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ANALYSIS OF BRIDGE DESIGN FOR METRO IN ELEVATED POSITION

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ABSTRACT:

A metro framework is a railroad transport framework in a urban zone with a high limit, recurrence and the level partition from other traffic. Metro System is utilized in urban communities, agglomerations, and metropolitan territories to ship enormous quantities of individuals. A raised metro framework is increasingly favored kind of metro framework because of simplicity of development and furthermore it makes urban regions progressively open with no development trouble. A raised metro framework has two significant components wharf and box support. The present examination centers around two significant components, wharf and box support, of a raised metro auxiliary framework.

Expectedly the wharf of a metro scaffold is planned utilizing a power based methodology. During a seismic stacking, the conduct of a solitary dock raised scaffold depends for the most part on the malleability and the displacement limit. It is imperative to check the malleability of such single wharfs. Power based strategies don't unequivocally check the displacement limit during the plan. The codes are presently moving towards a presentation based (displacement-based) plan approach, which consider the structure according to the objective exhibitions at the structure arrange.

KEYWORDS:

AGGLOMERATIONS, SCAFFOLD, GIRDER BRIDGES, CELL BOX GIRDER

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I. INTRODUCTION

A raised metro framework has two significant parts dock and box support. A commonplace raised metro extension model is appeared in Figure 1.1 (a). Viaduct or box brace of a metro scaffold expects dock to help the each range of the extension and station structures. Wharfs are developed in different cross sectional shapes like round and hollow, circular, square, rectangular and other structures. The docks considered for the present investigation are in rectangular cross area and it is situated under station structure. A commonplace dock considered for the present investigtion is appeared in Figure 1.1 (b).

Box supports are utilized widely in the development of a raised metro rail connect and the utilization of on a level plane bended in plan enclose brace spans present day metro rail frameworks is very appropriate in opposing torsional and twisting impacts initiated by shapes. The torsional and distorting unbending nature of box support is because of the shut area of box brace. The container area additionally has high twisting solidness and there is an effective utilization of the total cross segment. Box support cross areas may appear as single cell, multi spine or multi cell as appeared 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 complete cross section. Box girder cross sections may take the form of single cell, multi spine or multi cell as shown in Figure 1.2.

(a) Typical Elevated Metro Bridge

(b) Typical Pier

Figure 1.1: Typical Elevated Metro Bridge and its Elements

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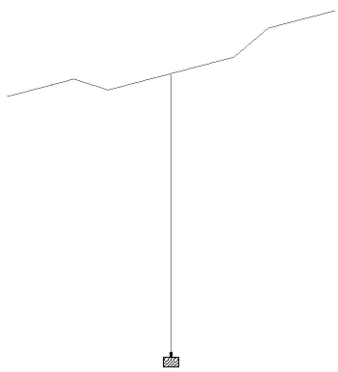
II. PERFORMANCE STUDY OF A PIER DESIGNED BY FBD AND DDBD

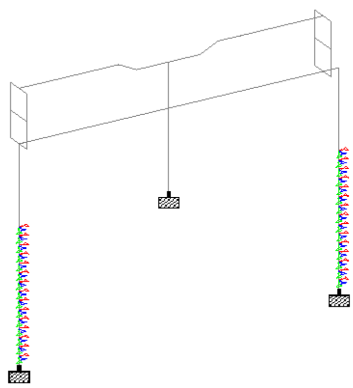
Execution investigation of the common wharf structured by a Force Based Design (FBD) Method and Direct Displacement Based Design (DDBD) Method is portrayed in this chapter. The wharf is structured based on FBD and DDBD Method. Execution appraisal is done for the planned dock and the outcomes are talked about quickly.

2.1 DESIGN OF PIER USING FORCE BASED DESIGN

The geometry of wharf considered for the present investigation is based on the plan premise report of the Bangalore Metro Rail Corporation (BMRC) Limited. The docks considered for the analysis are situated in the raised metro station structure. The viable tallness of the considered docks is 13.8 m. The wharfs are situated in Seismic Zone II, according to IS 1893 (Part 1): 2002. The displaying and seismic analysis is done utilizing the limited component programming STAAD Pro. The ordinary wharf models considered for the present investigation are appeared in figure 2.1.



