SEISMIC BEHAVIOUR OF REINFORCED CONCRETE BRIDGE AND CONTROL MEASURES FOR SEISMIC POUNDING

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INTRODUCTION

1. GENERAL

India has had a variety of the world's greatest earthquakes within the last century. In fact, quite one half area within the country is taken into account vulnerable to damaging earthquakes. The seismic building design code in India (IS 1893, Part-I) is additionally revised in 2002. The magnitudes of the look seismic forces are considerably enhanced generally, and also the seismic zonation of some regions has also been upgraded. There are many literature (e.g., IITM-SERC Manual, 2005) available that presents step-by-step procedures to gauge multi-storeyed buildings. The attention for existing bridges is relatively less. However, bridges are important components of transportation network in any country. The bridge design codes, in India, don't have any seismic design provision at this time. A outsized number of bridges are designed and constructed without considering seismic forces. Therefore, it is important to gauge the capacity of existing bridges against seismic force demand. There are presently no comprehensive guidelines to help the practicing structural engineer to gauge existing bridges and suggest design and retrofit schemes. So as handle this this problem, this work aims to hold out a seismic evaluation case study for an existing RC bridge using nonlinear static (pushover) analysis. Nonlinear static (pushover) analysis as per FEMA 356 isn't compatible for bridge structures. So, within the present study an improved pushover analysis is additionally won't to verify the results.

PUSHOVER ANALYSIS

This procedure is especially wont to estimate the strength and drift capacity of existing structure and also the seismic demand for this structure subjected to chose earthquake. This procedure can be used for checking the adequacy to recent structural design also. The effectiveness of pushover analysis and its computational simplicity brought this procedure to many seismic guidelines (ATC 40 and FEMA 356) and style codes (Eurocode 8 and PCM 3274) in previous few years

Pushover Analysis Procedure

Pushover analysis could be a static nonlinear procedure within which the magnitude of the lateral load is increased monotonically maintaining a predefined distribution pattern along the peak of the building (Fig. 4.1.1a). The relation between base shear and control node displacement is plotted for all the pushover analysis (Fig. 4.1.1b).

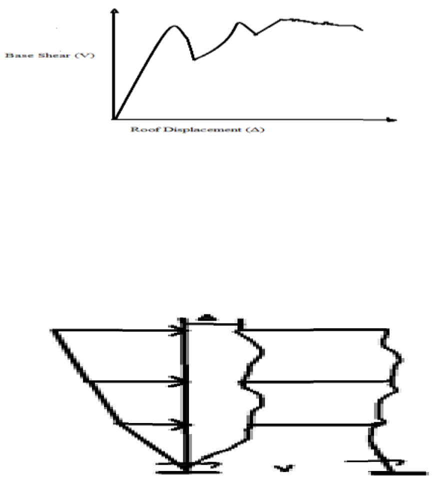


Fig. 1: Schematic representation of pushover analysis procedure

Generation of base shear – control node displacement curve is single most significant part of pushover analysis. This curve is conventionally called as pushover curve or capacity curve. The capacity curve is that the basis of 'target displacement' estimation as explained in Section So the pushover analysis is also dispensed may be carried out twice: (a) first time till the collapse of the building to estimate target displacement and (b) next time till the target displacement to estimate the seismic demand. The seismic demands for the chosen earthquake (storey drifts, storey forces, and component deformation and forces) are calculated at the target displacement level. The seismic demand is then compared with the corresponding structural capacity or predefined performance limit state to understand what performance the structure will exhibit. Independent analysis along each of the 2 orthogonal principal axes of the building is permitted unless concurrent evaluation of bi-directional effects is required. The analysis results are sensitive to the choice of the control node and selection of lateral load pattern. In general, the centre of mass location at the roof of the building is is taken into account as control node. For selecting lateral load pattern in pushover analysis, a set of guidelines as per FEMA 356 is explained in Section.

Lateral Load Patterns

In pushover analysis the building is pushed as selected load distribution pattern along the peak of the building. The magnitude of the whole force is increased but the pattern of the loading remains same till the tip of the method. The lateral load patterns should approximate the inertial forces expected within the building during an earthquake. The distribution of those forces determines relative magnitudes of shears, moments, and deformations within the structure. The distribution of these forces will vary continuously during earthquake response because the members yield and stiffness characteristics change. It also depends on the kind and magnitude of earthquake ground motion. Several investigations (Mwafy and Elnashai, 2000; Gupta and Kunnath, 2000) have found that a triangular or trapezoidal shape of lateral load provide an improved suited fit to dynamic analysis results at the elastic range but at large deformations the dynamic envelopes are closer to the uniformly distributed force pattern. Since the constant distribution methods are incapable of capturing such variations in characteristics of the structural behaviour under earthquake loading, FEMA 356 suggests the utilisation of a minimum tow different patterns for all pushover analysis. Use of two lateral load patterns is meant to bind the range that will occur during actual dynamic response. FEMA 356 recommends selecting one load pattern from each of the subsequent two groups:

Group – I:

i) Code-based vertical distribution of lateral forces employed in equivalent static analysis

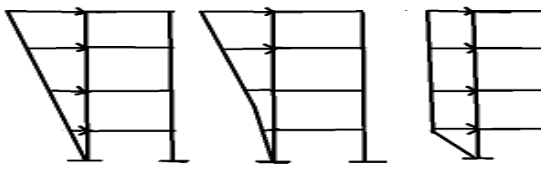


Fig. 2: Lateral load pattern for pushover analysis as per FEMA 356 (considering uniform mass distribution)

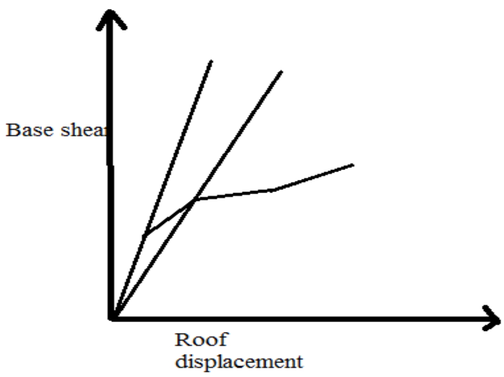


Fig. 3: Schematic representation of Displacement Coefficient Method (FEMA 356)

The process begins with the bottom shear versus roof displacement curve (pushover curve) as shown in Fig. 4.1.3a. An identical period (Teq) is generated from initial period (Ti) by graphical procedure.

