ENHANCING RESISTANCE CAPACITY OF SOFT STOREY BUILDING BY MEANS OF SHEARWALL INCORPORATED WITH STRUT

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Abstract – ***Open ground storey or soft storey is a typical feature in the modern construction of multistory building in urban India. This provision of providing open ground storey reduces the stiffness of the lateral load resisting system, which can be seen in buildings failed during Bhuj earthquake and Gujarat earthquake with soft storey. In the present work four different frames with different soil types and different G.F height are considered for comparative study and non-linear pushover analysis were also performed for concrete shear wall, steel wall and composite wall immersed in four corner of building by means of 3.6 m height ground floor with and without infill. Infill was modeled using equivalent strut as masonry infill having significant effect on the global behavior of building. The analysis of the structure are carried out with help of SAP 2000 software for the earthquake loading the provision of IS 1893(part-1) 2002 and FEMA 273. The result are compared and found that use of infill and shear wall reduce the displacement in static analysis whereas in pushover analysis strength of composite wall was found more than concrete shear wall and less as compared to steel wall, So it is economical to go for composite wall building in its corner incorporated with strut consider while analyzing.***

Key Words: *Masonry infill, lateral drift, strut model, Pushover analysis, Static analysis, shear wall.*

1. INTRODUCTION

Soft storey buildings are commonly used in the urban environment now days since they provide parking area which is most required. This type of building shows comparatively a higher tendency to collapse during earthquake because of soft storey effect. Large displacement gets induced at the first floor level of such buildings yielding large curvature in the ground storey columns.

An soft storey is one in which the lateral stiffness is less than 70 percent of that in the storey above or less than 80 percent of the average lateral stiffness of the three storey above. The energy developed during earthquake loading is dissipated by the vertical resisting element of the ground storey resulting the occurrence of plastic deformation which transforms the ground storey into mechanism in which the collapse is unavoidable. The behavior of soft storey framed building is totally differently as compared a bare frame building (without any infill) or fully infilled framed building under lateral loads. The bare frame is much less stiffer than fully infilled frame, it resists the applied lateral load through frame action and shows well distributed plastic hinges at failure condition. But when this frame is fully infilled truss action is introduced. A fully infilled frame shows lesser inter-storey drift, through it attracts higher base shear (due to increase to stiffness).A fully infilled frame yields lesser force in the frame elements and hence dissipates greater amount of energy through infill wall. The strength and stiffness of infill walls in frame buildings are ignored during the structural modeling in conventional design practice. The design in such cases will generally be conservational in the case of fully infilled frame buildings than others. But things will be somewhat different for an soft storey framed building.

Soft storey building being slightly stiffer than bare frame has larger storey drift (specially in the ground storey) and fails due to soft storey mechanism at the ground floor. Therefore, it may not be conservative to ignore strength and stiffness of infill wall while designing soft storey buildings.

Whereas, Pushover analysis is a static, nonlinear procedure to analysis any building is loaded incrementally with a certain definite predefined pattern (i.e. inverted triangular or uniform). Local non-linear effects are modeled and the structure is pushed until a collapse mechanism is developed in the same building. With increase in the magnitude of loads, weak links and failure modes of building are observed. At each step, the structure is pushed until enough hinges from to develop a curve between base shear and the corresponding roof displacement of the building and this curve commonly known as pushover curve. At each step, the total base shear and the top displacement are plotted to get this pushover curve at various phases this gives an idea of the maximum base shear that the structure is capable of resisting and the corresponding inelastic drift that it can overcome. For regular buildings, it also gives the estimate of global stiffness of the building.

1.1 PARAMETRIC STUDY

For Seismic Analysis

Considering a building frame of G+6 floors by varying the building frame system, height of ground storey, soil condition and masonry infill as strut.

For Pushover Analysis

Considering frame of G+6 floors with soft storey (3.6 m) having different types of wall like concrete shear wall, composite wall and steel wall at its four corner with and without infill.