(Type A)



(Type B)

Figure 2.1: Typical Pier Model

2.2 MATERIAL PROPERTY

The material property considered for the present pier analysis for concrete and reinforcement steel are given in Table 2.1.

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Table 2.1: MATERIAL PROPERTY FOR PIER

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	1.17×10^{-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	1.2×10^{-5} /^{0}C

2.3.DESIGN LOAD

The elementary design load considered for the analysis are Dead Loads (DL), Super Imposed Loads (SIDL), Imposed Loads (LL), Earthquake Loads (EQ), Wind Loads (WL), Derailment Load (DRL), Construction & Erection Loads (EL), Temperature Loads (OT) and Surcharge Loads (Traffic, building etc.) (SR). The approximate loads considered for the analysis are shown in Table 2.2. The total seismic weight of the pier is 17862 kN.

Table 2.2: Approximate 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

The force based design is carried out for Pier as per IS 1893:2002 and IRS CBC 1997 Code and the results are shown in Table 3.3. From the FBD, it is found out that the minimum required cross section of the pier is only 1.5 m x 0.7 m for 2 % reinforcement. The base shear of the pier is 891 kN.

2.3 DESIGN OF PIER USING DIRECT DISPLACEMENT BASED DESIGN

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 2.4. The performance level considered for the study is a Life Safety (LS) level.

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Table 2.4 Reinforcement Details as per Direct Displacement Based Seismic Design

Displacement Ductility	Drift Limit (m)	Cross Section	Base Shear V_b	Diameter of Bar	Number of Bars	% of Reinforcement
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	0.8 %

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 2.2. 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 %.

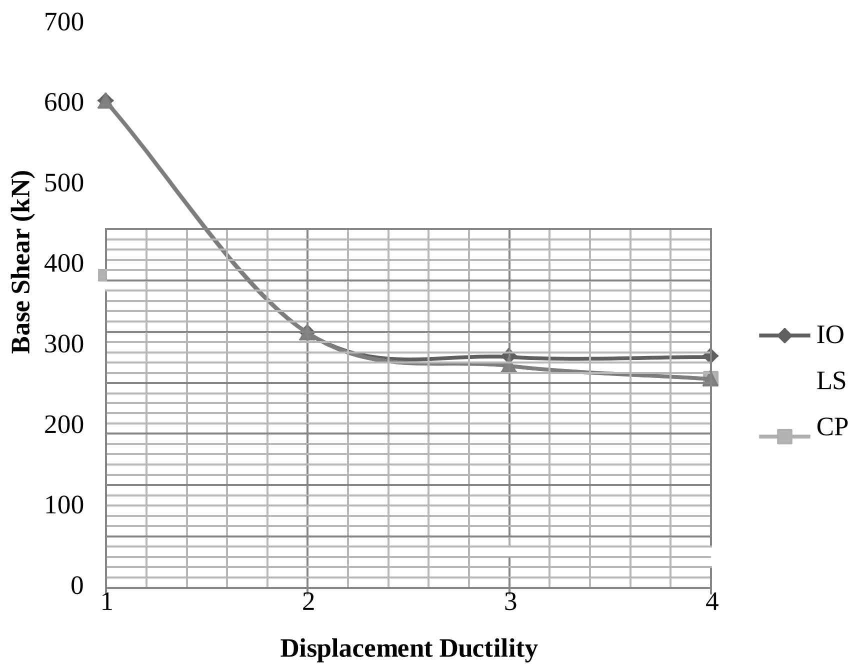

Figure 2.2: Effect of displacement ductility on base shear for different Performance levels

2.5 PERFORMANCE ASSESSMENT

The performance assessment is done to study the performance of designed pier by Force Based Design Method and Direct Displacement Based Design Method. For this purpose, Non-linear static analysis is conducted for the designed pier using SeismoStruct Software and the results are shown in Table 3.5. The section considered is 1.5 m x 0.7 m. Performance parameters behavior factor (R´), structure ductility (µ') and maximum structural drift (Δ'_{max}) are found for both the cases.

