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Pushover Analysis of Steel Frame Structures with Base Isolation Devices

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ABSTRACT

Pushover analysis has been widely used for seismic assessment of buildings as it's a nonlinear, static technique used to estimate deformations in a structure due to seismic force. In past years pushover analysis has accomplished majority of importance because of it being simple to perform and giving effective results. The main result of a pushover analysis is the capacity curve which is a force-displacement relation, involving the load to be applied incrementally until the structure collapses. The seismic performance of the buildings can be enhanced by using various base isolation devices, such as HDRB, LRB and LDRB.

This research work aims to explore the applicability of these devices in tall buildings. To achieve this purpose storey numbers ranging from 3 to 15 with a step size of 3 storeys have been modelled and analysed with inclusion of different types of damping devices to evaluate their feasibility in this model. Finally effect of inclusion of base isolation with its effect on different storeys have been evaluated and some useful outcomes and recommendations for effective seismic design have been presented from this analysis. The structures are designed accordance with Indian Standard, i.e. IS 800:2007 and the pushover analysis has been done using structural analysis and design software STAAD pro.

Keywords: Base isolation devices, Capacity curve, Critical damping, Dislocation, Earthquake resistant structures, Hinge-FEMA, Linear elastic, Non-liner static, Pushover analysis, Seismic isolator, Story drift.

Abbreviations: HDRB, high density rubber bearing; LRB, lead rubber bearing; LDRB, low density rubber bearing.

1. INTRODUCTION

Push-over analysis is the favoured technique for seismic presentation assessment of configuration by the main psychoanalysis strategies and system since it is accurate on the basis calculation and perception. Pushover examination permits tracing the succession of acquiescent and collapse on component and building height as well as the improvement of general competence bend of the structure. The anticipation from push-over examination is to approximate decisive comeback constraint forced on structural classification and its mechanism as secure as potential to those calculated by nonlinear vibrant examination. The information regarding the response features are provided using the pushover analysis which are not provided by elastically static examination or elastically dynamic examination.

The base isolation procedure is a seismic intend move towards in which because of the inclusion of a stretchy coating sandwiched between the groundwork and the superstructure the basic occurrence of the arrangement reduces to an importance inferior than the major force including frequencies of tremor earth movement. The isolators are not mainly acting to assimilate the vitality of the quake, however are giving an interface that responds tremor vitality over into the ground so diminishing its transmission into the structure. Additionally the capacity of damping which is provided usually by damping system helps in dispersing the power conveying while the occurrence of seismic activities. The impact of the disengagement framework is that during a seismic tremor the structure moves for all intents and purposes as an inflexible body on the isolators. The twisting is accumulated at the confinement interface, however not at all like the structure the disconnection framework can oblige enormous disfigurements without huge harm.

2. MATERIALS AND METHODS

For obtaining the displacement and frequency, frame structures ranging from 3 to 15 storeys have been modelled and analysed using STAAD Pro V8i with a size step of 3 storeys with the inclusion of different dampers and conventional fixed base support.

2.1 Design data for modelling the frames:-

- Tallness of each storey = 3.5 m
- Beam Properties **:-** ISMB 400
- Section Area of Beam :- 78.5cm^2
- Diameter of Beam :- 40cm
- Columns Properties = ISHB 400
- Section Area of Column :- 98.7cm^2
- Diameter of Column:- 40cm
- Self weight factor = -1
- Live weight = 4 kN /m^2
- Modulus of flexibility = 220000 N/mm^2
- Fe 415 grade of steel
- Span in direction X = 5m
- Span in direction Z = 5.5 m
- No. of bays in X direction:- 3,4,5,6,7 for 3,6,9,12,15 storeys respectively
- No. of bays in the Z direction:-3,4,5,6,7 for 3,6,9,12,15 storeys respectively

	HDRB	LRB	LDRB	Conventional
Spring Support	1300 kN/m^2	900 kN/m^2	550 kN/m^2	Fixed
Critical damping	18%	13%	9%	5%
Displacement in x direction	+/- 500mm	+/- 500mm	+/- 500mm	Nil

