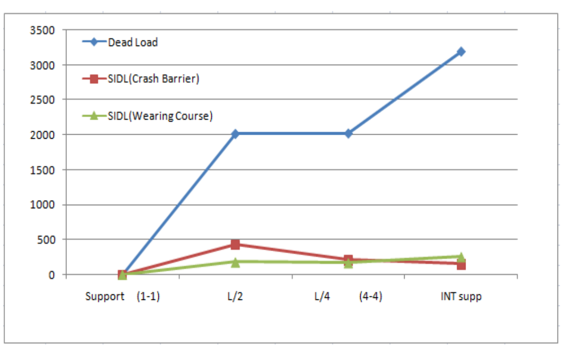
COMPARISON OF EXSTERNAL AND INTERNAL GIRDER FOR DEAD LOAD

PARAMETERS	EXSTERNAL GIRDER (max.)	INTERNAL GIRDER (max.)
Deflection (mm)	37.71	42.95
Bending Moment (kN.m)	7462.98	3589.36
Shear Force (kN)	272.33	140.52

COMPARISON OF EXSTERNAL AND INTERNAL GIRDER FOR LIVE LOAD

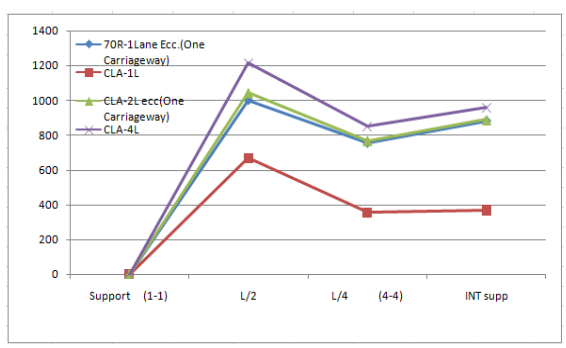
PARAMETERS	EXSTERNAL GIRDER	INTERNAL GIRDER
Deflection	27.71	22.28
Bending Moment	3666	1214
Shear Force	142	64

EXSTERNAL GIRDER

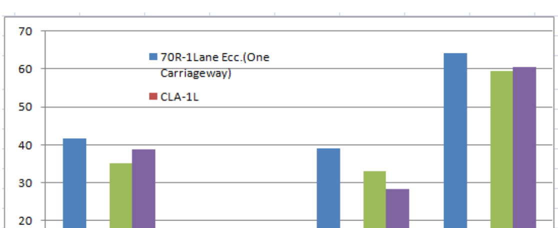


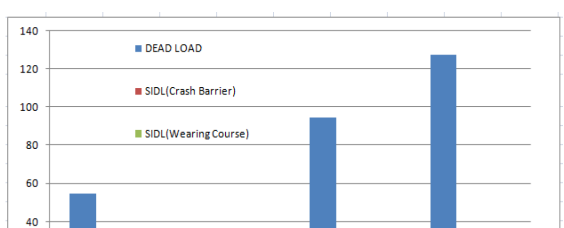
LONGITUDINAL BENDING MOMENT

INTERNAL GIRDER



LONGITUDINAL BENDING MOMENT





SHEAR FORCE SHEAR FORCE

From the above table & graphs it can be observer that the B.M & S.F in the external girder is almost twice as that of internal girder. Whereas there is no great difference in deflection on the girders. In case of moving load the S.F, Deflection & B.M value of internal girder is less than the half of that of the external girder.

6. COMPARISON OF SPANS

The comparison of different support configuration was done by comparing maximum values of shear force, Bending moment and Deflection of different spans. The below table gives a brief idea about the behavior of the bridge under different loading conditions.

