Analytical Studies on Elements of an Elevated Metro Bridge

A.Sindhuja[1] P.Rammaiah[2]
[1]M. Tech. Student [2]Associate Professor
[1,2]Department of Civil Engineering
[1,2]SVS Group of Institutions

Abstract— A metro system is a railway transport system in an urban zone with a high limit, recurrence and the evaluation partition from other activity. Metro System is utilized as a part of urban communities, agglomerations, and metropolitan regions to transport huge quantities of individuals. A hoisted metro system is more favored sort of metro system because of simplicity of development furthermore it makes urban regions more open with no development trouble. A raised metro system has two noteworthy elements pier and box girder. The present study concentrates on two noteworthy elements, pier and box girder, of a hoisted metro auxiliary system. Customarily the pier of a metro scaffold is composed utilizing a force based methodology. Amid a seismic stacking, the conduct of a solitary pier hoisted span depends for the most part on the flexibility and the uprooting limit. It is vital to check the flexibility of such single piers. Force based strategies don't unequivocally check the removal limit amid the outline. The codes are currently moving towards an execution based (dislodging based) outline approach, which consider the configuration according to the objective exhibitions at the configuration stage. Execution of a pier composed by a Direct Displacement Based Design is contrasted and that of a force-based outlined one. The outline of the pier is finished by both force based seismic configuration technique and direct removal based seismic outline strategy in the initial segment of the study.

Key words: Metro System, Elevated Metro Bridge

I. INTRODUCTION

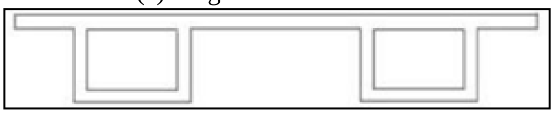
A metro system is an electric traveler railway transport system in a urban territory with a high limit, recurrence and the evaluation partition from other activity. Metro System is utilized as a part of urban communities, agglomerations, and metropolitan regions to transport extensive quantities of individuals at high recurrence. The evaluation detachment permits the metro to move openly, with less interferences and at higher general velocities. Metro systems are normally situated in underground passages, lifted viaducts above road level or level isolated at ground level. A raised metro auxiliary system is more favored one because of simplicity of development furthermore it makes urban regions more available with no development trouble. A raised metro basic system has the preferred standpoint that it is more financial than an underground metro system and the development time is much shorter.

A lifted metro system has two noteworthy parts pier and box girder. A commonplace raised metro span model is appeared in Figure 1.1 (a). Viaduct or box girder of a metro span obliges pier to bolster the every range of the extension and station structures. Piers are built in different cross sectional shapes like tube shaped, curved, square, rectangular and different structures. The piers considered for the present study are in rectangular cross area and it is situated under station structure. A common pier considered for the present study is appeared in Figure 1.1 (b).

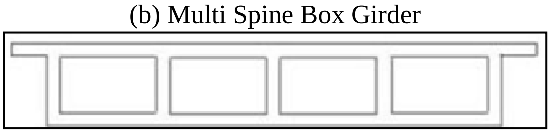
Confine girders are utilized widely the development of a hoisted metro rail span and the utilization of on a level plane bended in arrangement enclose girder spans present day metro rail systems is entirely appropriate in opposing torsional and twisting impacts prompted by ebbs and flows. The torsional and distorting unbending nature of box girder is because of the shut area of box girder. The container segment additionally has high twisting solidness and there is a proficient utilization of the complete cross segment. Box girder cross areas may appear as single cell, multi spine or multi cell as appeared in Figure 1.2.

