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Study on Performance of Regular and L-Shape Plan Irregular Building with Dampers, Shear Wall and Infill Wall

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Abstract - *As a result of advancement in technology and great economic development, high rise building, long span bridges are al designed with more flexibility. These structures are then exposed to a greater level of vibration which may be due to an earthquake or wind. An earthquake is a natural phenomenon, which causes rapid vibration on the surface of the earth, due to the movement of the tectonic plates. Irregular structures are those, which are having geometry discontinuity or mass discontinuity or the stiffness of the structure. These discontinuity will act as weakness to the structure and during an earthquake will take place at theses points of weakness. The objective of this study is to perform equivalent static analysis and time history analysis for a G+7 storey plan regular and plan irregular building. L-shape, C-shape and T-shape pal irregular buildings are considered for the analysis. The buildings are provided with dampers at the top storey, shear walls at the corners and infill walls all throughout the building and are analyzed by using FE software package of ETABS. The results obtained are then compared for storey displacement, storey drift, storey stiffness and time period. It was seen that by the application of dampers, shear wall and infill walls the buildings performed very well. There was reduction in the values of displacement and drift and an increase in the stiffness of the building.*

***Key Words*: Plan Irregular Building, Dampers, Shear Wall, Infill Wall, Time History Analysis, Equivalent Static Analysis.**

1. INTRODUCTION

Since the Chicago-style architecture started in the year 1880, it lead to the construction of tall buildings. To construct a building of a height about 1000m, it requires about two or three buildings at the base, interconnected with each other so that there must be stability for the structure. Till date Burl Khalifa situated in Dubai is the tallest building whose height is about 815m. The loads acting on any tall buildings are Gravity load and Lateral load. The Gravity load comprises of Dead Load, Live Load, Snow Load and the Lateral load comprises of Seismic Load and Wind Load.Due to the increase in the height of the structure leads to increase in building weight and cost. Due to which there is a need for a good structure and material. In order to withstand the lateral loads acting on the structure there is a need to provide the lateral load resisting system. These structural system transfer the lateral loads through the components which are interconnected among them. Hence, seismic load should be taken into account for the design of buildings, and should be modelled carefully so that we can obtain the real behavior of the structure. Earthquake is a natural disaster, which causes a lot of destruction to the human lives as well as manmade structures. A sudden slip on the fault causes an earthquake.

1.1. Dampers:

Tuned mass dampers was first introduced by Frahm in the year 1909 in the order to decrease the vibration of ship hull and also the rolling movement of ship. Then, Ormondroyd and Den Hartog in the year 1928 presented a paper, after which there was lot of discussions about the damping properties and tuning of mechanical vibration till the year 1940. This theory was first applied to a SDOF undamped system. In order to reduce the dynamic response of a structure tuned mass dampers are used which consists of a spring, mass and a damper attached to the building. It is made such that the frequency of tuned mass damper and the structural frequency is same so that during an excitation the damper will resonate.

1.2 Shear wall

In addition to the beams, columns and slabs, there may be a vertical plate like wall called as shear wall. These shear walls are built at the foundation and are extended up to the structure (as shown in fig 1.3). The main function of these walls are to carry the earthquake load to the foundation. For high rise buildings the thickness may be as high as 400mm. The construction of shear wall is not complicated, since the details of reinforcement is easy and can be applies it site easily.

1.3 Infill wall

In order to close the perimeter of the building and to act as a support an infill is constructed in a building. An infill wall tend to separate the inner and outer space of a frame system. Under seismic effect, the masonry infill may cause a number of effect such as torsion, soft story effect, short column effect, etc.

2. METHODOLOGY

In order to prevent a structure from being damaged during an earthquake, it is necessary for a Civil Engineer to design a structure for dynamic as well as for static analysis. Regular buildings those present in Zone IV and V of height of greater than40m and in Zone II and III of height greater than 90m dynamic analysis should be performed. Irregular building those present in Zone II and III of height greater than 40m and in Zone IV and V of height greater than 12m should be subjected for dynamic analysis.

