Comparative Study of Prestressed Concrete Girder and Steel Plate Girder Used in Bridge Construction Under City Areas

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Abstract: *This project presents the comparative study of Prestressed Concrete Girder and Steel Plate Girder coming under city areas. In India PSC Girders and Steel Plate Girders supported over piers and abutments are being used for a long time. There are certain problems incurred in PSC Girder which includes the self weight of PSC Girder which is very high and therefore it is difficult to launch and cast at site. Due to heavy weight of PSC Girder the size and depth of foundation become heavier and because of this structure becomes uneconomical. The possibility of working problems is more in PSC Girder, accidents often occur. For e.g. Varanasi(UP) 2018 in the month of May. To meet out these problems comparative study of superstructure of PSC Girder vs Steel Girder has been proposed. The study includes the design of Steel Plate Girder and PSC Girder for 25 m length of span. The analysis is carried out on CSI BRIDGE software. The analysis includes the calculation of bending moment, shear force, axial force, longitudinal displacement, vertical displacement, deflection. The above calculated parameters are compared for both the girders. The goal of this study is to determine most favorable option from the above two.*

Keywords: CSI BRIDGE, Prestressed Concrete Girder, Steel Plate Girder, Vertical Displacement.

1. INTRODUCTION

City areas require elevated access to cross any type of obstacle in order to avoid level crossing. Elevated roads are provided in order to avoid level crossing in railways. In India especially in UP system of such provisions are: -

(I) Prestressed, Steel, and Composite Girder supported over piers and abutments.
(ii) Service lanes proposed for the local traffic
The problems incurred in the above system are: -
a) The weight of the PSC Girder is very high and it is very difficult to launch and cast at site.
b) Due to heavy weight the size and depth of foundation become heavier and because of this the structure becomes uneconomical.

c) The possibility of working problems is more, accidents often occur. E.g. Varanasi (UP) in the month of May (2018).
To meet out these problems comparative study of superstructure of PSC Girder vs Steel Girder has been proposed.

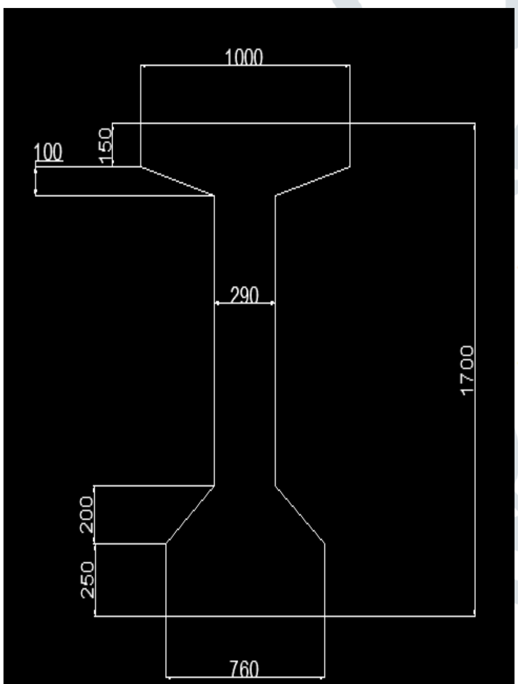
1.1 Prestressed Concrete Girder

Prestressed concrete is the most common form of construction. Prestressed Concrete Girder facilitates rapid construction of a bridge using girders that are fabricated off site and then transported and erected into place at the job site. It has become a well-established method of construction as the technology is now available in all developed and many developing countries. Ever since the development of prestressed concrete, the material has found extensive application in the construction of long span bridges. One of the most commonly used forms of superstructure in concrete bridges is precast girders with cast in situ slab. This type of superstructure is generally used for spans 20 to 40 m. T or I girder and box girder bridges are the most common example. There is a myth that PSC Girder is an economical option which is to be verified.

