Behaviour of Precast Concrete Girder Bridge Under Seismic Loading

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Abstract*- For earthquakeWall-type or shell-type prestressed concrete structures, such as prestressed concrete I-girders, box girders, nuclearcontainment vessels, offshore structures, shear walls, etc can be visualized as assemblies of membrane elements. Their behavior can be predicted if the behavior of the membrane elements is thoroughly understood.In order to apply precast decks or girdes to continuous composite bridges, several experiments andanalytical studies were performed. From many previous studies, design criteria for crack controls in transverse joints of prefabricated slabs were confirmed. These considerations were needed for serviceability. The bridges which satisfy service limit states, also, should be evaluated for ultimate strengths to define limit states.*

Keywords- Precast concrete, Bridge, Finite Element Method R.C.C. Bridge.

I. INTRODUCTION

Prefabricated bridge construction presents many advantages over conventional construction methods. In prefabricated construction, elements are cast off-site and then brought to the site ready to be erected in-place. This eliminates major-time consuming tasks from the project timeline, such as erection and removal of formwork, placement of steel reinforcement and concrete, and curing of the concrete. The result is shorter construction time and a reduction in traffic disruption.If the structure is not properly designed when the Earthquake is accrue especially in high seismic regions the structure is damage. Precast technology offers benefits such as reduce construction period, better quality control, cleaner and safer construction sites and others. Precast concrete means concrete which has been prepared for casting and the concrete either is statically reinforced or prestressed. Precast concrete structure refers to the combination of precast concrete elements and the structure is able to sustain vertical and horizontal loads or even dynamic loads.

Bridges are important components within the transportation systems. The road bridges are designed in our country as per IRC codes, where working stress method is used.The response reduction factor is one of the important factor in determination of design seismic force, which is mainly decided based on amount of ductility introduced in the structure. The bridges are generally placed in two categories: Ordinary and Important. Considering the importance of bridges, it is essential to adequately design new bridges and assess the response of existing bridges in areas subjected to earthquake hazards.The extensive damage of highway bridges in the 1989 Loma Prieta, 1994 Northridge and 1995 Hyogo-ken Nanbu earthquakes together with the research, triggered as a consequence of the recent earthquakes have led to significant advance in bridge seismic design and retrofitting. For this the traditional seismic coefficient method is being replaced with the ductility design method, which is based on nonlinear analysis of structure.

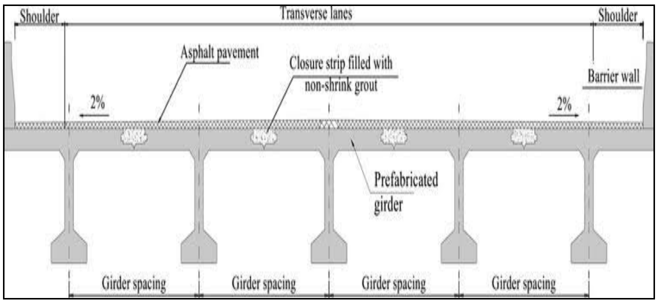


Fig.1 Cross Section Of Precast Concrete Girder Bridge

II. PERFORMANCE BASED DESIGN

A Performance based design is a process in which performance requirements are translated and integrated into a bridge design.” These criteria differ from traditional codes in that they correlate levels of damage noted in laboratory testing and real earthquake damage to quantifiable material properties and design parameters.Seismic design codes currently in use are prescribed-based and focus on the capacity of members satisfying strength and serviceability requirements. Current design methods are limited in designing the structure to a particular seismic load level not at all the possible load levels.

III. MODELLING AND ANALYSIS

The analysis of bridge can be done using a Grillage analogy and finite element method. Grillage analogy 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 and the analysis is on the single span concrete I-girder bridge.

IV. SPECIFICATIONS CONSIDERD IN BRIDGE DESIGN

General Data	
Length of bridge	40 m
Each Lane width	3.5 m
No. of Lane	2
Total Width	7.5 m
Composite Deck	0.2 m
Concrete Grade	4000 psi
Grade of steel	HYSD Fe 415
Roadway Width	7.5 m
Effective span	18.8 m
Clear span	20 m
Total length of Girder	19.9 m
Vehicle class	IRC A
Spacing of precast girders	2.2 m
Spacing of cross beams	3.5 m
No. of Girder	4

- Pre-Stressing Strands:

12.7 dia. seven wire low relaxation strands

Area of strands = 0.6452 m2

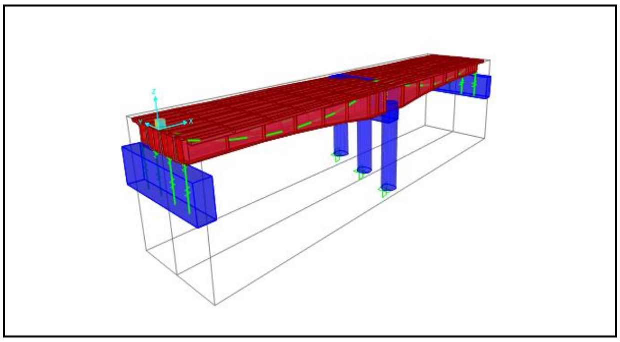
No of cable = 4

Ultimate strength fpu = 1860 Mpa

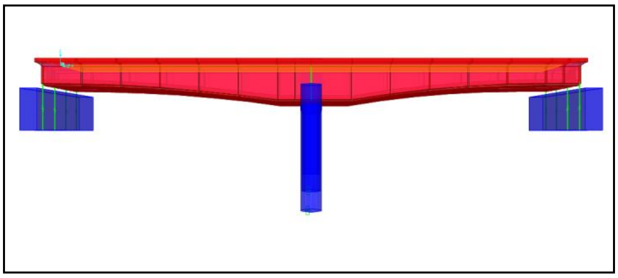
Yield strength = 0.9 fpu

=0.9×1860

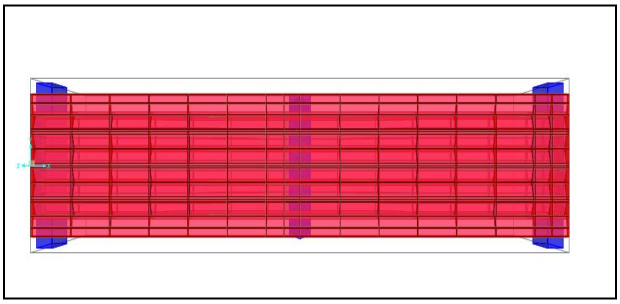
=1674 Mpa



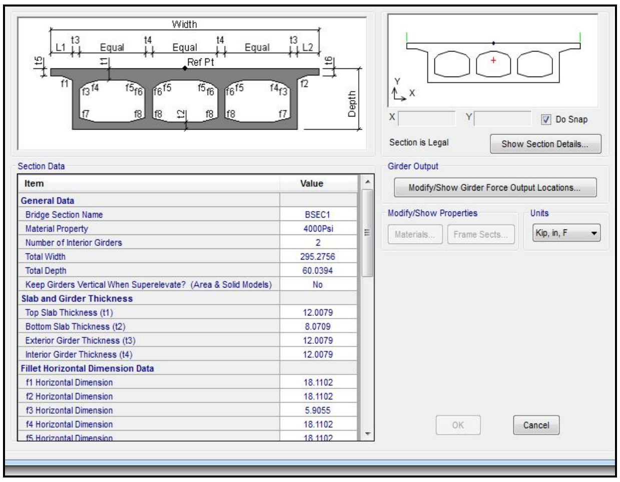
3-D View of Bridge



Side View of Bridge



Top View of bridge



Section Data

Item	Value
General Data	
Bridge Section Name	BSEC1
Material Property	4000Psi
Number of Interior Girders	2
Total Width	295.2756
Total Depth	60.0394
Keep Girders Vertical When Superelevate? (Area & Solid Models)	No
Slab and Girder Thickness	
Top Slab Thickness (t1)	12.0079
Bottom Slab Thickness (t2)	8.0709
Exterior Girder Thickness (t3)	12.0079
Interior Girder Thickness (t4)	12.0079
Fillet Horizontal Dimension Data	
f1 Horizontal Dimension	18.1102
f2 Horizontal Dimension	18.1102
f3 Horizontal Dimension	5.9055
f4 Horizontal Dimension	18.1102
f5 Horizontal Dimension	18.1102

Bridge Cross Section Data

TABLE for Forces on Girders by Design Req. Of Gravity

No.	Result For	Axial Force	Shear Vertical(V2)	Torsion
1	Left Ext. Girder	7922.24	50005.71	8675.01
		-11371.14	-49989.5	-8332.56
2	Int. Girder 1	10988.54	53121.75	3971.87
		-9105.4	-52903.1	-4094.96
3	Int. Girder 2	11236.36	54188.53	3709.13
		-8562.9	-54043.8	-3641.27
4	Right Ext. Girder	9746.05	48996.01	7943.83
		-10853.7	-48964.4	-8294.12

