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Earthquake Response of Different Shapes of Tall Vertically Irregular Mivan Wall Building

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***Abstract*— For an effective housing plan, buildings have to be constructed with minimum time and maximum quality. Aluminium formwork Mivan technology is a remedial measure for this problem in which walls and roofs are constructed in a single stage. The present work focuses to check the reduction of seismic response for different shapes. L shape, O shape and H shape for ten storey's conventional and Mivan wall building having stiffness and mass irregularity were analyzed by Response Spectrum Method using ETABV.9.7.1 software. Results were compared for time period, storey displacement and storey shear for both conventional beam column building and Mivan wall building. From the analysis results time period, Storey displacement and storey shear were minimum for L shape and Mivan buildings had their three results less than that of conventional building. Storey shear values were decreasing from base to top. It can be concluded that L shape Mivan building is the best shape by their seismic response in all the three irregularities.**

Keywords—Irregularity, Mivan, Response spectrum method

I. INTRODUCTION

India is one of the developing countries in the world. Construction industry contributes the best part of development. Past earthquake analysis shows disastrous effect on living and non living things amplified the necessity of conventional lateral load resisting systems. It has lead to adopt new technologies and approaches in order to increase the overall efficiency of the project. Luckily, certain progressive technologies providing quicker construction are already available in the country. For example autoclaved blocks, Prefabrication, tunnel formwork, and aluminium formwork (MIVAN Technology) of construction etc. Among them Mivan technology is used worldwide[8].Mivan is an aluminium formwork system used greatly for the construction of mass housing projects and residential buildings in which entire floors are casted monolithically with the help of pre-fabricated formwork units. This monolithic system of slabs and walls are one of the chief characteristics improving the seismic behaviour of RC walled structures.

In the present thesis work beam column buildings and Mivan wall buildings are compared to find out the best shape among them. For that ten storey vertically irregular beam- column buildings are created in ETABV.9.7.1 software. Then they are compared with Mivan wall buildings which are created by replacing the beams and columns by Mivan wall of 200mm thick. The vertical irregularities that are considering are mass irregularities and stiffness irregularities. For each irregularity three different shapes L, H and O shapes of buildings are created.

Main objectives of the project are;

- To study the earthquake response of Tall vertically irregular Mivan wall building by response spectrum analysis.
- To study the earthquake response of different shapes of Tall vertically irregular Mivan wall building by response spectrum analysis.
- To compare the earthquake response of different shapes of Tall vertically irregular Mivan wall buildings with normal beam – column building
- To find out the best shape of building which is having the highest seismic response characteristics.

II. BUILDING DESCRIPTION

The plan dimension of the building is 40 X 24 m Building is located on seismic zone IV and Type II soil.

TABLE I. SALIENT FEATURES OF THE BUILDING

1	Zone	IV
2	Soil type	Type II soil
3	Number of storey's	10 (G+9)
4	Beam size	450 x 600 mm
5	Column size	750 x 750mm
6	Storey Height	3m throughout the storey's
7	Material Properties	For column and wall = M40 For beam and slab = M25
8	Slab thickness	150mm
9	Mivan wall thickness	200mm
10	Seismic analysis	Response spectrum analysis

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III. MODELING AND ANALYSIS

Buildings with 40 x 24m plan dimension and storey number ten are created by using ETAB V.9.7.1 software. Then they are modified to obtain L, H and O shapes in Vertical direction. The structural models have the same story height of 3m. In the present work both conventional and Mivan wall buildings are created. Dynamic analyses for all the models are performed using response spectrum analysis.

In conventional buildings, beams of size 450 x 600 mm and columns of size 750 x 750mm are placed throughout the height of buildings. Support conditions are assumed as fixed. Same models are created in stiffness and mass irregularities.

In the case of Mivan wall buildings the columns and beams are replaced by special Mivan wall of 200mm thickness throughout the height. L shape models created in E TAB are shown below.

