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Comparison Of Prestressed Curved Multi-Cell Box Girder Bridge With Composite Trussed Bridge

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Abstract —*Due to explosive industrial growth in urban areas of India there has been a tremendous increase in traffic not only in urban areas but also on highways. For easy of traffic flow in urban areas flyovers have become a necessity. For the large spans the traditional beam and slab construction leads to an uneconomical solution and is also time consuming construction technology. To minimize the cost and time of the construction different types of precast girder section are developed. To achieve more economy pre-stressing is done to these girders usage of box girders leads to better stability as compared to conventional construction. To achieve more economy composite section can be used.In this work an attempt is being made to compare the economics of using composite trussed sections as against conventional pre-stressed box girders for a curved segment of a flyover. For analysis purpose of box girder and composite trussed bridge STAAD-pro is used. In terms of cost the composite bridge works out to be uneconomical but this is offset by many other advantages.*

Keywords- pre-stressed box bridge , composite bridge , staad pro , design , estimation , comparision

I. 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. A bridge is a structure providing passage over an obstacle without closing the way beneath. The required passage may be for a road, a railway, pedestrians, a canal or a pipeline. The obstacle to be crossed may be a river, a road, railway or a valley.The bridge type is related to providing maximum efficiency of use of material and construction technique, for particular span, and applications. As span increases, dead load is an important increasing factor. To reduce the dead load, unnecessary material, which is not utilized to its full capacity, is removed out of section, this results in the shape of box girder or a cellular structure, depending upon whether the shear deformations can be neglected or not. Span range is more for box bridge girder as compare to T-beam Girder Bridge resulting in comparatively lesser number of piers for the same valley width and hence results in economy. A box girder is formed when two web plates are joined by a common flange at both the top and the bottom. The closed cell which is formed has a much greater torsional stiffness and strength than an open section and it is this feature which is the usual reason for choosing a box girder configuration.Box girders are rarely used in buildings (box columns are sometimes used but these are axially loaded rather than in loaded in bending). They may be used in special circumstances, such as when loads are carried eccentrically to the beam axis.

II. PSC BOX GIRDER BRIDGE

Concrete Grade: M45
Reinforcement: Fe 415
Center to center span of girder: 47.5,40,35 m
Width of carriageway: 8.3 m
Height of box section: 2.335 m
Bottom width of box: 6.525 m
Clear cover for any reinforcement: 40 mm
Jack type: multi pull jack
Manhole opening: 0.9 x 0.9 m
Dimension of box girder:
Thickness of top slab: 200 mm
Thickness of bottom slab: 200 mm
Thickness of web:

- Exterior : 310 mm

- Interior : 310 mm

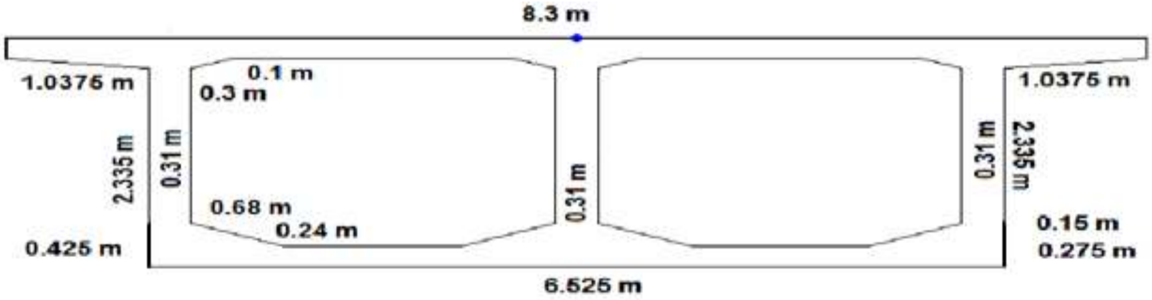
Thickness of cantilevers:

- At ends : 200 mm
- At junction : 300 mm

Dimension of haunches:

- At top slab :300 mm x 100 mm
- At bottom slab : 680 mm x 240 mm

Loadings: IRC 70 R
Super elevation: 4 %
Radius of curvature: 90.5 m
Angle of curvature θ: 30 degree



