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A REVIEW ON ELEVATED METRO BRIDGE SUBSTRUCTURE

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Abstract — *Now a days the Force based design (FBD) method is used for seismic design of metro bridge pier which has limitation to damage control of structure. It is understood that Displacement can be directly related to damage control not by force. This paper contains to design of metro bridge pier using direct displacement based design (DDBD) method confirming to IS provisions and traditional strength based method. Parametric analysis of pier is considered by different circular and square cross section having different heights of 8m, 10m, 12m and 15m are carried out using FBD and DDBD procedure. The seismic assessment obtains from the analysis of the pier design using both methods are compared.*

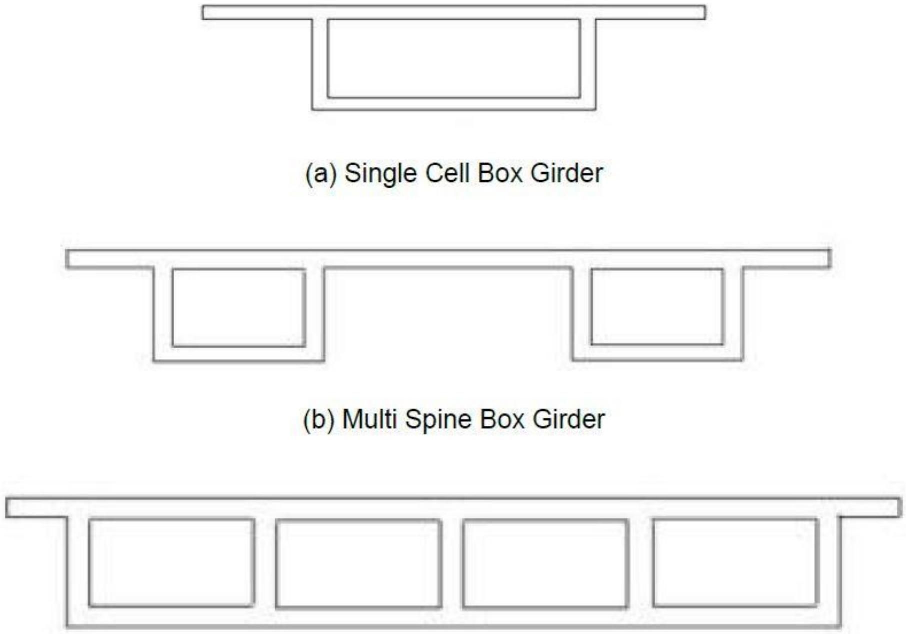
Keywords- *Force Based Design, Direct Displacement Based Design, Bridge substructure, Performance Based Design, Elevated metro system*

I. INTRODUCTION

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. The grade separation allows the metro to move freely, with fewer interruptions and at higher overall speeds. Metro systems are typically located in underground tunnels, elevated viaducts above street level or grade separated at ground level. 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. An elevated metro system has two major components pier and box girder. A typical elevated metro bridge model is shown in Figure 1.1

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. Box girder cross sections may take the form of single cell, multi spine or multi cell as shown in Figure 1.2

Figure 1 Typical Elevated Metro Bridge and its Elements



(a) Single Cell Box Girder

(b) Multi Spine Box Girder

(c) Multi Cell Box Girder

Figure 2 Types of Box Girder

II. LITERATURE REVIEW

A. Qiang Xue, Cheng – Chung Chen Performance-Based Seismic Design of Structures: A Direct Displacement-Based Approach, Engineering structure 25(2003)1803-1813

In this paper, a performance-based seismic design procedure, which is directly associated with pre-quantified performance criteria, is presented by employing a displacement-based approach .They carried out Non-linear time history analysis verified that this approach is applicable to control the target displacement to acceptable limit.The procedure can be extended to fulfil multiple performance objectives and to consider special effects such as the near-fault and accumulative damage. In the presented design procedure of the building, the factor plays an important role in controlling the design strength.

The result indicated that this approach is general and applicable for reduced spectrum into account of the inelastic behaviour.

