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Parametric Study on the Percentage Opening in Infill Wall Including Shear Wall at Building

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Abstract: RC framed infilled structures are most common type of building used these days. Masonry infill walls fulfill essential requirements of the building and make it functional. A lot of research work is done in last six decades on analysis of infill walls, their behaviour when they are subjected to lateral seismic loads, but still there's much more to understand about the behaviour of infill walls. The structural designers while designing a structure usually neglect the presence of infill walls in the design and analysis. They are treated as non-structural members. Further the presence of openings in masonry infill walls is an interesting part to be studied. The linear static analysis has to be performed with the help of computer software E-TAB. The seismic analysis of RC frame for high rise building should be done by considering the infill walls and shear wall for lift in the analysis .This analysis is to be carried out on the models such as bare frame, frame with fully infilled masonry wall, frame with openings in the infilled masonry wall, strut frame for fully infilled wall and strut frame for the openings in infilled masonry wall. The various parameters such as drift, shear force, time period, base shear and lateral stiffness in each case will be determined. The results of the study will help to understand the complex behavior of the masonry infills for different variations and will also provide useful information to improve and economize the design of masonry infilled RC frame structures.
Keywords: Masonry infill walls, openings, bare frame, strut frame, base shear, drift, strength and stiffness.

I. INTRODUCTION

Reinforced concrete (RC) frame buildings with masonry infill walls have been widely constructed for commercial, Industrial and multi storey residential uses in seismic regions. Masonry infill typically consists of bricks or concrete blocks constructed between beams and columns of a reinforced concrete frame. The masonry infill panels are generally not considered in the design process and treated as architectural (non-structural) components. The practice of using infill walls has been under scrutiny as it has both positive and negative effects on the behaviour of structure under lateral load. Though infill walls do not affect the behaviour of frames under gravity loading, lateral stiffness and strength of frames increase significantly under the action of lateral loads. Therefore, unsymmetrical distribution of mass owing to randomly placed infill can actually change the structural response to earthquake load. Again when a sudden change in stiffness takes place along the building height, the storey at which this drastic change of stiffness occurs is called a soft storey. Many multistorey buildings in India have open ground storey to accommodate for parking or reception lobbies. Infills have been generally considered as non-structural elements, although there are codes such as the Eurocode-8 that include rather detailed procedures for designing infilled R/C frames, presence of infills has been ignored in most of the current seismic codes except their weight. Thus the ignorance of infill in the modelling phase underestimates the seismic response of the structure. Nevertheless, the presence of masonry infill walls has a significant impact on the seismic response of a reinforced concrete frame building, increasing structural strength and stiffness (relative to a bare frame) .Infill reduces the lateral deflection of the building, displacement and bending moments in frame.