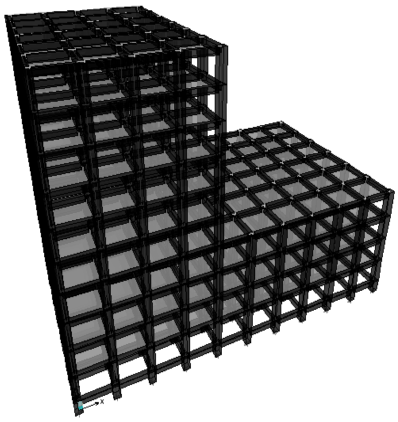

Fig. 1. L shape Conventional building

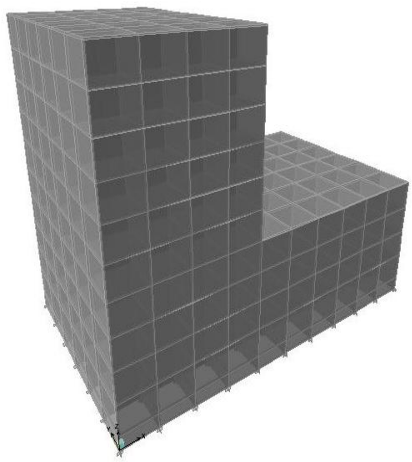

Fig. 2. L shape Mivan wall building

A. Loading Details

Loads which are applied on the building are dead load, imposed load and earthquake load. They are calculated as follows;

1) Dead Load: The dead load of the structure is obtained from Table 1, Page 8, of IS 875 – Part 1 – 1987. From the table, the unit weight of concrete is taken as 25kN/m^3. The software has an inbuilt dead load calculator. Floor finish is taken as 2 kN/m^2 .In dead load wall loads comes. Wall load is calculated as;

Wall load = Thickness of wall X Height of wall X Density of the brick
= 0.2 x 3 x 22
= 13.2 kN/m

Where;

Thickness of wall is taken as 200 mm and height of wall as 3m. Density of brick and plastering are obtained from IS 875. Density of brick as 20kN/ m^3. Density of plastering is 2kN/m^3 and then total density is obtained as sum of the brick density and plastering density as 22kN/m$^{3.}$

Terrace load is obtained as same as that of wall load .In terrace height of parapet wall is 1.2m. So terrace load is obtained as;

Parapet wall load = 0.2 x 1.2 x 22
= 5.28 kN/m

2) Imposed Load: The imposed load on the floor is obtained from Table 1 of IS 875 (Part 2) – 1987. The uniformly distributed load on the floor of the building is assumed to be 4.0 kN/m^2 (for assembly areas, corridors, passages, restaurants business and office buildings, retail shops etc). Imposed load on roof is taken as 1.5 kN/m^2, and on floors is 4.0 kN/m^2

3) Earth Quake Load: The structure is assumed to be in Zone-IV as per IS 1893 – 2002. So the zone factor is taken as per Table 2 of IS 1893 – 2002. Zone factor obtained is 0.24. The damping is assumed to be 5%, for concrete as per Table 3 of IS 1893-2002. Importance factor is taken as 1 as per Table 6 of IS 1893 – 2002.Type II soil is assumed here.

4) Load combinations: The load combinations are obtained from page no 13, clause 6.3.1.2 of. IS 1893 – 2002.The load combination selected here is;

DLEQX=1.2(DL+LL+SPECX)

Based on the analysis time period, Storey displacement and storey shear are compared for all the models in three irregularities.

IV. RESULTS AND DISCUSSION

A. Stiffness Irregularity

Stiffness irregularity is created by replacing Mivan walls by beams and columns in first storey for 10 storey building. Frame loads are not applied for the corresponding storeys.

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a. Time period (sec)

