Post Peak Response of Reinforced Concrete Frames with and without in Filled Panels

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Abstract - *The effect of masonry infill panel on the response of RC frames subjected to seismic action is widely recognized and has subject of numerous experimental investigations, while several attempts to model it analytically have been reported. In analytically analysis infill walls are modeled as equivalent strut approach there are various formulae derived by research scholars and scientist for width of strut and modelling. Infill behaves like compression strut between column and beam and compression forces are transferred from one node to another. In this study the effect of masonry walls on high rise building were studied. In construction, cross bracing is a system utilized to reinforce building structures in which diagonal supports intersect. Cross bracing can increase a building's capability to withstand seismic forces from an earthquake. The cross bracing is usually seen with two diagonal supports placed in an X shaped manner; these supports compression and tension forces. Viscous dampers are used to damp the motion of the building. Dampers were used since 1960s to protect tall buildings against wind effects. Non linear push over analysis on high rise building with different arrangement is carried out. For the analysis G+7 R.C.C framed building is modeled. Earthquake time history is applied to the models. The width of strut is calculated using equivalent strut method. Various cases of analysis are taken All analysis is carried out by software ETABS and SAP 2000. Storey displacement, storey drift is calculated and compared for all models .The result show that infill wall reduce displacements and storey drift. So it is essential to consider the effect of masonry infill for the seismic evaluation of moment resisting reinforced concrete frame.*

Key words: Infill walls, Equivalent strut, Storey displacement, Storey drift, viscous damper, Cross bracings.

1. INTRODUCTION

Earthquake is a sudden shock on the Earth's surface. The random ground motions cause the structure to vibrate. As a result of underground movement along a fault plane the surface of the earth shakes and causes vibration on the structure supported on the ground. The movement on the structure can be resolved in three mutually perpendicular directions. The response of a structure to ground vibrations is a function of the nature of foundation soil, materials, size and mode of construction of structures and duration of and characteristics of ground motion

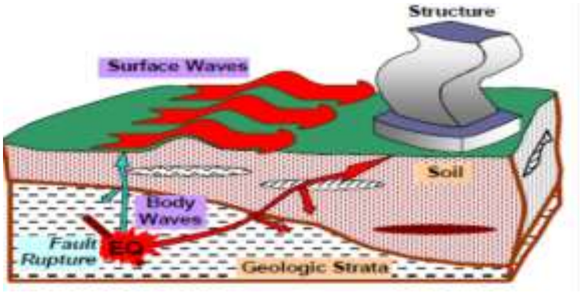

Fig-1 Building response to the earthquake ground motions

1.1 Bare frame

The majority of human occupation is catered by residential and office buildings for our living and working quarters. The necessary urban consolidation requires multi-level buildings which are more vulnerable to the effects of earthquakes. The most common structural system for both residential and office buildings consist of multi-level framed structures incorporating column-slab/beams which are the gravity and lateral load carrying elements. In the building construction, framed structures are frequently used due to ease of construction and rapid progress of work. A typical reinforced concrete building is made of horizontal members (beams and slabs) and vertical members (columns and walls) and supported by foundations that rest on ground.

2. 1Frame with infill wall

Masonry infill panels have been widely used as interior and exterior partition walls for aesthetic reasons and functional needs. The vertical spaces between columns and floors are filled with infill walls. Masonry infills are normally considered as non-structural elements and their stiffness contributions are generally ignored in practice. However, infill walls tend to interact with the frame when the structure is subjected to lateral loads, and also exhibit energy-dissipation characteristics under seismic loading. Masonry walls contribute to the stiffness of the infill under the action of lateral load. The term "infilled frame" is used to denote a composite structure formed by the combination of a moment resisting plane frame and infill walls. The infill may be integral or non-integral depending on the connectivity of the infill to the frame. When column receive horizontal force at floor levels, they try to move in horizontal direction, but masonry walls tend to resist these forces. Due to their heavy weight and thickness, these walls attract rather large horizontal forces. However,

since masonry is a brittle material, these walls develop cracks once their ability to carry horizontal load is exceeded. Thus, infill walls act like sacrificial fuses in buildings; they develop cracks under severe ground shaking but help share the load of the beams and columns until cracking. Earthquake performance of infill walls is enhanced by mortars of good strength, making proper masonry courses, and proper packing of gaps between RC frame and masonry infill walls.
The composite behaviour of an infilled frame imparts lateral stiffness and strength to the building.