A. Slab Design

To do the transverse analysis of the box girder, for the design of top slab. The effective width of dispersion of wheels of different vehicles in both longitudinal and transverse direction is calculated. This provides the area of dispersion. Total load of one wheel is divided by the area of dispersion, which gives the intensity of load on that particular area.
After finding out the intensity for the different wheels of different vehicles the line model is created by keeping a width is equal to 1 m and the same intensity is applied over the length of width of dispersion of a wheel and analysis has been carried out for the different cases and finally the maximum bending moment and shear force is taken for the design of top slab.
For the design of slab the transverse analysis has been carried out in STAAD software and the result of the analysis has been taken for the design purpose.
In STAAD first we have to prepare the transverse model of a bridge deck, and then apply computed dead load on it, after calculate the effective width of dispersion for different type of vehicles as per clause IRC: 18-2000 and its intensity on slab. Then after analyze the program, after analyzing we get the maximum BM. Using the maximum BM design the deck slab.

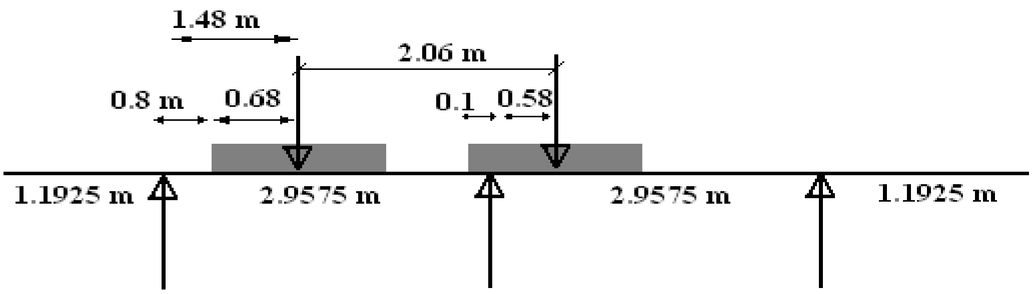


Figure 1. Effective width of dispersion of IRC 70 R T Vehicle

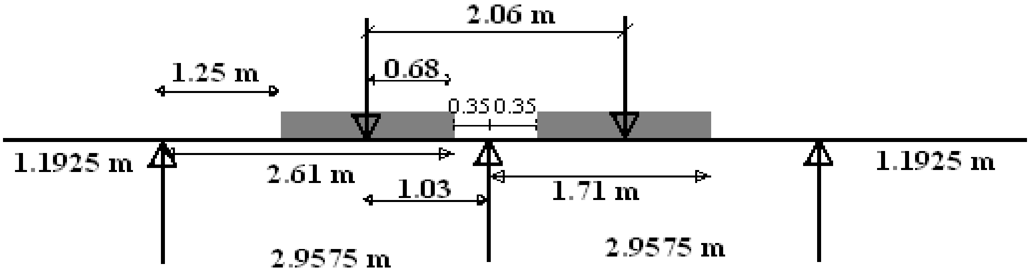


Figure 2. Effective width of dispersion of IRC 70 R T on Interior Support

B. Check for Minimum Section Modulus

Longitudinal analysis has been carried out in STAAD software and the bending moment due to dead load and live load has been taken form that for further calculation.

