STUDIES ON MAJOR ELEMENTS OF AN ELEVATED METRO BRIDGE

DIMPLE CHANYAL

[*1]**M. Tech Student, Department of Civil Engineering, Roorkee Institute of Technology, Uttarakhand, India**

ABSTRACT

This Research paper is limited to study of two two major elements.of metro bridge , pier and box girder .In the first part of this study, the performance assessment on designed pier by Force Based Design and Direct Displacement Based Design is carried out. The design of the pier is done by both force based design method and direct displacement based design method.In the second part, parametric study on behavior of box girder bridges is carried out by using finite element method. The numerical analysis of finite element model is validated with model of Gupta The parameter considered to present the behavior of Single Cell Box Girder, Double Cell Box Girder and Triple Cell Box Girder bridges are radius of curvature, span length and span length to the radius of curvature ratio. These parameters are used to evaluate the response parameter of box girder bridges namely longitudinal stresses at the top and bottom,shear, torsion, moment, deflection and fundamental frequency of three types of box girder bridges.

Keywords: Analysis ,direct displacement method, staad pro, sap2000, fininte method, forced based method

1. INTRODUCTION

In this Paper An elevated metro system has 2 major elements pier and box girder. A typical elevated metro bridge model is Viaduct or box girder of a metro bridge requires pier to support the each span of the bridge and station structures. Piers are constructed in various cross sectional shapes like cylindrical, elliptical, square, rectangular and other forms. The piers considered for the present study are in rectangular cross section and it is located under station structure. A typical pier considered for the present study is shown in box girders are used extensively in the construction of an elevated metro rail bridge and the use of horizontally curved in plan box girder bridges in modern metro rail systems is quite suitable in resisting torsional and warping effects induced by curvatures. The torsional and warping rigidity of box girder is due to the closed section of box girder. The box section also possesses high bending stiffness and there is an efficient use of the entire cross section. An elevated metro structural system has the advantage that it is more economic than an underground metro system and the construction time is much shorter.

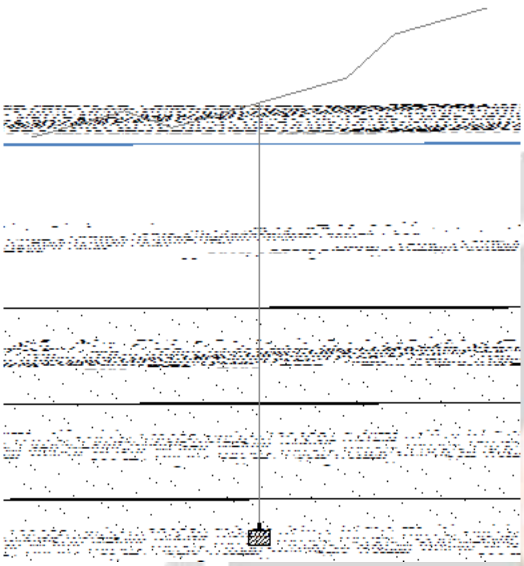
1.1 METHODOLOGY

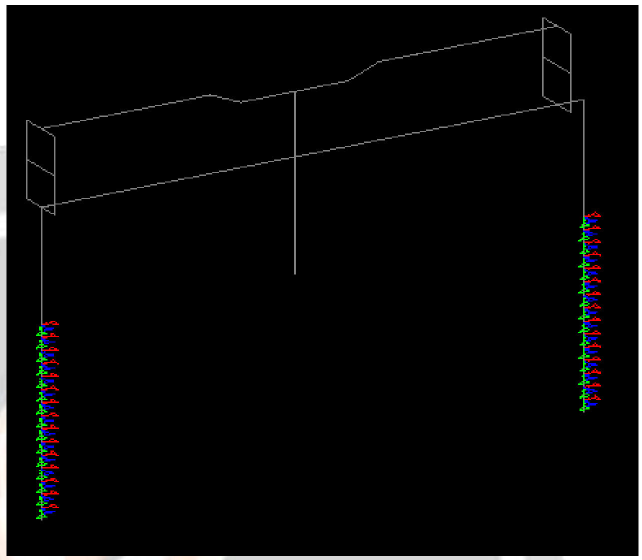
Force Based Design Method (FBD) is the conventional method to design the metro bridge pier. In Force based design method, the fundamental time period of the structure is estimated from member elastic stiff nesses, which is estimated based on the assumed geometry of the section. The appropriate force reduction factor (R) corresponding to the assessed ductility capacity of the structural system and material is selected in the force based design and applied to the base shear of the structure. The design of a pier by force based seismic design method is carried out as per IS 1893: 2002 Code.

