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Performance of Infill Walls as a Global Retrofitting Technique

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Abstract-Considering the recent growth in the field of infrastructure development in India, many towns are getting upgraded into smarter cities. The challenge before the planer to set a well planed city is to overcome the problem related to parking that arises due to increasing number of vehicular traffic.In many cities it has been observed that the residential parking space is provided in the building itself by utilizing open ground storey. Past earthquakes have demonstrated the vulnerability of such kind of structures. Infill walls act as a lateral force resisting element for high rise structures. But less amount of research is dedicated to understand the behaviour of infill wall as a retrofitting method. Hence, the objective of this paper is to assess the potential of global retrofitting technique i.e. incorporation of infill walls in the open ground storey. For this purpose three dimensional models are adopted to understand the effect of infill wall. Comparative results are presented in graphical form to justify the chosen global retrofitting technique.

Keyword Retrofitting technique, Infill walls, Response Spectrum Method, Non-linear Analysis, Pushover Analysis.

1. Introduction

Recent earthquake in India shows that not only non-engineered structures but also engineered buildings in our country are heavily suspected even to moderate earthquake. Seismic hazards in this context of engineering design is generally defined as the predicted level of ground acceleration which would be exceeded at the site under consideration due to an occurrence of an earthquake anywhere in the region. The urbanization increases rapidly and will continue during the next decade because of that we need to maintain our engineered structure as earthquake resistance structure.Reinforced concrete (RC) framed buildings with infill walls are usually analysed and designed as a bare frames, without considering the strength and stiffness contributions of the infills. However, during earthquake, these infill walls contribute to the response of the structure and the behaviour of infilled framed buildings is different from that predicted for bare frame structures. Therefore, based on the understanding of the actual response, design provisions need to be developed [1]. Presence of infill walls in the frame alters the behavior of the building under lateral loads [2]. A large number of buildings are constructed with masonry infills for architectural needs or aesthetic reasons. However, because of the complexity of the problem and absence of a realistic, yet simple analytical model, the combination of masonry infill panels is often neglected in the nonlinear analysis of building structures. [3].Due to increasing population since the past few years car parking space for residential apartments in populated cities is a matter of major concern. Hence, the trend has been to utilize the ground storey of the building itself for parking. These types of buildings having no infill masonry walls in ground storey, but infilled in all upper storeys, are called as Open Ground Storey buildings. There is significant advantage of these category of buildings functionally but from a seismic performance point of view such buildings are considered to have increased vulnerability [2]. Hence, this paper presents the potential of infill wall as a global retrofitting technique by using a comparative study with the help of Equivalent static analysis, Response Spectrum analysis and Pushover analysis.

2. Structural Modelling:

The open ground storey farmed buildings behaves differently as compared to a bare framed building (without any infill) or a fully infilled framed building under lateral load. A bare frame is much less stiff than a fully infilled frame, it resists the applied lateral load through frame action and shows well distributed plastic hinges at failure. To study the effect of infill on structure, a typical three-storey residential building reported by [1] has been adopted along with material data. Three typical building models have been developed in Etabs software, models such as bare frame model (without wall), Infilled frame model (with wall) and open ground storey. Non-linear dynamic analysis is considered to be the most accurate but at the same time it is rigorous among all methods. Hence,Equivalent static analysis, Response Spectrum analysis and Pushover analysis is considered for comparative study. Data of models developed for analysis such as load data, seismic definitions and geometric data are as follows,

Table 1 Load Data

Live Load	3 kN/m2
Roof Live Load	1 kN/m2
Floor Finished Load	1 kN/m2

Table 2 Seismic Definitions

Earthquake Zone	III
Damping Ratio	5%
Importance Factor	1
Response Reduction Factor	3(OMRF)
Type of Soil	Medium Soil
Type of Structure	RC Structure
Time Period	User Calculated from IS 1893-2000

Table 3 Geometric and Material data

Density of RCC Considered	25 kN/m3
Density of infill Considered	20 kN/m3
Thickness of Slab	130 mm
Dimension of Beam	300mm x 300mm
Dimension of Column	300mm x 450 mm
Exterior wall	230mm
Interior wall	115 mm
Poisson's Ratio of infill	0.15
Conc. Cube Comp. Strength, fck	20000 N/mm2
Bending Reinforcement yield strength , fy	415000 N/mm2
Shear Reinforcement yield strength , fys	415000 N/mm2

The plan and elevation of three models which we were studied are as follows:

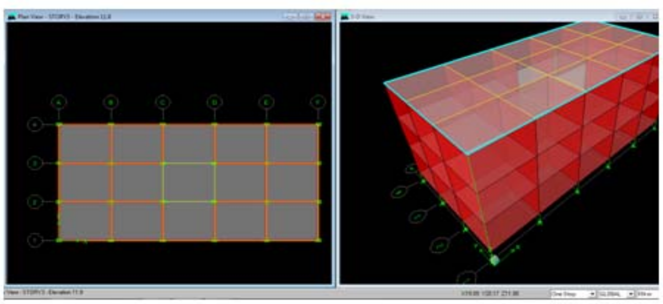


Fig1: Plan and Elevation of structure without infill

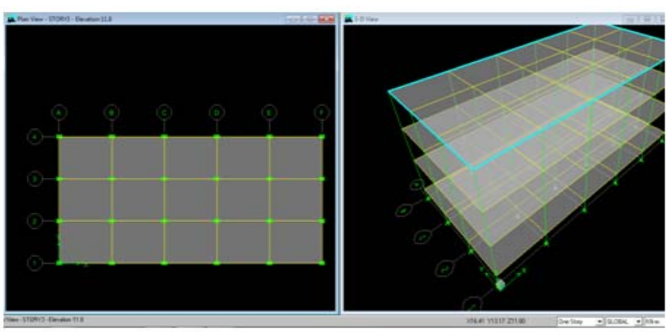


Fig2: Plan and Elevation of structure with infill

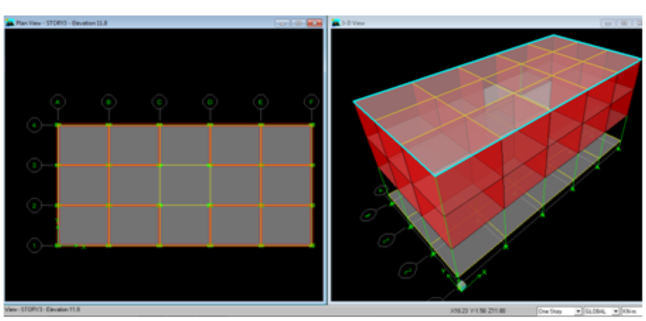


Fig3: Plan and Elevation of structure with open ground storey

3. Performance Analysis:

As mentioned above, developed three typical models were analysed for both static and dynamic loading conditions to evaluate the effect of infill on the seismic behavior of structure with and without infill. Results are presented in graphical format to understand the behavior of structure. We have compared point displacement; storey drift and storey shear for three models modeled in Etabs software.

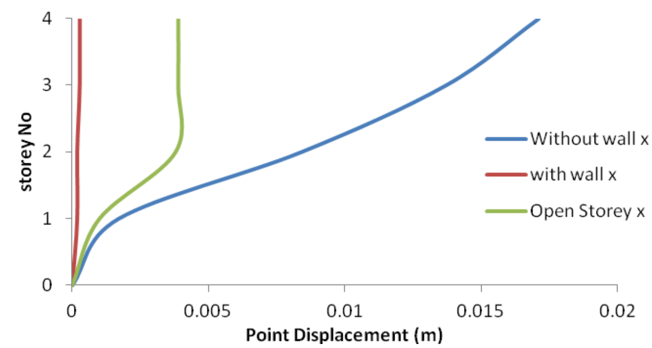


Fig 4: Point Displacement in X Direction

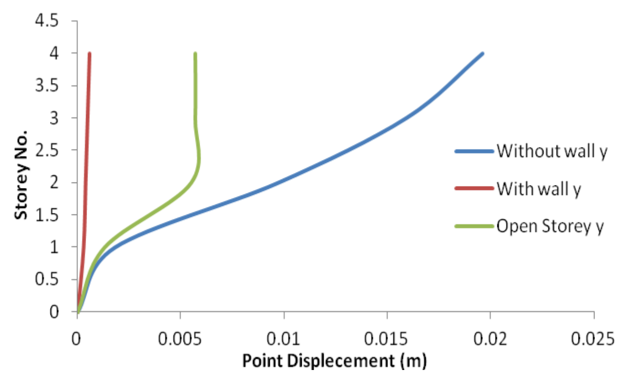
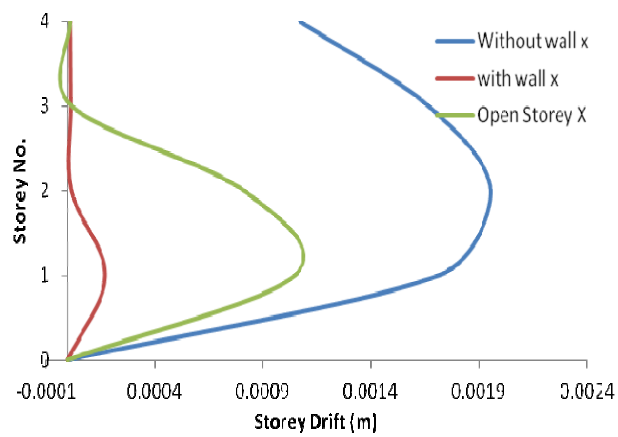