II. LITERATURE

Nikhil Agrawal et.al studied the performance of masonry infilled reinforced concrete (RC) frames including open first storey of with and without opening. This opening is expressed in terms of various percentages , in this paper, symmetrical frame of college building (G+5) located in seismic zone-III is considered by modelling of initial frame. According to FEMA-273, & ATC-40 which contain the provisions of calculation of stiffness of infilled frames by modelling infill as "Equivalent diagonal strut method". This analysis is carried out on the models such as bare frame, strut frame, strut frame with 15% centre &corner opening, which is performed by using computer software STAAD-Pro from which different parameters are computed. Comparison is done in between bare frame and centre and corner opening only**.** And it is shown with the help of graph. The increase in the opening percentage leads to a decrease on the lateral stiffness of infilled frame. Deflection is very large in case of bare frame as compare to that of infill frame with opening. If the effect of infill wall is considered then the deflection has reduced drastically. And also deflection is more at last storey because earthquake force acting on it more effectively.Deflection in case of centre opening is large compare to corner opening[1]. Jaykumar R. Gaikwad et.al presented on masonry infill walls and shear wall for lift used in high-rise buildings. There are three types of buildings used for investigation of Masonry infills and shear wall i.e, RC Bare frame, RC Frame with masonry infill and RC Frame with masonry infill and shear wall for lift. The Non-linear static Pushover analysis has performed with the help of computer software E-TAB. The seismic analysis of RC frame for high rise building should be done by considering the infill walls and shear wall for lift in the analysis which reduces storey drift drastically than the bare frame[2].Putul Haldar et.al presents an analytical study on the seismic performance and fragility analysis of Indian code-designed RC frame buildings with and without URM infills. Infills are modeled as diagonal struts as per ASCE 41 guidelines and various modes of failure are considered. HAZUS methodology along with nonlinear static analysis is used to compare the seismic vulnerability of bare and infilled frames. The comparative study suggests that URM infills result in a significant increase in the seismic vulnerability of RC frames and their effect needs to be properly incorporated in design codes[3].M. S. Razzaghi et.al demonstrated that neglecting the effects of infill walls during the nonlinear dynamic analysis of the RC frames may lead to the dramatic misunderstanding the seismic performance of the structure. To this end seismic response of 18 models of the same structure and different arrangements of the infill walls to four different ground motions were investigated using PERFORM 3D software. Results of this study revealed that changing the arrangement of infill walls may change the damage state of the building during an earthquake.[4]. L.D. Decanini et.al" studied the effect of openings on the lateral stiffness and strength of infilled frames by means of numerical and experimental analyses available in the literature and a simple model to take into account the presence of openings is presented. Within the equivalent strut method, the stiffness and strength reduction due to openings can be obtained by decreasing the effective width of the strut. By means of all the available data, the main parameters affecting the response of infills with opening are identified and the influence of these factors on the strength and stiffness of the infills is evaluated. Afterwards, a function for the reduction factor, which takes into account the main parameters involved, is calibrated. The equations proposed for the reduction factor reflect different aspects experimentally observed: the strength and stiffness reduction decrease when strengthening elements are present around the opening; the influence of the opening size diminishes when the opening is strengthened; when a non strengthened opening with an area greater than 40% of the infill area is present, then the contribution of the infill is small while if the opening is strengthened the reduction factor is always greater than 0.4[5].

III.OBJECTIVE AND METHODOLOGY

A. Objective

The main objective of the present study is to carry out the linear static analysis of the RC frames with different configurations. In total 5 models are considered for analysis and then analysis results are compared for various parameters such as base shear, Time period, storey forces, storey drift, storey displacement and storey stiffness.

B. Methodology

1) Modelling of G+5 RC building in E-TABS with various different configurations
2) Various cases are considered such as RC bare frame, Frame with fully infilled wall, Frame with openings in the wall and frame with equivalent diagonal strut model accounting for fully infilled wall and wall with openings.
3) Linear static analysis is carried out for all 5 models.
4) Analysis results are formulated.
5) Comparison of various parameters such as base shear, time period , storey forces , story shear, storey displacement and storey stiffness.

IV. ANALYTICAL METHOD

This study involves seismic analysis of the RC frame building with five models that includes bare frame, fully infilled masonry frame, infilled masonry frame with openings, RC frame by replacing fully infilled masonry walls with equivalent diagonal struts and RC frame by replacing infilled masonry walls with openings by equivalent diagonal struts for openings. The parameters such as displacements, time period, base shear and stiffness are studied. ETABS software is used for the analysis of the building and linear static analysis is used. The Fig 1 shows the plan of the building used for analysis. Fig 2(a) shows the elevation along F-F for RC bare frame, Fig 2(b) shows the elevation along F-F for RC frame withfully infilled wall, Fig 2(c) shows the elevation along F-F for RC frame with openings in infilled wall, Fig 2(d) shows the elevation along F-F for RC frame replaced by equivalent strut for fully infilled wall and Fig 2(e) shows the elevation along F-F for RC frame replaced by equivalent strut for openings in infill wall. Table 1 shows the input data for all the five models.