2.1 EQUIVALENT STATIC ANALYSIS

In case of a regular simple building, the equivalent static analysis is sufficient. In this method the effect of an earthquake is represented in a form of a series of forces applied on a structure. A building should be a low-rise-building and is been mentioned in the code. By using the formula from the code the shear forces at each story is been calculated in this method and only the fundamental code is considered as the building is a low-rise-building. In case of a tall structure, where higher modes are to be considered or the torsional effect are to be taken into consideration, this method is not applicable and requires dynamic analysis.

2.2 TIME HISTORY ANALYSIS

It is a process of analysis, in which the base of the building is subjected to a particular time history ground motion, for which the dynamic response of the structure at every time increment is analyzed. Other sources for time histories can be from the recorded ground motion from the previous occurred earthquakes. But these readings do not specify the site conditions, so as to take into consideration the seismological characteristics suitable for the particular site. From the three main parameters of the time history. I.e. distance, soil condition and magnitude the recorded ground motion are selected randomly.

3 STRUCUTRAL MODELLING

The main objective of the project is to study the seismic and time history analysis of a regular and plan irregular structures with dampers, shear walls and infill walls. The analysis is carried out by using the ETABS software. A regular building, L-shape plan irregular building are considered in the analysis. The dampers are provided at the top of the structure, shear walls are placed at the re-entrant corners and the infill walls are placed at the outer surfaces throughout the structures. The result are plotted and are compared for the displacements, story drift, story stiffness and time period.

3.1 PRELIMINARY DATA:

Floor plan area: 20mx15m,
Story height=3m,
Column size=300mmx450mm,
Beam size= 450mmx250mm,
Number of bays along X-direction: 5,
Number of bays along Y –direction=5,
Width of bay along X-direction= 4m,
Width of the bay along Y-direction=3m,
Grade of steel=Fe415,
Grade of concrete =M25,
Number of stories=G+7,
Slab thickness=125mm,
Shear wall thickness=230mm,
Infill wall thickness= 230mm,
Live loads on floors= 3 kN/m^2,
Floor Finish= 2 kN/m^2,
Density of concrete= 25kN/m^3,
Density of masonry infill=20kN/m^3,
Modulus of Elasticity of masonry infill=2100MPa,
Seismic Zone= V,
Zone Factor= 0.36,
Type of soil= soft soil,
Importance factor=1.5.
The loads are considered as per IS code.
The Dead Load are considered from the code IS 875 (Part I),
The Live Load are considered from the code IS 875 (Part II),
The Earthquake Load are considered from the code IS 1893(Part I)-2002.

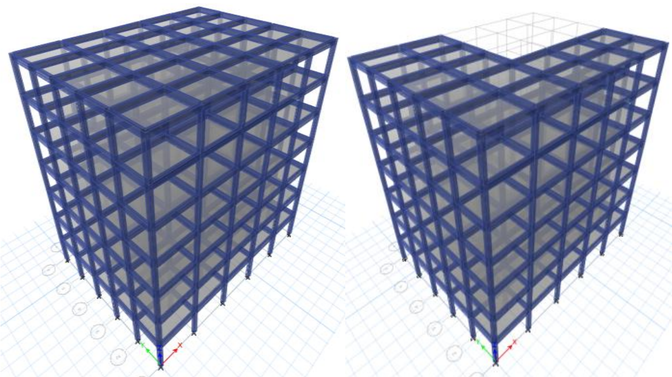


Fig 1: 3d plan of bare frames of regular and L-shape building respectively.

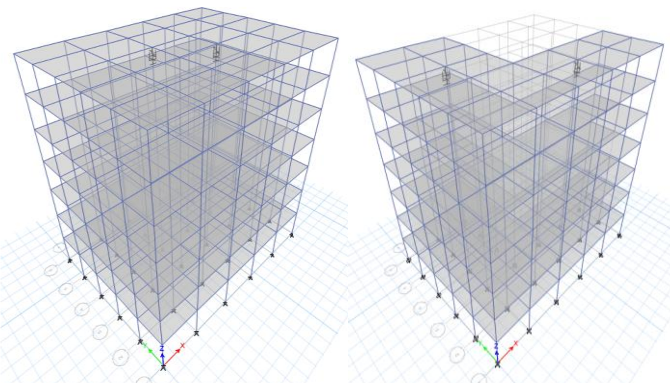


Fig 2: 3d plan of regular and L-shape building provided with dampers respectively.