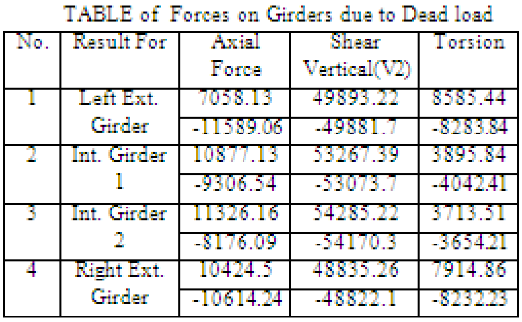


TABLE of Forces on Girders due to Dead load

No.	Result For	Axial Force	Shear Vertical(V2)	Torsion
1	Left Ext. Girder	7058.13	49893.22	8585.44
		-11589.06	-49881.7	-8283.84
2	Int. Girder 1	10877.13	53267.39	3895.84
		-9306.54	-53073.7	-4042.41
3	Int. Girder 2	11326.16	54285.22	3713.51
		-8176.09	-54170.3	-3654.21
4	Right Ext. Girder	10424.5	48835.26	7914.86
		-10614.24	-48822.1	-8232.23

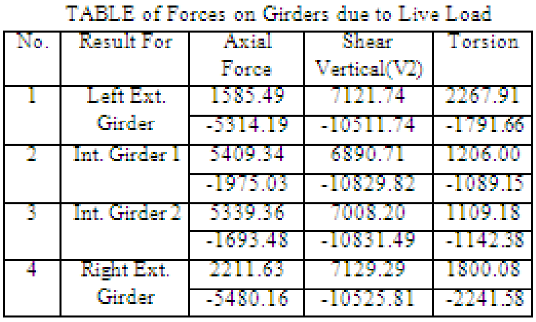


TABLE of Forces on Girders due to Live Load

No.	Result For	Axial Force	Shear Vertical(V2)	Torsion
1	Left Ext. Girder	1585.49	7121.74	2267.91
		-5314.19	-10511.74	-1791.66
2	Int. Girder 1	5409.34	6890.71	1206.00
		-1975.03	-10829.82	-1089.15
3	Int. Girder 2	5339.36	7008.20	1109.18
		-1693.48	-10831.49	-1142.38
4	Right Ext. Girder	2211.63	7129.29	1800.08
		-5480.16	-10525.81	-2241.58

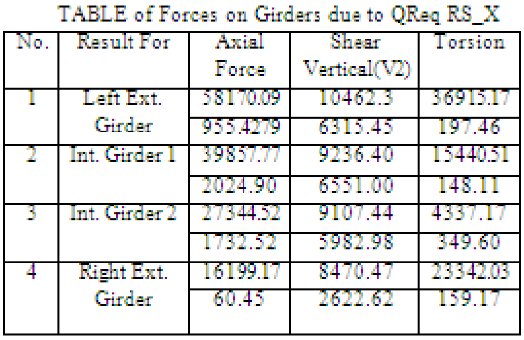


TABLE of Forces on Girders due to QReq RS_X

No.	Result For	Axial Force	Shear Vertical(V2)	Torsion
1	Left Ext. Girder	58170.09	10462.3	36915.17
		955.4279	6315.45	197.46
2	Int. Girder 1	39857.77	9236.40	15440.51
		2024.90	6551.00	148.11
3	Int. Girder 2	27344.52	9107.44	4337.17
		1732.52	5982.98	349.60
4	Right Ext. Girder	16199.17	8470.47	23342.03
		60.45	2622.62	159.17

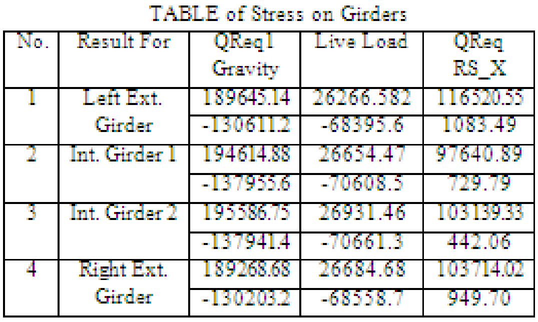


TABLE of Stress on Girders

No.	Result For	QReq1 Gravity	Live Load	QReq RS_X
1	Left Ext. Girder	189645.14	26266.582	116520.55
		-1306112	-68395.6	1083.49
2	Int. Girder 1	194614.88	26654.47	97640.89
		-1379556	-70608.5	729.79
3	Int. Girder 2	195586.75	26931.46	103139.33
		-1379414	-70661.3	442.06
4	Right Ext. Girder	189268.68	26684.68	103714.02
		-1302032	-68558.7	949.70