The behavior factor (R´) is the ratio of the strength required to maintain 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 considered in its design. FEMA 273 (1997), IBC (2003) suggests the R factor in force-based seismic design procedures. It is generally expressed in the following form taking into account the above three components,

III. PARAMETRIC STUDY ON BEHAVIOUR OF CURVED BOX GIRDER BRIDGES

Parametric investigation of box support scaffolds utilizing limited component technique is depicted in this chapter. The parameters of box brace scaffolds considered in this investigation are range of ebb and flow, range length, length to the sweep of ebb and flow proportion and number of boxes. The different reactions parameters considered are the longitudinal worry at the top and base, shear, torsion, minute, redirection and essential recurrence.

Numerical analysis did by Gupta et al. (2010) is utilized for approval of the limited component model.

3.1 VALIDATION OF THE FINITE ELEMENT MODEL

To approve the limited component model of box brace connects in SAP 2000, a numerical model from the writing (Gupta et al., 2010) is considered. Figure 3.1 demonstrates the cross segment of essentially bolstered Box Girder Bridge considered for approval of limited component model. Box brace considered is exposed to two concentrated burdens (P = 2 X 800 N) at the two trap of mid range. Range Length accepted in this investigation is 800 mm and the material property considered are Modulus of versatility (E) =2. 842GPa and Modulus of inflexibility (G) =1. 015GPa.

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The mid range avoidance of the displayed box brace scaffold is contrasted and the writing and it is introduced in the Table 3.1. From the Table 3.1, it tends to be reasoned that the present model gives the precise outcome.

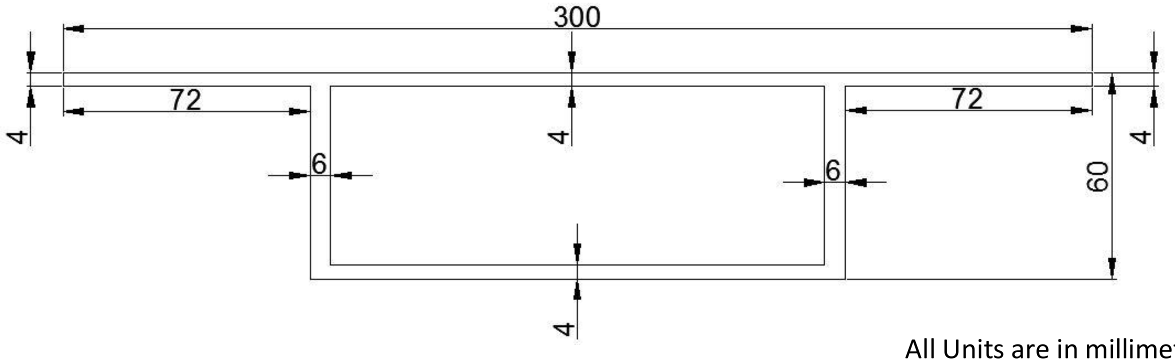

Figure 3.1: Cross Section of Simply Supported Box Girder Bridge

3.2 CASE STUDY OF BOX GIRDER BRIDGES

The geometry of Box Girder Bridge considered in the present study is based on the design basis report of the Bangalore Metro Rail Corporation (BMRC) Limited. In this study, 60 numbers of simply supported box girder bridge model is considered for analysis to study the behaviour of box girder bridges. The details of the cross section considered for this study is given in Figure 3.2 and various geometric cases considered for this study are presented in Table 3.2. The material property considered for the present study is shown in Table 3.3.

