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Seismic Analysis of Regular and Irregular Multistorey Buildngs Using Staad.Pro

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Abstract:- Earthquake is a natural phenomenon which involves shaking of ground and can be caused anywhere. Once the ground shakes, a structure resting on it will experience motion at its base. Due to this motion the structure may deform back and forth which may cause lateral displacement and storey drift that can affect the structural behavior of the building. To overcome this, structural engineers should design the structure considering the seismic loads and improve the seismic behavior of the building. However, design for improving the seismic behavior for irregular structures will not be as simple as regular structures. Here comes the challenge for structural engineers and designers to get better seismic performance from irregular structures as possible because the necessity for irregular structures have become a lot today. In this paper, seismic performance of G+15 irregular buildings of re-entrant corner irregularity, vertical geometric irregularity and stiffness irregularity is modelled and analyzed for its seismic behavior using the software STAAD.Pro and compared with the seismic behavior of regular structure. Response spectrum analysis of dynamic analysis method is used and from the analysis, base shear, lateral displacement, time period and storey drift are determined. Based on the determined parameters, comparison is made among the irregularities and also between the regular and irregular structure. As a result, the seismic performance of a regular structure is found to be good as expected whereas the seismic performance of the irregularities are not satisfactory enough. However when comparing the three considered irregularities with one another, the stiffness irregularity is found much better than the other two irregularities meanwhile the re-entrant corner irregularity have shown the worst behavior towards the seismic loads. The vertical geometric irregularity is found intermediate. It is neither better as stiffness irregularity nor worst as re-entrant corner irregularity. In case of irregularity, it is always suggested to prefer irregularities like stiffness irregularity and avoid the worst re-entrant corner irregularity as much as possible since it gives a poor seismic response and even it is possible to get a better seismic performance, it earns an highly uneconomical design.

***Keywords**:- Seismic Analysis, Response Spectrum Analysis, Base Shear, Lateral Displacement And Storey Drift*

I. INTRODUCTION

Buildings with simple and regular geometry will have very less damage and better seismic performance due to the uniform distribution of mass and stiffness throughout the plan and elevation of the structure. In case of irregular structures, we cannot expect the same seismic behaviour and less deformation as obtained in regular structures because the distribution of mass and stiffness will not be uniform in irregular structure. Due to this non uniform distribution, it becomes quite challenging for the structural designers to provide a design to the irregular structures for a better seismic performance. In this modern world, we cannot avoid the irregular structures compromising all structures to be designed regular. Although it is crucial to improve the seismic response of irregular buildings, it becomes the ideal duty for designers to prevent blaming the irregularities for a structural collapse and obtain the appropriate remedy. Irregularities of various types namely re-entrant corner irregularity, vertical geometric irregularity and stiffness irregularity as specified in Indian standards is figured below.

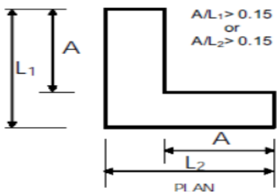

Fig.1:- Re-Entrant Corner Irregularity

Fig.2:- Stiffness Irregularity

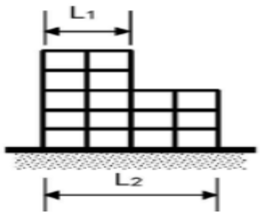

Fig.3:- Vertical Geometric Irregularity.

II. LITERATURE REVIEW

Prof. M.R.Wakchaure, Anantwad Shirish, Rohit Nikam, suggested that the purpose of study was to analyse plan irregularities on high-rise structures and to observe the behaviour of structures. For this, ETABS a linear dynamic analysis and design program for three dimensional structures has been used. Dynamic analysis has been carried out to know about deformations, natural

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frequencies, time periods, floor responses and displacements. Dileshwar Rana et.al (2015), has shown the performance & behavior of regular & vertical geometric irregular RCC framed structure under seismic motion. Five types of building geometry are taken in this project: one regular frame & four irregular frames. A comparative study is made between all these buildingconfigurations height wise and bay wise. All building frames are modeled & analyzed in software Staad.Pro V8i. The comparison of results have been done. storey wise for each bay and then bay wise for same building height. It is concluded that as the amount of setback increases the shear force also increases. The fluctuation of critical shear force from regular to vertical geometric irregular is very high(from 0KN to 80KN for 4 bay configurations) and (from 10KN to 120KN for 8 bay configurations). Suchita K. Hirde et.al (2016), has made an attempt to study the building models with plan irregularities. This paper presents the performance of the symmetric and asymmetric buildings subjecting to seismic loads. The guidelines and the methodology of the Indian standard of practice IS 1893 (Part I): 2002 is used to analyse the structures. In retrofitted building the hinges developed in beams are at Life safety which is acceptable criteria for the building. After retrofitting with X steel bracing it is observed that performance level of building is changed to life safety level from Collapse level. The T shaped building retrofitted with X-bracing has base shear of 6393.5KN whereas in the same building (when not retrofitted) has the base shear of 5936.1KN. The displacement is reduced from 624mm to 586mm in bracing retrofitted building.