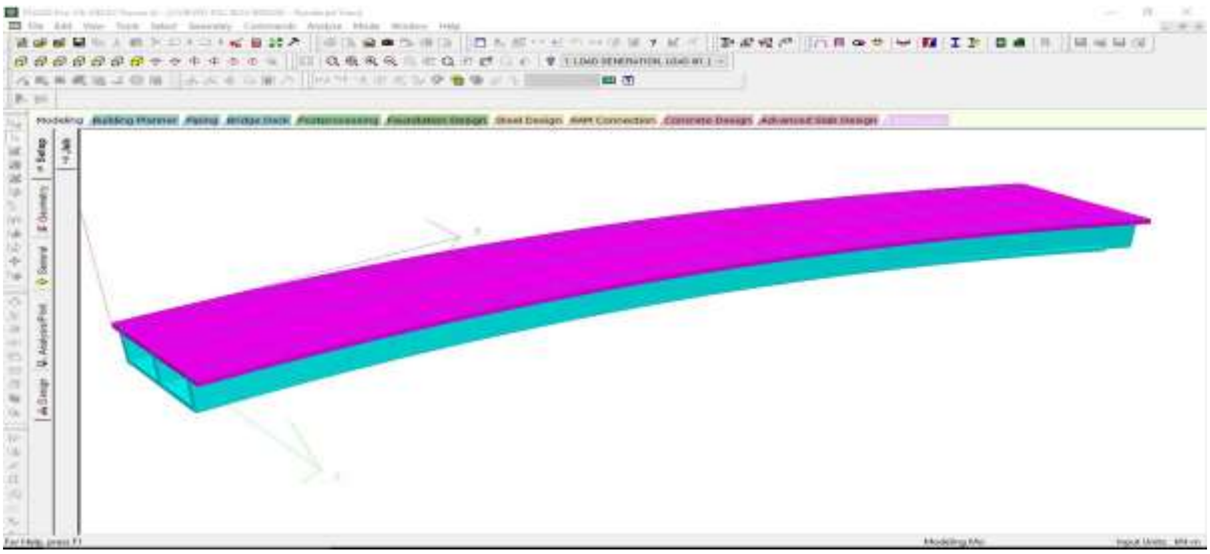


Figure 3. STAAD Bridge Model

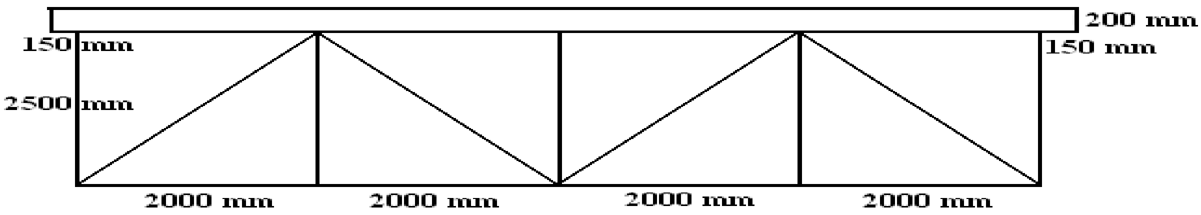
Bending moment in longitudinal direction shell be taken from STAAD software.

Span (m)	BM due to Dead Load, M_g	BM due to Live Load, M_q	Total BM = $M_g + M_q$
47.5	21350	15850	37200
40	16025	13175	29200
35	13000	10600	23600

Table 1. Bending Moments

III. TRUSSED BRIDGE

Concrete Grade: M45
Structural Steel: Fe 250
Center to center span of girder: 47.5,40,35 m
Width of carriageway: 8.3 m
Height of section: 2.5 m
Bottom width of box: m
Jack type: multi pull jack
Thickness of top slab: 200 mm
Loadings: IRC 70 R
Super elevation: 4 %
Radius of curvature: 90.5 m
Angle of curvature θ: 30 degree.