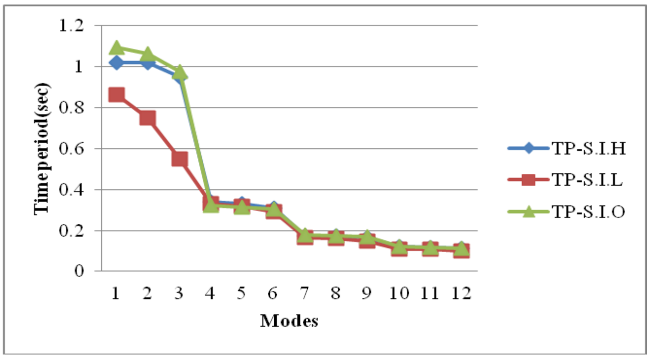

Fig. 3. Time period V/S Modes of conventional building

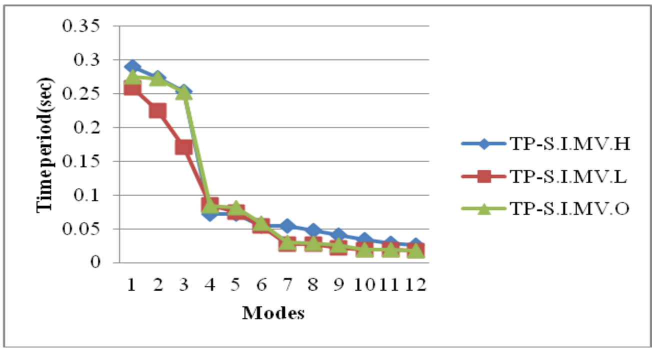

Fig. 4. Time period V/S Modes of Mivan wall building

While comparing the time period values of three shapes, for L shape building has the minimum time period in both cases. Time period values of Mivan wall buildings are much lesser than beam column buildings for all shapes. Maximum values of time period for all the shapes in conventional building lie in between 0.8 – 1.2 second. But in Mivan it is reduced to 0.25 – 3 seconds.

b. Storey Displacement (mm)

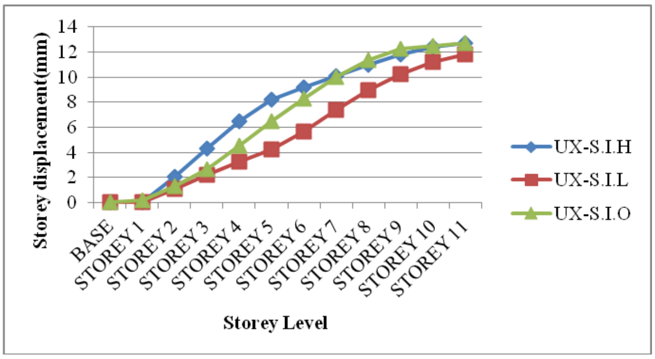

Fig. 5. Storey displacement V/S Storey Levels of conventional building

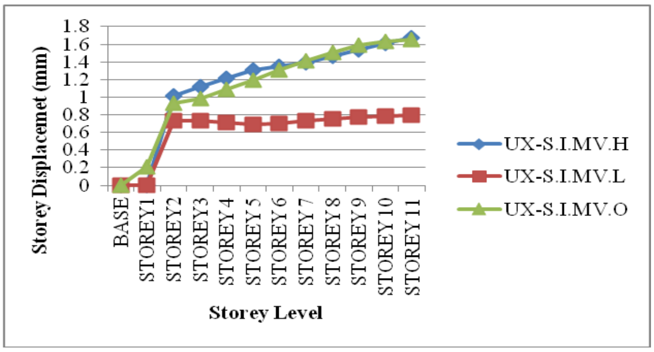

Fig. 6. Storey displacement V/S Storey Levels of Mivan building

From the above graphs in case of conventional building and Mivan, L shape has less displacement value than others. The values are approximately half the values of other two. Also storey displacement values of Mivan are less than that of conventional building. That is maximum storey displacement value of all shapes in conventional building lies in the range of 10 – 12mm. But in the case of Mivan it is reduced to 0.8 – 1.6mm.

c. Storey shear(kN)

