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# ANALYSIS OF REGULAR AND IRREGULAR SHAPED BUILDINGS IN VARIOUS SEISMIC ZONES WITH DIFFERENT SOIL CONDITIONS

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*Abstract*— ***Earthquake forces excite the structure and sets it into vibration in a short time. It is understood from the past earthquake events that buildings with irregularities in its configuration are more vulnerable to earthquake damages when compared to buildings with regular configuration and elevation. In the present study two buildings are designed, one in regular(rectangle) and the other in irregular(plus) shape in plan with same beam, column, slab thickness and plinth area and are analysed in various seismic zones with different soil conditions using Response spectrum analysis (Linear Dynamic analysis) to study the variation of Storey drift, Base shear, Support reactions and Storey displacements and to draw a comparison between the regular and irregular (in plan) buildings. Rectangular and Plus shaped buildings both are designed as symmetrical in plan and the study is carried out with help of Staad pro software.***

***Keywords— Regular building, irregular building, soil conditions, staad pro, seismic zones, dynamic analysis***

## I. INTRODUCTION

Earthquake is the sudden disturbance occurred on earth surface, which is actually originated below the earth surface. Most of the earthquakes are occurred by the movement of tectonic plates and some of them occur due to man-made explosions like mining etc., Massive energy is released during tectonic movements which create shock waves. The effect of earthquake on a structure depends on distance of the structure from its focus, epicentre and mostly on the magnitude of the earthquake. The stability of the building to withstand against the earthquake forces depends on its structural configuration, integrity, zone factor and the soil condition in which the building exists. India is categorized as four zones according to Indian standard code IS 1893:2002. Namely Zone II, III, IV and Zone V.

According to IS 1893:2002, buildings with simple and regular geometry and configuration perform well during the earthquake over irregular buildings and suffer more damage when compared to the regular buildings.

As explained in IS 1893:2002 irregularities in buildings are mainly divided into two namely Plan irregularities and Vertical irregularities. Plan irregularities are further divided into torsion irregularity, re-entrant corners, diaphragm discontinuity, out-of-plane offsets and non-parallel systems. Vertical irregularities are further classified as stiffness irregularity (soft storey), mass irregularity, vertical geometric irregularity, discontinuity in capacity. A structure having any one of the irregularities mentioned above is said to be irregular.

In this study Plan Irregularity (Re-entrant corners) is mainly taken into consideration, two buildings are designed as regular (rectangular in plan) and irregular (plus in plan) with same plinth area, floor-to-floor height, column dimensions, beam dimensions and slab thickness.

## II. RELATED WORK

### *A. Arun Babu M and Ajisha R (May-2018):*

This paper is about a G+10 structure, which was analysed using time history analysis method in different zones with various soil conditions and the paper states that, the Base Shear by Static analysis is maximum in Hard soil condition and decreases towards Medium and Soft soil conditions, Base shear when comparing with zones Base shear values increases with the zone value, Storey displacement also increases with zone and the Base shear obtained by Time History Analysis method is comparatively lesser than the Static earth quake analysis due to this the quantity of steel required has also become less.

### *B. Gaurav Kumar and Prof. V.K. Singh (April-2018):*

This paper is about the behaviour of irregular plan buildings, by considering the irregular plan buildings as L shape, C shape and T shape the paper concluded the following results, Story drift value is maximum in the L shape building and the value is minimum in the C shape building, Storey displacement is also maximum in L shape when compared to Square building, in terms of torsion L,C shape buildings are failed in torsion.

*C. **Dr. Shriram, H. Mahure, Khan MD. Muhateshem Azhar (Nov-2018):***

In this paper Rectangular, Square, Triangular and Circular plan buildings with same area are analysed in SAP and the effects are presented, the paper states that Base reaction in less in Triangular shape buildings compared to other, in terms of joint displacement in X, Y, Z- direction Circular shape building is best, Square shape gives minimum modal participation factor value when compared to others, for joint acceleration in X-direction rectangular shape is best and in Y, Z-direction Square shape building is best.

## III. METHODOLOGY

In the present study two buildings are considered, one is designed as regular (rectangular in plan) and the other as irregular (plus in plan). In this study Plus plan building contain re-entrant corners. Two buildings are modelled in staad pro software and response spectrum analysis (linear dynamic analysis) is performed in the staad pro software by changing different seismic zones and adopting various soil conditions. Namely hard, medium and soft soil conditions.

