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Analysis of Multipurpose Buildings with Infill Walls

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***Abstract*—It is common practice by structural engineer to consider the infill panels as non-structural member and their stiffness contribution in structure is neglected. A multipurpose building is one which can be used for more than one purpose. Generally they vary in bay width and position of infill panels. In this study the effect of selected parameter i.e. height of building, number of bays, time period and change in position of infill panels of a RC building were investigated. 19 Structures were analyzed using SAP2000. It was observed that with the increase in number of bay the base shear capacity of structure also increases and the ductility of structure reduces. Time period of structure reduces with increase in number of bay and height of structure. Also with the change in position of infill panels in different floors the variation in capacity of structure was observed due to stiffness irregularity.**
Keywords*—Infill walls; Pushover analysis; Equivalent Static Analysis; Response Spectrum Analysis; RC building

I. INTRODUCTION

It is common practice to ignore the effect of infill panels as structural member, but in reality infill panels being stiffer than column attract more base shear and are responsible for increase in initial stiffness. Time period of structure depends on mass and stiffness distribution along height .Hence the introduction of infill panels increases both mass and stiffness of structure which in turn increases the time period of structure. Same phenomenon is responsible for increase in base shear capacity of structure. In this study two different type of structure were considered. In first number of bay are varied along with the height of structure. 4, 8, 12 storey structures were considered and the number of bays were increased from 3 to 6 simultaneously for each structure. In second type a 6 storey structure was considered and was analyzed as fully infilled frame and with subsequent removal of infill wall on different floor. Infill is modeled by using equivalent strut approach. Equivalent Static Analysis (ESA), Response Spectrum Analysis (RSA) and Non-linear static Pushover Analysis were performed on 19 structures using SAP2000 to find out the effect of change in parameter i.e. height of building, number of bay and change in position of infill panels.

II. MODELING 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. Infill walls are treated as equivalent diagonal compression strut element.

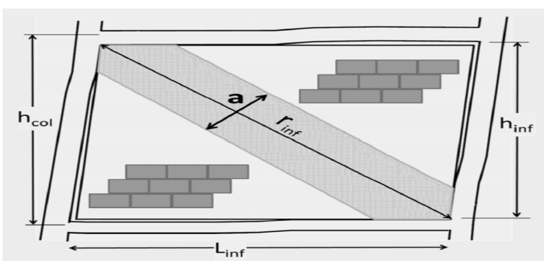


Fig. 1) Equivalent diagonal compression strut model for infill wall (FEMA 365,200)

The axial stiffness of an equivalent strut can be calculated with Equation 1(a) according to Section 7.5.2 of FEMA-356.

$K_{inf} = (a.E_m.t_{inf})/r_{inf}$ ……………………..1(a)

Where, a is equivalent diagonal compression strut width can be calculated by using equation 1(b)

$a = 0.175\ ((\lambda_1.h_{col})^{-0.4})r_{inf}$ ……………………1(b)

Where, λ_1 is coefficient used to determine equivalent width of infill strut can be calculated by using equation 1(c)

$\lambda_1 = ((E_m.t_{inf}.\sin 2\theta)/(4.E_f.I_{col}.h_{inf}))^{0.25}$ ……………1(c)

Where, E_m and E_f 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.

III. DETAILS OF STRUCTURE CONSIDERED

The considered structures are symmetrical about transverse direction only. Details of first type in which number of bays and height of structure is varied and for second type in which the position of infill panels are varied are given in table no.1.

TABLE I. DETAILS OF STRUCTURE

	Structure 1	***Structure 2***
Grade of concrete	M25	M25
Type of soil	Medium soil	Medium soil
Seismic zone	Zone V	Zone V
Size of external column (in mm)	400 X 400	300 X 600
Size of interior column (in mm)	300 X 300	300 X 450
Size of beam (in mm)	230 X 300	300 X 450
Thickness of slab (in mm)	150	150
Thickness of exterior wall (in mm)	230	230
Thickness of interior wall (in mm)	115	115
Live load	3 KN/m2	3 KN/m2
Floor finish	1 KN/m2	1 KN/m2
Floor to floor height	3 m	3.2 m
Foundation level	1.2m	1.2m
Number of storeys	4, 8, 12	6
Number of bays in X-direction	3, 4, 5, 6	5
Number of bays in Y-direction	3	3
Thickness of Parapet wall (1m height)	230mm	230mm