Table 1. Description of support properties

2.2 Pushover definition:-

- Moment frame including the effects of geometric non-linearity
- No. of push load steps:- 250
- Hinge type:- FEMA
- Site category:- Class C (seismic zone III)
- Spectrum parameters:- SS,0.1; S1,0.25
- Push control displacement = 0.5m along X axis; push superstructure

3. RESULTS AND DISSCUSSION

Pushover analysis is performed on each of the frames and the non-linear static analysis investigates the frequency and displacement in each frame structure. For the pushover cases gravity loads are considered in the push direction (i.e. X direction), the following results were obtained:-

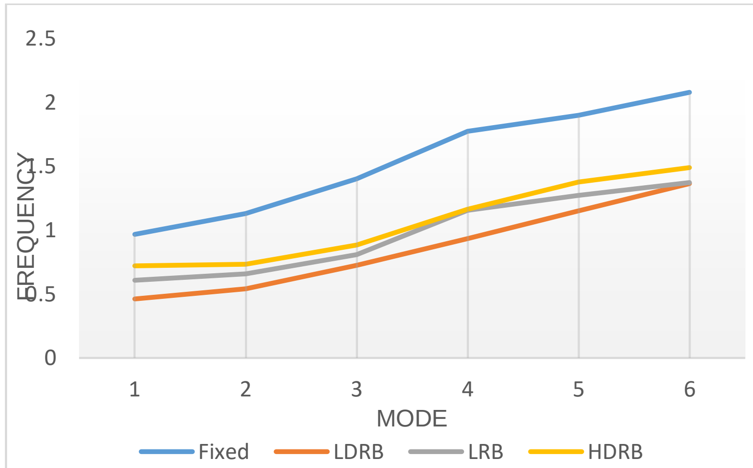

Figure 1: Graphical view of frequency-type of 3 storey structure

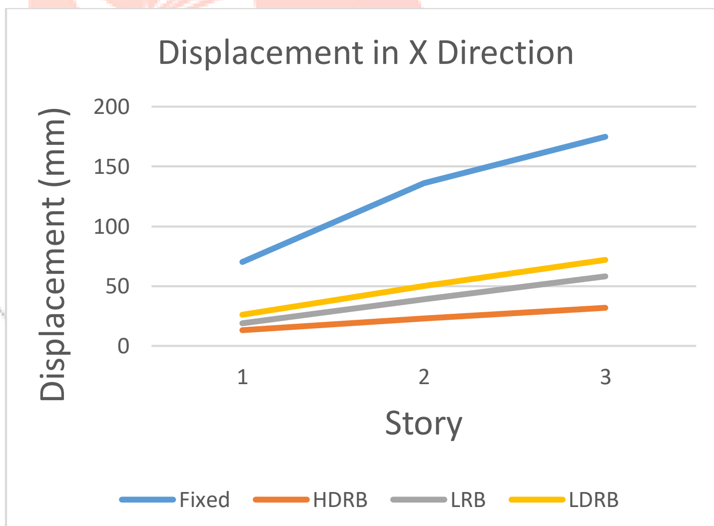

Figure 2: Dislocation in direction x graphically for 3 storey structure

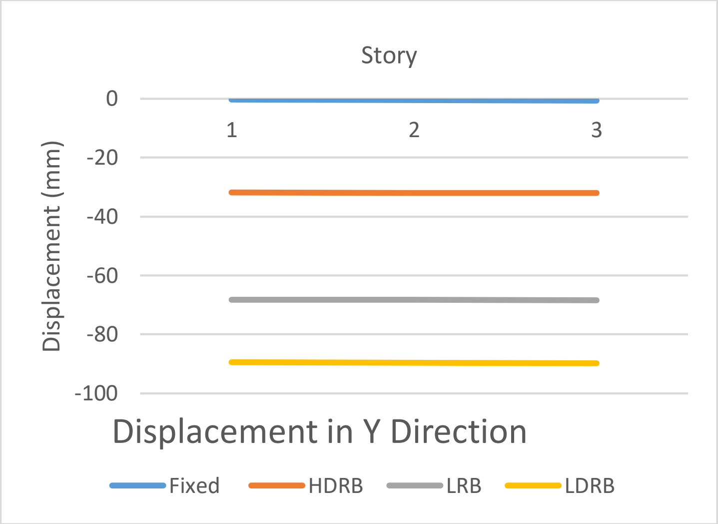

Figure 3: Displacement in Y direction for 3 storeyed structure graphically

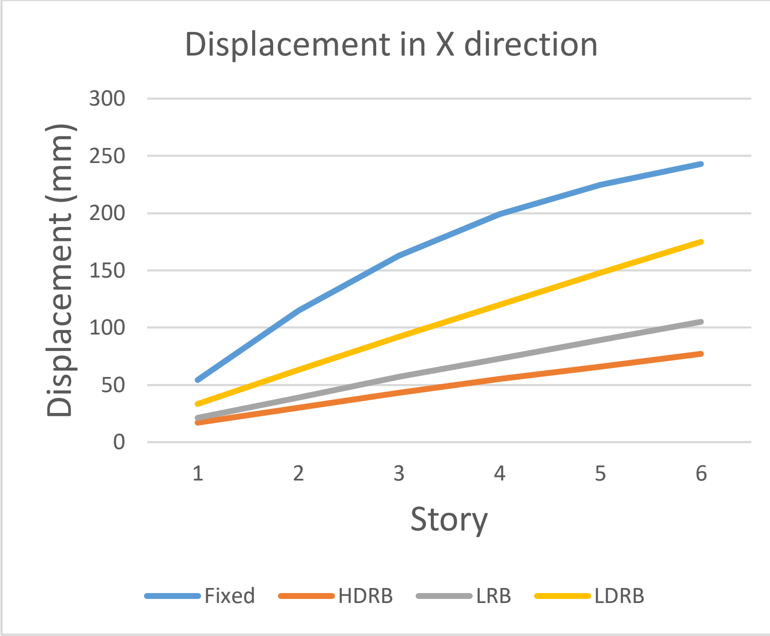

Figure 5: Dislocation in direction x graphically in 6 storey structure

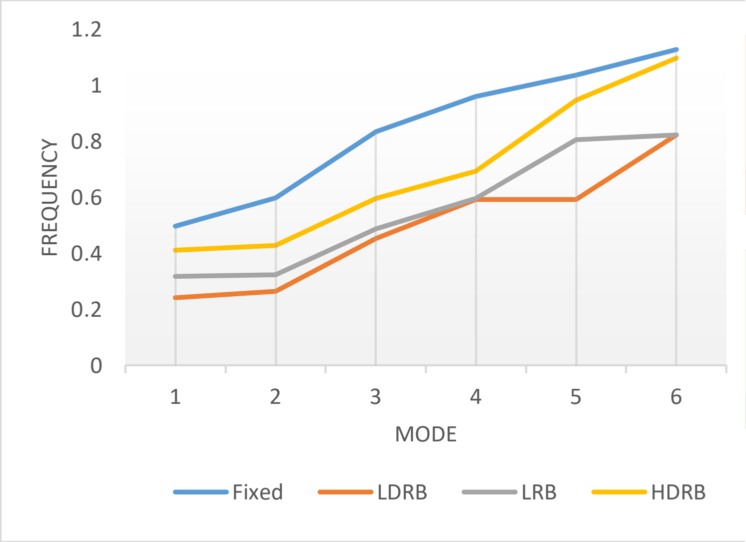

Figure 4: Graphical view of frequency-type of 6 storey structure