1.2 DESIGN DATA

- Live load : 4 kN/m^2 at typical
  : 2 kN/m^2 at roof
- Floor finish : 1.0 kN/m^2
- Water Proofing : 2 kN/m^2
- Grade of steel : Fe 415, Fe 250
- Grade of concrete : M25
- Ht. of ground Storey (soft): 3.6 m, 4.8m, 6.0m
- No. of bays : 6 @ 4.5 both way
- Ht. of other storey : 3.2 m
- Column size : 600x600 mm
- Beam size : 300x600 mm
- Slab thickness : 150 mm
- Wall thickness : 230 mm External
  : 150 mm Internal
  : 230 mm shear wall
  : 50 mm steel wall
  : 230 mm composite wall with 5 mm plate
- Earthquake load : As per 1893(part 1) 2002
- Seismic zone : II (Aurangabad)

For static analysis there is consideration of four types of frame, first is ordinary moment resistance frame (OMRF) second frame ordinary moment resistance frame with concrete shear wall third is OMRF with strut and last consist of OMRF with shear wall and strut. Under each floor consider above their lies three different ground floor height (soft storey) having 3.6 m, 4.8 m and 6.0 m height respectively. With every height difference type I, type II, type III soils are taken for analysis. Type I is a hard rock, type II is medium type of soil and type III is the loose soil (back cotton soil). Therefore all together total 36 frames are obtained for finding out the lateral drift and base shear.

In Pushover analysis total of six different models 3.6 m G.F height are taken for analysis. Model I having concrete shear wall at its four corners without infill, Model II having concrete shear wall at its four corners with infill, Model III consist of steel wall incorporated in four of building without infill, Model IV is modeled again for steel wall with infill, in Model V composite wall without strut (infill) is consider in four corners of building and the last Model VI is composite wall with infill in four corners of frame. Pushover analysis is carried out for maximum performance point by pushing the building in X-direction.

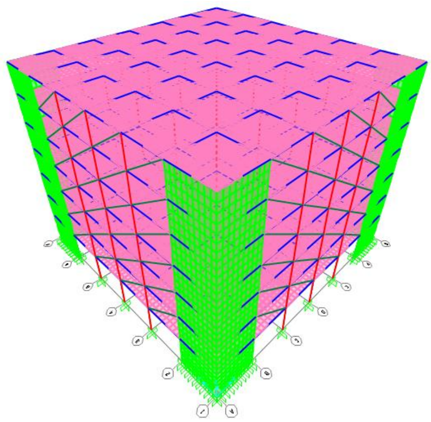
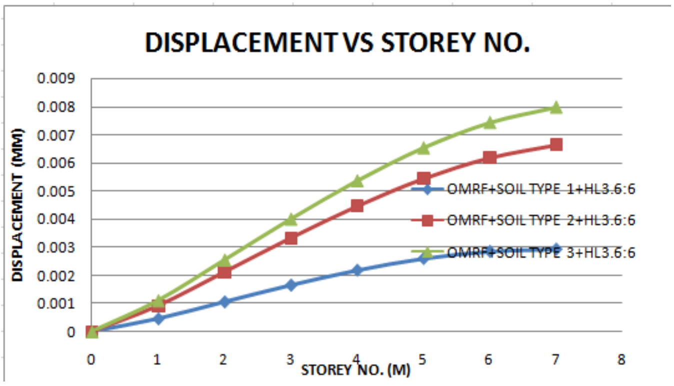


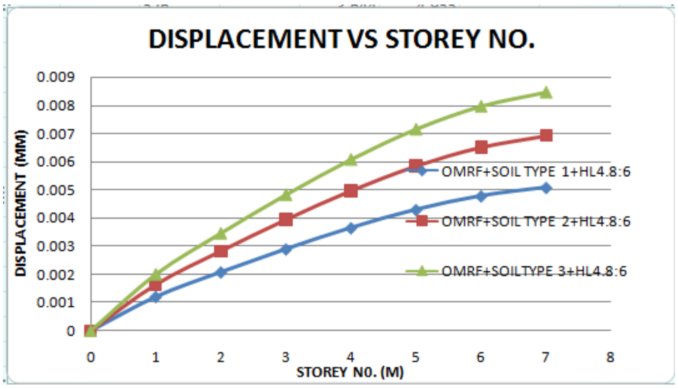
Fig-1 One of the Model taken for analysis