## IV. BUILDING CONFIGURATION

Buildings are designed in rectangular and plus shape (in plan), the total height of the building from base to top is 33 meters, two buildings are designed with same plinth area and symmetrical in plan. The dimensions of beams, columns and slab thickness are same for rectangle and plus plan buildings.

TABLE I
BUILDING CONFIGURATION DATA

| | |
|---|---|
| Type of buildings | Residential |
| No. of Storeys | G+10 |
| Plinth area (in $m^2$) | 320 $m^2$ |
| Height of the buildings | 33 m |
| Slab thickness | 150 mm |
| Wall thickness (External, Internal) | 230mm, 150mm |
| Unit weight of masonry wall | 20 $Kn/m^3$ |
| Floor to floor height | 3 m |
| Columns | 0.6m × 0.6m |
| Beams | 0.5m × 0.4m |
| Concrete grade | M30 |
| Unit weight of concrete | 25 $Kn/m^3$ |
| Live load on each floor | 3.0 $Kn/m^2$ |
| Live load on roof | 2.0 $Kn/m^2$ |
| Floor finish (including roof) | 1.0 $Kn/m^2$ |

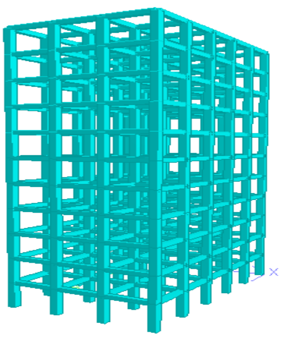

*Fig.1 3D-View of Rectangular building*

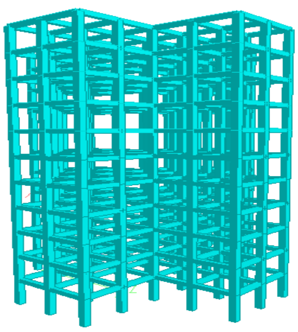

*Fig.2 3D-View of Plus building*

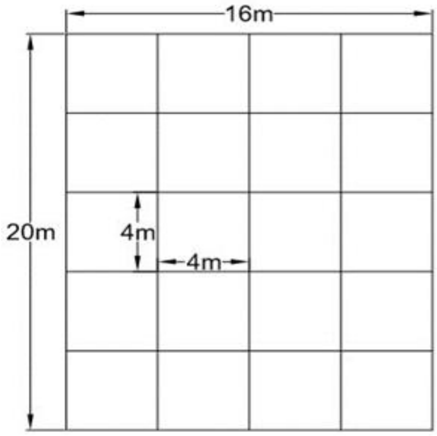


*Fig.3 Top-View of Rectangular building*

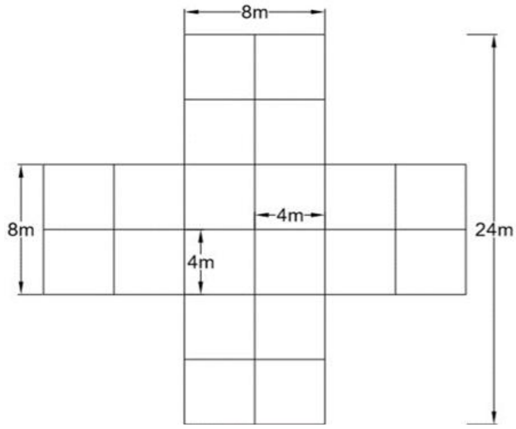


*Fig.4 Top-View of Plus building*

## V. RESULTS & DISCUSSION

A. **Storey drifts:** Storey drift is defined as the displacement of one level or storey relative to the other level or storey above or below. Maximum storey drift values observed in two buildings in all seismic zones and soil conditions are tabulated as follows (all values are in mm):

TABLE II
MAXIMUM STOREY DRIFTS IN PLUS BUILDING

| *Zone* | *II* | *III* | *IV* | *V* |
|---|---|---|---|---|
| **Hard** | 2.03 | 3.25 | 4.88 | 7.32 |
| **Medium** | 2.76 | 4.42 | 6.64 | 9.96 |
| **Soft** | 3.08 | 4.93 | 7.39 | 11.09 |