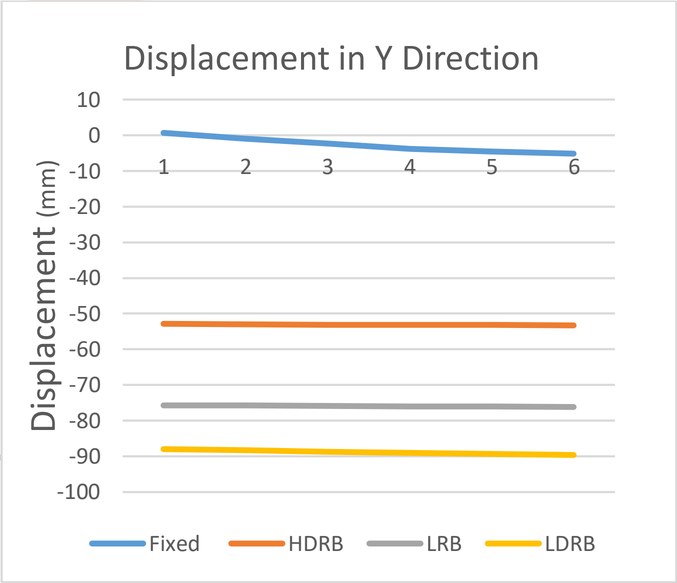

Figure 6: Displacement in Y direction for 6 storeyed structure graphically

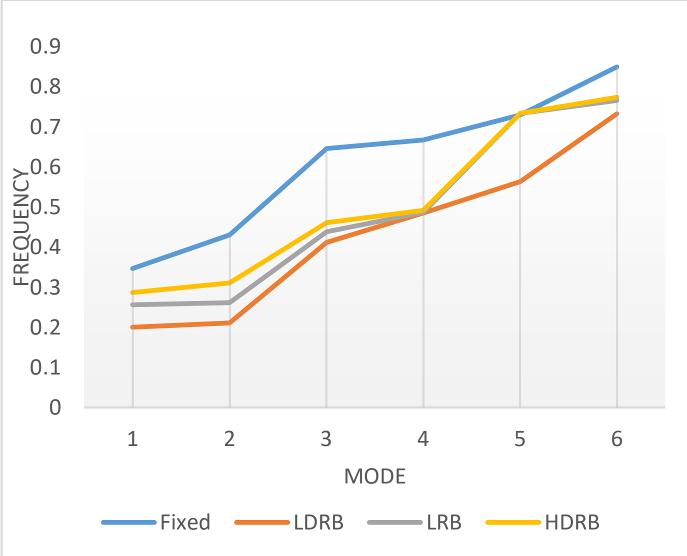

Figure 7: Graphical view of frequency-type of 9 storey structure

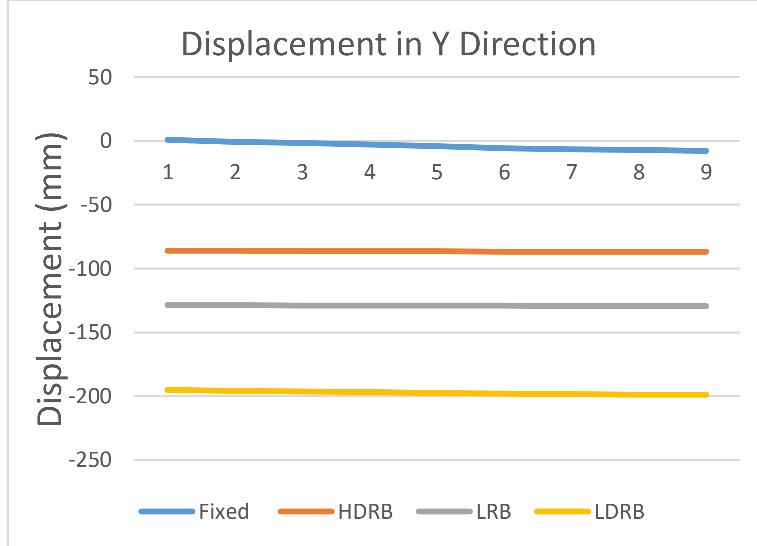

Figure 9: Displacement in Y direction for 9 storeyed structure graphically

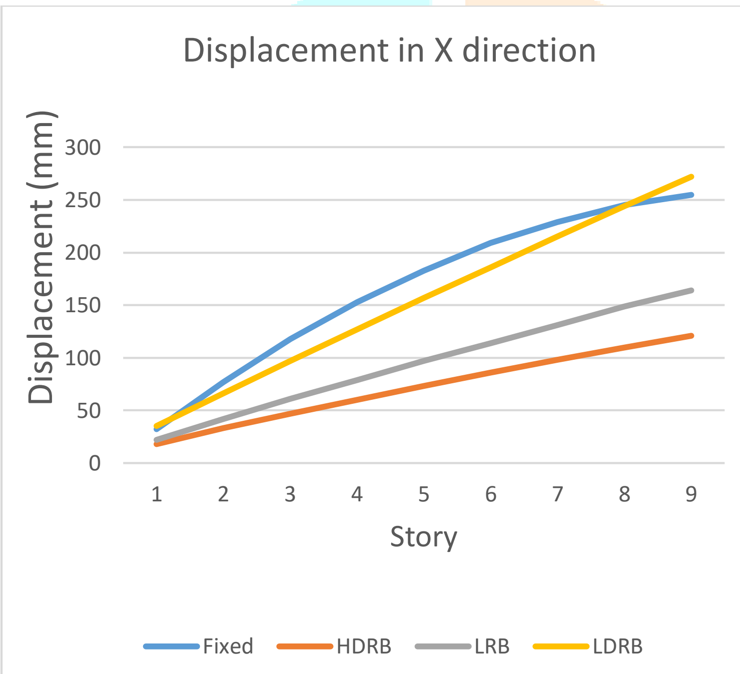

Figure 8: Dislocation in direction x graphically in 9 storey structure

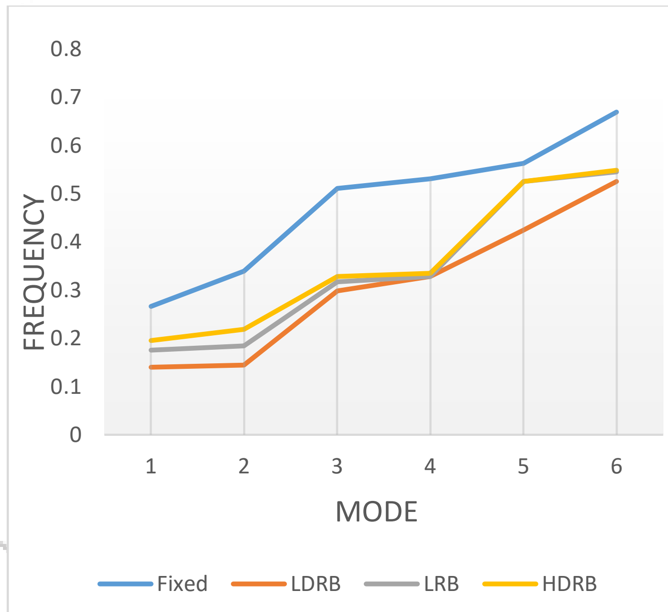

Figure 10: Graphical view of frequency-type of 9 storey structure

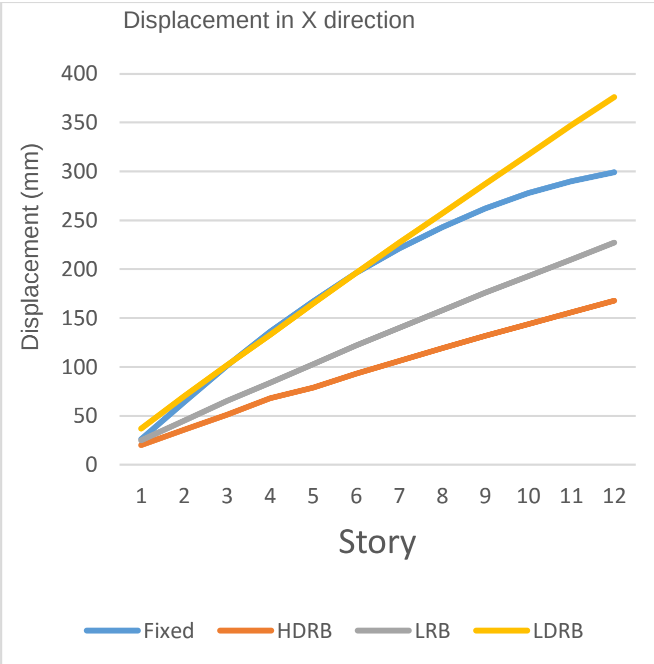