2. RESULTS

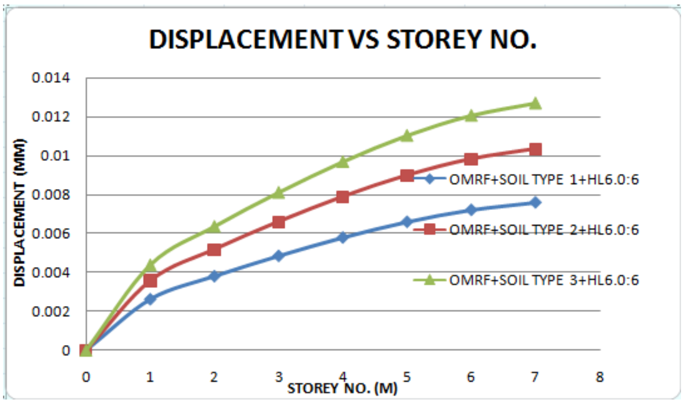
For static analysis:-



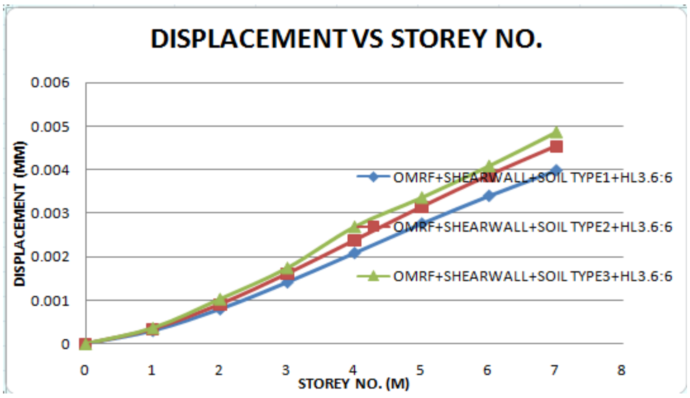
Graph 1: Ordinary moment resistance frame with soil type I,II,III and 3.6 m ground floor height.



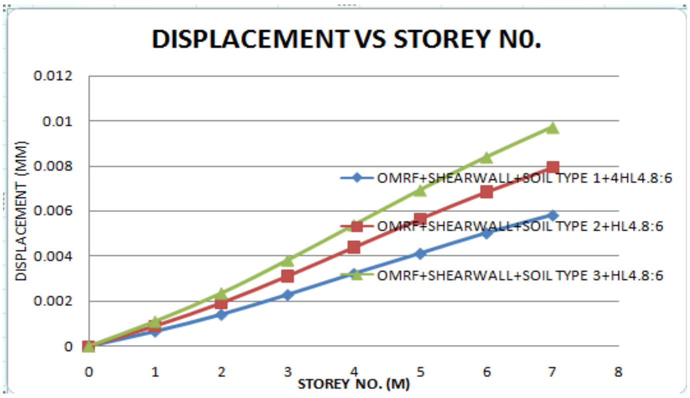
Graph 2: Ordinary moment resistance frame with soil type I,II,III and 4.8 m ground floor height.