III. RESPONSE SPECTRUM ANALYSIS

This study is carried out to check the effect of the irregular building in G +15 storey in seismic zone 4. The analysis is carried out with response spectrum analysis and the results are obtained and tabulated in terms of storey drift, base shear, time period and lateral displacement.

A. Response Spectrum Analysis :

Response spectrum analysis permits the multiple modes of response of a building to be taken in to account. It can be performed for all simple or complex structures. The response of a structure can be defined as a combination of many special shapes in a vibrating string corresponding to the harmonics. It can be used to determine the modes of a structure. For each mode, a response is read from the design spectrum, based on the modal frequency and the modal mass and they are then combined to provide an estimate of total response of the structure. Modal responses are combined make use of square root of sum of squares (SRSS), complete quadratic combination (CQC) and absolute (ABS) strategies.

- *Storey Drift :*

storey drift is the drift of one level of a multi storey building relative to the level below. Interstorey drift is the difference between the roof and floor displacements of any given storey as the building sways during the earthquake normalized by the storey height.

- *Base Shear :*

Base shear is an estimate of the maximum expected lateral force on the base of a structure due to seismic activity. Whenever seismic activity (earthquake) occurs, the base of the structure experiences a lateral force, whose maximum value is termed as base shear and its mathematical value is given as product of net vertical force at the base and a factor called horizontal seismic coefficient whose value depend upon factors like seismic zone etc.

- *Lateral Displacement :*

Lateral displacement is defined as the absolute value of displacement experienced in any storey of a structure under the action of lateral forces.

- *Time Period :*

A time period (denoted by T) is the time needed for one complete cycle of oscillation or vibration to pass in a given point. As the frequency of a wave increases, the time period of the wave decreases.
The unit for time period is 'seconds'.

IV. ANALYTICAL WORK

PARAMETERS	**DESCRIPTION**
No. of stories	G + 15
Height of the building	51.2m
Storey height	3.2
Plan dimension	20m x 20m
Beam dimension	0.45m x0.45m
Slab thickness	150mm
Wall thickness	230mm
Column dimension	0.60m x 0.60m
Unit weight of concrete	25kN/m^3
Unit weight of brick masonry	20kN/m^2
SEISMIC DATA	
Earthquake zone	Zone 1V
Type of analysis	Response spectrum analysis
Damping Ratio	5%
Soil type	II (IS:1893-2002)
Zone factor	0.24 (Cl.6.4.2 of IS:1893-2002)
Importance factor	1 (Table 6 of IS:1893-2002)
Response reduction factor	5 (Table 7 of IS:1893-2002)

Table 1

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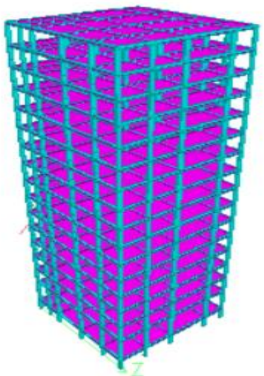


3D View

➢ *Plan*

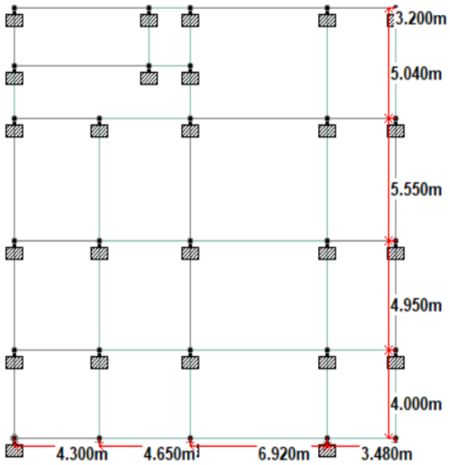
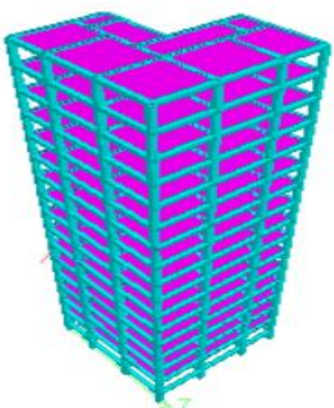


Fig.4:- Regular.



