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Seismic Analysis of Elevated Metro Bridge

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Abstract: A metro rail system is more preferred type of metro system due to ease of construction and also it makes urban areas more accessible with very less construction difficulty. metro concept is very easy to transport large numbers of people and transportation. In metro city like Delhi, Kolkata, Chennai and Mumbai is very populated city An elevated metro system has two major elements pier and box girder. The codes are now moving towards a performance-based (displacement-based) design approach, which consider. All the information are given by MMRC and considered the data value in this design as per the target performances at the design stage. Which is located to ShyamNager metro station in Mumbai, The present study focuses on pier of an elevated metro structural system conventionally the Double Decker pier of a metro bridge is designed using a force based approach. During a seismic loading, the behaviour of a single pier elevated bridge relies mostly on the ductility and the displacement capacity. It is important to check the ductility of such single piers. Force based methods do not explicitly check the displacement capacity during the design. The codes are now moving towards a performance-based (displacement-based) design approach, which consider the design as per the target performances at the design stage. Performance of a pier designed by a Direct Displacement Based Design is compared with that of a force-based designed one. The design of the pier is done by both force based seismic design method and direct displacement based seismic design method the study.
Keywords: Elevated Structure, Double Decker Pier, Displacement Based Seismic Design, force Based Design, displacement Staad prov8i.

I. INTRODUCTION

The Metro bridges are analysed the displacement and bending moment and shear force distribution are calculated due to the applied loads. For this, the finite element method further, seismic analysis by the bridge structure is performed on structural analysis software staad pro v8i. An elevated metro system has two major components pier and box girder. A typical elevated metro bridge model is shown in Figure 1.1 (a). 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. Box girders are used extensively in the construction of an elevated metro rail bridge. The tensional 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 complete cross section. Box girder cross sections may take the form of single cell. Seismic analysis of Double Decker pier as per strength based method and performance based method. The force based design and displacement analysis for single degree of freedom structure as per IRS 5,16,24, 78, IS 1893 part1:2002 and RDSO guideline -13 The both are performance study of different configuration. A typical Elevated Double Decker pier model show in fig 1.1.

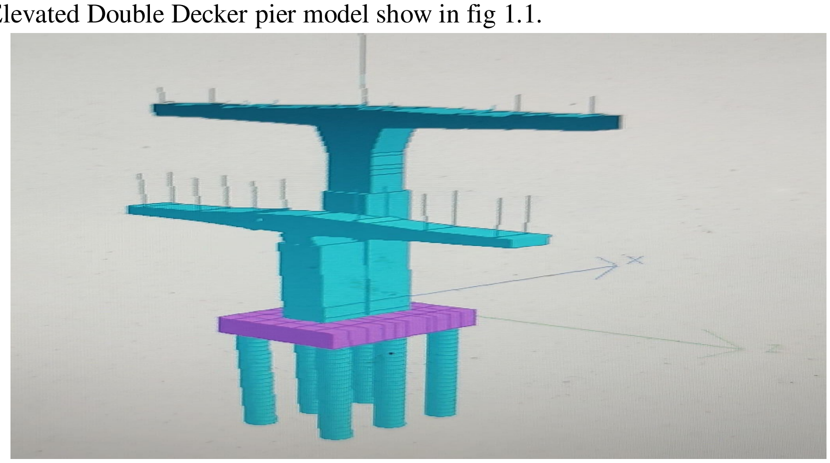

Fig-1.1:- double decker pier model

A. Objective

1) To study the performance of a double decker pier designed by force based design method and direct displacement based design method.
2) Seismic analysis perform on double Decker pier metro bridge for zone-3.
3) To find the results Displacement, Bending moment and shear force by finite aliment method to double Decker pier are calculated due to the applied loads

B. Scope

1) The present study is limited to these practical case the come cross in an Double Decker pier metro bridge projects.
2) With regard to the geometry of the pier considered the present study is limited to.
3) Rectangular pier cross section.
4) Double Decker pier structural system.
5) Reinforcement concrete pier.

II. DESIGN OF PIER

Conventionally the Double Decker pier of a metro bridge is designed using a force based approach. Recent studies (Priestley et al., 2007).The pier height for taller pier effect will be calculated as per ACI 318 to workout additional moments arising. show that the force based design may not necessarily guarantee the required target performances.

The design of a pier by force based seismic design method is carried out as per IS 1893: 2002 Code. The design procedure to find the base shear of the pier by FBD method is summarized below.

1) *Step 1:* The structural geometry of the pier is assumed.
2) *Step 2:* Member elastic stiffness are estimated based on member size.
3) *Step 3:* The fundamental period is calculated by:

$$T = 0.075\ h0.75$$

Where h = Height of Building, in m.