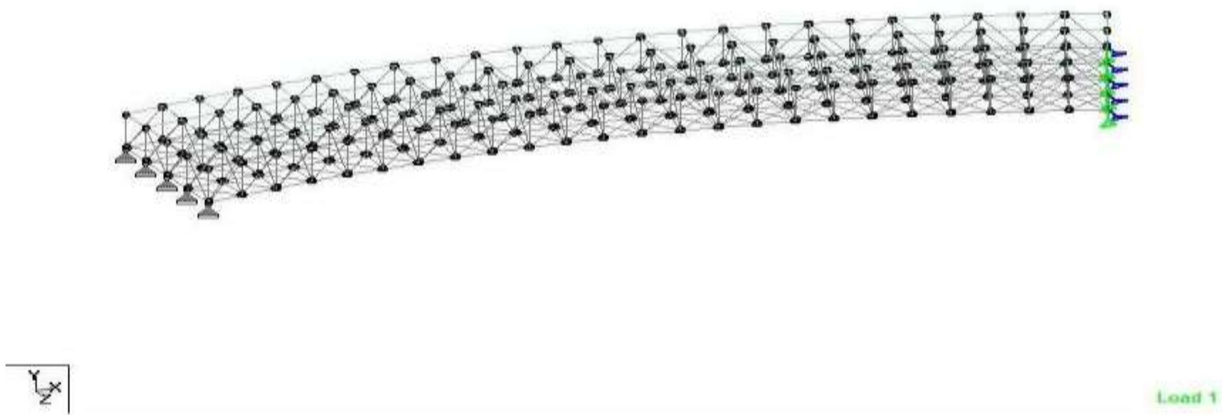


Figure 4. Composite Trussed Model in Staad Pro

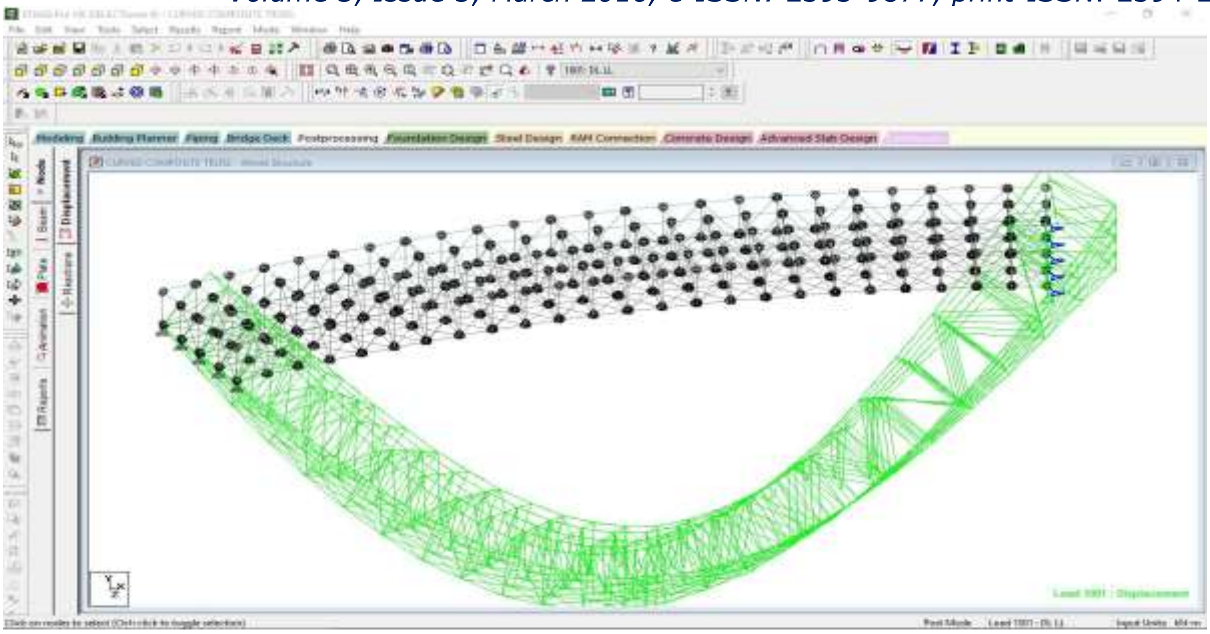


Figure 5. Deflection of Bridge due to DL LL

C. Design of Compression Member

Steel Grade			250
Axial Load, kN			3186.642
Length of Member, m			2.5
Modulus of Elasticity of Steel			195000
Section			TUBE
Width of Section, m			0.3
Depth of Section, m			0.3
Thickness, m			0.02
Partial Safety Factor			1.10
End support	Hinged		
End support	Hinged		
Area, m^2			22400
Center of Gravity, mm		Cxx	150
Center of Gravity, mm		Cyy	150
Moment of Inertia, mm^4		Ixx	798186666.67
Moment of Inertia, mm^4		Iyy	798186666.67
Radius of Gyration, mm		rxx	188.77
Radius of Gyration, mm		ryy	188.77
Classification of the Section			
ε = (250/fy)^0.5		1	
d/t_w		15	
Classification		SEMI-COMPACT SECTION	
Buckling Curve Classification			
Buckling Curve	c	0.49	
Resistance to Flexural Buckling			

Slenderness Ratio, kL/r		13.24	
Euler Buckling Stress	f_{cc}	10972.63	
	λ	0.15	
	ϕ	0.50	
f_{cd}, N/mm^2		233.01	
Design Strength in kN= A * f_{cd}		5219.37	**SAFE**

Type of Channel section	**ISMC 300**	
Type of End Conditions:	1 Support End Condition	HINGED
	2 Support End Condition	HINGED
Factored axial load, kN	P	1586.98
Length of Member, m	L	2.5
Required Area, mm²	Area	12695.84
Yield strength of steel, MPa	fy	250
Partial Safety factor	γ_{mo}	1.1
Modulus of Elasticity for Steel, N/mm2	E	200000
Section Properties		
Depth of Section, mm	d	300
Thickness of Web, mm	t_w	7.8
Area of Cross Section, mm^2	A	9128
Moment of Inertia @ x - x Axis, mm^4	Ixx	127252000
Moment of Inertia @ y - y Axis, mm^4	Iyy	46461000
Module of Section @ x - x Axis, mm^3	Zxx	8484
Module of Section @ y - y Axis, mm^3	Zyy	5162
Radii of Gyration, mm	rxx	118.1
Radii of Gyration, mm	ryy	71.3
Section		
Ratio of Depth of Web to Thickness of Web	d/t_w	38.46
Ratio of yield stress	ε	1.00
Cross - Section is	SEMI COMPACT SECTION	
Effective Length		
Factored for effective Length	k	**1**
Effective Length, m	Le	2.50
Effective Slenderness Ratio	kL/rmin	35.06
For Built-up section	1.05 * λmin	36.82
Design of Compression Member		
	Axis	Value