TABLE III
MAXIMUM TOREY DRIFTS IN RECTANGULAR BUILDING

| *Zone* | *II* | *III* | *IV* | *V* |
|---|---|---|---|---|
| **Hard** | 1.14 | 1.83 | 2.75 | 4.12 |
| **Medium** | 1.59 | 2.49 | 3.74 | 5.61 |
| **Soft** | 1.9 | 3.05 | 4.58 | 6.84 |

B. **Storey displacements:** Maximum storey displacements found in buildings in four seismic zones with all soil conditions are tabulated as follows (all values are in mm):

TABLE IV
MAXIMUM STOREY DISPLACEMENTS IN PLUS BUILDING

| *Zone* | *II* | *III* | *IV* | *V* |
|---|---|---|---|---|
| **Hard** | 16.8 | 26.91 | 40.36 | 60.55 |
| **Medium** | 22.87 | 36.6 | 54.9 | 82.34 |
| **Soft** | 25.49 | 40.78 | 61.17 | 91.76 |

TABLE V
MAXIMUM STOREY DISPLACEMENTS IN RECTANGULAR BUILDING

| *Zone* | *II* | *III* | *IV* | *V* |
|---|---|---|---|---|
| **Hard** | 9.37 | 15 | 22.49 | 33.74 |
| **Medium** | 12.75 | 20.4 | 30.59 | 45.89 |
| **Soft** | 15.61 | 24.97 | 37.45 | 56.18 |

C. **Support reactions:** Maximum support reactions observed in two buildings with different soil conditions in various seismic zones are as tabulated as follows (all values are in Kilonewton-per metre):

TABLE VI
MAXIMUM SUPPORT MOMENTS IN PLUS BUILDING

| *Zone* | *II* | *III* | *IV* | *V* |
|---|---|---|---|---|
| **Hard** | 98.33 | 155.11 | 230.81 | 344.36 |
| **Medium** | 132.4 | 209.61 | 312.57 | 467 |
| **Soft** | 147.11 | 233.15 | 347.88 | 519.97 |

TABLE VII
MAXIMUM SUPPORT MOMENTS IN RECTANGULAR BUILDING

| *Zone* | *II* | *III* | *IV* | *V* |
|---|---|---|---|---|
| **Hard** | 61.91 | 91.68 | 135.22 | 201.74 |
| **Medium** | 79.77 | 122.8 | 183.11 | 273.58 |
| **Soft** | 94.67 | 148.97 | 223.06 | 333.5 |

 

D. **Comparison graphs:**

*1)* ***Storey drift****:* Following graphs compare the maximum storey drift values observed in two buildings in all seismic zones with respect to soil condition.