$$\alpha_h = \frac{\pi}{2}\sqrt[4]{\frac{4Ef\ Ic\ h}{Emtsin2\theta}}$$

$$\alpha_L = \pi\sqrt[4]{\frac{4Ef\ Ib\ L}{Emtsin2\theta}}$$

where Em and Ef = Elastic modulus of the masonry wall and frame material, respectively
t, h, L = Thickness, height, and length of infill wall, respectively
Ic and Ib = moment of inertia of column and the beam of the frame, respectively

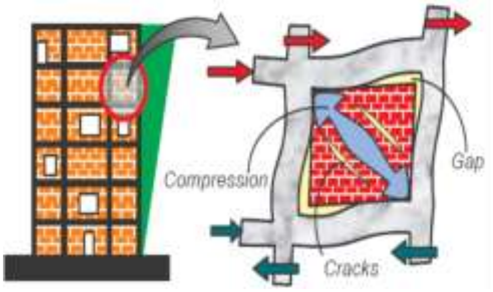

Fig- 2. Infill walls in reinforced concrete structure

3.1Cross Bracings

In construction, cross bracing is a system utilized to reinforce building structures in which diagonal supports intersect. Cross bracing can increase a building's capability to withstand seismic forces from an earthquake. The cross bracing is usually seen with two diagonal supports placed in a X shaped manner; these supports compression and tension forces. Depending on the forces, one brace may be in tension while the other is slack.

The steel bracing used is of cross pattern (X-bracing) which is more commonly used. The cross bracing derives its primary benefit from the intersection of the two diagonals, which cuts down their unsupported buckling length in compression. The size of steel brace used is of size 2ISA 60x60x8 connected back to back at a spacing 8 mm. Steel bracing members (double angle back to back) are modeled as truss member. X bracing (cross bracing) system has been considered. In the cross pattern of steel bracing, additional joints (nodes) are created at intersection point of diagonal braces. The connection between steel brace and frame have been made rigid by providing end length offset with rigid zone factor 1, i.e. the entire connected zone has been made rigid.

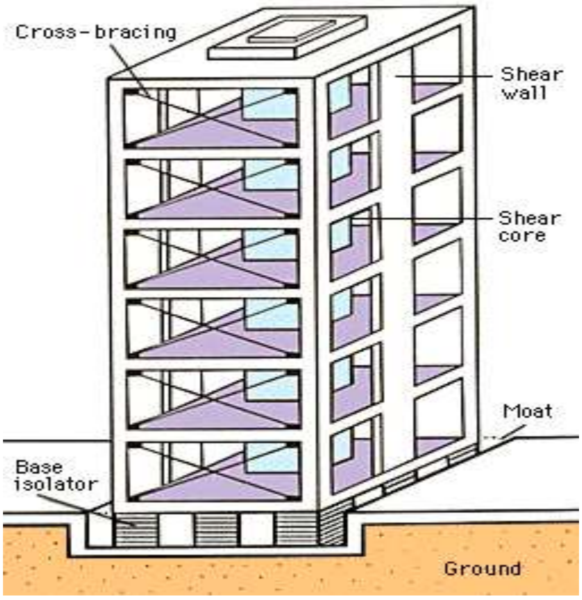

Fig- 3: Cross Bracings

4.1 Seismic Dampers

Another approach for controlling seismic damage in buildings and improving their seismic performance is by installing seismic dampers in place of structural elements, such as diagonal braces when seismic energy is transmitted through them, dampers absorb part of it, and thus damp the motion of the building. Dampers were used since 1960s to protect tall buildings against wind effects. Commonly used types of seismic dampers include viscous dampers.