1.2 Plate Girder

A plate girder is basically an I beam built up from plates using bolting or welding. It is a deep flexural member that can be carried by rolled beams. Plate girders can have a greater height than rolled steel girders and are not limited to standardized shapes. The ability to customize a girder to the exact load conditions allows the bridge design to be more efficient. Plate Girder has smaller weight in comparison to PSC Girder. Stiffeners are occasionally welded between the compression flange and the web to increase the strength of the girder. The use of plate girders rather than rolled beam sections for the two main girders gives the designer freedom to select the most economical girder for the structure. Plate girders are often used in structures up to 30-40m.

Fig 1.1 cross section of PSC Girder



1.3 PSC Girder Details

Table 1

GENERAL DATA	VALUES
Grade of concrete	M 35
Reinforcement Provided	HYSD 500
Tendons Provided	7ply, 12.7 mm diameter
Type of bearing	Elastomeric bearing

1.4 Plate Girder Details

Table 2

GENERAL DATA	VALUES
Total Depth	1200 mm
Total Flange Width	400 mm
Web Thickness	13 mm
Bottom Flange Width	250 mm
Bottom Flange Thickness	25 mm
Grade of Steel	Fe 410
Welded Connection is to be provided	Fillet Welding
Weight of Girder per m run	10 KN/M

2. Methodology

To commence with the PSC Girder was manually designed by using limit state method based on IS 456:2000, IS 1343:2012, IRC 112:2011, IRC 18:2000. Based on the steps and formulas involved, a design program was prepared in MS Excel. The veracity of the program was checked by first designing the manually designed girder by using the program and comparing the result. The results generated from the program and the hand calculations was further verified on CSI BRIDGE software.

The Steel Girder was also firstly designed by using limit state method based on IS 800:2007, IRC 112:2011, IRC 24:2010. Based on steps and formulas involved, a design program was prepared in MS Excel. The veracity of the program was checked by first designing the manually designed girder by using the program and comparing the results. The results generated from the program and the hand calculations was further verified on CSI BRIDGE software.

For both the girders length of span considered is 25m subjected to same vehicular loading. Four longitudinal and six cross girders have been placed for the given length of span. The vehicular loading considered is Class70 (R) for 2 lane and Class(A) for 1 lane. All the guidelines as mentioned in IRC: 24-2010, IS:800-2007, IS:1343-2012 have been kept in mind while designing girder. For better understanding plan of the girder has also been made on AUTO CAD.