Fig 5: Point Displacement in Y Direction



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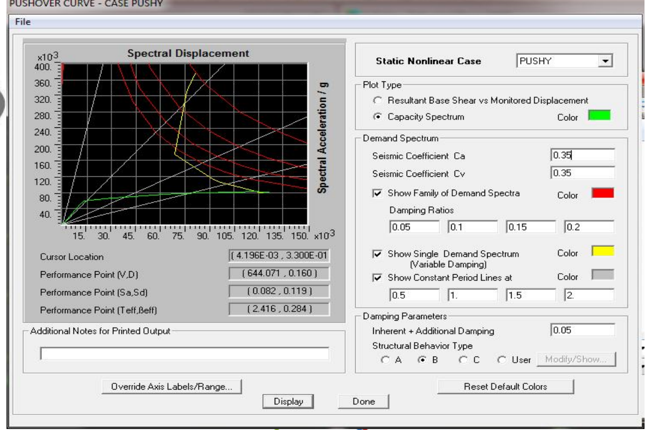

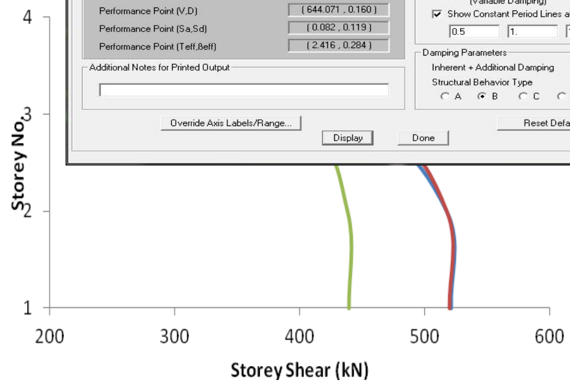

Fig 8: Storey Shear in X Direction

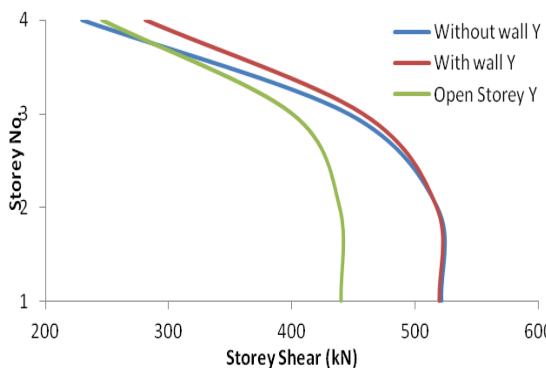

Fig 9: Storey Shear in Y Direction

Pushover Analysis Results: Pushover analysis involves the application of increasing lateral forces or displacements to a nonlinear mathematical model of a building. The nonlinear load-deformation behavior of each model is presented below,