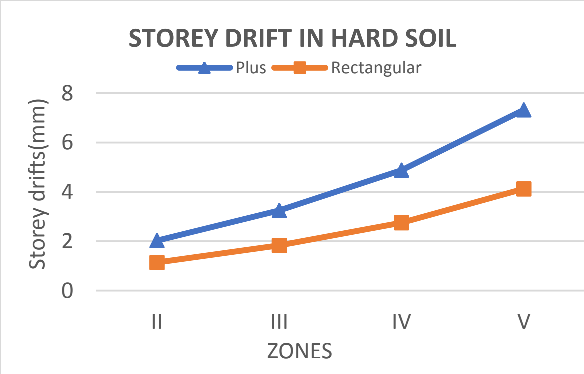


*Fig. 5 Storey drifts in Hard soil Condition*

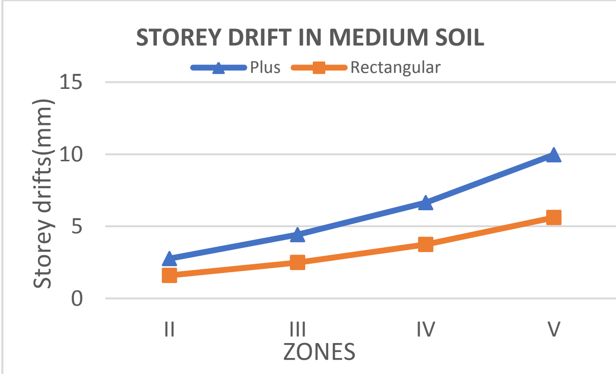


*Fig. 6 Storey drifts in Medium soil Condition*

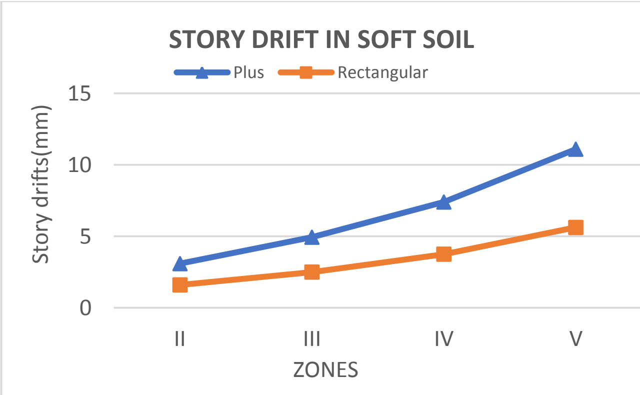


*Fig. 7 Storey drifts in Soft soil Condition*

*2)* ***Storey displacements*****:** Following graphs compare the maximum storey displacement values observed in two buildings in all seismic zones with respect to soil condition.

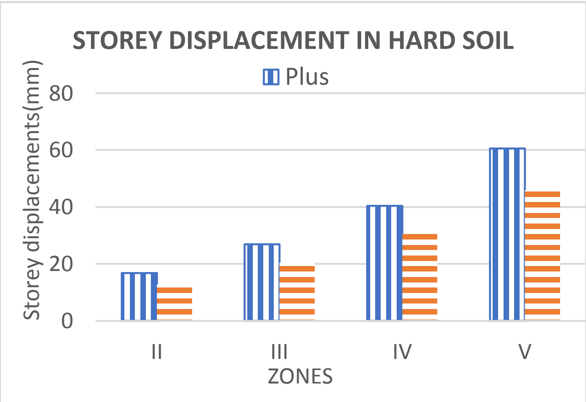


*Fig. 8 Storey displacements in Hard soil Condition*

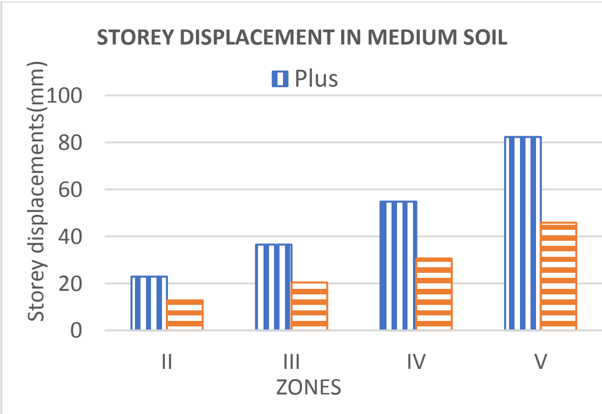


*Fig. 9 Storey displacements in Medium soil Condition*

 

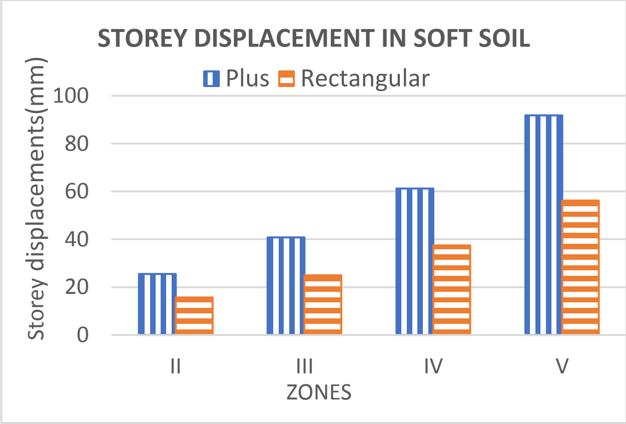


*Fig. 10 Storey displacements in Soft soil Condition*

*3)* ***Support moments***: Following graphs compare the maximum support moment values observed in two buildings in all seismic zones with respect to soil condition.