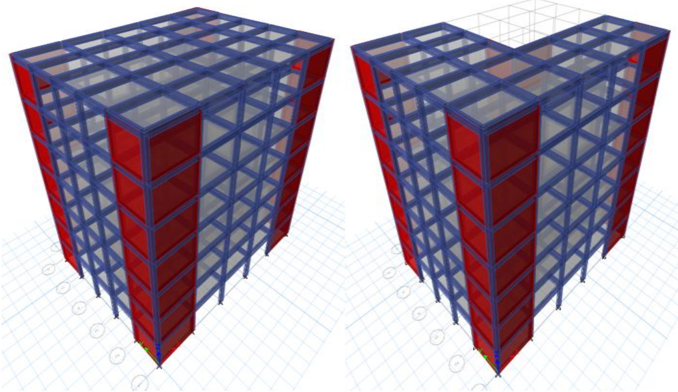


Fig 3: 3d plan of regular and L-shape building provided with shear wall respectively.

4 RESULTS

Based on the results that are obtained comparison was made for the time period, storey displacement, and storey stiffness for both equivalent static analysis and time history analysis considering the bare frame, with dampers, with shear wall and with infill wall for all the models.

4.1 TIME PERIOD

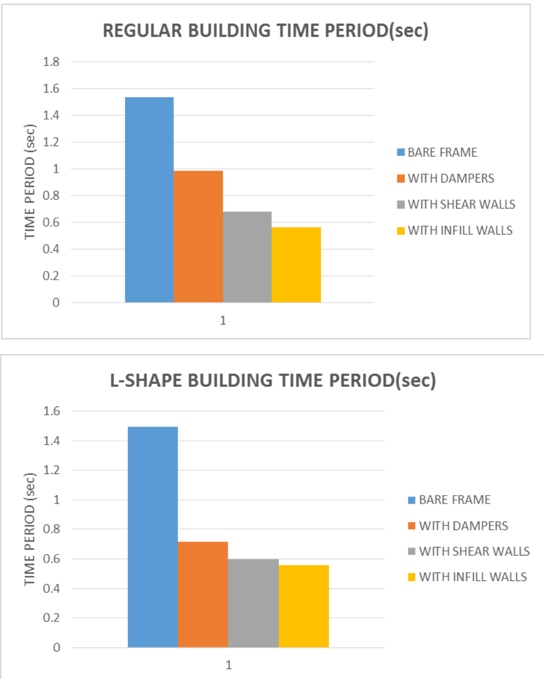


Fig 5: Time period plot for regular and L-shape building for different cases

The time period results are plotted as shown above. For all the cases the time period is maximum for the regular building. For the bare frame the time period is maximum for the regular building and is reduced by 2.8% for L-shape. In case of dampers it is reduced by 2.7% for L-shape. With the

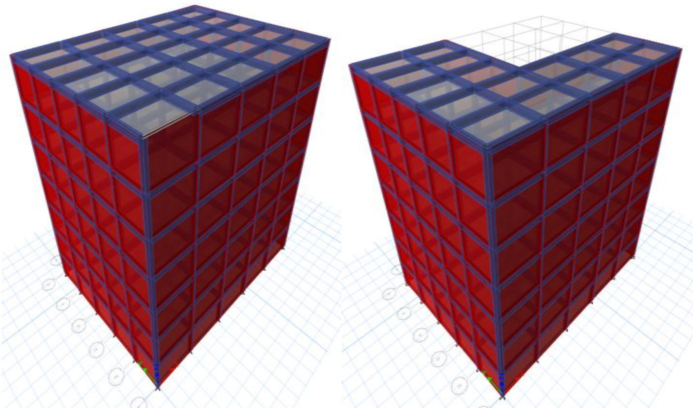


Fig 4: 3d plan of regular and L-shape building provided with infill wall respectively

addition of shear walls the time period is reduced by 1.8% for L-shape.