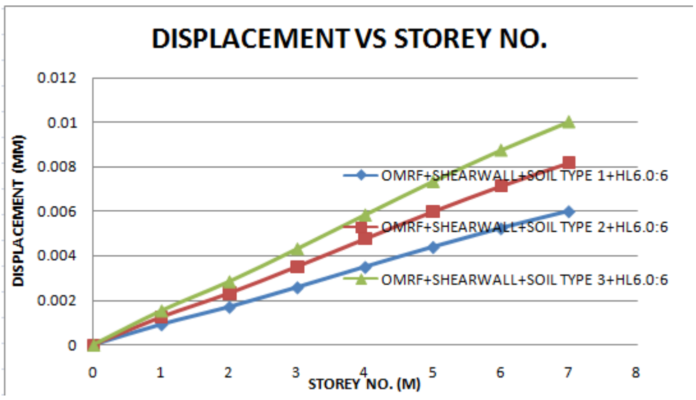
Graph 3: Ordinary moment resistance frame with soil type I,II,III and 6.0 m ground floor height.



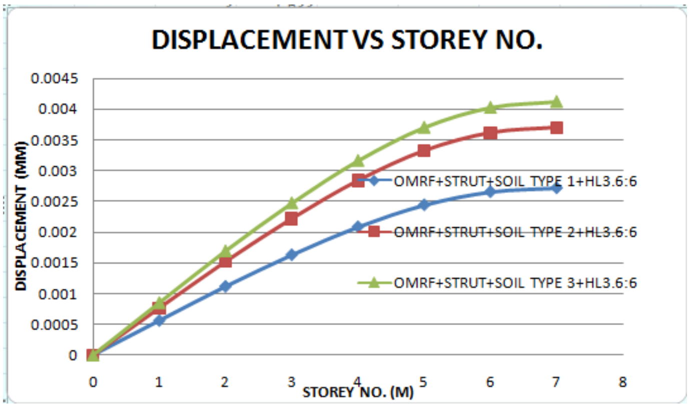
Graph 4: Ordinary moment resistance frame+ shearwall with soil type I,II,III and 3.6 m ground floor height.



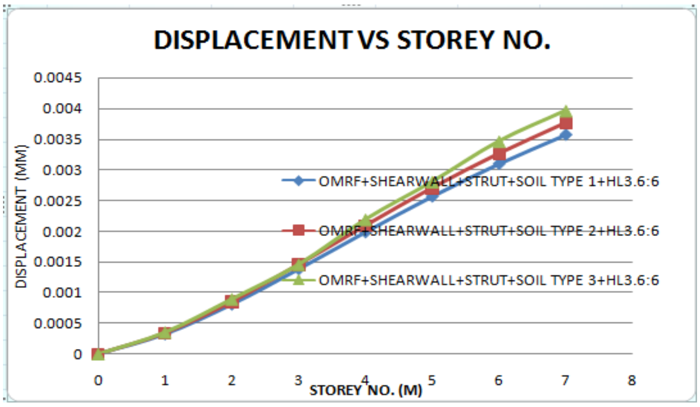
Graph 5: Ordinary moment resistance frame+ shearwall with soil type I,II,III and 4.8 m ground floor height.



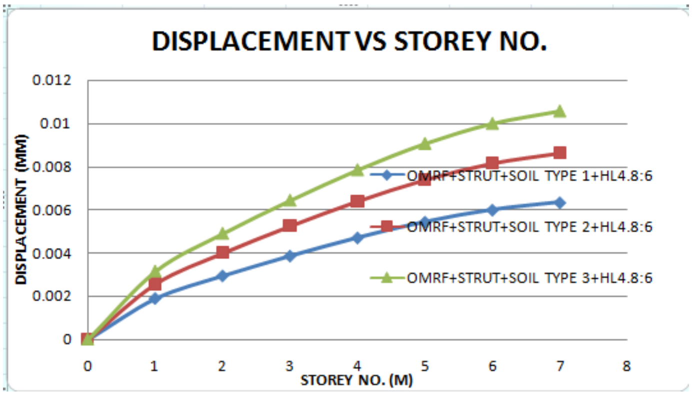
Graph 6: Ordinary moment resistance frame+ shearwall with soil type I,II,III and 6.0 m ground floor height.



