Journal of Civil Engineering and Environmental Technology
Print ISSN : 2349-8404; Online ISSN : 2349-879X; Volume 2, Number 9; April – June, 2015 pp 71 – 76
Krishi Sanskriti Publications
http://www.krishisanskriti.org/jceet.html

Analysis of Building with Infill Walls

Shriyanshu Swarnkar[1], Dr. Debarati Datta[2]
[1]M.Tech,
Structural Engineering
Visvesvaraya National Institute of Technology
[1]+91-9765658839, [1]shriyanshu.2@gmail.com
[2]Assistant Professor,
Applied Mechanics Department
Visvesvaraya National Institute of Technology
[2]+91-7304912308, [2]d_debarati@yahoo.co.in

Abstract: *Infill wall is the generic name given to a panel that is built in between the floors of the primary structural frame of a building and provides support for the cladding system. Infill walls now a day are considered to be non-load bearing member. In the design and assessment of building, the infill walls are usually treated as non-structural element and they are ignored in analytical models because they are assumed to be non-beneficial to the structural response. Infill walls not only increase the strength and stiffness of the frame, but they actually lead to greater seismic force imparted to the building because of their stiffening effect on the whole structure (i.e., reduction of the fundamental period). In this study 4, 8 and 12 storey buildings with their number of bays increasing from 3 to 6 were modelled as bare and infilled frame. Equivalent Static Analysis (ESA), Response Spectrum Analysis (RSA) and non-linear static Pushover analysis were performed on all structures. Base shear capacity for both ESA and RSA were compared for bare and infilled frame. Pushover curves were plotted for all structures and comparison was made.*

1. INTRODUCTION

Infill walls are frequently used as interior partitions and exterior wall in buildings. In the design and assessment of building, the infill walls are usually treated as non-structural element and they are ignored in analytical models because they are assumed to be non-beneficial to the structural response. Under seismic loading masonry infill in reinforced concrete buildings cause undesirable effects such as short-column effect, soft-storey effect, torsion and out-of-plane collapse. Masonry infill walls are stiffer in nature, thus attracts more lateral seismic shear force on building. This research work is mainly focused on seismic behavior of RC frames infilled with masonry panels.

1.1 Equivalent Static Analysis (ESA)

It is a type of static analysis. This method of analysis requires the conversion of the structure into an equivalent lumped mass system with springs connected between them. The stiffness of the springs is equivalent to that provided by the columns of the framed system. The approximate fundamental natural period of the building is calculated on the basis of the height of the building, h, and the base dimension parallel to the direction of application of earthquake, d, as per the empirical formulations are given in IS 1893-2002.

$$T_a = (0.09*h)/\sqrt{d} \qquad \ldots\ldots\ldots\ldots\ldots (1)$$

On the basis of the fundamental time period and the type of soil on which the structure exists, average response acceleration coefficient, Sa/g, is calculated. Thereafter, the design horizontal seismic coefficient, Ah is calculated taking into consideration the zone in which the building lies, the importance factor of the building and response reduction factor based on the type of structure.

$$A_h = (Z/2)*(I/R)*(S_a/g) \qquad \ldots\ldots\ldots.. (2)$$

The values of the three coefficients are explicitly mentioned in the code. The total seismic weight of the building when multiplied with A_h gives the Design Base Shear.

$$V_B = W*A_h \qquad \ldots\ldots\ldots\ldots.. (3)$$

This value of shear is distributed along the height of the building at different floor levels as given in code to obtain the value of Design Lateral Forces.

$$Q_i = V_B * \frac{W_i * h_i^{\,2}}{\sum_{j=1}^{n} W_j * h_j^{\,2}} \qquad \ldots\ldots\ldots.. (4)$$

Where n is the number of storeys in the building is the number of levels at which the masses are located.

1.2 Response Spectrum Analysis (RSA)

It is a dynamic analysis. Response spectra basically is the plot of any parameter with respect to time period of a single degree of freedom structure with different fundamental natural time periods subjected to same ground motion excitation. It relies on a graph plotted between spectral acceleration coefficient and time period of structure for different types of soils on which the structure rests for different percentage of damping.