4) *Step 4:* Seismic Weight of the building (W) is estimated
5) *Step 5:* The design horizontal seismic coefficient Ah for a structure determined by

$$Ah = Z\ I\ Sa\ 2\ R\ g$$

Where, Z = Zone factor
I = Importance factor
R = Response reduction factor,
Sa/g = Average response acceleration coefficient Z, I, R and Sa/g are calculated as per IS 1893:2002 Code.

6) *Step 6:* The total design lateral force or design seismic base shear force (VB) along any principal direction is given by

$$VB = Ah\ W$$

Where Ah = Design Horizontal Seismic Coefficient and
W= Seismic Weight of the Building

A. Perform Study Of A Double Decker Pier

The substructure and superstructure is viaduct generally comprises of simply supported spans. The shape of the pier follows the flow of force .pier gradually wide at the top to support the bearing under the box webs. The pier is rectangular with curve at corners and grooves for aesthetic finish .The longitudinal pier present study is based on the design basis report of the viaduct will be conducted according to the RDSO guideline of 2015 . Limited Performance study displacement of the pier designed by a Force Based Design (FBD) Method and Direct Displacement Based Design (DDBD) Method is described in this chapter. Performance assessment is carried out for the designed pier and the results are discussed briefly. The box girder superstructure shall be constructed with precast by long line /short line method using over head launcher for span 250m radius. For the stress induced in segment during any stage of construction shall not exceed 50% of cube strength .The typical pier models considered for the present study are shown in figure 2.1.

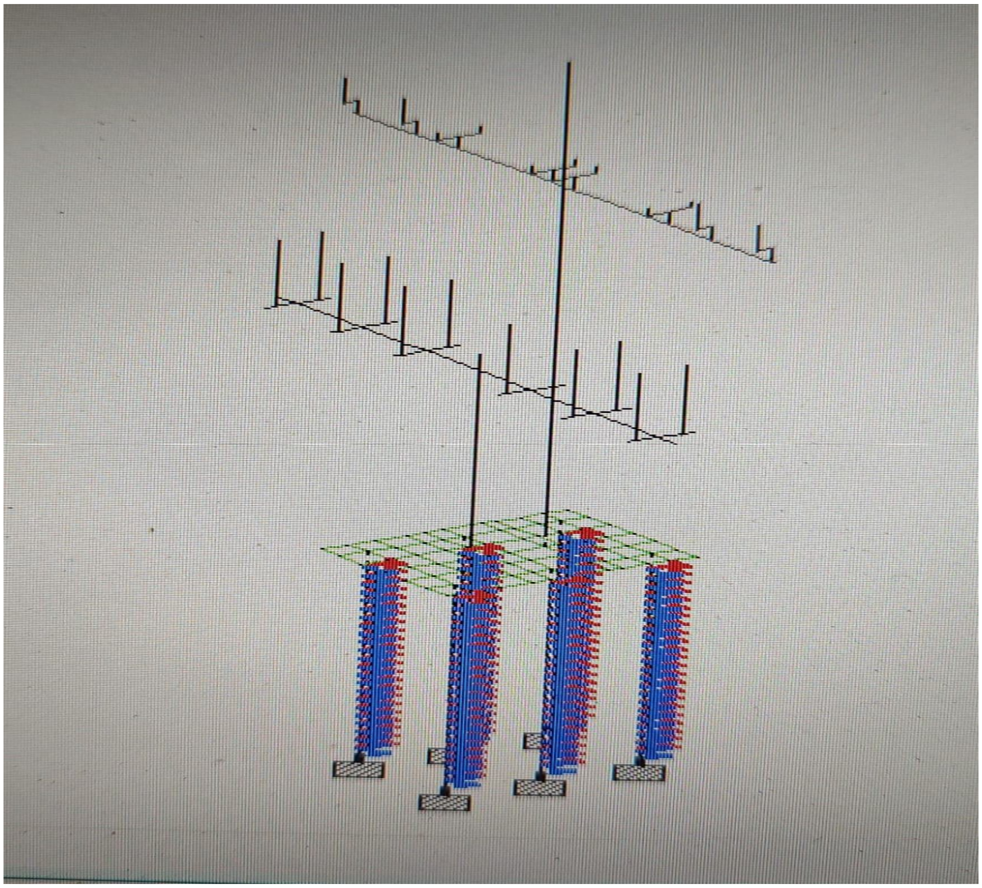

Fig-2.1:-Double Decker pier model by Staad pro v8i software.