Fig 1. Plan of the RC building

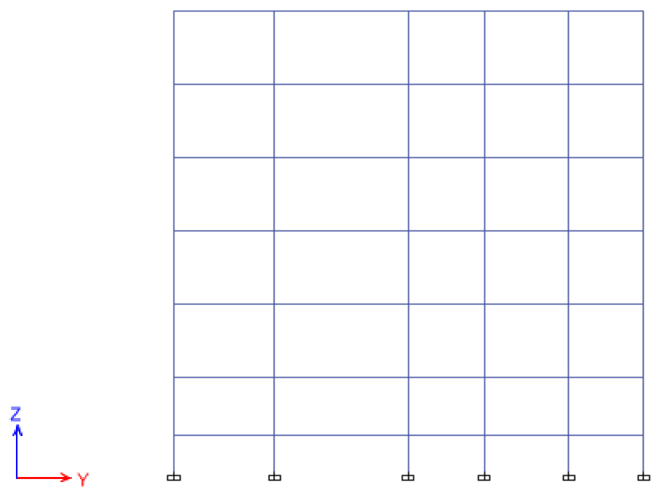

Fig 2(a). Model1 , RC bare frame

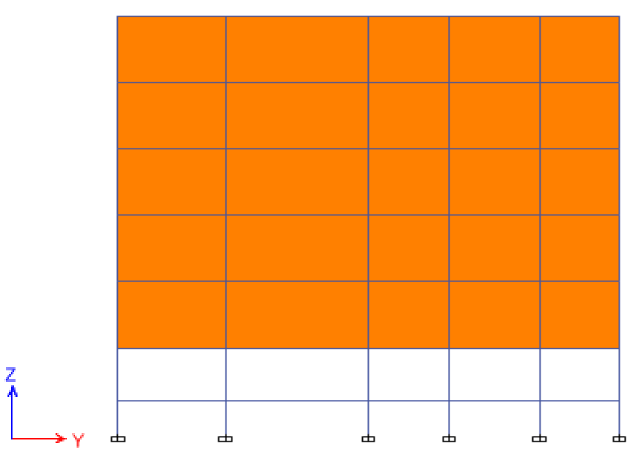

Fig 2(b).Model 2, RC frame with fully infilled wall

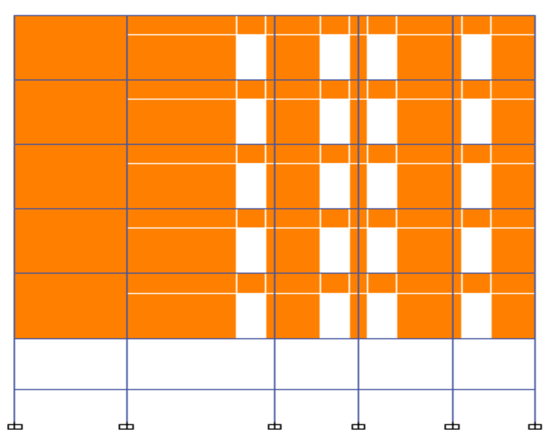

Fig 2(c). Model 3, RC infilled frame with openings

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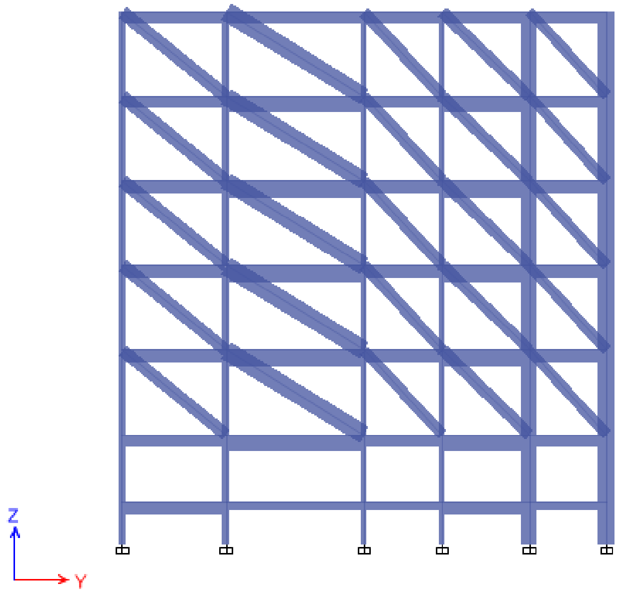

Fig 2(d). Model 4, RC frame replaced by equivalent strut for fully infilled wall.

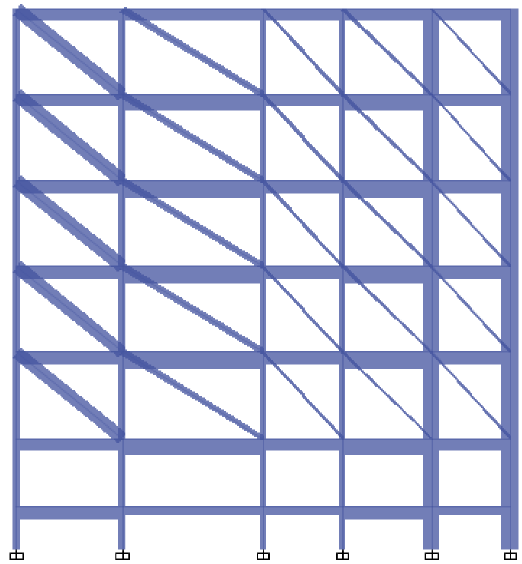

Fig 2(e). Model 5, RC frame replaced by equivalent strut for openings in infill wall.