1.3 Pushover Analysis

It is a static nonlinear analysis under permanent vertical loads. Displacement is incrementally increased from zero to a prescribed ultimate displacement or until the structure is unable to resist further loads. The sequence of yielding, plastic hinge formation and failure of various structural components are noted and the total force is plotted against displacement to define a capacity curve.

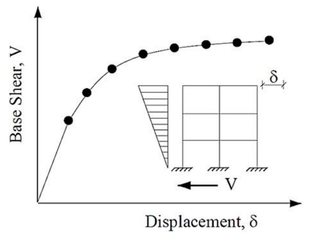


Fig.1) Capacity curve of structure

1.4 Modelling of Infill

Macro-models are based on a physical understanding of the behavior of infill frame. The infill frame is typically represented by a single global structural member, mainly by equivalent diagonal struts because it is found that the infill panel separates from the surrounding frame at relatively low lateral load, after which contact between the frame and infill is limited to the two opposite compression corners. The composite action between the infill wall and the surrounding frame depends upon the area of contact between them. Various researchers have given different methods of macro modeling one of these given by FEMA 356 is explained below.

Modeling Infill Walls as Struts:-

The most common method of modeling infill walls is to use equivalent diagonal compression struts (fig 2).

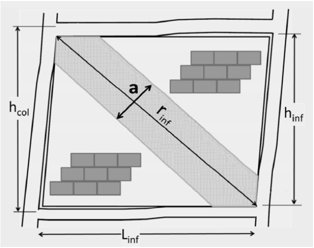


Fig. 2) Equivalent diagonal compression strut model for infill wall (FEMA 365,200)

The axial stiffness of an equivalent strut can be calculated with Equation (4) according to Section 7.5.2 of FEMA-356.

$$K_{inf} = (a.Em.t_{inf})/r_{inf} \quad \text{…………………… (4)}$$

Where, a is equivalent diagonal compression strut width can be calculated by using equation (5)

$$a = 0.175((\lambda 1.h_{col})-0.4)r_{inf} \quad \text{…………..(5)}$$

Where, λ1 is coefficient used to determine equivalent width of infill strut can be calculated by using equation (6)

$$\lambda 1= ((Em.t_{inf}.\sin 2\theta)/ (4.Ef.I_{col}.h_{inf}))^{0.25} \quad \text{.....(6)}$$

Where, Em and Ef are the elastic moduli of the infill and the frame material, respectively, t_{inf} is the thickness of the infill wall, h_{col} and I_{col} are the height and moment of inertia of the section of the column of the surrounding frame, h_{inf} is the height of the infill wall panel and r_{inf} is the length of the diagonal strut.

2. DETAILS OF STRUCTURE CONSIDERED

The considered structure is symmetrical about transverse direction only. Details of structure are given in table no. 1.

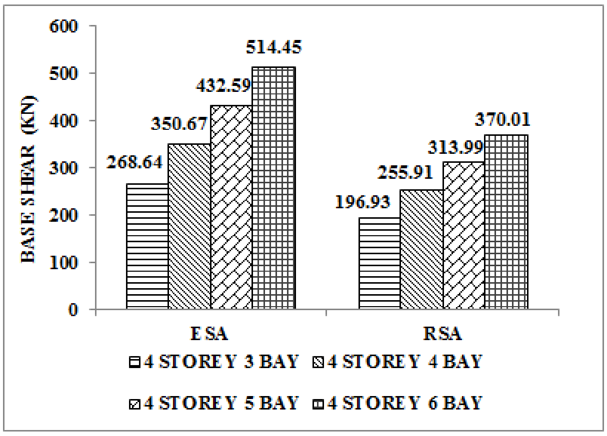
Table 1. Details of structure

Grade of concrete	M25
Type of soil	Medium soil
Seismic zone	Zone V
Size of external column (in mm)	400 X 400
Size of interior column (in mm)	300 X 300
Size of beam (in mm)	230 X 300
Thickness of slab (in mm)	150
Thickness of exterior wall (in mm)	230
Thickness of interior wall (in mm)	115
Live load	3 KN/m2
Floor finish	1 KN/m2
Floor to floor height Foundation level	3 m 1.2m
Number of storeys	4, 8, 12
Number of bays in X-direction	3, 4, 5, 6
Number of bays in Y-direction	3
Thickness of Parapet wall (1m height)	230mm