(a) Typical Elevated Metro Bridge (b) Typical Pier
Fig. 1: Typical Elevated Metro Bridge and its Elements

(a) Single Cell Box Girder



(b) Multi Spine Box Girder



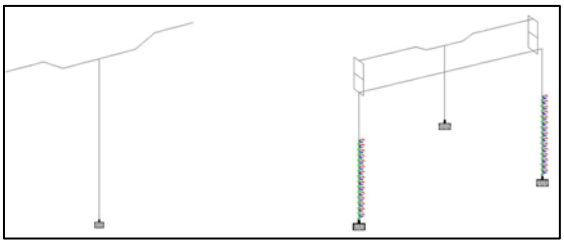
(c) Multi Cell Box Girder
Fig. 2: Types of Box Girder

II. METHODOLOGY

A. Performance Study of a Pier Designed by FBD and DDBD

1) Design of Pier using Force based Design

The geometry of pier considered for the present study is based on the design basis report of the Bangalore Metro Rail Corporation (BMRC) Limited. The piers considered for the analysis are located in the elevated metro station structure. The effective height of the considered piers is 13.8 m. The piers are located in Seismic Zone II, as per IS 1893 (Part 1): 2002. The modelling and seismic analysis is carried out using the finite element software STAAD Pro. The typical pier models considered for the present study are shown in figure.



(Type A) (Type B)
Fig. 3: Typical Pier Model

2) Material Property

The material property considered for the present pier analysis for concrete and reinforcement steel are given in Table 1.

Properties of Concrete	
Compressive Strength of Concrete	60 N/mm^2
Density of Reinforced Concrete	24 kN/m^3
Elastic Modulus of Concrete	36000 N/mm^2
Poisson's Ratio	0.15
Thermal Expansion Coefficient	1.17 x 10 $^{-5}$ /^{0}C
Properties of Reinforcing Steel	
Yield Strength of Steel	500 N/mm^2
Young's Modulus of Steel	205,000 N/mm^2
Density of Steel	78.5 kN/m^3
Poisson's Ratio	0.30
Thermal Expansion Coefficient	1.2 x 10 $^{-5}$ /^{0}C

Table 1(a): Material Property for Pier

Design Load			
Load from Platform Level	**Load**	**Load from Track Level**	**Load**
Self-Weight	120 kN	Self-Weight	160 kN
Slab Weight	85 kN	Slab Weight	100 kN
Roof Weight	125 kN	**Total DL**	260 kN
Total DL	330 kN	SIDL	110 kN
SIDL	155 kN	**Train Load**	190 kN
Crowd Load	80 kN	Braking + Tractive Load	29 kN
LL on Roof	160 kN	Long Welded Rail Forces	58 kN
Total LL	240 kN	Bearing Load	20 kN
Roof Wind Load	85 kN	**Temperature Load**	
Lateral	245 kN	For Track Girder	20 kN
Bearing Load	14 kN	For Platform Girder	14 kN
		Derailment Load	80 kN/m

Table 1(b): Material Property for Pier

Pier Type	**Cross Section (m)**	**Diameter of Bar (mm)**	**Number of Bars**	**% of Reinforcement**	
				Required	**Provided by BMRC**
Pier Type A	2.4 x 1.6	32	#32	0.8 %	1.48 %
Pier Type B	2.4 x 1.6	32	#38	0.8 %	1.48 %

Table 2: Reinforcement Details as per Force Based Design

B. Design of PIER using Direct Displacement based Design

Displacement Ductility	Drift Limit (m)	Cross Section (m)	Base Shear V_b (kN)	Diameter of Bar (mm)	Number of Bars	% of Reinforcement Required
1	0.276	1.5 x 0.7	604	32	#16	1.2 %
2	0.276	1.5 x 0.7	150	32	#12	0.8 %
3	0.276	1.5 x 0.7	86	32	#12	0.8 %
4	0.276	1.5 x 0.7	60	32	#12	%

Table 3: Reinforcement Details as per Direct Displacement Based Seismic Design

III. PARAMETRIC STUDY ON BEHAVIOUR OF CURVED BOX GIRDER BRIDGES

A. Validation of the Finite Element Model

To validate the finite element model of box girder bridges in SAP 2000, a numerical example from the literature (Gupta et al., 2010) is considered. Figure 4.1 shows the cross section of simply supported Box Girder Bridge considered for validation of finite element model. Box girder considered is subjected to two concentrated loads (P = 2 X 800 N) at the two webs of mid span. Span Length assumed in this study is 800 mm and the material property considered are Modulus of elasticity (E) =2. 842GPa and Modulus of rigidity (G) =1. 015GPa.