Table 1. Input Data.

Dimension in plan	22m x 25m
No. of floors	G+5
Each storey height	3 m
Depth of foundation	1.5m
Beam size	230mmx450mm, 230mmx600mm
Column size	230mmx 600mm
Slab thickness	125mm, 135mm, 110mm
Wall thickness	230mm
Shear wall thickness	200mm
Grade of concrete for beam	M20
Grade of concrete for column	M25
Grade of steel	Fe415
Density of concrete	25 kN/m^3
Poission's ratio of concrete	0.2
Zone (Z)	VI (0.24)
Soil type	I (Hard soil)
Importance factor (I)	1
Reduction factor (R)	5
Damping	5%
LL for all the storey	3 kN/m^2
LL for roof	1.5 kN/m^2

V. RESULTS AND DISCUSSION

A. Comparison of base Shear

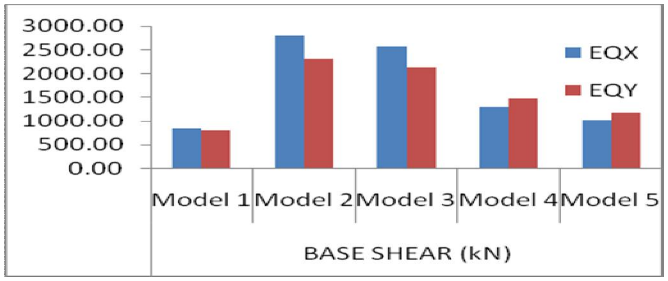

Fig 3 Comparison of base shear in X and Y direction

Fig. 3 shows the graph for comparison of base shear for all models.The percentage increase in the base shear with respect to model 1 is 69.8%, 66.9%, 35%, 16.5% for model 2,model 3, model 4 and model 5 respectively along X- direction and the percentage increase in the base shear with respect to model 1 is 65.14%, 62.14%, 45.64%, 31.6% for model 2,model 3, model 4 and model 5 respectively along Y- direction.. In comparison to model 3, model 2 has taken 9% extra base shear along X-direction and 8 % extra storey force along Y-direction. Similarly, when compared to model 4, base shear for model 5 reduced by 22% and20.53% along X and Y direction respectively.

B. Comparison of Story Forces

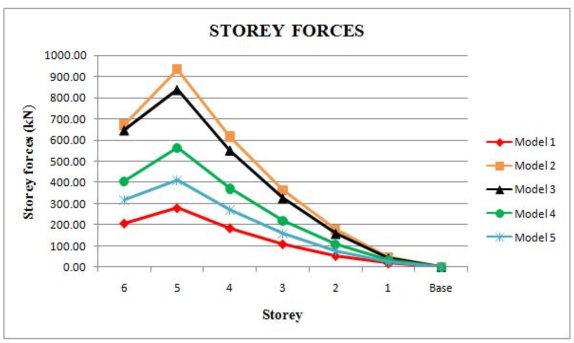

Fig 4 (a) Comparison of storey forces along X- direction

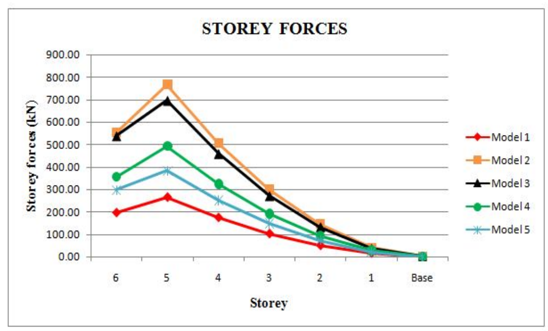

Fig 4 (b) Comparison of Storey forces along Y-direction

Fig 4 (a) and Fig 4 (b) shows graph for comparison of storey forces along X and Y direction. The percentage increase in storey forces with respect to model 1 is 70.07%,,66.65%,,50.46%.,,31.92% for model 2, model 3, model 4 and model 5 respectively along X- direction . The percentage increase in storey forces with respect to model 1 i.e bare frame is 65.48%, 61.88%, 46.22%.,30.92% for model 2, model 3, model 4, model 5 respectively along Y- direction. In comparison to model 3, model 2 has taken 10% extra storey force along X-direction and 9.42 % extra storey force along Y-direction .Similarly, when compared to model 4, storey force for model 5 reduced by 27.2% and 22% along X and Y direction respectively.