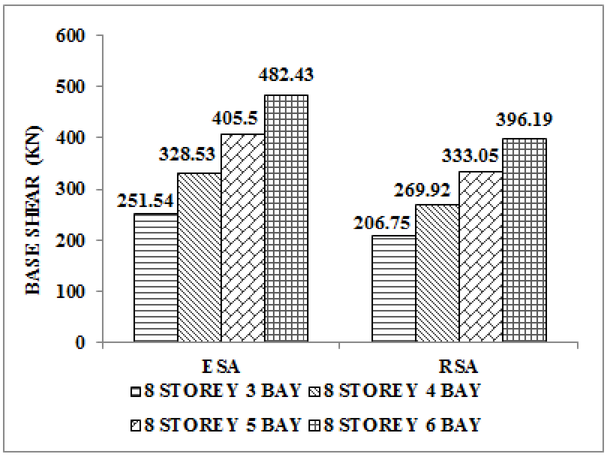
3. ANALYSIS DETAILS

Equivalent Static Analysis (ESA), Response Spectrum Analysis (RSA) and non-liner static Pushover analysis were performed on all bare and infilled structure using SAP2000. All the structures are designed for gravity loading i.e. 1.5(DL+LL). ESA and RSA are performed in x-direction only because infills are provided in x-direction only. Monitored displacements for pushover analysis are provided at 4% height of structure. Hinges provided are as per FEMA 356 and are assigned at a relative distance of 0 to 1.

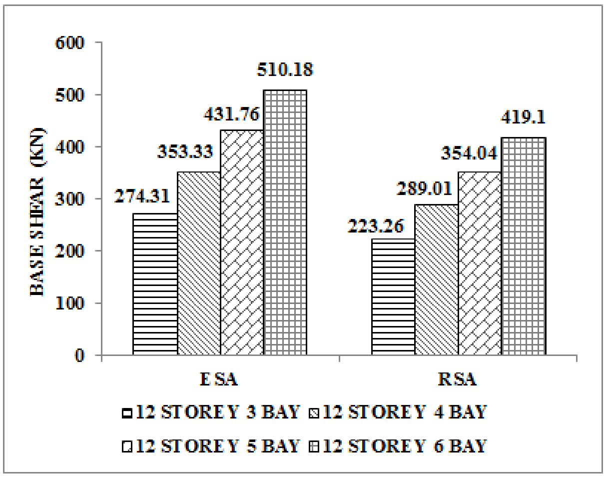
4. RESULTS



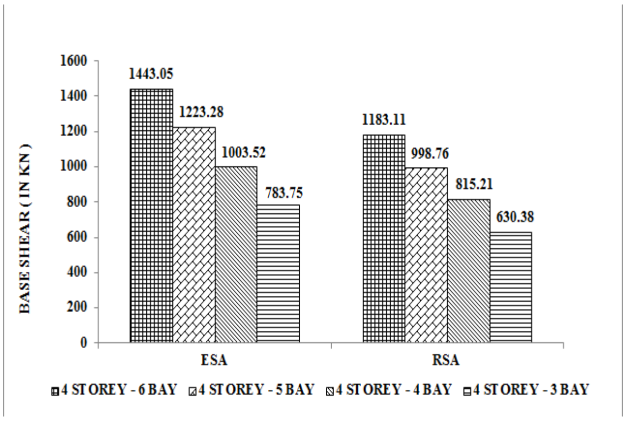
4.1. Base Shear comparison for 4 storey structure without infill