Table 1 Displacement –based design of the RC bridge column by approach (a)

D_t (m)	D_y (m)	μ	A_y (g)	V_y (tonf)	M_{req} (tonf-m)	K_{req} (tonf/m)	Design by stiffness		Check by strength	
							Section (cm)	ρ_l (%)	D_{y-des} (m)	error
0.1575	0.02625	6	0.0644	26.063	136.833	992.893	80×80	2.5	0.055	1.1
0.1575	0.055	2.86	0.1348	54.61	286.697	992.893	80×80	2.5	0.055	0<0.01

Table 2 Displacement –based design of the RC bridge column by approach (b)

D_t (m)	D_y (m)	μ	A_y (g)	V_y (tonf)	M_{req} (tonf-m)	K_{req} (tonf/m)	Design by strength		Check by stiffness	
							Section (cm)	ρ_l (%)	D_{y-des} (m)	error
0.1575	0.02625	6	0.0644	26.063	136.833	992.893	70×70	1.0	0.0549	1.1
0.1575	0.0549	2.87	0.1318	54.509	286.177	992.893	80×80	2.5	0.055	0.002<0.01

B. K. Mackie, V. Suarez, and Oh-Sung Kwon Seismic Performance Assessment of Concrete Bridges Designed by Displacement-Based Methods , AASHTO 2006

This paper investigates performance-based seismic assessment of the DDBD procedure. In this paper, they have compared FBD and DDBD methods And they have explain advantages of DBD method over force based method. They have also explain the analysis procedure for the DDBD. They have carried out four case studies, each case study was designed using DDBD for a specified hazard level and they have conducted non-linear time history analysis to assess the performance of each and more specifically, the probabilistic distribution of peak displacement response in reference to the original target displacement is used for design.

They came to conclusion that, in all case studies, the probability of exceeding the target displacement is 25%. This information enables a modifier to the original target displacement to achieve a specified risk level without iteration.

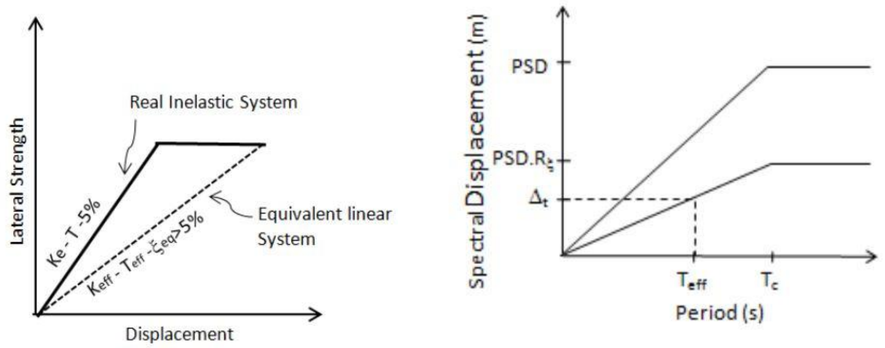


Figure 3 Fundamentals of DDBD (a) Equivalent Linearization (b) Displacement Spectrum

C. Khan, T. J. Sullivan, and M. J. Kowalsky Direct Displacement–Based Seismic Design of Reinforced Concrete Arch Bridge , Jounal of Bridge Engineering ASCE 2014.19:44-58

In this paper, a displacement-based design procedure for continuous concrete bridges is proposed. The procedure is applicable to Single Degree of Freedom (SDOF) bridges as well as Multi-Degree Of-Freedom (MDOF) bridges with flexible or rigid superstructures, and for varying degrees of abutment restraint. The background and development of the design procedure is presented first, followed by validation studies using dynamic inelastic time-history analysis. The procedure is applied to the transverse response of bridge structures; however, it is equally well-suited for longitudinal response.

The results indicate that the bridges designed with direct displacement-based design generally achieved their target displacement
pattern.