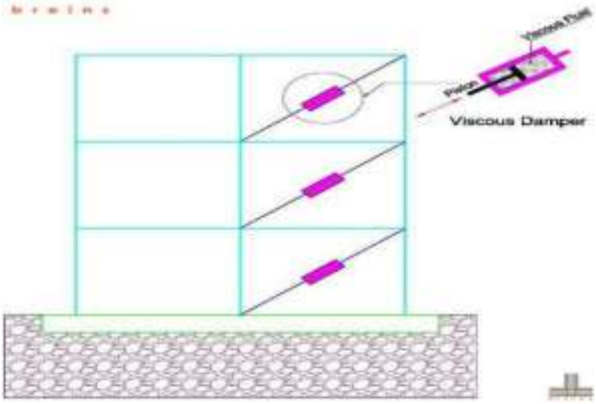

Fig- 4: Viscous Dampers

2. EXPERIMENTAL PROGRAM

Two buildings with bare frame and the building with infill wall is fairly symmetric in plan and in elevation. In both the buildings, the columns are supported on isolated footings with plinth beams. The concrete slab is 120 mm thick at each floor level. The brick wall thicknesses are 230 mm for external walls and 120 mm for internal walls. Imposed load is taken as 3kN/m^2 for all floors. The grade of concrete and steel used in both the buildings are M25 and Fe 415 respectively. The building is intended for residential use. The building is founded on medium strength of soil.

The building is modelled as
1. Bare frame

2. Frame with infill

3. With Cross bracings

4. With Viscous dampers

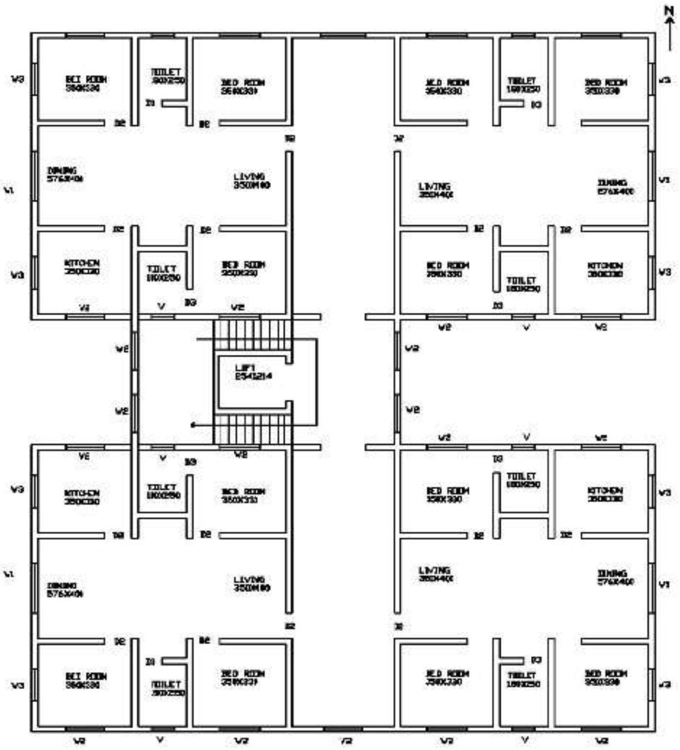

Fig-5: Typical floor plan

3. ANALYSIS OF FRAMES

a) Response spectrum method
b) Non –linear method

3.1Non linear method

Non- linear static method is an improvement over linear static or dynamic method in the sense that it allows inelastic behaviour of the structure. The method is simple to implement and provides information on the strength, deformation and ductility of the structure, as well as the distribution of demands. Push-over analysis provides a reasonable estimation of the global deformation capacity, especially for structures that primarily respond according to the first mode. Non linear analysis of the building is carried out using the software ETABS. In the implementation of pushover analysis, modelling is one of the important steps. The model must consider non-linear behaviour of structure or elements. Analysis was performed using ETABS, which is a general purpose of structural analysis program for static and dynamic analysis of structures.

