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Nonlinear Static Analysis Of 3-D RC Framed Asymmetric Building With Lead Rubber Isolator Using Sap2000v15

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ABSTRACT
Many buildings in the present scenario have irregular configurations both in plan and elevation. This in future may be subjected to devastating earthquakes. So it is also necessary to enhance the seismic performance of asymmetric buildings by using seismic control techniques. In the present study a total of 9 models, asymmetrical in plan (L-shape) are taken for analysis to cover the broader spectrum of low, medium & high rise buildings for the seismic control of the structures using pushover analysis, two different techniques were considered such as lead rubber bearing isolator and masonry infill walls, the analysis has been carried out using SAP2000V15. The results of bare frame and other building models have been compared, the presence of lead rubber base isolator, top story drift get reduced as compared with masonry infill wall. The trend was found to be reversed for high rise buildings especially with the application of isolation systems due to the massive increase in the story displacements suggesting the ineffectiveness of the base isolators for high rise buildings successively the plastic hinge pattern formed after carrying out the pushover analysis was also studied which indicated that structural performance was considerably improved.
Keywords – bare frame, lead rubber bearing isolator, masonry infill

I. INTRODUCTION

The buildings with regular geometry and uniformly distributed mass and stiffness in plan as well as in elevation suffer much less damage compared to irregular configurations. The promise of nonlinear static analysis that is pushover analysis is to produce structures with predictable seismic performance. Seismic isolation is relatively recent and evolving technology. The main feature of the base isolation technology is that it introduces flexibility in the structures. Advantages of lead rubber isolator with RC framed buildings properly designed and detailed buildings with lead rubber base isolator shown good response in past earthquakes. Although infill panels considerably enrich both the strength and stiffness of the frame, because of lack of knowledge of the multiple behavior of the frame and infill, their influence is not taken into account. Hence the structural action of infill walls cannot be neglected. Therefore, masonry infill panel should be considered as structural element. The main aim of the present study is to illustrate the effect of base isolation and masonry infill wall as shell element on the response of low, medium and high rise L-shape asymmetric buildings.

II. DESCRIPTION OF STRUCTURAL MODELS

In this study, a total number of 9 different models of 5, 10 and 15 story R.C framed buildings are considered for analysis, the building has seven bays in X direction and five bays in Y direction with the plan dimension 28 m x 20 m and a story height of 3.5 m each in all the floors. The building is kept asymmetric in plan. The alignment and size of column is kept same throughout the height of the structure. The building is considered to be located in zone IV. The building is founded on medium strength soil through isolated footing under the columns. Elastic moduli of concrete and masonry are taken as 25000 MPa and 3500 MPa respectively and their poisons ratio as 0.20 and 0.17 respectively. The unit weights of concrete and masonry are taken as 25.0 KN/m^3 and 20.0 KN/m^3 respectively the floor finish on the floors is 1.0 KN/m^2. The live load on floor is taken as 3.5 KN/m^2. In seismic weight calculations, 50% of the floor live loads considered. Thickness of slab and masonry infill wall as 0.120 m and 0.23 m respectively. The base isolation used in this study is New Zealand rubber bearing system [6]. Nonlinear static analysis is used on both of fixed base and base isolated buildings. In fixed base condition, all of structures are considered in elastic stage and in base-isolated condition, the superstructure of the building is considered in elastic stage and base isolator is considered in inelastic stage.

III. ANALYTICAL MODELS CONSIDERED FOR ANALYSIS

Model 5A: Five story bare frame with fixed base. However masses of the walls (230mm thick) are included on all stories.

Model 5B: Five story bare frame with Lead Rubber Isolator. However masses of the walls (230mm thick) are included on all stories.

Model 5C: Five story building with fixed base has masonry infill wall as shell element in all the stories.

Model 10A: Ten story bare frame with fixed base. However masses of the walls (230mm thick) are included on all stories.

Model 10B: Ten story bare frame with Lead Rubber Isolator. However masses of the walls (230mm thick) are included on all stories.