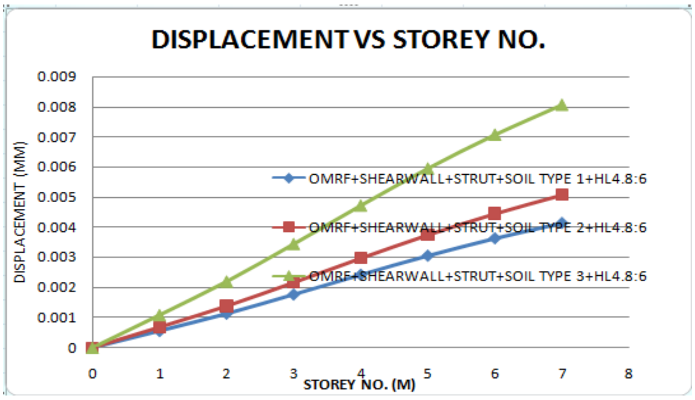
Graph 7: Ordinary moment resistance frame+ strut with soil type I,II,III and 3.6 m ground floor height.



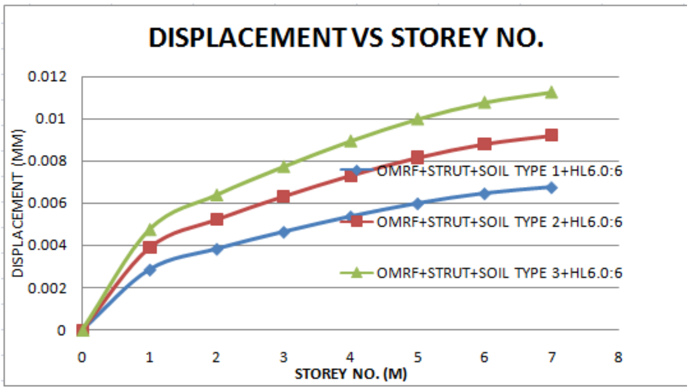
Graph 10: Ordinary moment resistance frame+ shear wall+ strut with soil type I,II,III and 3.6 m ground floor height.



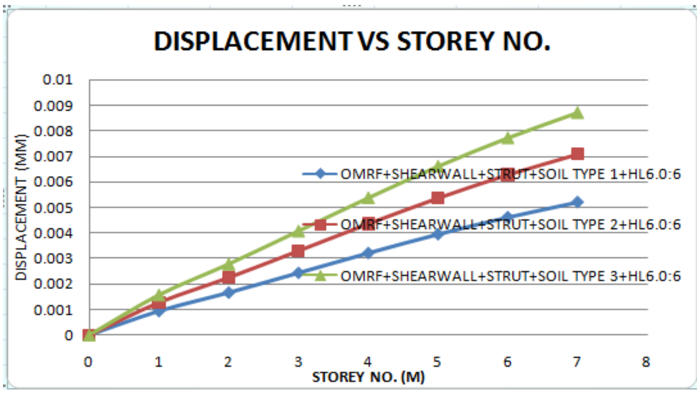
Graph 8: Ordinary moment resistance frame+ strut with soil type I,II,III and 4.8 m ground floor height



Graph 11: Ordinary moment resistance frame+ shear wall+ strut with soil type I,II,III and 4.8 m ground floor height.

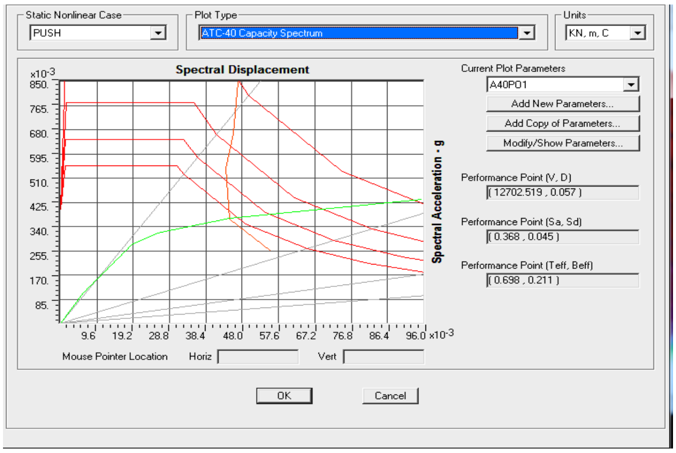


Graph 9: Ordinary moment resistance frame+ strut with soil type I,II,III and 6.0 m ground floor height