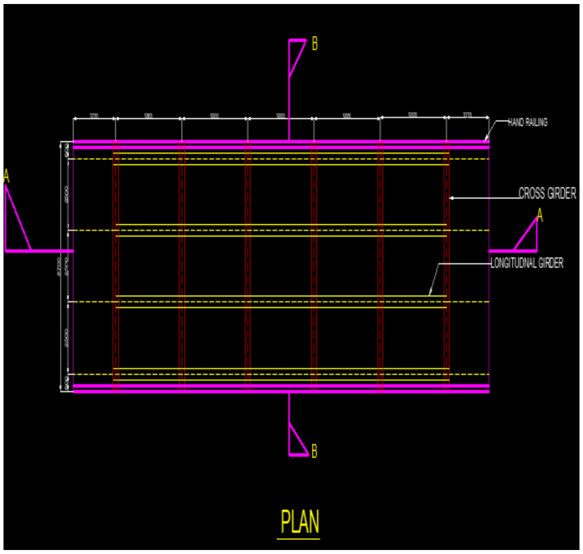


Fig 2.1 Plan of PSC Girder

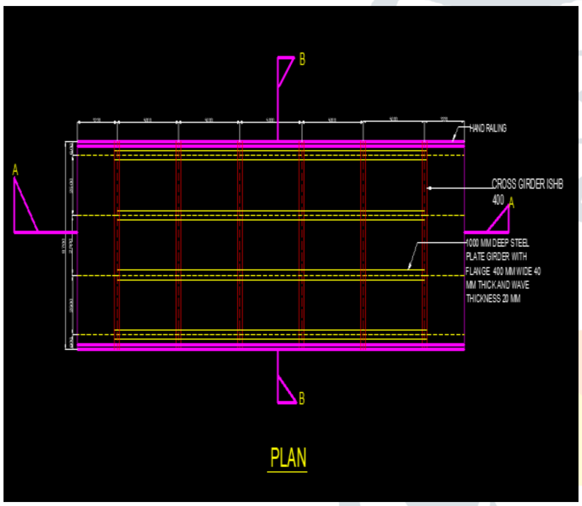


Fig 2.2 Plan of Plate Girder

3. Analysis and Comparison of Results

The analysis of both the girders was carried out on CSI bridge software. The parameters for analysis are: -

a) Shear Force
b) Bending Moment
c) Vertical Displacement
d) Axial Force

3.1 Shear Force

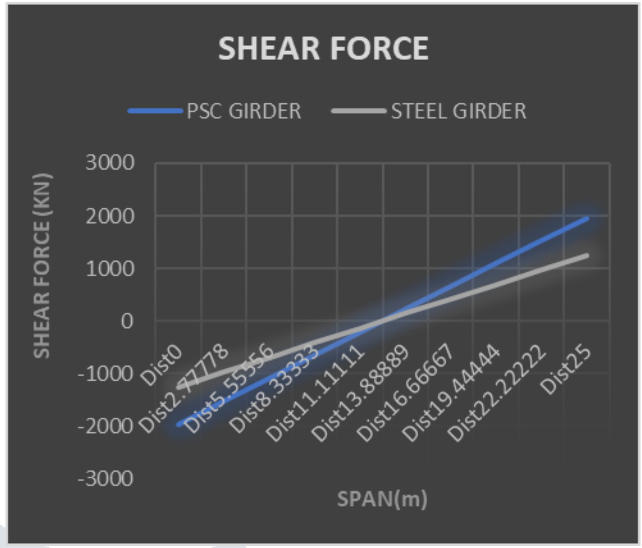


Fig 3.1 Shear Force in KN

Table 3

SPAN (m)	PSC GIRDER (KN)	PLATE GIRDER (KN)
0	-1581.023	-1253.239
2.77778	-1208.482	-974.742
5.55556	-858.904	-696.244
8.33333	-513.136	-417.746
11.11111	-170.831	-139.249
13.88889	170.831	139.249
16.66667	513.296	417.746
19.44444	859.064	696.244
22.22222	1208.641	974.742
25	1579.285	1253.239

3.2 Bending Moment

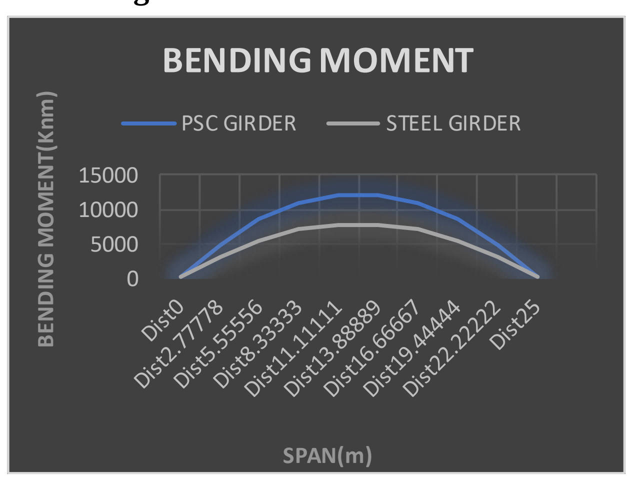


Fig 3.2 Bending Moment in Kim

Table 4

SPAN(m)	PSC GIRDER (Knm)	PLATE GIRDER (Knm)
0	0	0
2.77778	4846.5319	3094.4176
5.55556	8481.4308	5415.2309
8.33333	10904.6968	6962.4397
11.11111	12116.3298	7736.0441
13.88889	12116.3298	7736.0441
16.66667	10904.7	6962.4397
19.44444	8481.431	5415.2309
22.22222	4846.5319	3094.4176
25	0	0