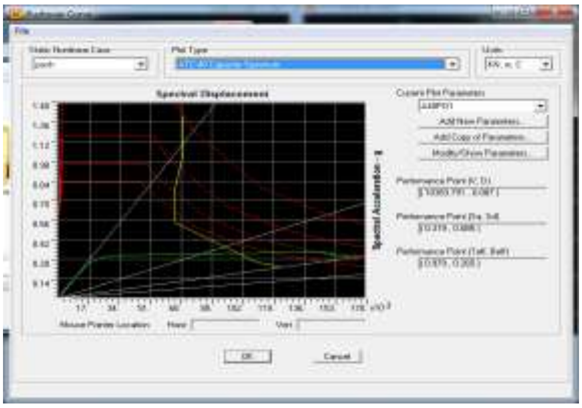

Fig- 6: push over spectrum

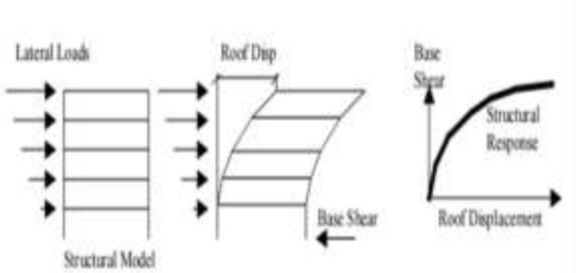

Fig-7: Static approximation used in the push over analysis

4. RESULTS AND DISCUSSION

Results from non-linear analysis

Non –linear analysis is carried out by SAP2000 and the results obtained are:

4.1Storey Drift in X direction

Floor deflections are caused when buildings are subjected to seismic loads. These deflections are multiplied by the ductility factor, resulting in the total deflections which account for inelastic effects. The drift in a storey is computed as a difference of deflections of the floor at the top and bottom of the storey under consideration. The total drift in any storey is the sum of shear deformations of that storey, axial deformations of the floor systems, overall flexure of the building and foundation rotation

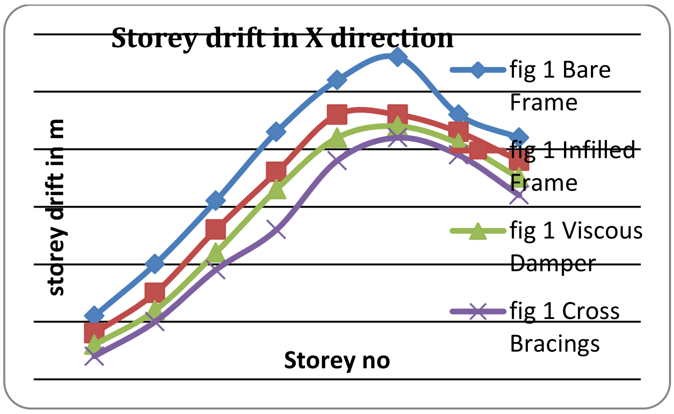

Chart-1: Storey Drift in X direction

Storey drift in any storey due to minimum specified design lateral force shall not exceed 0.004h times the storey height. The storey drift of the bare frame in X direction is 9.5% more than that of infilled frame 16.66% more than that of viscous damper ,23.8% more than that of the cross bracings.

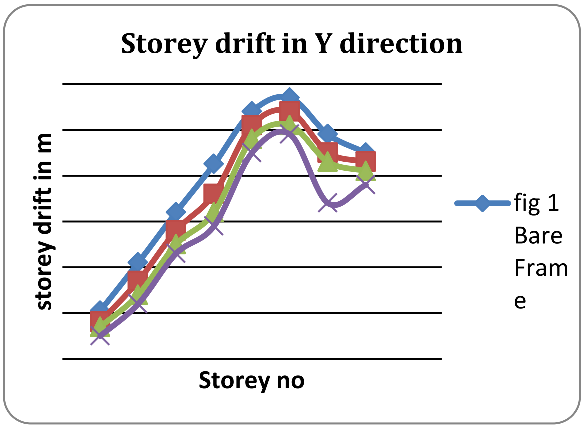

Chart-2: Storey Drift in Y direction

Storey drift in any storey due to minimum specified design lateral force shall not exceed 0.004h times the storey height. The storey drift of the bare frame in Y direction is 12.24% more than that of infilled frame 16.3% more than that of viscous damper ,22.4% more than that of the cross bracings.