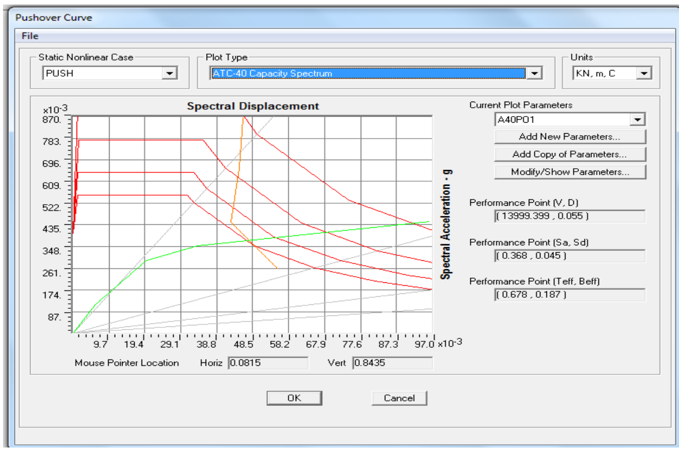


Graph 12: Ordinary moment resistance frame+ shear wall+ strut with soil type I,II,III and 6.0 m ground floor height.

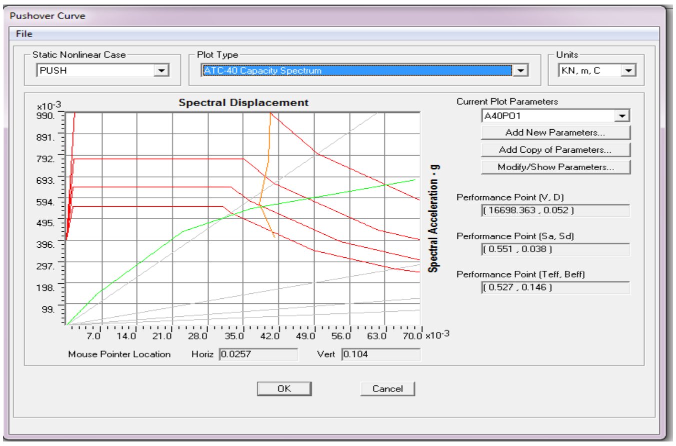
For pushover analysis



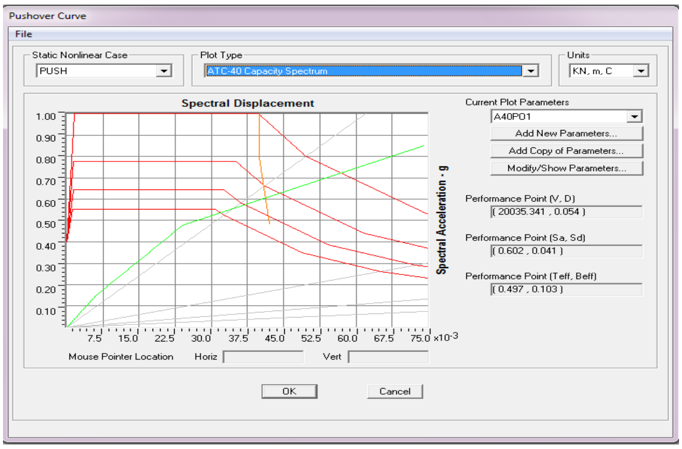
Graph 13: Capacity curve for frame with concrete shear wall.