4.2 STOREY DISPLACEMENT:

4.2.1 EQUIVALENT STATIC ANALYSIS:

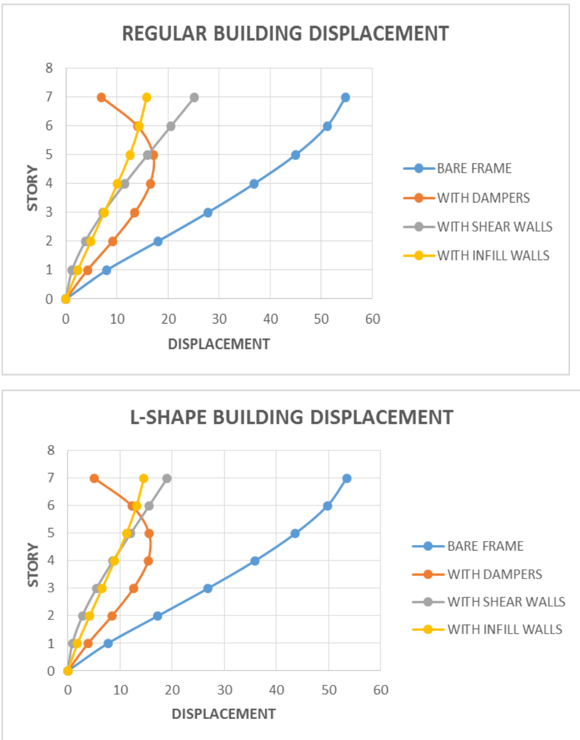


Fig 6: Storey displacement plot for regular and L-shape building obtained from equivalent static analysis for different cases

4.2.1 TIME HISTORY ANALYSIS:

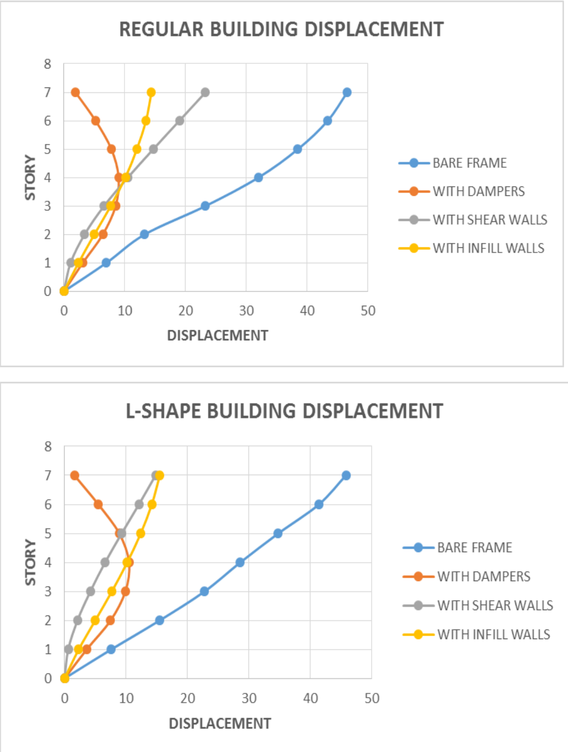


Fig 7: Storey displacement plot for regular and L-shape building obtained from time history analysis for different cases.

The storey displacement results are plotted in the graphs as shown above. In case of a bare frame it has been observed that the displacement is minimum at the lower stories, and keeps on increasing as the storey height increases. The displacement for regular building is more in equivalent static method than the time history method, while the displacement for L-shape building is greater for time history method than equivalent staic method. Hence the irregular building are more prone for earthquake. For buildings with dampers the displacment keeps on increasing till the 4th storey and starts reducing later as storey level increases. With the addition of shear walls the displacement reduces largely in X direction than Y direction.