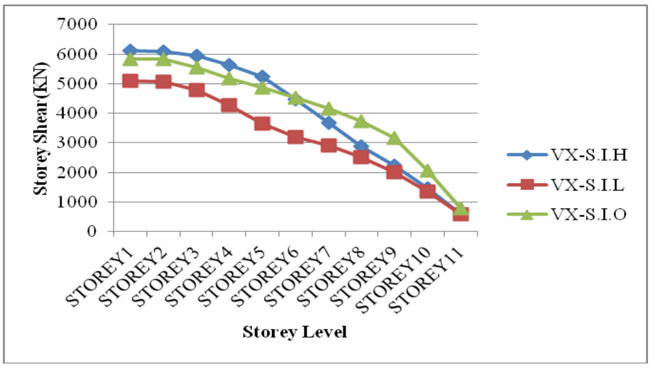

Fig. 7. Storey shear V/S Storey Levels of conventional building

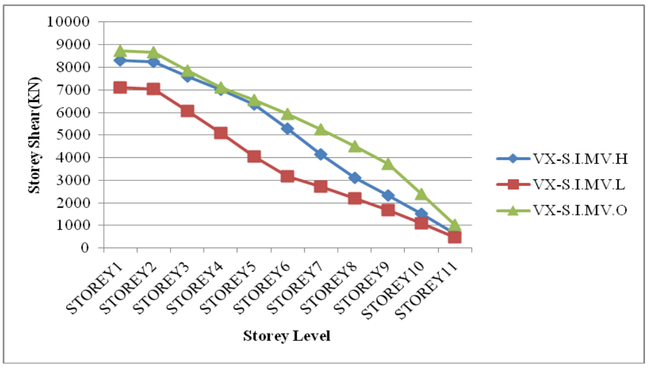

Fig. 8. Storey shear V/S Storey Levels of Mivan building

From the above graphs it is clear that storey shear decreases from bottom storey's to top. For both conventional and Mivan buildings minimum storey shear is for L shape as compared to other shapes.

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B. Mass Irregularity

Mass irregularity is created by placing 8kN/m^3 instead of 4kN/m^3 in 8th storey for ten storey building.

a. Time period (sec)

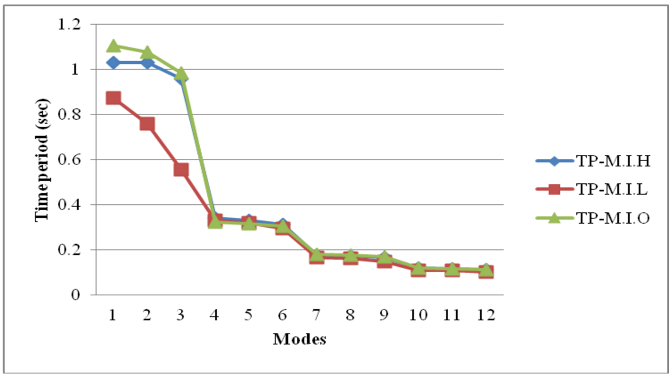

Fig. 9. Time period V/S Modes of conventional building

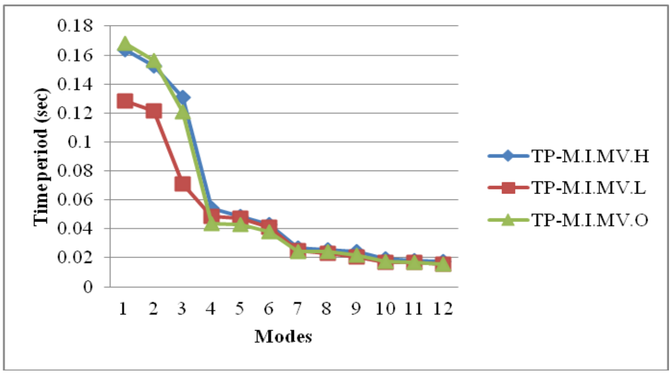

Fig. 10. Time period V/S Modes of Mivan wall building

By comparing above graphs it is found that time period is decreasing from 1st mode to 12th mode. In conventional building and Mivan building minimum time period is for L shape. It is about 0.8 sec and 1.6 sec respectively. Mivan building shows lower time period values than conventional. Maximum values of time period for all shapes in conventional building lie in between 0.8 to 1.6 seconds. But in Mivan it is reduced to 0.12 to 0.16 seconds.

b. Storey Displacement (mm)