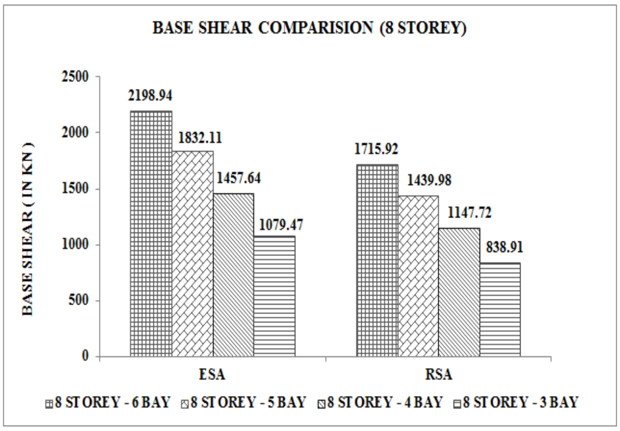
4.2. Base Shear comparison for 8 storey structure without infill



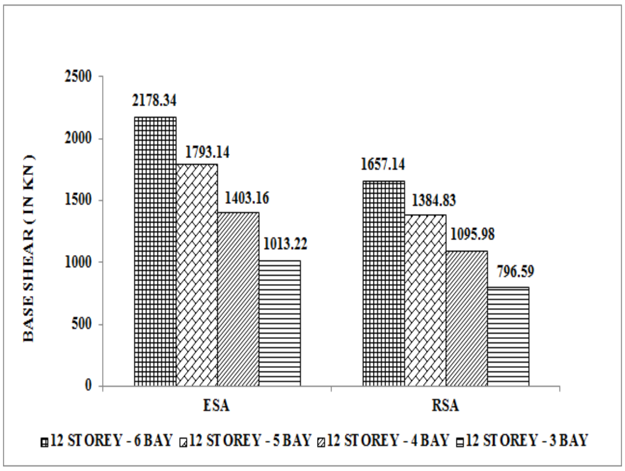
4.3. Base Shear comparison for 12 storey structure without infill



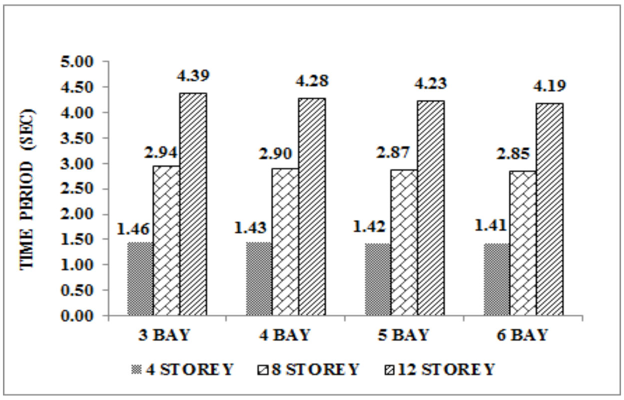
4.4. Base Shear comparison for 4 storey structure with infill



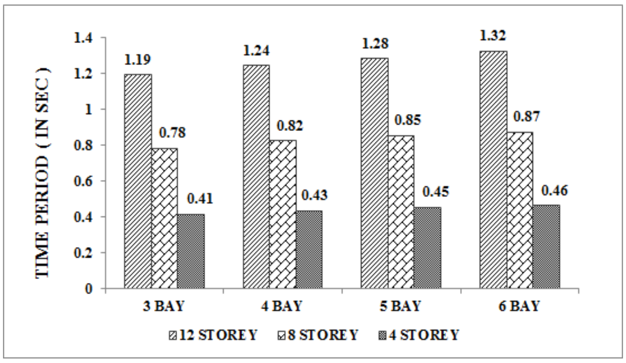
4.5. Base Shear comparison for 8 storey structure with infill



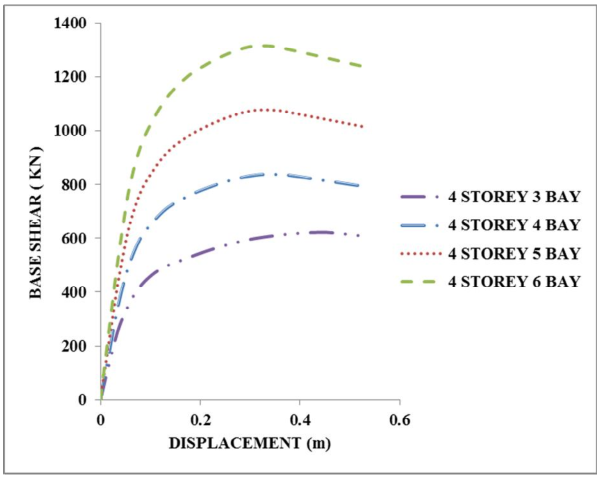
4.6. Base Shear comparison for 12 storey structure with infill