C. Comparison of Storey shear

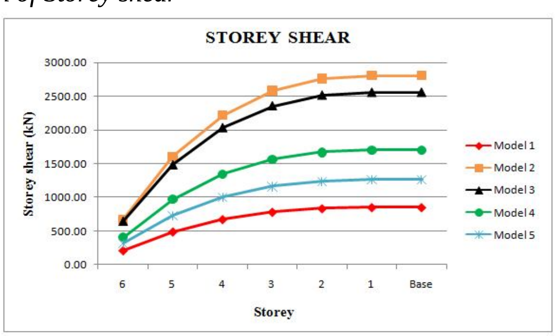

Fig 5 (a) Comparison of storey shear along X-direction

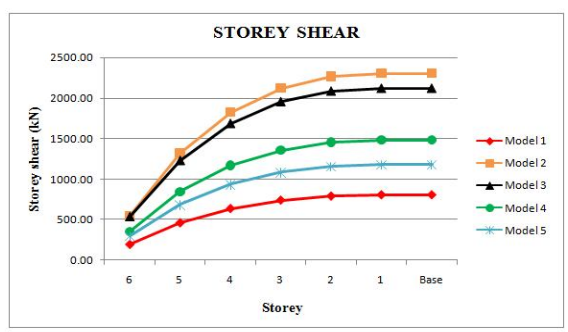

Fig 5(b) Comparison of Storey Shear along Y-direction

Fig 5(a) and Fig 5 (b) shows the graph for comparison of storey shear along X and Y direction. The percentage increase in storey shear with respect to model 1 i.e bare frame is 69.78%, 66.87%, 50.11%., 32.71% for model 2, model 3, model 4 and model 5 respectively along X- direction. The percentage increase in storey forces with respect to model 1 i.e bare frame is 65.14%, 62.88%, 45.82%., 31.73% for model 2, model 3, model 4, model 5 respectively along Y- direction. In comparison to model 3, model 2 has taken 9% extra storey shear along X-direction and 8 % extra storey shear along Y-direction. Similarly, when compared to model 4, storey shear for model 5 reduced by 25.84% along X direction and 20.64% along Y-direction.

D. Comparison of Storey displacement

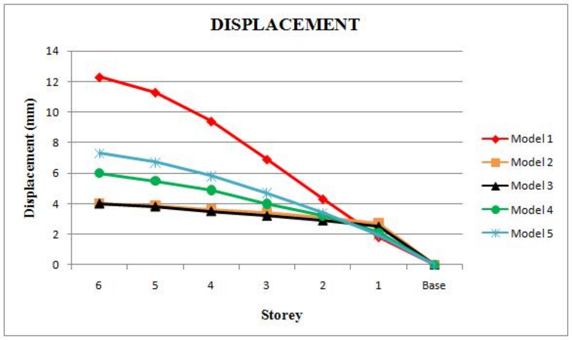

Fig 6 (a) Comparison of storey displacement along X-direction

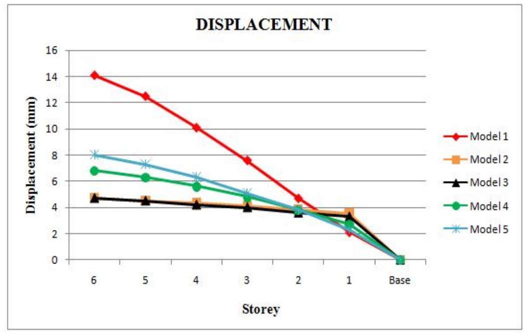

Fig 6 (b) Comparison of Storey displacement along Y-direction

Fig 6(a) and Fig 6(b) shows the graph for Comparison of storey displacement along X and Y direction respectively. The percentage reduction of storey displacement along X- direction with respect to model 1 is 67.48%, 67.5%, 51.22%., 40.65% for model 2, model 3, model 4 and model 5 respectively. The percentage reduction in storey displacement in Y- direction with respect to model 1 is 66.67%, 66.7%, 51.77%., 43.26% for model 2, model 3, model 4 and model 5 respectively. We can observe that there is no much reduction in displacement in between model 2 and model 3 along both X and Y direction. It can be seen that, when compared to model 4, storey displacement for model 5 increased by 17.8% along X direction and 15% along Y-direction.