MR DAMPER MODELLING

The nonlinear Bingham plastic model are often accustomed be used to model the MR damper force. That's supported force is based on the scheme of Fig. 6.1 that is based on a viscous damper combined in parallel with a Coulomb friction element.

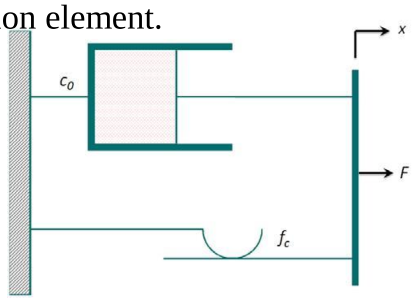


Fig 3. The Bingham plastic model for MR dampers: a Coulomb

friction element in parallel with a viscous damper

The MR damper force is given by:

$F_D = c_0\dot{z} + f_c \,\mathrm{sgn}(\dot{z}) + f_0$

where co is that the damping coefficient, fc is that the frictional force associated with the field-dependent yield stress and fo is that the offset within the force.

The idea proposed during this paper is characterized by the mixing of an air cushion with an MR damper. The concept takes place ranging from the passive device illustrated in figure and supported the mix with a typical viscous damper. The architecture of the device is based on the relies connection between the spring and also the damper.

The proposed device employs an air cushion integrated with an MR damper. A primary scheme (solution a) is illustrated in Fig. 4:

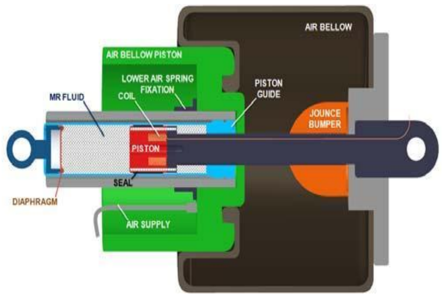
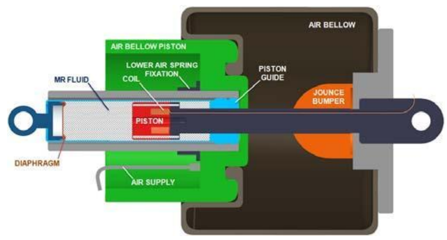


Fig 4. Air cushion integrated with an MR damper (solution *a*).

the MR fluid flows through the annular gap between the piston and also the cylinder. A magnetic circuit, supplied by the excitation coil located within the piston, is employed to come up with controllable force yield by varying the coil current. The resultant damping force is thanks to both shear damping and valve damping forces. It changes dynamically with the force field generated by the input current. Another scheme is proposed in Figure (solution b).

It is supported the utilisation based on the employment of the valve mode: indeed, suitable orifices are realized within the piston and seals are adopted between the piston and also the cylinder.

Fig 5. Air cushion integrated with an MR damper (solution *b*)



The last scheme (solution c) relies on the presence of orifices and annular gap.

Fig.6. Air cushion integrated with an MR damper (solution c). The answer a relies on the mix of both the shear and also the valve mode. The magnetic circuit involves inevitably the piston and also the cylinder. The answer b is characterized by the sole valve mode and also the cylinder. The answer c presents the operational modes of the solutions a and b, with a magnetic flux that crosses the orifices and also the annular gap. The increasing of the fluid volume to be controlled is that the principal feature of this last solution. At the identical time, an augmented magnetic reluctance is thanks to the presence of both the orifices and also the annular gaps

RESULTS AND DISCUSSIONS

Earthquake motion	Direction	Amplitude	Predominant periods (sec)
EI Centro wave	E-W	216.5	0.507
	N-S	344.4	0.560
	V	209.3	0.110

Table 1. Main characteristics of the chosen earthquake ground motion

Joint	Displacement of deck (mm)		
	Without damper	With MR dampers	With Air spring+MR dampers
981	25.3	13.62	10.45
1109	32.44	8.3	5.2
1253	22.62	9.31	6.7
1239	38.27	12.44	10.63

Table.2 Peak pounding forces

Location	EI Centro			
	Time (s)	Pounding force ($\times 10^{7}$) N		
		Without damper	With MR damper	With Air spring+MR damper
Interior pier	1	0.04643	0.04626	0.04613
	2	0.2116	0.1858	0.1645
	3	0.3792	0.1937	0.1118
	4	0.01204	0.01092	0.0989
	5	0.02113	0.02039	0.01003

Table 3. Displacement of deck with and without dampers

CONCLUSIONS

Bridges extends horizontally with its two ends restrained and which makes the dynamic

characteristics of bridges different from buildings. By analysing the structure using FEMA-356 (TLP) pushover analysis, it was

concluded that:

i) Here the performance of the bridge, consistent with FEMA-356, is not acceptable. Therefore it requires retrofitting.

ii) For FEMA-356 loading hinges are concentrated at the centre of the bridges.

iii) Modal analysis of a 3D bridge model reveals that it has many closely-spaced modes.

iv) Further investigation is required so as to create a generalised evaluation procedure for bridge structures with different configuration

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