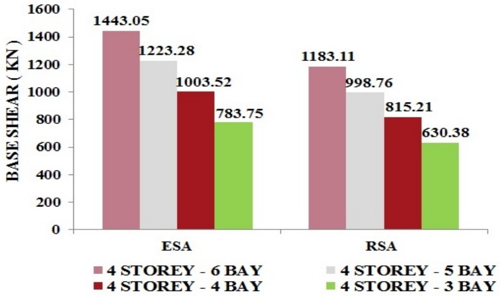
IV. ANALYSIS DETAILS

Equivalent Static Analysis (ESA), Response Spectrum Analysis (RSA) and non-liner static Pushover analysis were performed on structure 1 and nonlinear static Pushover analysis was performed on structure 2 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.

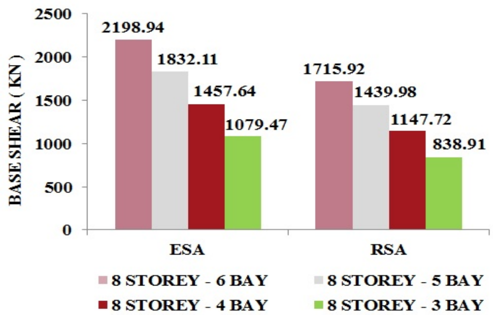
Monitored displacements for pushover analysis are provided at 4% height of structure. Hinges provided are as per FEMA 356 and are assigned at a relative distance of 0 to 1.

V. RESULTS

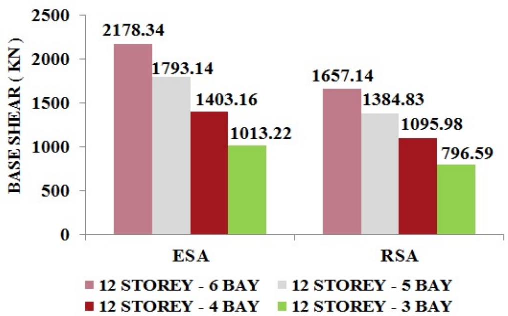
A. Base Shear comparison for structure 1 (4 storey)



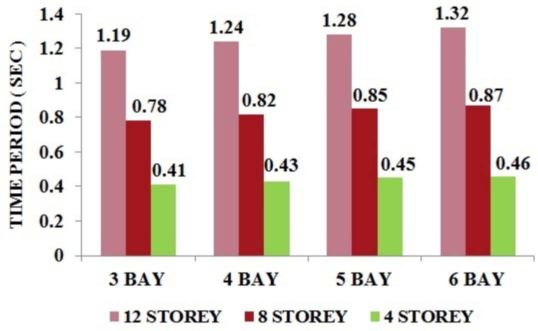
B. Base Shear comparison for structure 1 (8 storey)