B. Material property

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

Table 1: Material Property for

1)	Pier Properties of Concrete Compressive Strength of Concrete	= 60 N/mm2
2)	Density of Reinforced Concrete	= 24 kN/m3
3)	Elastic Modulus of Concrete	= 36000 N/mm2
4)	Poisson's Ratio	= 0.15
5)	Thermal Expansion Coefficient	= 1.17 x 10 -5 / 0C
6)	Properties of Reinforcing Steel Yield Strength of Steel	= 500 N/mm2
7)	Young's Modulus of Steel	= 205,000 N/mm2
8)	Density of Steel	= 78.5 kN/m3
9)	Poisson's Ratio	= 0.30
10)	Thermal Expansion Coefficient	= 1.2 x 10 -5 / 0C

C. . 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 as per MMRC DBR report for the analysis are shown in Table 2. The total seismic weight of the pier is

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Table 2: Approximate design load case

Load from platform level	Load	Load from track level	Load
Self weight	120kN	Self weight	160KN
Slab weight	85KN	Slab weight	100KN
Roof weight	125KN	Total dl	260KN
Total dl	330KN	SIDL	110KN
SIDL	155KN	Train load	190KN
Crowd load	80KN	Breaking +Tractive load	29KN
LL on roof	160KN	Long welded rail forces	58KN
Total ll	240KN	Bearing load	20KN
Roof wind load	85KN	Temperature load	
Lateral	245KN	For track girder	20KN
Bearing load	14KN	Platform girder	14KN
		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 2. From the FBD, it is found out that the minimum required cross section of the pier is only 2m X2.2m m for 0.8 % reinforcement

Table-3.: Approximate design load case

Pier type	Cross section (m)	Dia. Of bar (mm)	Number of bar	Required	Provided by MMRC
Flyover pier	2 x 2.2	32	36	0.8%	1.48 %
Viaduct pier top level	2 x 2.2	32	38	0.8%	1.48%

D. Performance Assessment result

The performance assessment is done to study the performance of seismic analysis is conducted for the designed pier using Saad pro v8i Software Performance parameters Displacement, max shear force max banding moment, behavior are found for both x and z directions and the results are shown in fig 2.4.1 and 2.4.2

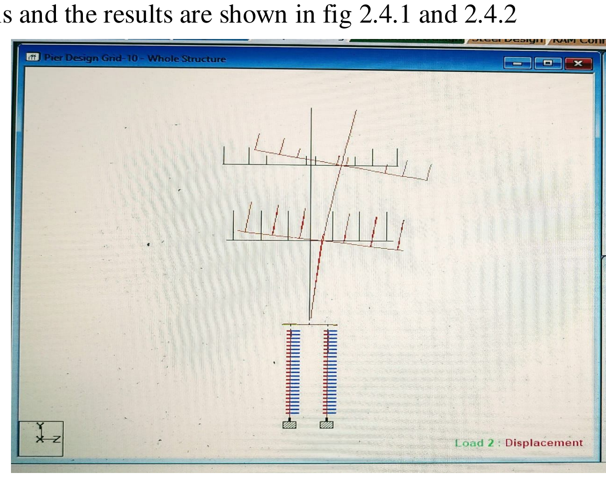

Fig2.4.1Performance displacement by Staad pro

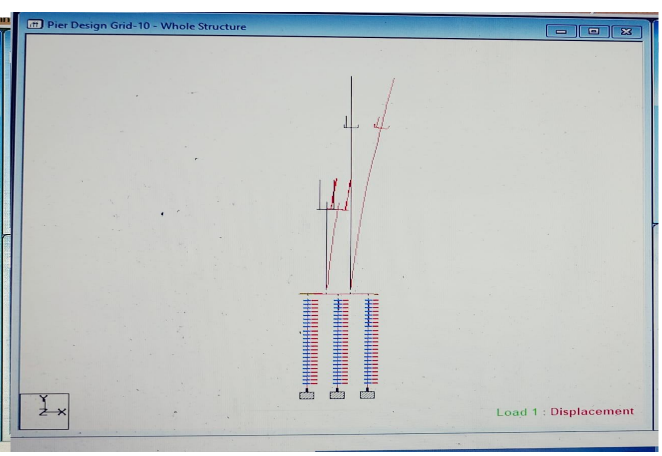

Fig2.4.2: Performance displacement by Staad pro

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Table-4: Displacement result of double Decker pier

z			Horizontal	Vertical	Horizontal
	Node	L/C	X mm	Y mm	Z mm
Max X	11208	1 SLX	21.324	-0.121	0
Min X	12341	2 SLZ	-0.64	-6.324	6.043
Max Y	5090	2 SLZ	0.18	9.697	16.316
Min Y	5102	2 SLZ	-0.18	-9.699	16.316
Max Z	11208	2 SLZ	0	0	24.147
Min Z	11272	1 SLX	5.791	-0.542	-0.078
Max rX	9001	2 SLZ	0.178	9.551	18.702
Min rX	11526	1 SLX	0.51	0.337	0.001
Max rY	12341	1 SLX	5.847	0.116	0
Min rY	11253	2 SLZ	0.585	5.755	6.123
Max rZ	11542	2 SLZ	0.021	-0.337	0.562
Min rZ	9001	1 SLX	16.431	0.331	-0.007
Max Rst	11208	2 SLZ	0	0	24.147