Model 10C: Ten story building with fixed base has masonry infill wall as shell element in all the stories.

Model 15A: Fifteen story bare frame with fixed base. However masses of the walls (230mm thick) are included on all stories.

Model 15B: Fifteen story bare frame with Lead Rubber Isolator. However masses of the walls (230mm thick) are included on all stories.

Model 15C: Fifteen story building with fixed base has masonry infill wall as shell element in all the stories.

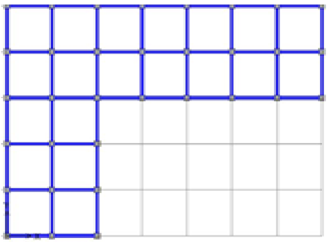

Fig1: plan

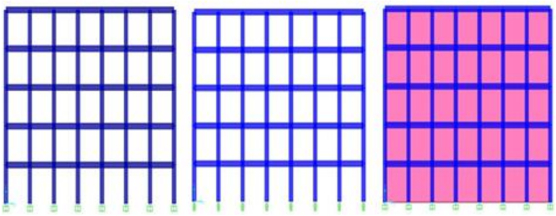

Fig 2: Elevations of model 5A, 5B and 5C

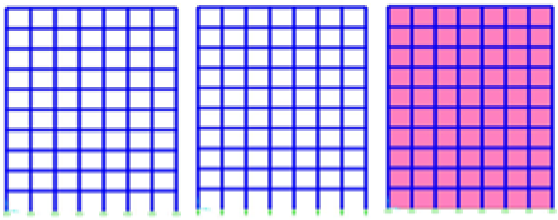

Fig 3: Elevations of model 10A, 10B and 10C

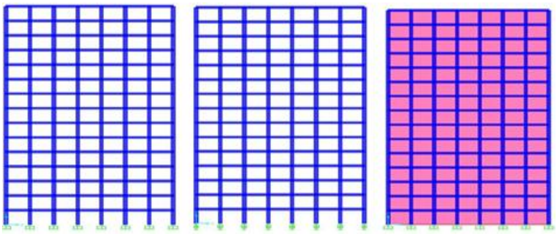

Fig 4: Elevations of model 15A, 15B and 15C

IV. RESULTS AND DISCUSSION

In this paper the results of the selected building models studies are presented. Analysis were carried out using SAP2000V15 and different parameters studied such as Fundamental natural time period, Base shear, torsional moment, story displacement and story drifts, the tables and figures are shown below.

Table 1: Fundamental Natural Time Period

FUNDAMENTAL NATURAL TIME PERIOD	
Model No.	**T in sec**
5A	0.71886
5B	3.62464
5C	0.19853
10A	1.62007
10B	3.56055
10C	0.47643
15A	2.5934
15B	4.5859
15C	0.85854

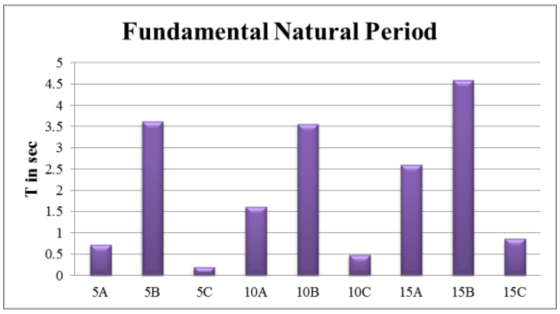

Fig 5: Model Vs Time period for different building model

It can be observed that the % increase of fundamental natural time period of model 5B, 10B and 15B are 80.16%, 54.5% and 43.44% compared to as model 5A, 10A and 15A. Also the % reduction of fundamental natural time period of model 5C, 10C and 15C are 72.38%, 70.6% and 67.09% as compared to model 5A, 10A and 15A.