C. Base Shear comparison for structure 1 (12 storey)



D. Time Period comparison for structure 1



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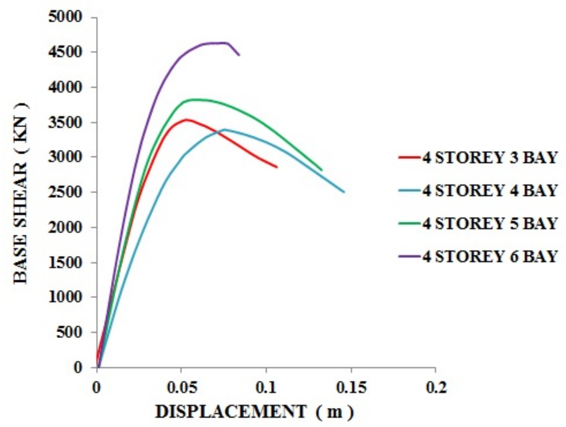
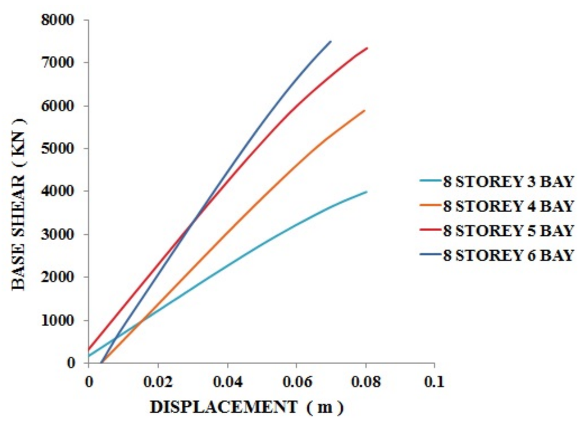
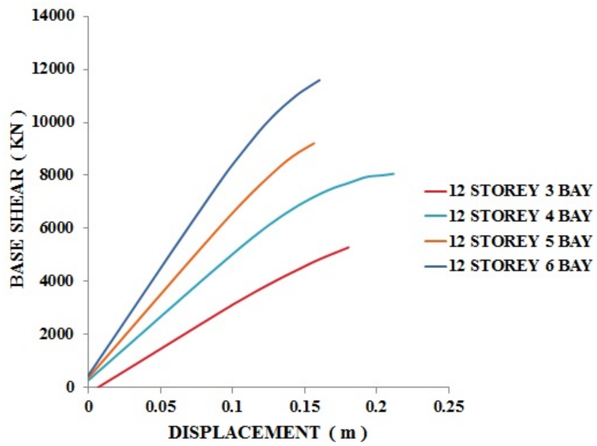
E. Comparison of Pushover curve for 4 storey x direction for structure 1



F. Comparison of Pushover curve for 8 storey x direction for structure 1



G. Comparison of Pushover curve for 12 storey x drection for structure 1



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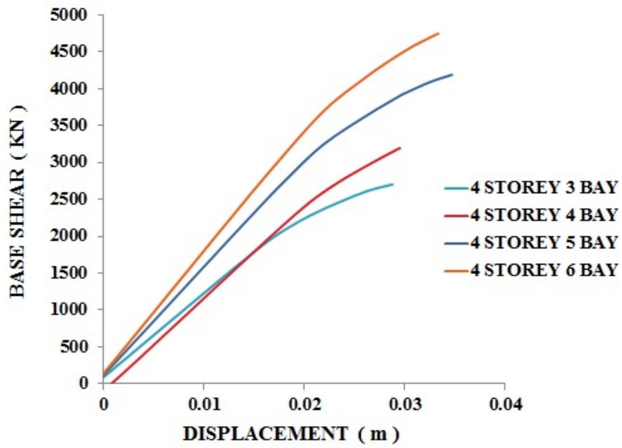
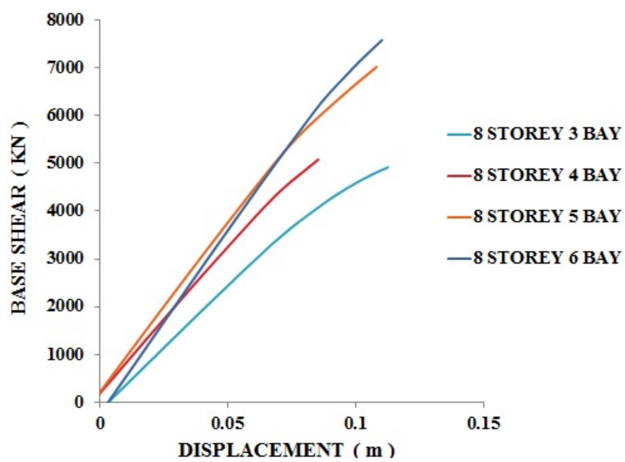
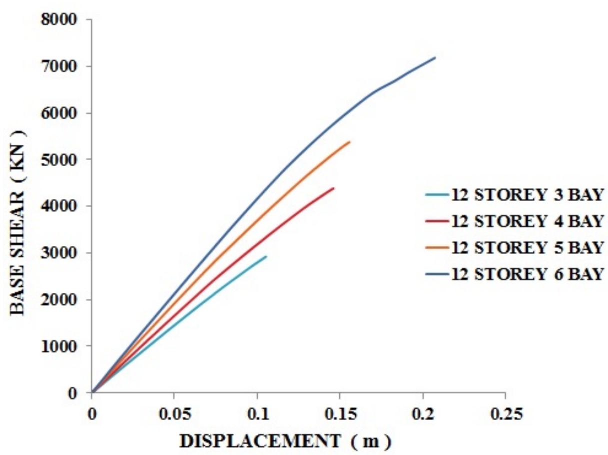
H. Comparison of Pushover curve for 4 storey y direction for structure 1