Buckling about any Axis	c	0.49	
Euler Buckling Stress	fcc	1606.86	
Non - dimensional effective slenderness ratio	λ	0.39	
Inclination of the tension field stress in web	Φ	0.63	
Design Stress in Compression, N/mm^2	fcd	204.60	**< 217**
Factored Load, KN	Pd	**1868**	
		SAFE	
4.6.3 Check for Tension Member:			
Ultimate Stress, Mpa	410		
Partial Safety Factor	1.25		
Max. Tension	1901		
Slenderness Ratio	48.33	**Slenderness Ratio in Permissible Limit**	
Design Strength in kN= 0.8A*fu/γmo	3302.5664	**CHECK OK**	

IV. ESTIMATION

Sr No	Particular	Unit	Unit Cost	Quantity	Total Amount
1	Concrete	cum	14,000	246.095125	34,45,332
2	Steel Fe 415	tonne	47,000	40	18,80,000
3	Crash Barrier	m	3,500	95	3,32,500
4	Bearings	nos.	20,000	6	1,20,000
5	Pre-stressing Cables	tonne	1,00,000	12.004125	12,00,413
		Total Amount in Rs.			**69,78,244**

Table 2. PSC 47.5 m cost

Sr No	Particular	Unit	Unit Cost	Quantity	Total Amount
1	Concrete	cum	14,000	207.238	29,01,332
2	Steel Fe 415	tonne	47,000	29	13,63,000
3	Crash Barrier	m	3,500	80	2,80,000
4	Bearings	nos.	20,000	6	1,20,000
5	Pre-stressing Cables	tonne	1,00,000	7.14875	7,14,875
		Total Amount in Rs.			**53,79,207**

Table 3. PSC 40 m cost

Sr No	Particular	Unit	Unit Cost	Quantity	Total Amount
1	Concrete	cum	14,000	181.33325	25,38,666
2	Steel Fe 415	tonne	47,000	26	12,22,000
3	Crash Barrier	m	3,500	70	2,45,000

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4	Bearings	nos.	20,000	6	1,20,000
5	Pre-stressing Cables	tonne	1,00,000	5.08725	5,08,725
		Total Amount in Rs.			**46,34,391**

Table 4. PSC 35 m cost

Sr No	Particular	Unit	Unit Cost	Qty	Amount
1	Concrete Slab	cum	14,000	78.85	11,03,900
2	Crash Barrier	m	3,500	95	3,32,500
3	Structural Steel	tonne	80,000	162.0210845	1,29,61,687
4	Bearings	Nos.	20,000	10	2,00,000
5	Steel Fe 415	tonne	47,000	7.8	3,66,600
		Total Amount in Rs.			1,49,64,687

Table 5. composite trussed bridge 47.5 m cost

Sr No	Particular	Unit	Unit Cost	Qty	Amount
1	Concrete Slab	cum	14,000	66.4	9,29,600
2	Crash Barrier	m	3,500	80	2,80,000
3	Structural Steel	tonne	80,000	135.1789944	1,08,14,320
4	Bearings	Nos.	20,000	10	2,00,000
5	Steel Fe 415	tonne	47,000	6.6	3,10,200
		Total Amount in Rs.			1,25,34,120

Table 6. composite trussed bridge 40 m cost

Sr No	Particular	Unit	Unit Cost	Qty	Amount
1	Concrete Slab	cum	14,000	58.1	8,13,400
2	Crash Barrier	m	3,500	70	2,45,000
3	Structural Steel	tonne	80,000	121.7579494	97,40,636
4	Bearings	Nos.	20,000	10	2,00,000
5	Steel Fe 415	tonne	47,000	5.8	2,72,600
		Total Amount in Rs.			1,12,71,636