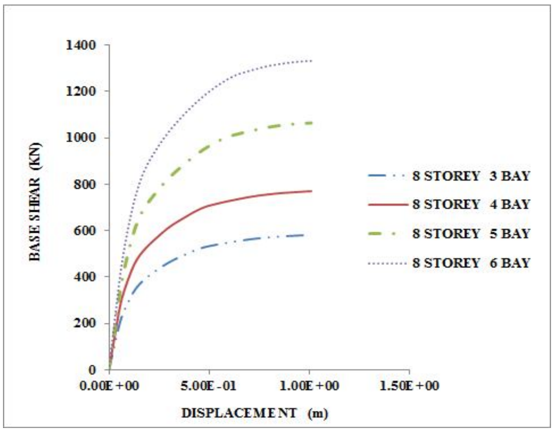
4.7. Time Period comparison for bare structure



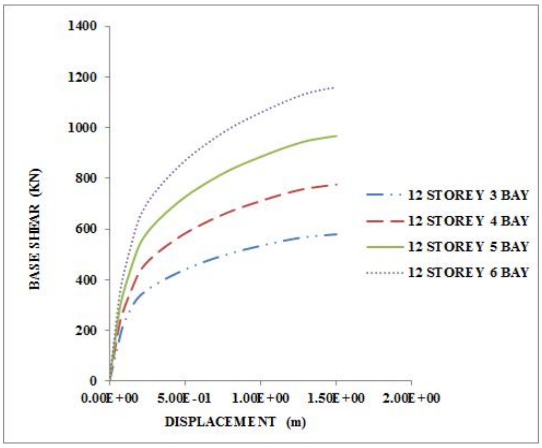
4.8. Time Period comparison for infilled structure



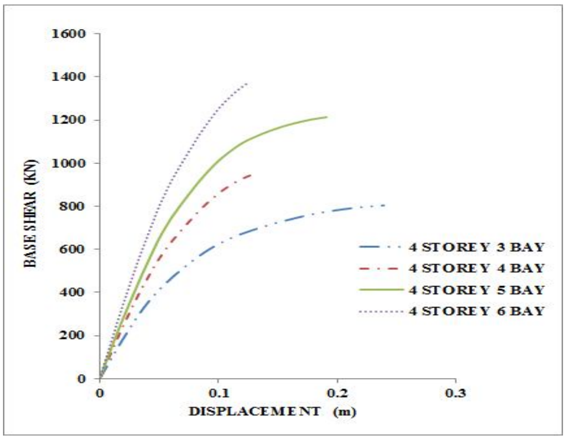
4.9. Comparison of Pushover curve for 4 storey bare structure in x direction.



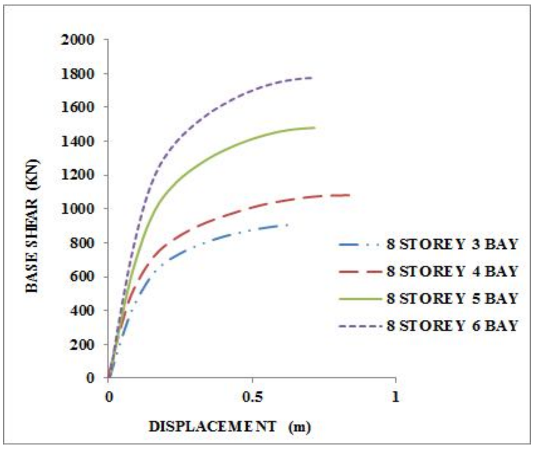
4.10. Comparison of Pushover curve for 8 storey bare structure in x direction.