The direct displacement based seismic design (DDBD) is proposed by Priestley et al. (2007) is used in the present study to design a metro bridge pier. The design philosophy of DDBD is based on the determination of the optimum structural strength to achieve a given performance limit state, related to a defined level of damage, under a specified level of seismic intensity., Priestley et al. (2007). The pier designed by DDBD method gives the uniform risk factor for the whole structure.

1.2MODELING AND ANALYSIS

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 modeling 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 3.1.





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

The direct displacement based seismic design method proposed by Priestley et al. (2007) and IRS CBC 1997 Code is used to design of Pier Type B and the results are shown in Table 3.4. The performance level considered for the study

The parametric study is carried to know the effect of displacement ductility on base shear for different Performance levels and the results are shown in Figure 3.2. The figure shows that as the displacement ductility level increases the base shear of the pier decreases and also the difference between different performance levels is about 40 %.

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	1.5x0.7	604	32	#16	1.2%
2	0.276	1.5x0.7	150	32	#12	0.8%
3	0.276	1.5x0.7	86	32	#12	0.8%
4	0.276	1.5x0.7	60	32	#12	0.8%

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
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Bearing Load	14 kN	For Platform Girder	14 kN
		Derailment Load	80 kN/m

PERFORMANCE ASSESSMENT

The performance assessment is finished to check the performance of designed pier by ForceBased Design Methodology and Direct Displacement Based Design Method. For this purpose,Non-linear static analysis is conducted for the designed pier using Seismo Struct Software and the results are shown in Table 3.5. The section thought of is 1.5 m x 0.7 m. Performance Parameters behavior factor (R´), structure ductility (µ') and maximum structural drift (∆' max) area unit found for each cases.The behavior factor (R´) is the ratio of the strength needed to keep the structure elastic. To the inelastic design strength of the structure. The behavior factor, R´, therefore accounts for the inherent ductility, over the strength of a structure and difference in the level of stresses thought of in its design. FEMA 273 (1997), IBC (2003) suggests the R factor in force-based Seismic design procedures. It's typically expressed within the following types of taking into account The above 3 components,

$$R=R_{\mu} \times R_{s} \times Y$$

Where, Rµ is the ductility dependent component also known as the ductility reduction issue, RS is the over-strength factor and Y is termed the allowable stress factor. With reference to Figure 3.3, in which the actual force–displacement response curve is perfect by a bilinear Elastic–perfectly plastic response curve, the behavior issue parameters may be defined as where, Ve, Vy, Vs and Vw correspond to the structure's elastic response strength, the idealized Yield strength, the primary important yield strength and the allowable stress design strength. The structure ductility, µ', is defined in as maximum structural drift (∆´max) and theDisplacement corresponding to the perfect yield strength (∆y) In Force Based Design, a force reduction factor (R) of 2.5 is used, and the design base shear Is estimated to be 891kN in the FBD. The performance parameters of the section designed Using FBD shows that the be heavier factor R is found to be about 2.74. The same pier is designed using a DDBD method for target displacement ductility and drift, the performance Parameters structural ductility and structural drift are found out for these cases. It shows that the achieved performance parameters are higher than assumed in the design stage in both Cases of DDBD. Though the FBD may not always guarantee the performance parameter required, in the present case the pier achieves the target demand. In the case of DDBD,

The design considers the target displacement ductility and drift at the design stage, and the present study shows that in each the examples the DDBD method achieves the behavior factors more than targeted Values. These conclusions can be considered only for the selected pier. For General conclusions large number of case studies is needed and it is treated as a scope of future work

Designed			Type of design	V_b (kN)	% of Steel	Φ (mm)	No. of Bars	Performance Parameters Achieved		
μ	Δ	R						μ	Δ	R
		2.5	FBD	891	2 %	32	#28			2.74
1	0.276		DBD	604	1.2 %	32	#16	3.5	0.35	3.25
2	0.276		DBD	150	0.8 %	32	#12	3.4	0.34	11.63

Performance Assessment of designed Pier

4. CONCLUSIONS

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 behavior factors more than targeted Values.Analysis and design of the elevated Metro Bridge as per IRC codes (here IRC 70R loading) can be easily done by STAAD.Pro. In connection with STAAD.beava. Mechanism is well understood.The maximum resultant nodal displacement is for node 1529; 0...015mm in x, -51.203mm in y and -.287mm in x.The maximum resultant beam end displacement is for beam 1930 and node 1529 equivalent to 51.204.

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