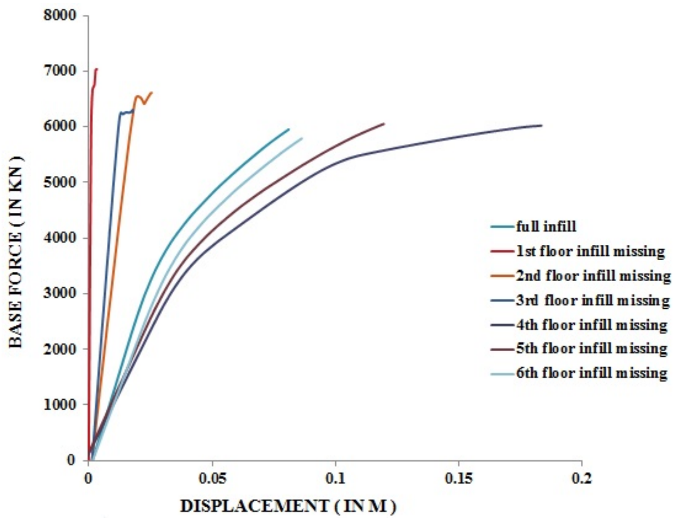
I. Comparison of Pushover curve for 8 storey y direction for structure 1



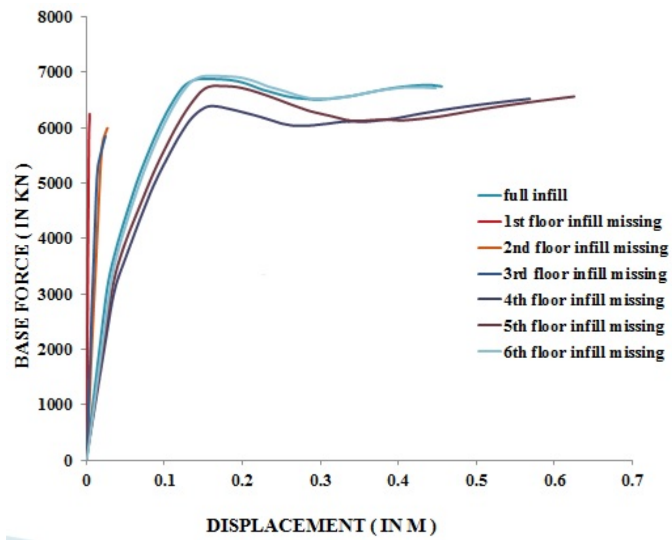
J. Comparison of Pushover curve for 12 storey y direction for structure 1



K. Comparison of Pushover curve for structure 2 in x-direction



L. Comparison of Pushover curve for structure 2 in y-direction



VI. CONCLUSIONS

From the results of ESA, RSA and Pushover analysis of structure 1 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. 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.

From results of pushover analysis of structure 2 it was found that:-

A. From the pushover curves in X direction, it has been observed that the consideration of infill in stiffness of structure will increase the base shear capacity of the structure but structure will become rigid.

B. While changing the position of the infill, storey wise, the variation in the capacity of the structure has been observed, due to the stiffness irregularity.

C. From the pushover curves in X direction, it has been observed that the consideration of infill in stiffness of structure will increase the base shear capacity of the structure but structure will become rigid.

D. While changing the position of the infill, storey wise, the variation in the capacity of the structure has been observed, due to the stiffness irregularity.

REFERENCES

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