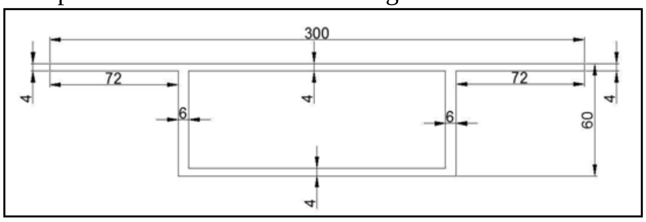


Fig. 4: Cross Section of Simply Supported Box Girder Bridge

Parameter	Gupta et al. (2010)	Present Study
Mid Span Deflection (mm)	4.92	4.91

Table 4: Mid Span Deflection of Simply Supported Box Girder Bridge

Span Length(m)	**Radius of Curvature(m)**	**Theta (radian)**	**Number of Boxes**
Radius of Curvature			
31	∞	0.0000	1,2,3
31	100	0.3100	
31	150	0.2067	
31	200	0.1550	
31	250	0.1240	

31	300	0.1033	
31	350	0.0886	
31	400	0.0775	
Span Length			
16	120	0.1333	1,2,3
19	120	0.1583	
22	120	0.1833	
25	120	0.2083	
28	120	0.2333	
31	120	0.2583	
Span Length to Radius of Curvature Ratio			
12	120	0.1000	1,2,3
24	120	0.2000	
36	120	0.3000	
48	120	0.4000	
60	120	0.5000	
72	120	0.6000	

Table 5: Geometries of Bridges used in Parametric Study

Properties of Material	Value
Weight per unit volume	235400 N/m^3
Mass per unit volume	24000 N/m^3
Modulus of Elasticity (E)	32500 x 10^6 N/m^2
Poisson's Ratio (υ)	0.15
Coefficient of thermal expansion (A)	1.170 x 10^{-5} / °C
Shear Modulus (G)	1.413 x 10^{10} N/m^2
Specific Concrete Compressive Strength (f_c')	45 x 10^{6}N/m^2

Table 6: Material Properties

IV. Conclusions

The performance assessment of selected designed pier showed that,

- Force Based Design Method may not always guarantee the performance parameter required and in the present case the pier just achieved the target required.
- In case of Direct Displacement Based Design Method, selected pier achieved the behaviour factors more than targeted Values.

The parametric study on behaviour of box girder bridges showed that,

- As the radius of curvature increases, responses parameter longitudinal stresses at the top and bottom, shear, torsion, moment and deflection are decreases for three types of box girder bridges and it shows not much variation for fundamental frequency of three types of box girder bridges due to the constant span length.
- As the span length increases, responses parameter longitudinal stresses at the top and bottom, shear, torsion, moment and deflection are increases for three types of box girder bridges and fundamental frequency decreases for three types of box girder bridges.

Reference

[1] Abdelfattah, F. A. (1997). Shear lag in steel box girders. Alexandria Eng. J., Alexandria Univ., Egypt, 36 (1), 1110–1118.
[2] Armstrong, W. L. and Landon, J. A. (1973). Dynamic testing of curved box beam bridge. Fed. Hwy. Res. and Devel. Rep. No. 73-1, Federal Highway Administration, Washington, D.C.
[3] Balendra, T. and Shanmugam, N. E. (1985). Vibrational characteristics of multicellular structures. J. Struct. Engrg., ASCE, 111 (7), 1449-1459.