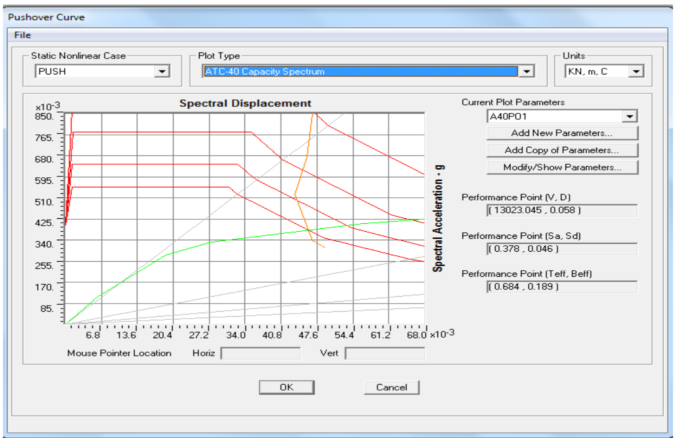
Graph 16: Capacity curve for frame with concrete shear wall and strut.



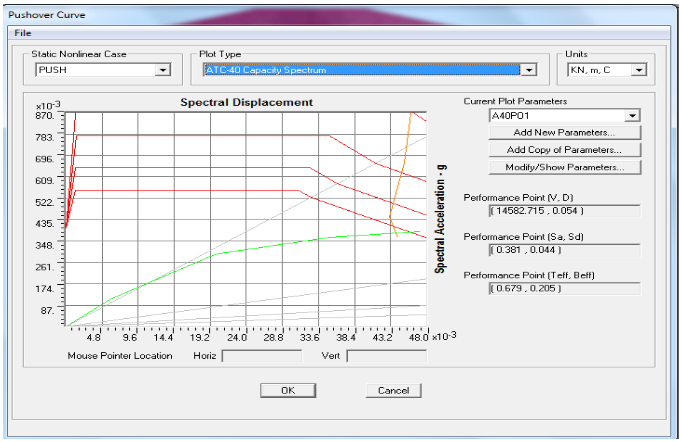
Graph 14: Capacity curve for frame with concrete steel wall.



Graph 17: Capacity curve for frame with steel wall and strut.



Graph 15: Capacity curve for frame with composite wall.



Graph 18: Capacity curve for frame with composite wall and strut.

3. CONCLUSIONS

CONCLUSIONS FROM SEISMIC ANALYSIS OF DIFFERENT TYPES OF FRAMES WITH DIFFERENT G.F STOREY:

For any particular frames with a particular ground storey height, the top story displacement (drift) increases as the soil type changes from type I *i.e.* hard rock to type III *i.e.* soft soil.

With inclusion of shear wall in OMRF, the lateral displacement of top storey reduces considerably 43.75% for a 3.6 m ground storey height with soil type III.If the effect of infill is considered *i.e.* when the struts are included in OMRF, then a significant amount of reduction is seen in the lateral drift of building..When combined effect of shear wall and infill is considered, further reduction is observed in lateral drift as compared to that of bare frame. As the soil type change from soil type I to soil type III for any particular frame with constant soft ground storey height, it is accompanied by increase in base shear.

CONCLUSIONS FROM PUSHOVER ANALYSIS OF FRAMES WITH DIFFEENT TYPES OF WALL WITH OR WITHOUT INFILL:

Addition of struts *i.e.* consideration of infill improves the strength (lateral resistance) by around 9.27 % in concrete shear wall building, 10.37 % in composite wall building and 12.67 %in steel shear wall building.

The strength performance of steel shear wall building with/without struts is found to be 30.12 % and 23.93 % higher than compared to that of concrete shear wall building. However the cost of steel shear wall is 600 % higher as compared to that of concrete wall. Hence, practically provision of steel shear wall is unreasonable.

The performance of composite is intermediate between concrete and steel shear wall model. Also, the cost of composite wall is just 34 % high as compared to that of concrete shear wall.

Provision of steel shear wall is not recommended though its performance is better. However, in building of high importance, composite shear wall may be suggested due to its performance and small increase in cost.

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