4.3 STOREY STIFFNESS:

4.3.1 EQUIVALENT STATIC ANALYSIS:

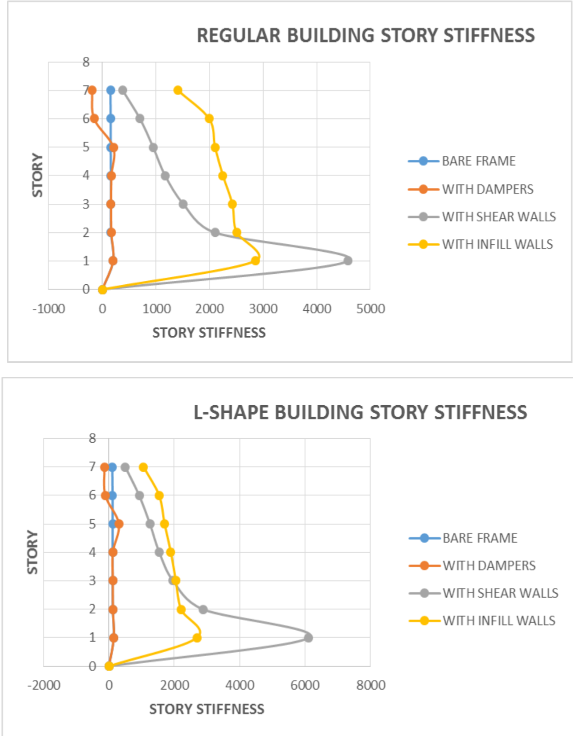
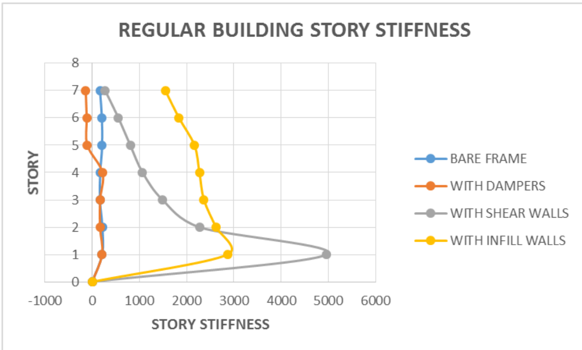


Fig 8: Storey stiffness plot for regular and L-shape building obtained from equivalent static analysis for different cases

4.2.1 TIME HISTORY ANALYSIS:



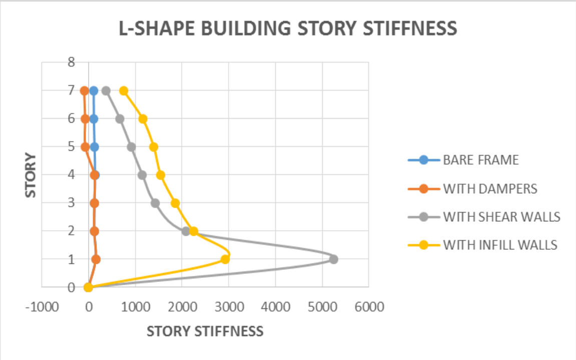


Fig 9: Storey stiffness plot for regular and L-shape building obtained from time history analysis for different cases

3. CONCLUSIONS

The conclusions obtained from the analysis and results of the present study can be summed up as follows.

- From the results obtained, it is seen that all the buildings fulfill the displacement criteria in case of both Equivalent Static Method and Time History Method. The displacement value obtaioned in the Equivalent Static Method is higher than the values obtained from Time History Method.
- For a high rise building it is necessary to perform Time History analysis as the stuctural response can be predicted in a better way than other methods. It was seen that the displcament value is more at the joint than at the center of mass.
- The displacement values for all the four buildings is less at the lower stories and keeps on increasing for higher stories.
- With the use of dampers, it was observed that the effect of lateral deflection can be minimised, the buildings with dampers performed well than the buildings without dampers.Due to the application of Tuned Mass Dampers the displacement is reduced leading to the reduction in the story drift.
- It is conculded that buildings with shear walls has performed very well than the buildings without shear walls. These shear walls also reduces the storey displacement and storey drift for all the four buildings.
- Masonry infill walls will help in increasing the strength, stiffness, and ductility of the structure.
- The post cracking behaviour can be incresed by the reinforcement provided in the infill wall thus preventing the out-of plane collapse.

The storey stiffness results are plotted as shown above. From the results it has been observed that the storey stiffness at the first two floors is high and then it reducess for the next two floors and the cycle is repeated. For the bare frame the storey stiffness is maximum for the regular building in equivalent static as well as time history method. With dampers the storey stiffness is more for L-shape building in equivalent static method and for time history method the storey stiffness is maximum for the regular building. In the presence of shear walls the storey stiffness is more for the L-sahpe building without the time history analysis, but the stiffness is reduced for these buildings after the time history analysis is performed.

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