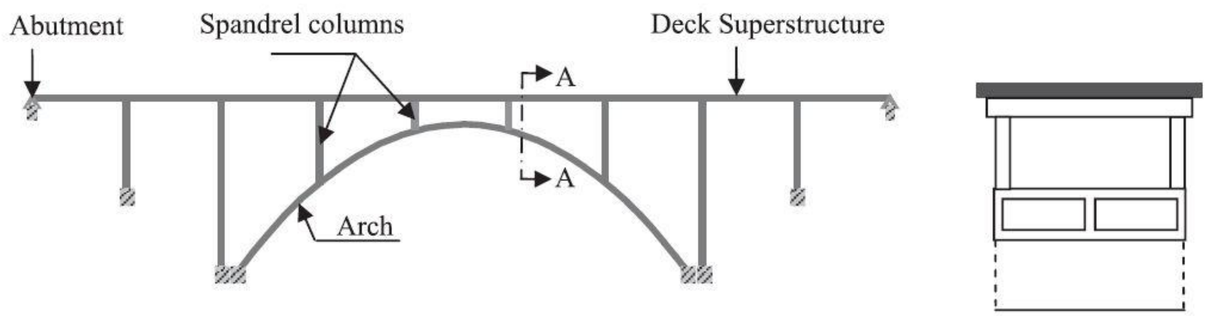
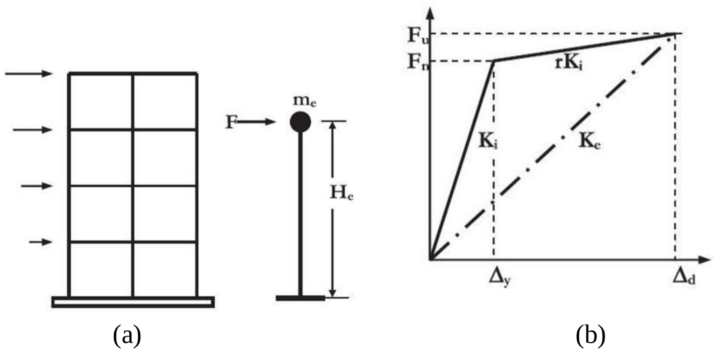
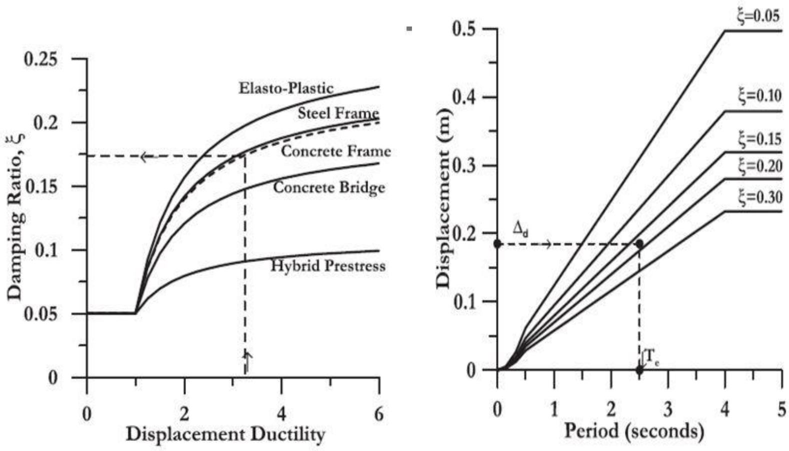


Figure 4 Elevation and section view of a typical RC deck arch bridge: (a) elevation view; (b) section A-A





(c) (d)

Figure 5 (a) SDOF simulation; (b) effective stiffness Ke (c) equivalent damping versus ductility (d) Design displacement spectra

D. Qiang Xue A Direct Displacement – Based Seismic Design Procedure of inelastic Structure, Engineering structure 23(2001)1453-1460

In this paper with the use of displacement based procedure, they derived formula and applied for new design. From the derived formula was applied to Single Degree of Freedom (SDOF) as well as Multi-Degree Of-Freedom (MDOF).
The result indicate that procedure was easily implemented to primary design phased of DBD procedure.