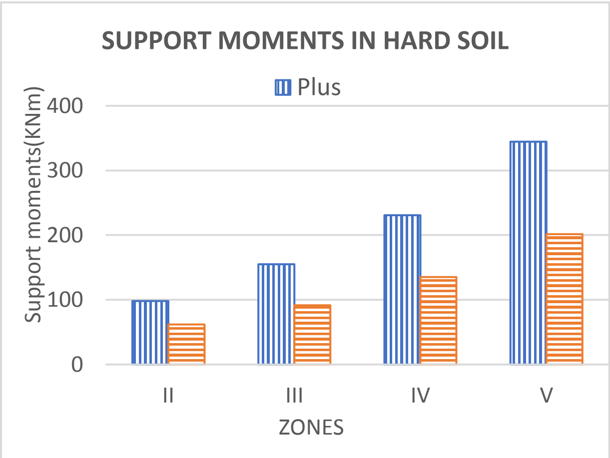


*Fig. 11 Support moments in Hard soil Condition*

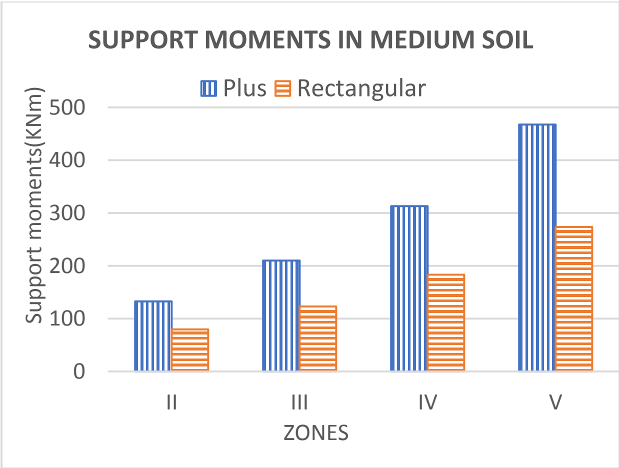


*Fig. 12 Support moments in Medium soil Condition*

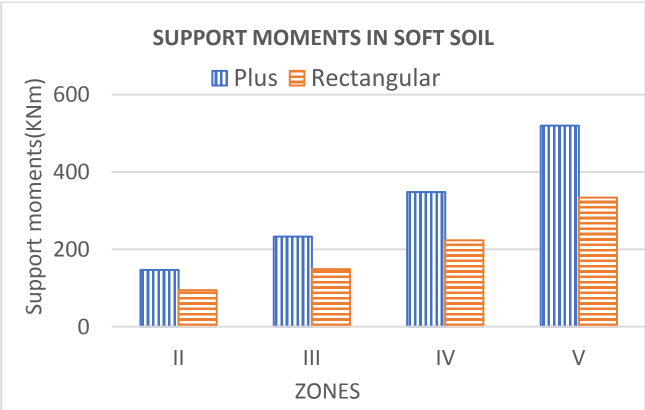


*Fig. 13 Support moments in Soft soil Condition*

## VI. CONCLUSIONS

- Storey drifts in both the Plus plan and Rectangular plan buildings follow the same trend, storey drift values increased from bottom storey and reaches the maximum value in fourth storey and thereby decreases towards top storey.
- Storey drifts in two buildings increase with the Zone value from II to V, and the maximum storey drifts are observed in Zone V with Soft soil condition.

- In every Seismic zone with any Soil condition the Storey drift values observed in Plus Plan building are more compared with the Rectangular Plan building.
- Storey displacements in two buildings are increased from bottom storey and the higher values are observed in top storey.
- Storey displacements in both buildings increased with Zone value from II to V, and the maximum storey drifts are observed in Zone V with Soft soil condition.
- Storey displacement values found in Plus Plan building are more when compared with Rectangular Plan building in all Seismic Zones with three soil conditions.
- Support moments found to be more in Plus plan buildings when compared with Rectangular buildings, increased with Zone from II to V, and maximum values are found in Zone V with Soft soil condition.
- In Plus plan buildings the support moments are maximum in re-entrant corners.
- Base shear values are maximum in Plus Plan buildings when compared with the Rectangular plan buildings, base shear values are increased with the Zone value and the maximum values are observed in Soft soil condition.

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