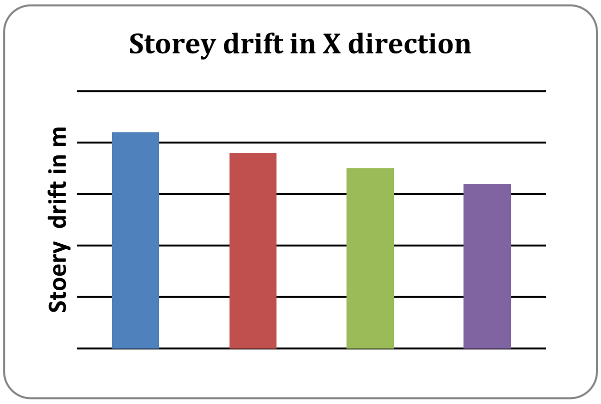

Chart-3: Bar Chart for storey drift in X direction

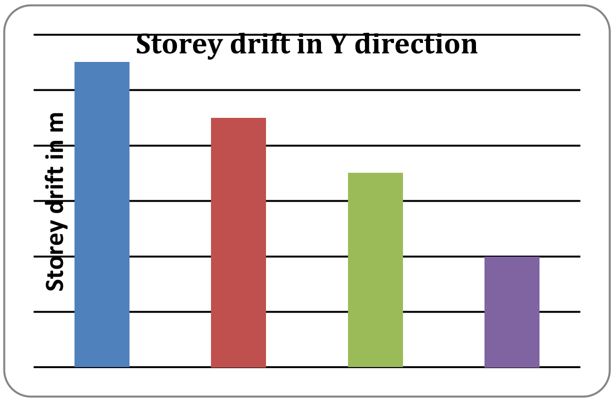

Chart-4: Bar chart for Storey Drift in Y direction

4.2Roof Displacement in X direction

The displacement obtained from the non-linear analysis is shown below: Displacement refers to the lateral displacement of the roof of the building with respect to the base.

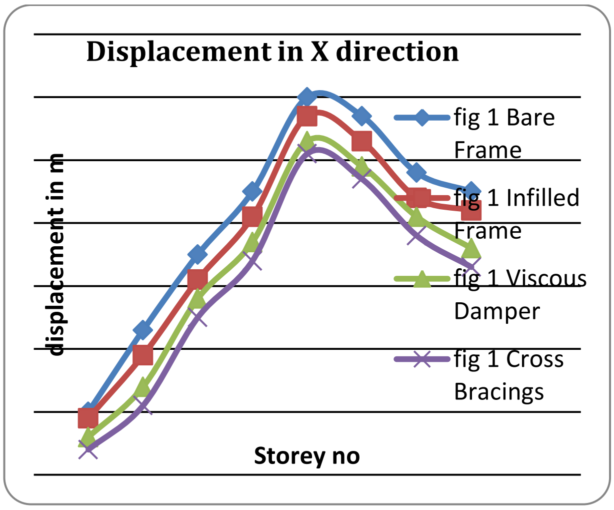

Chart-: 5 Roof Displacement in X direction

From the above graph it is clear that as the height of the storey increases roof displacement is also increases. The displacement of the bare frame in X direction is 6.6% more than that of infilled frame 20% more than that of viscous damper 26.6% more than that of the cross bracings.

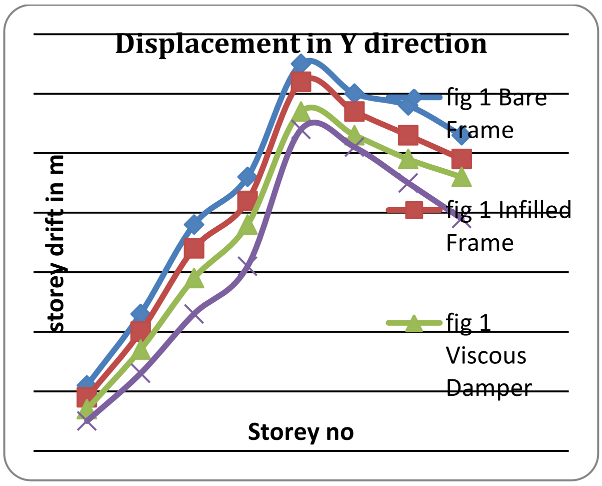

Chart-: 6 Roof Displacement in Y direction

From the above graph it is clear that as the height of the storey increases roof displacement is also increases. The displacement of the bare frame in Y direction is 7.5% more than that of infilled frame 13.2% more than that of viscous damper,26.4% more than that of the cross bracings.