III. CONCLUSIONS

1) Force Based Design Method may not always guarantee the performance parameter required and in the present case the pier just achieved the target required.
2) In case of find the seismic analysis of double decker perform in selected pier and achieved the behaviour factors by software bases and result get.
3) In this paper parametric study on behaviour of double decker bridge pier of 29.4m high and fly over pier height 21.29m with span 20m both side were analysed using DDBD method as per RDSO:2015. It is observed that behaviour of double decker pier seismic design loading for zone-III .
4) As the span length increases, responses parameter longitudinal stresses at the top and bottom, shear, Displacement, torsion, moment and Deflection are increases .
5) The conclusion can be considered only for selected pier. for generals conclusions large numbers of case studies are required as a scope in future work.

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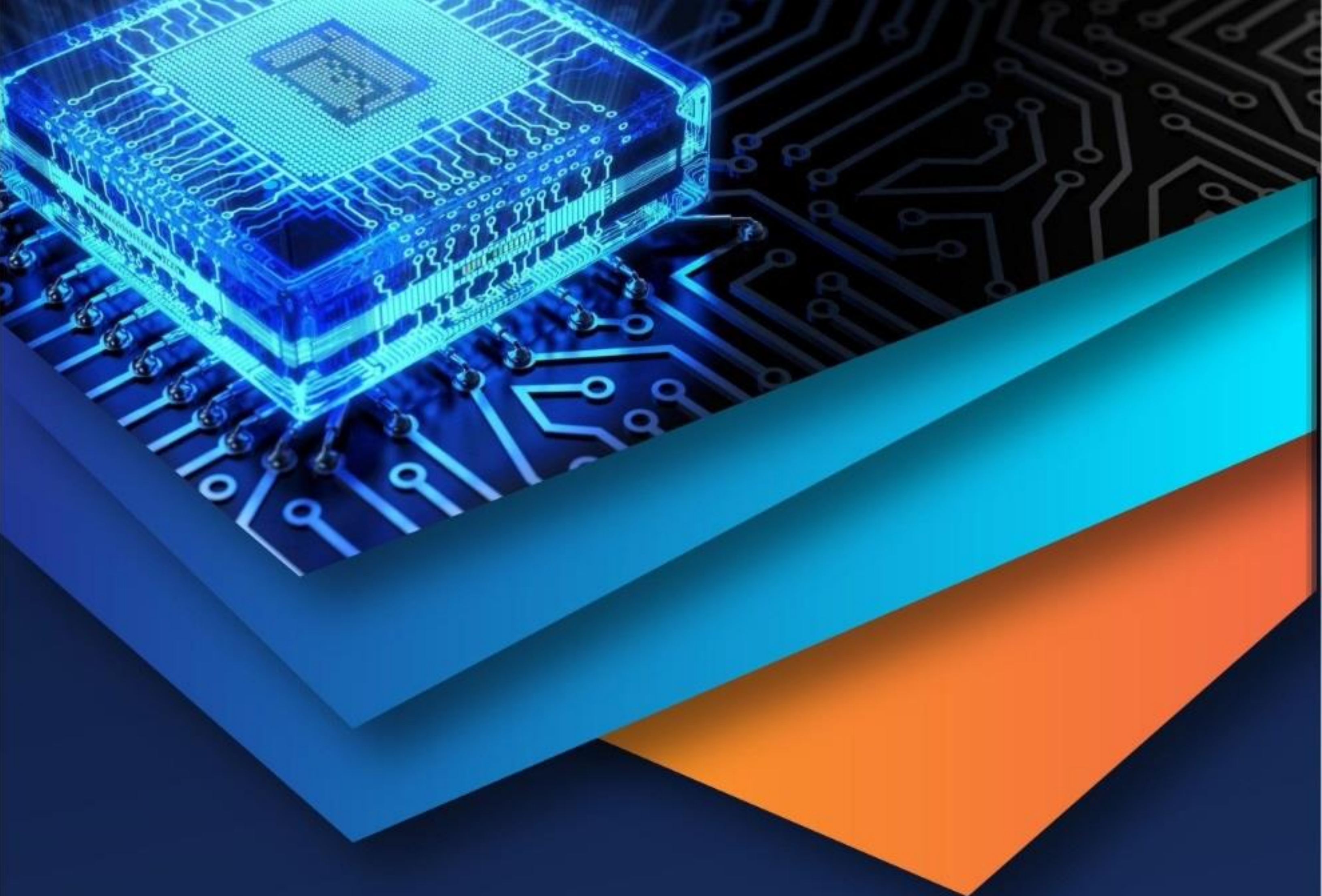

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