Table 2: Base Shear

BASE SHEAR (KN)		
MODEL NO.	**PUSH Y dir.**	**PUSH X dir.**
5A	4096.05	4379.94
5B	656.432	744.759
5C	41175.8	43306
10A	2646.65	3148.85
10B	1995	2139.98
10C	24513.6	28136.4
15A	2093.36	2441.24
15B	1705.71	1838.96
15C	19830.4	27367.6

From table 2, it is observed that % reduction of base shear is 84%, 24.6% and 18.51% for model 5B, 10B and 15B compared to model 5A, 10A and 15A. The % increase of base shear is 90.05%, 89.20% and 89.44% for model 5C, 10C and 15C compared to model 5A, 10A and 15A along transverse direction.

From table 2, it is observed that % reduction of base shear is 83%, 32.04% and 24.67% for model 5B, 10B and 15B compared to model 5A, 10A and 15A. The % increase of base shear is 89.88%, 88.8% and 91.07% for model 5C, 10C and 15C compared to model 5A, 10A and15A along longitudinal direction.

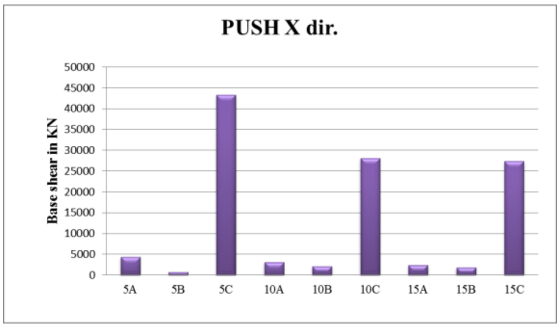

Fig 6: Base Shear of all different building models along longitudinal direction

Table 3:Torsional Moments

TORSIONAL MOMENTS KNm		
Model No.	**Push 1**	**Push2**
5A	53547	55266
5B	3639.712	12982.172
5C	644398.8	581481.84
10A	36077.34	39891.105
10B	22718.07	28090.396
10C	392561.4	262899.88
15A	29587.45	30715.217
15B	21077.03	22707.117
15C	323894.6	160599.51

From table3, it is observed that % reduction of torsional moment is 93.202%, 37.03% and 28.76% for model 5B,10B and 15B compared to model 5A,10A and 15A.and the % increase of torsional moment is 91.6%, 90.81% and 90.86% for model 5C,10C and 15C compared to model 5A,10A and 15A.

From table3, it is observed that % reduction of torsional moment is 76.51%, 29.58% and 26.07% for model 5B,10B and 15B compared to model 5A,10A and 15A.and the % increase of torsional moment is 90.5%, 84.82% and 80.87% for model 5C,10C and 15C compared to model 5A,10A and 15A.

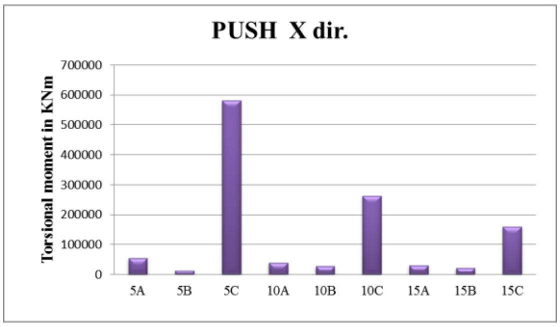

Fig 7: Torsional moments of all different building models along longitudinal direction

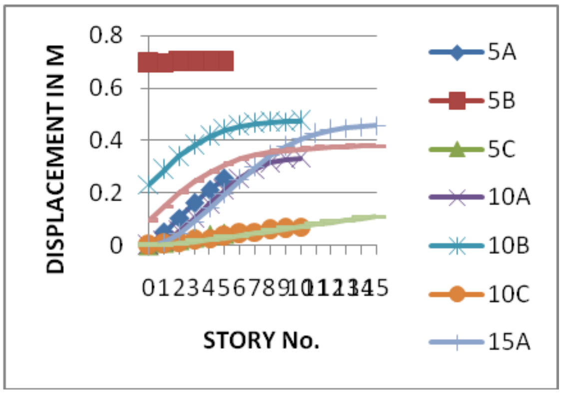

Fig 8: Displacement Vs Story level for different building models along transverse direction