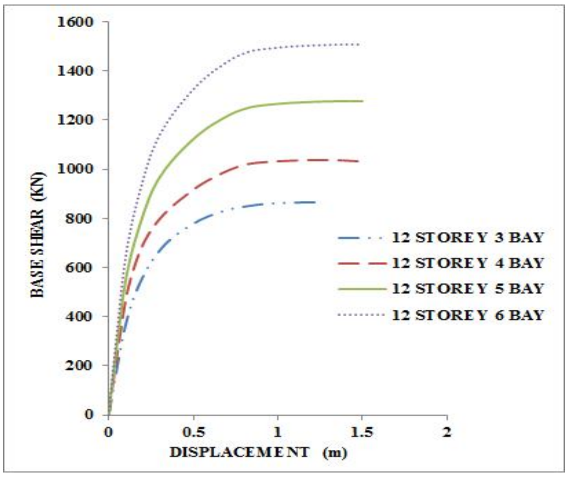
4.11. Comparison of Pushover curve for 12 storey bare structure in x direction.



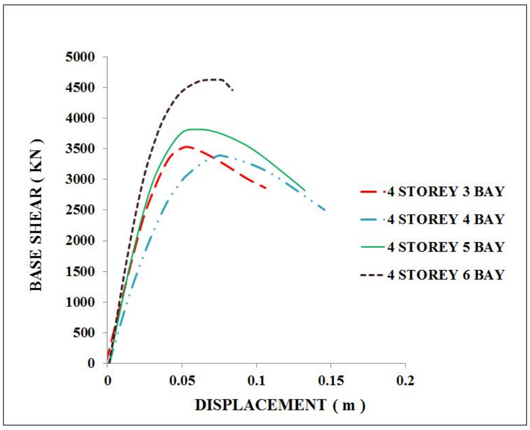
4.12. Comparison of Pushover curve for 4 storey bare structure in y direction.



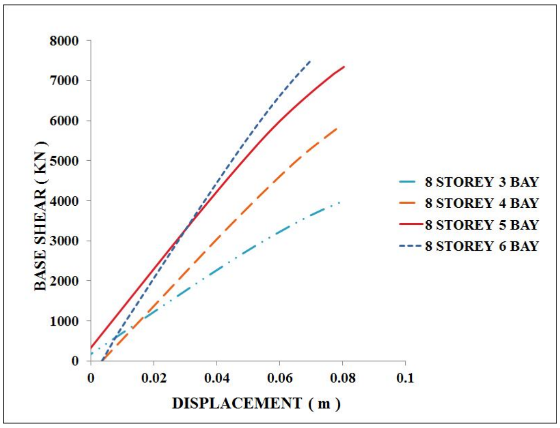
4.13. Comparison of Pushover curve for 8 storey bare structure in y direction.



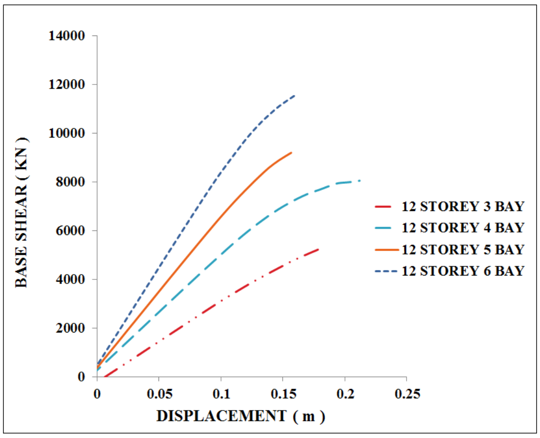
4.14. Comparison of Pushover curve for 12 storey bare structure in y direction.



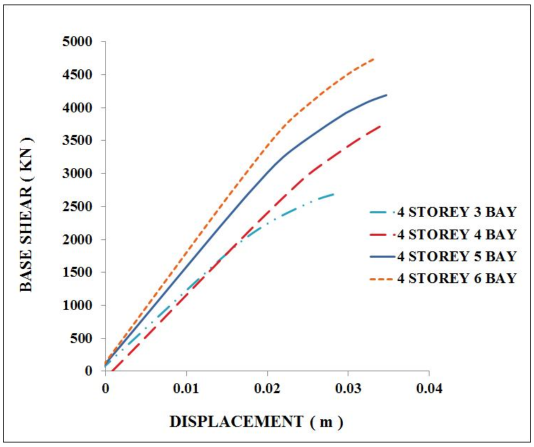
4.15. Comparison of Pushover curve for 4 storey infilled structure in x direction.