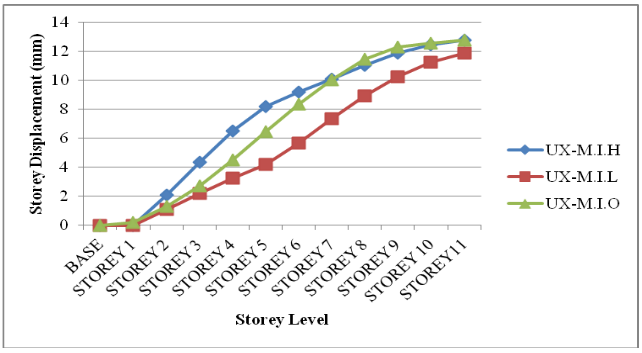

Fig. 11. Storey displacement V/S Storey Levels of conventional building

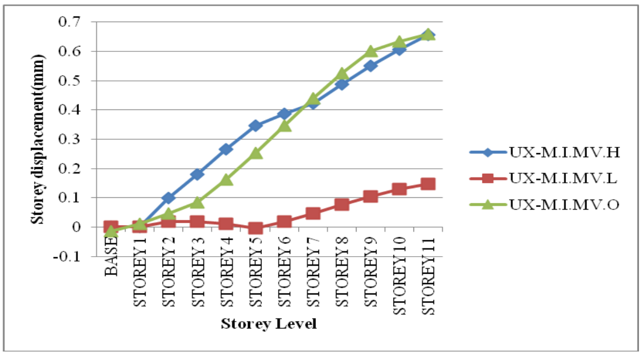

Fig. 12. Storey displacement V/S Storey Levels of Mivan building

By comparing the above two graphs storey displacement values of L shape building is minimum as compared to other two shapes. Also displacements values of conventional building are greater than Mivan. Maximum storey displacement value of all shapes in conventional building lies in the range of 10 – 12 mm. But in the case of Mivan it is reduced to 0.1 to 0.6mm.

c. Storey shear(kN)

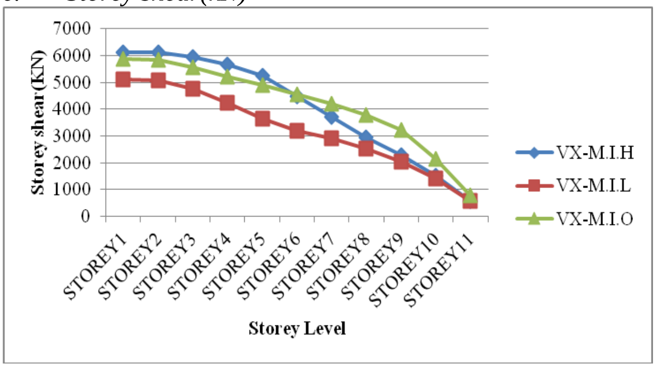

Fig. 13. Storey shear V/S Storey Levels of conventional building

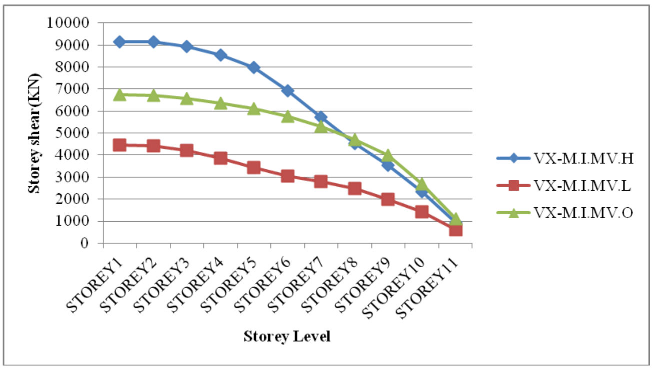

Fig. 14. Storey shear V/S Storey Levels of Mivan building

From the above graphs the storey shear values are decreasing from bottom to top storeys. For both conventional and Mivan wall buildings minimum storey shear is for L shape as compared to other shapes. Minimum value of L shape is approximately 4000kN in both conventional and Mivan.

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V. CONCLUSION

From the analysis following conclusions are obtained;

- Time period, storey displacement and storey shear are minimum for L shape Mivan building.
- All the results of Mivan wall building are less than that of conventional building.
- From all the results it is found that Mivan buildings are very effective in resisting the lateral forces induced by earthquake.
- Because of the box effect of modular type scheme, it is increasing overall stiffness of the building thus, reducing the sway problem in the structure.
- From the work it is concluded that L shaped Mivan building is the best shape in terms of their response characteristics.

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