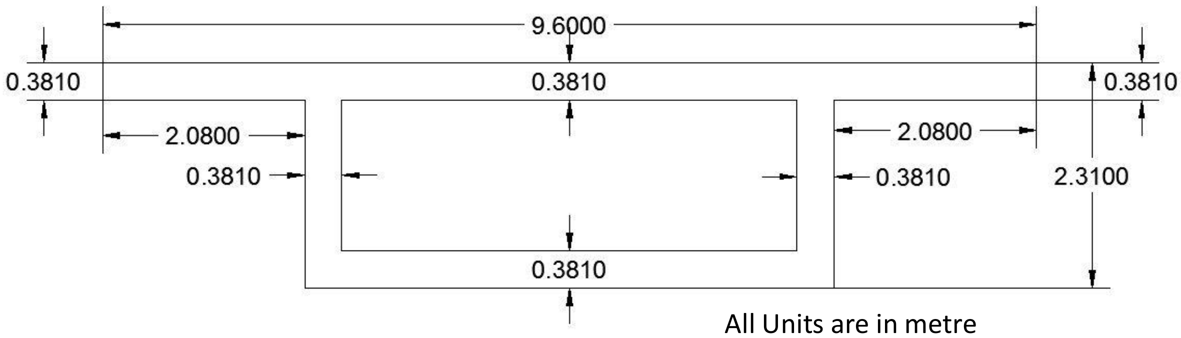

Figure 4.2: Cross Section of Simply Supported Box Girder Bridge considered for study

3.3 FINITE ELEMENT MODELLING

The finite element modelling methodology adopted for validation study is used for the present study. The modelling of Box Girder Bridge is carried out using Bridge Module in SAP 2000. The Shell element is used in this finite element model to discretize the bridge

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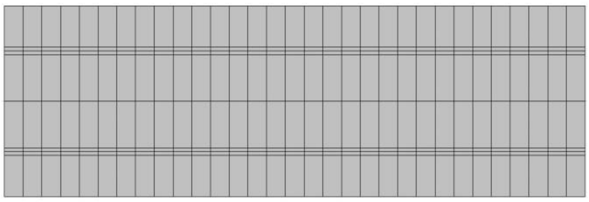
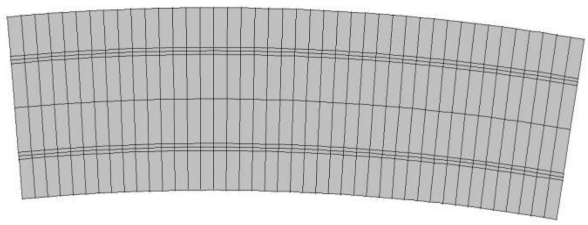
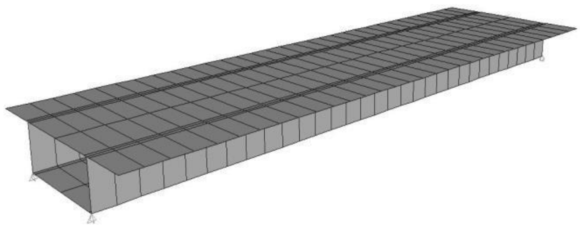
cross section. At each node it has six degrees of freedom: translations in the nodal x, y, and z directions and rotations about the nodal x, y, and z axes. The typical finite element discretized model of straight and curved simply supported box Girder Bridge in SAP 2000 is shown in figure 4.3(a) and 4.3(b).



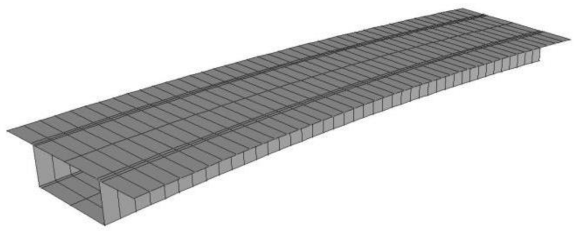
Plan



Plan



3D Model



3D Model

Figure 3.3(a): Discretized model of simply supported Straight Box Girder Bridge in SAP 2000

Figure 3.3(b): Discretized model of simply supported Curved Box Girder Bridge in SAP 2000

CONCLUSIONS

A metro system is an electric passenger railway transport system in an urban area with a high capacity, frequency and the grade separation from other traffic. An elevated metro system is the most preferred form of metro structure due to ease of construction and less cost compared to other types of metro structures. An elevated metro system has two major components pier and box girder. In this project, study has been carried out on these two major elements.

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 behaviour 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 et al. (2010). The parameter considered to present the behaviour of S ingle 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.

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.

These conclusions can be considered only for the selected pier. For General conclusions large numbers of case studies are required and it is treated as a scope of future work.

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.

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