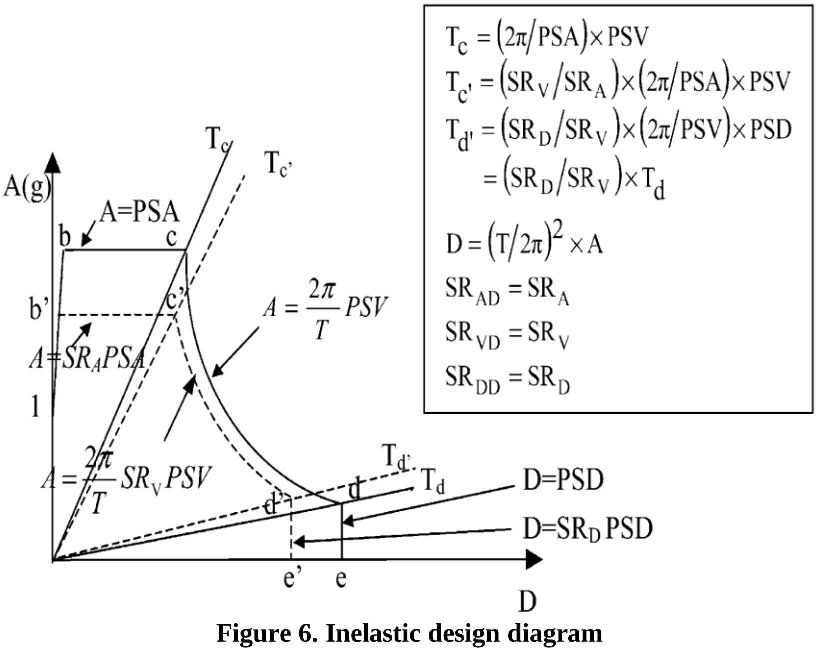


Figure 6. Inelastic design diagram

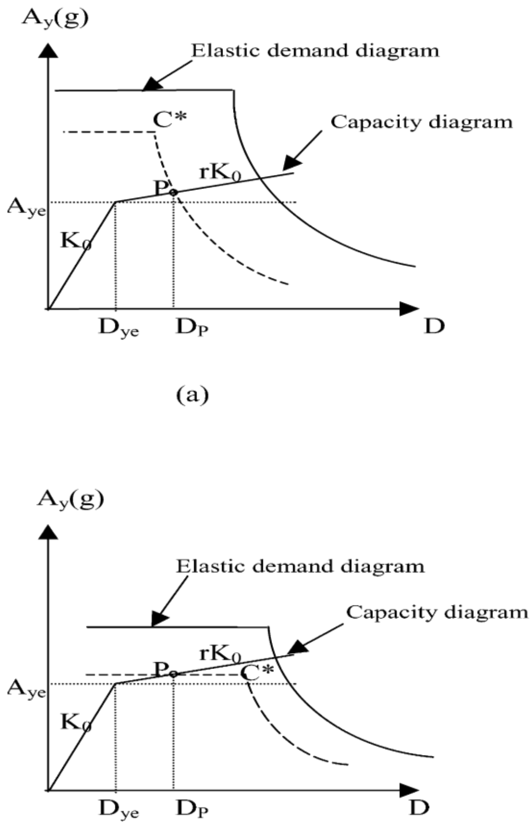


Figure 7 performance point from a non-iterative capacity-spectrum method

CONCLUSION

From the above literature we conclude that

1. Displacement-based design procedure, given the target displacement and the elastic design spectrum, the required stiffness and strength of a structure can be evaluated numerically with the assumption of ductility ratio and post-yielding stiffness ratio.

2. 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 behavior factors more than targeted Values.

3. Non-linear time history analysis verified that this approach is applicable to control the target displacement.

4. Paper suggest to use different design procedure for single degree of freedom (SDOF) and Multi degree of freedom (MDOF).

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3. Khan, T. J. Sullivan, and M. J. Kowalsky Direct Displacement–Based Seismic Design of Reinforced Concrete Arch Bridge , Jounal of Bridge Engineering ASCE 2014.19:44-58
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