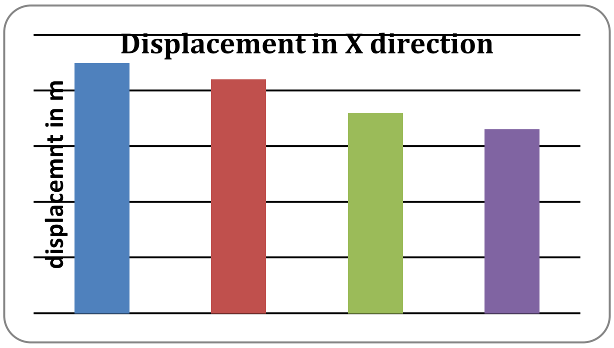

Chart-: 7 Bar chart for Roof Displacement in X direction

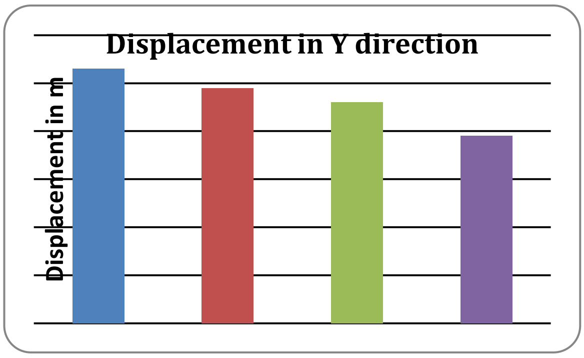

Chart-: 8 Bar chart for Roof Displacement in Y direction

5. Plastic hinge Mechanism

Plastic hinge patterns of the 2 to 8 storey frames are compared at different levels of roof displacement to provide information about local and global yielding and ultimate displacement. The global yielding point corresponds to the displacement on the capacity curve when the system starts to soften. Lumped plasticity idealization of a cantilever is a commonly used approach in models for information capacity estimates. The ultimate deformation capacity of component depends on the ultimate curvature and plastic hinge length. Plastic hinges formation starts with beam ends and base columns of lower stories , then propagates to upper stories and continue with yielding of interior intermediate columns in the upper stories.

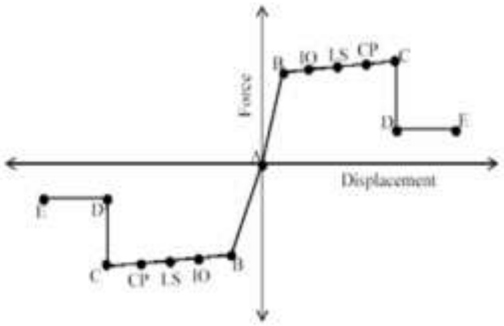

Fig-8: Force –deformation curve for beams and columns

6. CONCLUSIONS

1. From the linear analysis of the transverse frame of apartment the roof displacement in X direction is 9.5% more than that of infilled frame 16.66% more than that of viscous damper ,23.8% more than that of the cross bracings.

2. From the linear analysis of the transverse frame of apartment the roof displacement in Y direction is 12.24% more than that of infilled frame 16.3% more than that of viscous damper ,22.4% more than that of the cross bracings.

3. From the linear analysis of the transverse frame of apartment the storey drift of the bare frame in X direction is 6.6% more than that of infilled frame 20% more than that of viscous damper ,26.6% more than that of the cross bracings.

4. From the linear analysis of the transverse frame of apartment storey drift of the bare frame in Y direction is 7.5% more than that of infilled frame 13.2% more than that of viscous damper,26.4% more than that of the cross bracings.

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