E. Comparison of Storey Stiffness

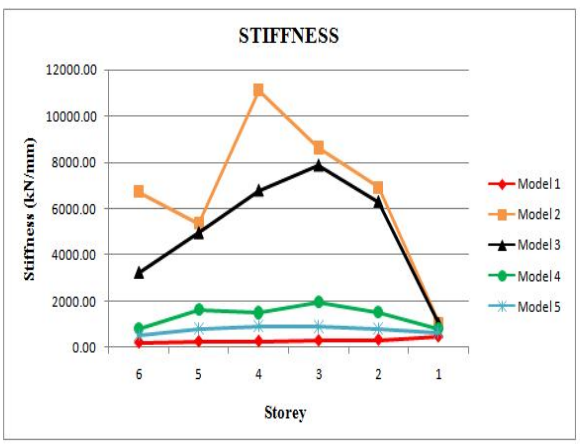

Fig 7 (a) Comparison of storey Stiffness along X-direction

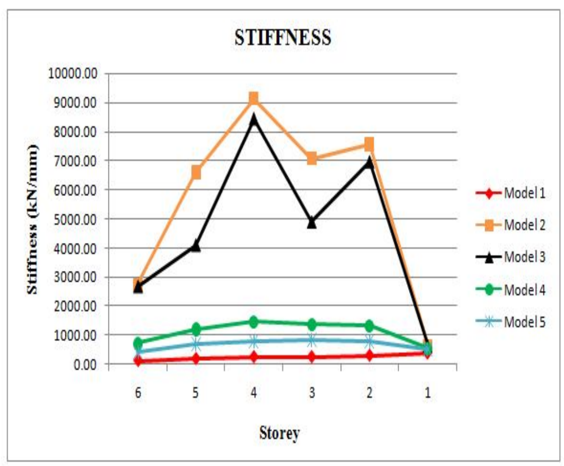

Fig 7 (b) Comparison of Storey Stiffness along Y-direction

Fig 7(a) and Fig 7 (b) shows the graph for Comparison of storey stiffness along X and Y direction. From the graph, it is observed that, the storey stiffness is minimum for model 1 as compared to rest of the models along both direction. It is observed that stiffness for model 3 is less compared to model 2 along both the direction. The percentage decrease in the stiffness for model 5 is found to be 39% as compared to model 4 along X- direction and Y- direction

VI. CONCLUSION

A. Following are the Conclusions That can Been Made From the Results Obtained from The Analysis Carried Out ,

1) The base shear is minimum in bare frame and maximum in frame with fully infilled masonry wall and it decreases with opening in masonry infill.
2) The base shear found to be considerably less when equivalent strut model are considered for fully infill and with openings in the masonry wall.
3) Time period of RC bare frame is more as compared with RC frame with fully infilled masonry wall, further there is marginal difference in the time period for the RC frame with openings in masonry infilled wall.
4) The time period of equivalent strut model are comparatively more than RC frame with masonry infill walls and RC frame with openings in infill wall.
5) Storey forces in RC bare frame is minimum and is maximum in RC frame with fully infill masonry walls further reduces with openings in masonry walls.
6) Storey forces are considerably reduced in equivalent strut model with fully infilled masonry and openings in masonry infill wall.
7) Storey displacement is maximum in RC bare frame and minimum in RC frame with fully infilled masonry wall , further no significant change in displacement is found with openings in masonry infill walls.
8) Marginal difference is observed in storey displacement for equivalent strut models and is found to increase in displacement for upper storeys
9) Storey stiffness is minimum in RC bare frame as there is no infilled masonry walls when compared to infilled masonry wall. But there is significant effects of shape and geometry of the RC frame model.
10) In general all the parameters discussed will depend on the shape and geometry of the structure.

VII. SCOPE FOR FUTURE WORK

The present study can be extended to response spectrum analysis and non-linear analysis. The openings can be modelled by finite element analysis and the further analysis can be proceeded .The beams, columns and slab can be designed according to the IS-456 2000 and applied to the frame element of the building. The buildings are analysed and results are computed.

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