Table 7. composite trussed bridge 35 m cost

SPAN (M)	PSC BOX BRIDGE (RS.)	COMPOSITE TRUSS BRIDGE (RS.)	% COST REQUIRED IN COMPARISSION OF CTB
47.5	69,78,244	1,49,64,687	47
40	53,79,207	1,25,34,120	43
35	46,34,391	1,12,71,636	41

Table 8. comparission of cost

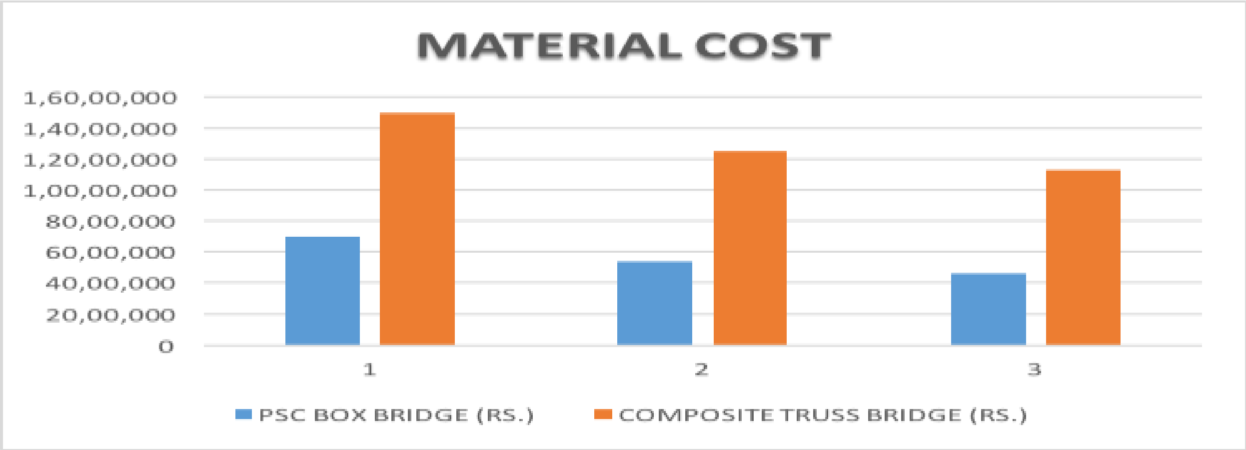

Figure 8. comparission of cost

V. Conclusion

A detailed comparative study between a Curved Composite Trussed Bridge and Curved PSC Box Girder B**ridge** reveals the fact that in terms of cost a Composite Trussed Bridge works out to be uneconomical.
However it has the following distinct advantages as compared to the PSC Box Girder Bridge.

1) Self-weight of structure becomes almost half.
2) This leads to a economical pier design considering both gravitational and lateral loads due to earthquake.
3) Lesser cost of bearings due to reduced forces.
4) Actual construction time is significantly reduced due prefabrication and erection.
5) Lesser hardship for diverted traffic due to shorter construction time.
6) High salvage value.
7) Can be easily retrofitted for increased traffic load of future.

It can be concluded that a pre-stressed composite truss bridge although is uneconomical in terms of cost it has may intangible benefits associated with it

VI. Future Scope

The scope of the study is vertical loads only,
Future studies can include

1) Evolution of optimum Truss Profiles for various spans
2) Different profiles of pre-stressing
3) Usage of High Strength Structural Steel

VII. REFERANCES

[1] Ayman M. Okeil and Sherif El-Tawil, Warping Stresses in Curved Box Girder Bridges: Case Study, Journal of Bridge Engineering, Vol. 9, No. 5, September 1, 2004.

[2] Lin Liao and Baisong Du, Finite Element Analysis of Composite Truss Structures Containing Pre-tensioned Cables, ICCE-17 July 26-31, 2009, Hawaii, USA

[3] Weiwei Lin and Teruhiko Yoda, Analysis, Design and Construction of Curved Composite Girder Bridges: State-of-the-Art, International Journal of Steel Structures, September 2010, Vol 10, No 3, 207-220.

[4] Andrew Gallagher & Barry Skinner, Advanced Bridge Analysis and Design Methods Simplified, Journal of Bridge Engineering, Vol. 9, No. 5, September 1, 2004.

[5] Vishal U. Misal , N. G. Gore, P. J. Salunke , Analysis and Design of Prestressed Concrete Girder , International Journal of Inventive Engineering and Sciences (IJIES), January 2014.