3.3 Vertical Displacement

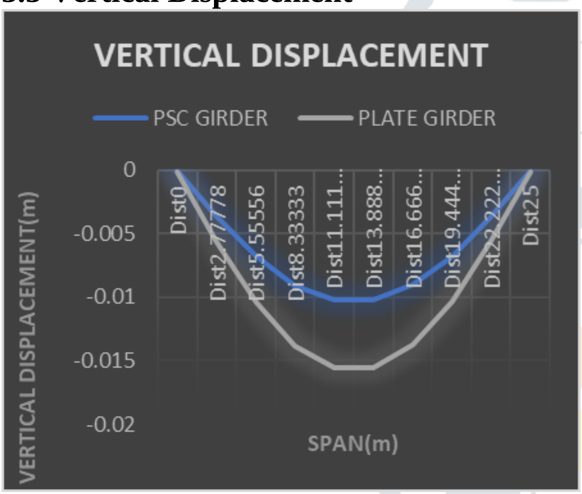


Fig 3.4 Vertical Displacement in m

Table 5

SPAN(m)	PSC GIRDER (m)	PLATE GIRDER (m)
0	0	0
2.77778	-0.003196	-0.005639
5.55556	-0.005862	-0.010381
8.33333	-0.007771	-0.013805
11.11111	-0.00876	-0.015586
13.88889	-0.008749	-0.015564
16.66667	-0.007742	-0.013745
19.44444	-0.005825	-0.010298
22.22222	-0.003165	-0.005566
25	0	-0.000089

3.4 Axial Force

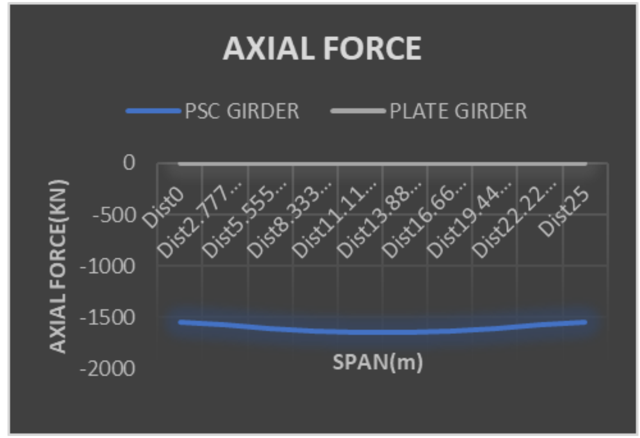


Fig 3.5 Axial Force in KN

Table 6

SPAN(m)	PSC GIRDER (KN)	PLATE GIRDER (KN)
0	-1546.48	0
2.77778	-1574.297	0
5.55556	-1604.139	0
8.33333	-1629.368	0
11.11111	-1639.55	0
13.88889	-1639.55	0
16.66667	-1639.55	0
19.44444	-1604.139	0
22.22222	-1574.297	0
25	-1545.454	0

4. Results and Conclusions

I) The percentage difference in bending moment of the girders is 56%.
ii) The maximum bending moment in PSC girder is 12116 Knm at the mid span and in Plate Girder is 7736 Knm.
iii) The percentage difference in shear force is 26%.
iv) The maximum shear force in PSC Girder is 1581 KN and in Steel Plate Girder is 1253 KN.
v) The Vertical Displacement of Plate Girder is 45% greater than PSC Girder.
vi) 25 m length of span is considered for the analysis of PSC Girder and plate girder and for both girders displacement and stresses are within the permissible limit.

vii) From the graphs it could be clearly seen that the bending moment, shear force of PSC Girder is very much greater than Steel plate girder and the reason behind this increase is the self-weight of the

PSC Girder which generates a large bending moment as well as shear force.

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