Figure 11: Dislocation in direction x graphically in 12 storey structure

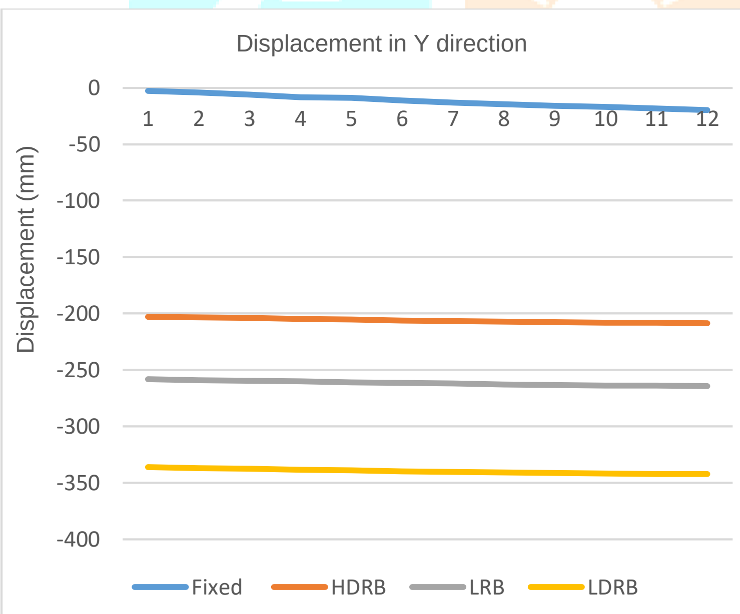

Figure 12: Displacement in Y direction for 12 storeyed structure graphically

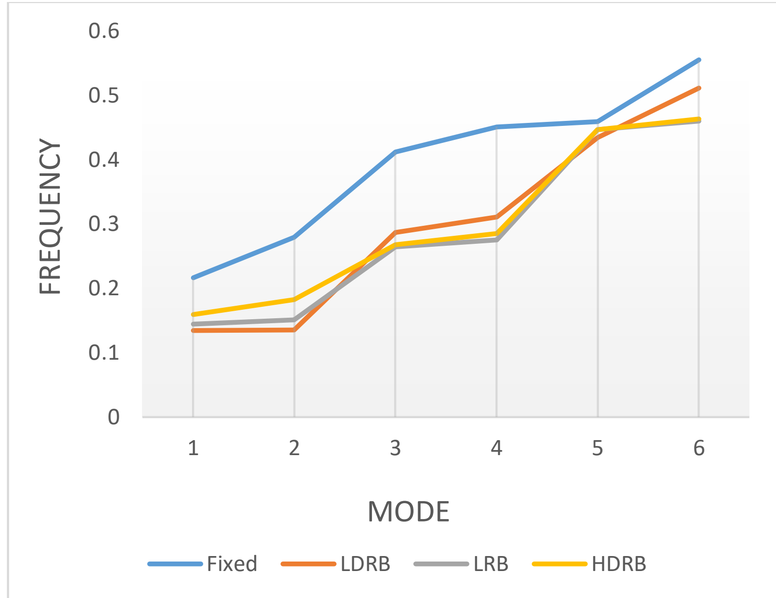

Figure 13: Graphical view of frequency-type of 15 storey structure

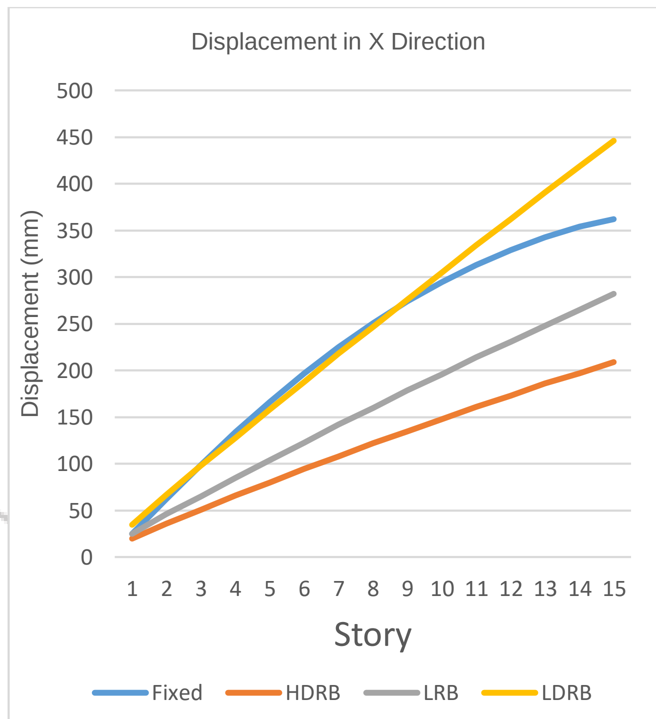

Figure 14: Dislocation in direction x graphically in 15 storey structure

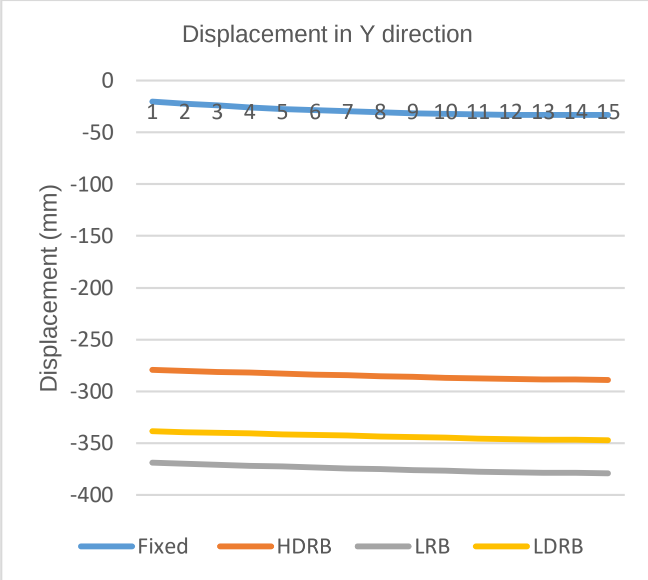

Figure 15: Displacement in Y direction for 15 storeyed structure graphically

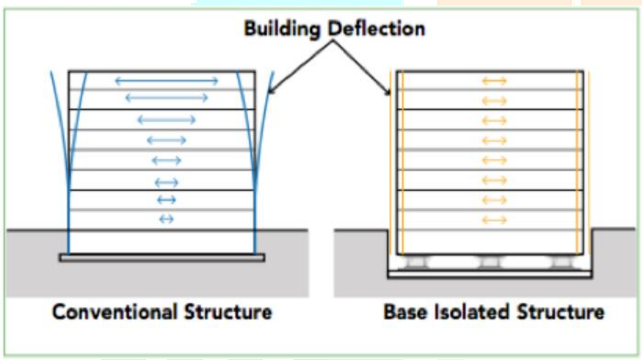

Fig.16 Deflection responses of conventional and base isolated structures

4. CONCLUSIONS

Steel frames in accordance with IS 800:2007 perform better in seismic activities. Base shear was significantly reduced for buildings with dampers. The displacement in Y direction for base isolators is higher than fixed support as the software doesn't consider the thickness of spring support and the displacement in Y direction can be used to modify the height of the damper accordingly. During analysis, multiple members failed during controlled deformation action for the fixed support as compared to the base isolation devices. The buildings with conventional support became unstable and a small increase in push load caused large deformations which was generally not the case with base isolators. Rubber bearings, especially HDRB performed better than the hybrid bearing (lead-rubber). Pushover analysis is very helpful mechanism for admittance of strength elastically and also requisites for the deflections and also displaying weak areas of the structure. Pushover analysis is very helpful mechanism for admittance of strength elastically and also requisites for the deflections and also displaying weak areas of the structure.

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