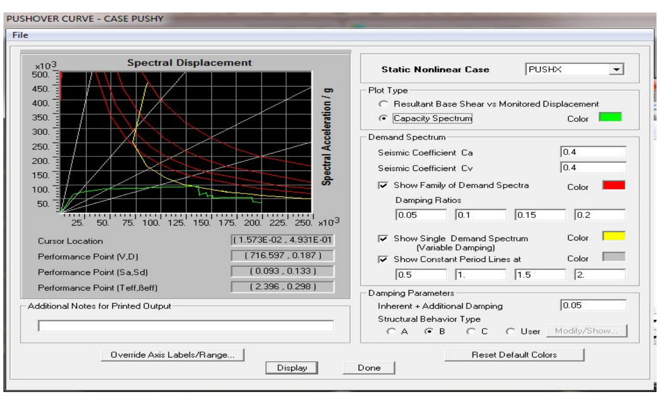

Fig 10: Performance point of without wall structure in X Direction

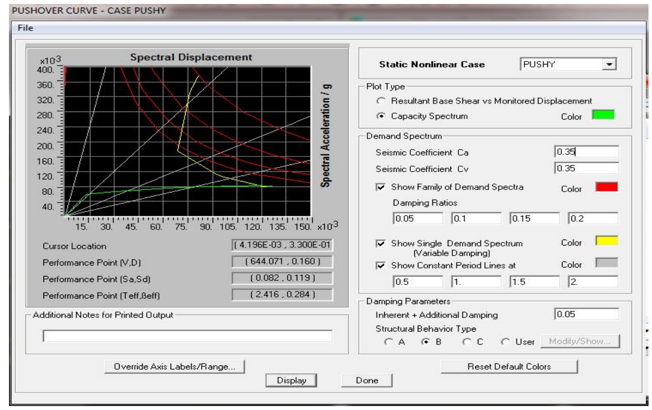

Fig 11: Performance point of without wall structure in Y Direction

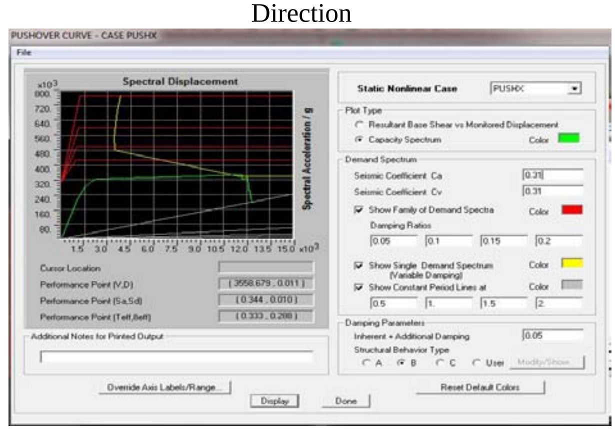

Fig 12: Performance point of with wall structure in X Direction

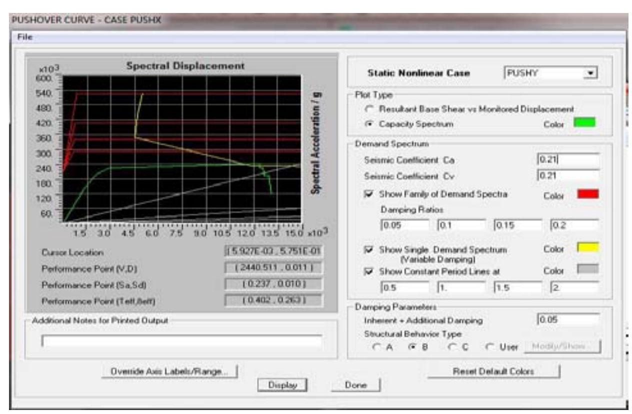

Fig 13: Performance point of with wall structure in Y Direction

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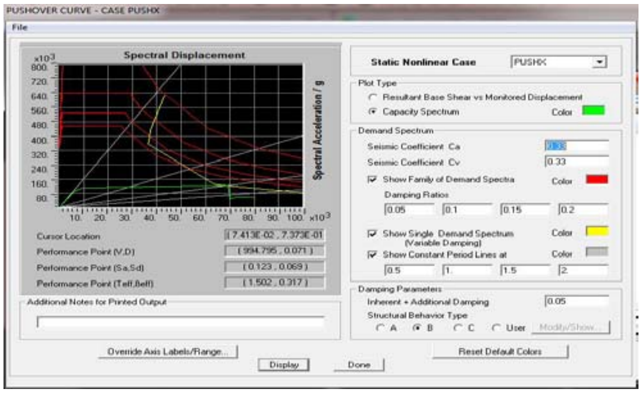

Fig 14: Performance point of structure with open storey in X Direction

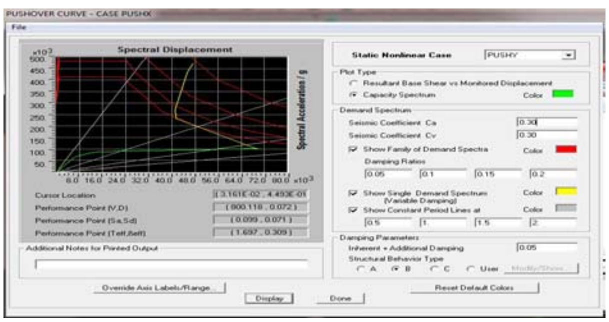

Fig 15: Performance point of structure with open storey in Y Direction

From the above results for Static, Dynamic and Non-linear static pushover analysis done on three models namely, bare frame model, infill frame model and open ground storey model shows that point displacement, storey drift reduces considerably with the inclusion of infill wall. Whereas base shear increase by considering infill during analysis. It can be observed that analysis of the model without considering infill strength and stiffness gives a conservative estimation for all beam and column elements in a low-rise open ground storey building.

4. Conclusion

The effect of the brick infills on the overall response of the structure as a global retrofitting technique is presented to understand the behavior of infill frames. Nonlinear static (Pushover) analysis is carried out for all the building models considered. First pushover analysis is done for the gravity loads incrementally under load control. The lateral pushover analysis is followed after the gravity pushover, under displacement control. Nonlinear analysis reveals that open ground storey fails through a ground storey mechanics at a comparatively low base shear and displacement and the mode of failure is found to be brittle. The effect of brick infills on seismic performance as a global retrofitting technique needs to be well understood and based on that, design methodologies, which exploit the benefits of infills in a rational manner, need to be developed.

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