From figure 5.12 it is observed that the maximum % increase of Lateral displacements is 93%, 94% and 91.58% for model 5B, 10B and 15B as compare to model 5A, 10A and 15A. Whereas for the lateral displacements are reduced to a maximum of 82.14%, 83.23% and 84.93% for model 5C, 10C and 15C as compare to model 5A, 10A and 15A.

Fig 9: Ductility ratio for different building models along longitudinal direction

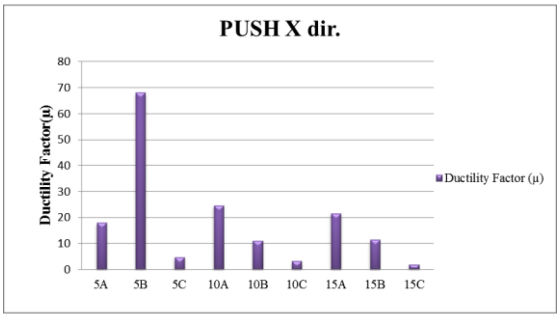

Table 4: Ductility ratio and Response reduction factor along longitudinal direction

Model No.	Yield Displacement in m	Ultimate Displacement in m	Ductility Factor (µ)	Response Reduction Factor {R}
5A	0.013154	0.236536	17.98	5.91
5B	0.010282	0.700031	68.08	11.62
5C	0.003912	0.01859	4.75	2.91
10A	0.011975	0.295701	24.69	6.95
10B	0.045081	0.500032	11.09	4.60
10C	0.010897	0.035288	3.23	2.34
15A	0.018601	0.401785	21.60	6.49
15B	0.030556	0.350265	11.46	4.68
15C	0.036874	0.069162	1.87	1.65

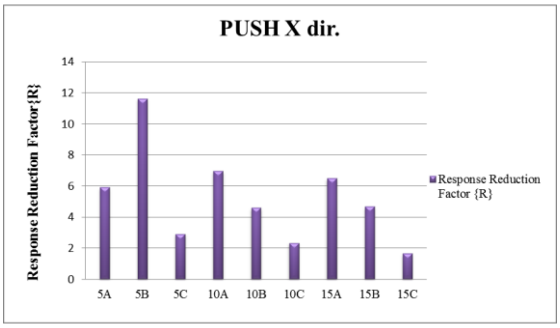

Fig 10: Response reduction factor for different building models along longitudinal direction

From table 4. It can be observed that the ductility ratio for model 5B is greater than the other models in both transverse and longitudinal direction. It can also be observed that the response reduction factor for model 5B is greater than the all other models in both transverse and longitudinal direction.
Hence it can be concluded that the model 5B is more flexible than the other models.

V. CONCLUSION

1. Fundamental natural time period increases with the use of Lead Rubber Isolation, and decreases when masonry infill wall is considered.
2. Increased flexibility of the system led to increase of the total displacements due to the elasticity of the existing isolation.
3. The presence of masonry infill influences the overall behavior of structures when subjected to lateral forces. Story displacements are considerably reduced while contribution of masonry infill wall is taken into account.
4. Ductility ratio is maximum for Lead Rubber Isolation structure i-e model-5B and for full infill building i-e model 5C, 10C and 15C it get reduced. It indicates that these structures will show adequate warning before collapse.
5. Lead Rubber Isolation structures are having highest response reduction factor as compared to infill frame structures. It indicates that Lead Rubber Isolation structures are capable of resisting the forces still after first hinge.
6. From the above study we conclude that model-5B i-e five story asymmetric R C framed building with Lead Rubber Isolation shows better performance among the others for the given seismic parameters.
7. Model 5B shows a maximum reduction in terms of torsional moment as compare to other models.

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