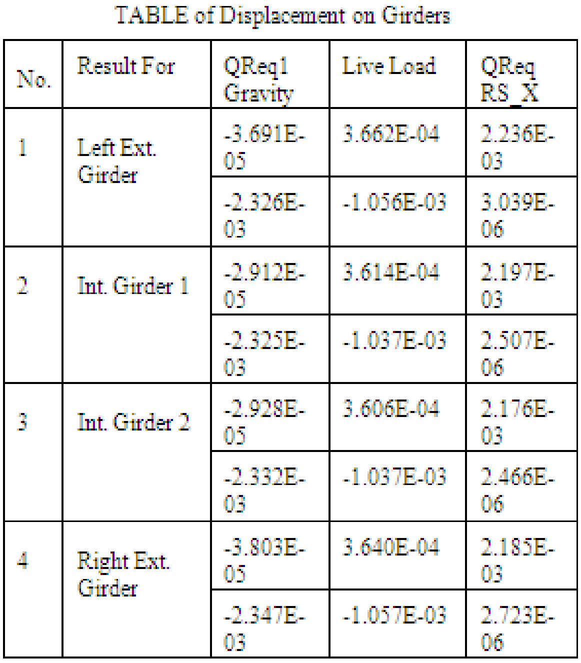


TABLE of Displacement on Girders

No.	Result For	QReq1 Gravity	Live Load	QReq RS_X
1	Left Ext. Girder	-3.691E-05	3.662E-04	2.236E-03
		-2.326E-03	-1.056E-03	3.039E-06
2	Int. Girder 1	-2.912E-05	3.614E-04	2.197E-03
		-2.325E-03	-1.037E-03	2.507E-06
3	Int. Girder 2	-2.928E-05	3.606E-04	2.176E-03
		-2.332E-03	-1.037E-03	2.466E-06
4	Right Ext. Girder	-3.803E-05	3.640E-04	2.185E-03
		-2.347E-03	-1.057E-03	2.723E-06

V. CONCLUSION

1. Spectral displacement is close to 0.09m which is acceptable as no hinge was formed in structure .
2. Cross beams distributed live load evenly through girders under differential loading, and so this system of girderand cross beam was adopted after several model variations.
3. In deformed shape, bearings allowed more lateral displacement than necessary, hence bearings failed in shearhowever showed satisfactory results for overturning..
4. For this model the spacing of girders was more, thus the deck slab was considerably thick. If deck slab thicknessis to be reduced than girder spacing has to be reduced thereby increasing the number of girders.

REFERENCES

[1] H. Valipour , A. Rajabi, S.J. Foster, M.A. Bradford, “Arching behaviour of precast concrete slabs in a deconstructable composite bridge deck,” ;*Construction and Building Materials87* (2015) 67–77.

[2] Vasseghi; “ Energy dissipating shear key for precast concrete girder bridges” ; *Scientia Iranica A* (2011) 18 (3), 296–303.

[3] Hai Nguyen, Hiroshi Mutsuyoshi, Wael Zatar ; “Hybrid FRP-UHPFRC Composite Girders: Part 1 – Experimental and Numerical Approach” ; *Composite Structure S0263-8223*(2014)00575-3.

[4] R.L. Pedro , J. Demarche, L.F.F. Miguel, R.H. Lopez ; “ An efficient approach for the optimization of simply

supported steel-concrete composite I-girder bridges" ; *Advances in Engineering Software 112* (2017) 31–45

[5] Petra Bujanakova,Miroslav strieska; " Development of precast concrete bridges during the last 50 years in Slovakia " ; *Procedia Engineering 192* (2017) 75 – 79

[6] Hai Nguyen , Wael Zatar , Hiroshi Mutsuyoshi ; "Hybrid FRP–UHPFRC composite girders: Part 2 – Analytical approach" ;*Composite Structures* (2015)

[7] Hyung-Keun Ryu, Sung-Pil Chang ; ' Ultimate strength of continuous compositebox-girder bridges with precast decks' ; *Journal of Constructional Steel Research 61* (2005) 329–343.

[8] G. Morgenthal, Y. Yamashaki, " Aerodynamic Behaviour of Very Long Cable-Stayed Bridges during Construction" , *Procedia Engineering 14* (2011) 1463–1471.

[9] K.L. Almer, D.H.Sanders; "Continuity Of Precast Bridge U-Girders Connected To A Cast-In-Place Substructure Subjected To Seismic Loads," ;**Earthquake Engineering** (2008).

[10] Dr. Sachin Admane, Prof. Y R Suryawanshi, Mr. Ajit Dhumal, "Literature Work Study Of Precast Concrete Connections In Seismic,"; **International Journal of Civil Engineering and Technology (IJCIET),** Volume 6 (2015) 39-49.