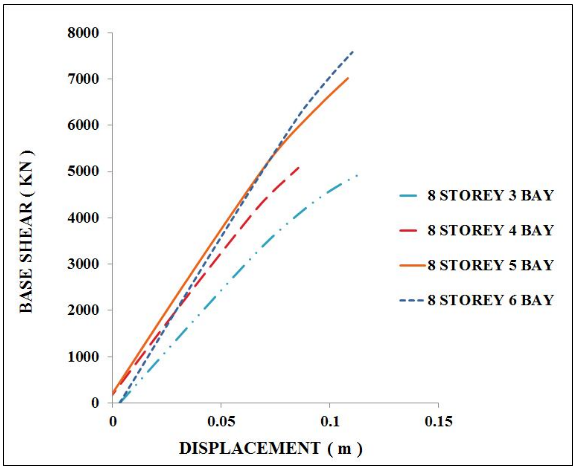
4.16. Comparison of Pushover curve for 8 storey infilled structure in x direction.



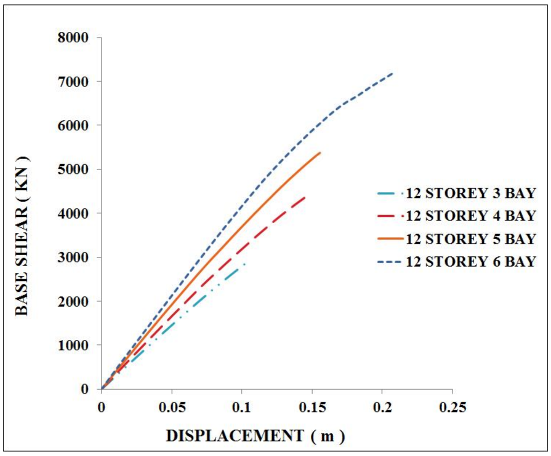
4.17. Comparison of Pushover curve for 12 storey infilled structure in x direction.



4.18. Comparison of Pushover curve for 4 storey infilled structure in y direction.



4.19. Comparison of Pushover curve for 8 storey infilled structure in y direction.



4.20. Comparison of Pushover curve for 12 storey infilled structure in y direction.

5. CONCLUSIONS

From the results of ESA, RSA and Pushover analysis of bare and infilled structure it was found that:-

a) Increase in the number of bay increases the base shear capacity of the structure.

b) Time period also increases with number of bay and height of structure.

c) Increase in number of bay increases overall stiffness of the structure.

d) With the introduction of infill panels the behavior of structure changes from ductile to rigid. Bare structures are more ductile as compare to infilled structure.

e) Infill panels being stiffer than columns fail first and simultaneously from which it was observed that infill panels are responsible for initial stiffness of the structure. As all infill panels fail there is sudden decrease in the overall stiffness, which leads to the collapse of columns.

6. REFERENCES

[1] FEMA 356, Federal Emergency Management Agency (FEMA), Washington, DC, USA.

[2] IS 1893. (Part 1) (2002). Criteria for earthquake resistant design of structures, Part1 general provision and buildings (fifth revision), BIS, New Delhi, India.

[3] Al-Chaar, G.Issa, M.Sweeney, 2002. “Behavior of masonry-infilled nonductile reinforced concrete frames” *Journal of Structural Engineering 128, 1055–1063.*

[4] J. Dorji and D.P. Thambiratnam “Modelling and Analysis of Infilled Frame Structures Under Seismic Loads” *The Open Construction and Building Technology Journal, 2009*

[5] Mohammadi, M., and Nikfar, F. (2013). “Strength and Stiffness of masonry infilled frame with central opening based on experimental results.” *J. Struct. Eng., ASCE, 139(6), 974-984*.

[6] Murty, C.V.R. and Jain, S.K. (2000). "Benificial influence of masonry infills on seismic performance of RC frame buildings." *Proc., 13th World Conference on Earthquake Engineering, New Zealand*.