6.1 EXTERNAT GIRDER:

PARAMETER	LOAD TYPE		30 SIMPLY	30-30-30 CON.	35-20-35 CON.	25-40-25 CON.
COMPARISON OF BENDING MOMENT						
B.M.	DEAD LOAD		5268	4660	6332	7463
	LIVE LOAD	70R	3488	3350	3119	2726
		CL-A-1	1820	1708	2010	1805
		CL-A-2	2956	2813	2982	2610
		CL-A-4	2465	2571	2754	2421
	DESIGN VALUE		8756	8010	9451	10189
COMPARISON OF SHEAR FORCE						
S.F.	DEAD LOAD		268	245	283	273
	LIVE LOAD	70R	120	140	146	142
		CL-A-1	81	93	106	104
		CL-A-2	98	116	135	129
		CL-A-4	93	109	129	124
	DESIGN VALUE		388	385	429	415
COMPARISON OF DEFLECTION						
DF.	DEAD LOAD		28.45	20.62	39.18	37.71
	LIVE LOAD	70R	18.89	16.05	19.30	26.00
		CL-A-1	11.41	9.37	11.45	15.48
		CL-A-2	17.06	14.53	18.1	27.71

		CL-A-4	14.64	13.52	16.76	22.91

6.2 INTERNAT GIRDER:

PARAMETER	LOAD TYPE		30 SIMPLY	30-30-30 CON.	35-20-35 CON.	25-40-25 CON.
COMPARISON OF BENDING MOMENT						
B.M.	DEAD LOAD		5024	2790	3002	3589
	LIVE LOAD	70R	2083	706	998	881
		CL-A-1	1254	267	441	368
		CL-A-2	1967	646	989	888
		CL-A-4	1960	707	1084	957
	DESIGN VALUE		7107	3496	4086	4546
COMPARISON OF SHEAR FORCE						
S.F.	DEAD LOAD		126	130	140	141
	LIVE LOAD	70R	62	58	65	64
		CL-A-1	19	11	14	13
		CL-A-2	55	47	60	59
		CL-A-4	55	48	61	60
	DESIGN VALUE		188	188	205	205
COMPARISON OF DEFLECTION						
DF.	DEAD LOAD		28.43	24.64	43.85	42.95
	LIVE LOAD	70R	12.62	11.90	14.63	19.62
		CL-A-1	6.47	5.73	7.30	10.18
		CL-A-2	11.94	11.48	14.28	19.47
		CL-A-4	11.89	11.42	16.21	22.29

7. CONCLUSION

In this paper results of linear analysis of I-girder Bridge with different support configuration namely

a. 30-30-30m simply supported span.
b. 30-30-30m continuous span.
c. 35-20-35m continuous span.
d. 25-40-25m continuous span.

The result presented highlights the effect of spacing of the supports on the behavior of the bridge in terms of deflection, bending moment ad shear force. This detailed study is carried out using STAAD. Pro software and grillage modeling is done. It can be concluded that from the presented study that continuous span with equally spaced support is superior to other three support configurations. The following points highlights the reason of considering 30-30-30m continuous span to be the most efficient configuration of supports.

- The maximum design Bending moment of concluded span is much lesser than the other three configurations
- The difference between sudden changes in Bending moment is not too high. Thus while designing the girder the prestressed cable profile will also be smooth.
- The design shear force values of other three configurations are much quite higher than the concluded span.

- The deflection value is less in case of 30-30-30 continuous span while the deflection values of other three configurations are much higher.

It can also be believed that the result presented in this paper will be of valuable guidance to the designers.

8. REFERENCES

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- KRISHANA RAJU “DESIGN OF BRIDGES” OXFORD AND IBH PUBLICATION CO.PVT.LTD”
- PROF. DR.ING.G.ROMBACH “CONCEPTS FOR PRESTRESSED CONCRETE BRIDGES
- PRESTRESSED CONCRETE : N KRISHANA RAJU
- IRC 112 (2011): CODE OF PRACTICE FOR CONCRETE ROAD BRIDGES.
- IS 6006-1993:INDIAN STANDARD SPECIFICATION FOR UNCOATED STRESS RELIEVED STRAND FOR PRESTRESSED CONCRETE
- BRIDGE DESIGN USING THE STAAD.PRO/BEAVA AASHTO CODE
- COMPREHENSIVE DESIGN EXAMPLE FOR PRESTRESSED CONCRETE (PSC) GIRDER SUPERSTRUCTURE BRIDGE WITH COMMENTARY
  (Task order DTFH61-02-T-63032)
- ASIAN JOURNAL OF CIVIL ENGINEERING (BUILDING AND HOUSING) VOL. 11, NO. 1 (2010)

THANK YOU