3D view

➢ *Plan*

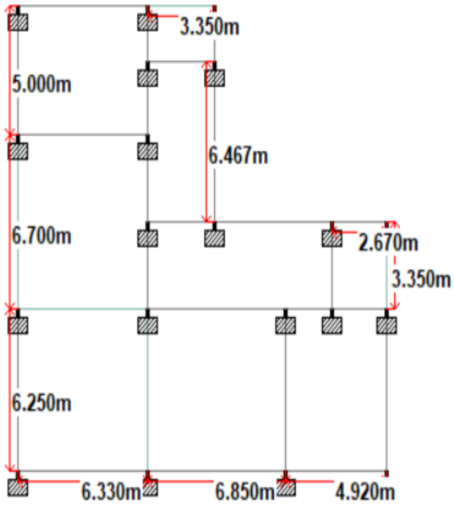
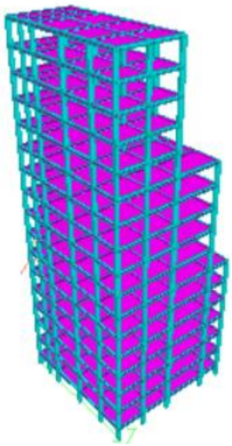


Fig.5:- Re-Entrant Corner Irregularity.



3D View

➢ *Plan*

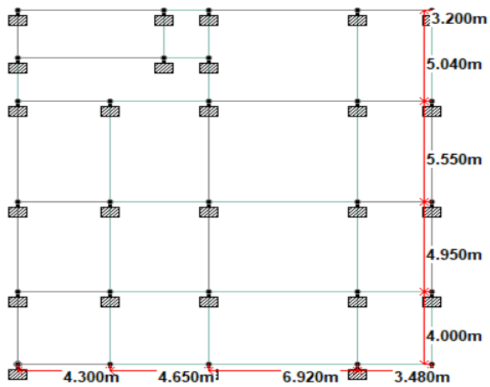
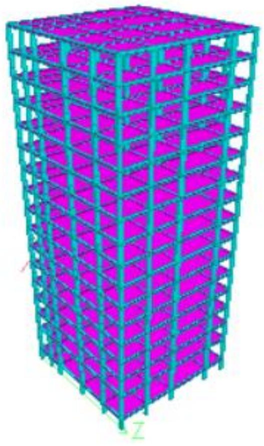


Fig.6:- Vertical Geometric Irregularity



3D view

- *Plan*

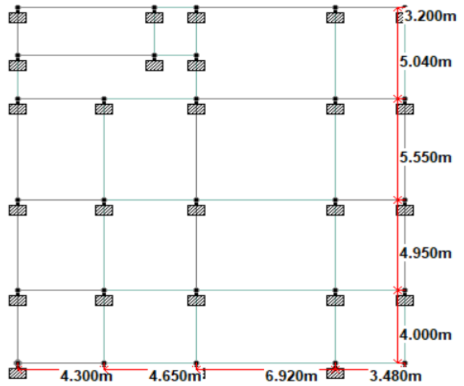


Fig.7:- Stiffness Irregularity

V. RESULTS AND DISCUSSION

- The base shear for regular structure is found to be 3027 KN. The storey drift, bending moment and displacement obtained for a regular structure is 0.2mm, 162knm and 2.75mm respectively.
- For a re-entrant corner irregular structure, the base shear is found to be 1913 KN. The storey drift, bending moment and displacement obtained for a re-entrant corner irregular structure is 0.9mm, 191knm and 12.75mm respectively.
- The base shear for vertical geometric irregular structure is found to be 2700KN. The storey drift, bending moment and displacement obtained for a vertical geometric irregular structure is 0.6mm, 175knm and 6mm respectively.
- For a stiffness irregular structure is found to be 3200 KN. The storey drift, bending moment and displacement obtained for a stiffness irregular structure is 0.5mm, 171knm and 4mm respectively.

- *Storey Drift :*

STRUCTURE TYPES	MAXIMUM STOREY DRIFT (MM)
REGULAR	0.2
RE-ENTRANT CORNER	0.9
VERTICAL GEOMETRIC IRREGULAR	0.6
STIFFNESS IRREGULAR	0.5

Table 2:- Maximum Storey Drift for Various Structure Types

- *Base Shear :*

STRUCTURE TYPE	BASE SHEAR (KN)
RE-ENTRANT CORNER	1913.25
VERTICAL GEOMETRIC IRREGULAR	2700
STIFFNESS IRREGULAR	2925
REGULAR	3027

Table 3:- Base Shear for Various Structure Types.

- *Displacement :*

STRUCTURE TYPES	MAXIMUM DISPLACEMENT (MM)
REGULAR	2.75
RE-ENTRANT CORNER	12.5
VERTICAL GEOMETRIC IRREGULAR	6
STIFFNESS IRREGULAR	4

Table 4:- Maximum Displacement for Various Structure Types

- *Bending Moment :*

STRUCTURE TYPES	MAXIMUM BENDING MOMENT (KNM)
REGULAR	162
RE-ENTRANT CORNER	191
VERTICAL GEOMETRIC IRREGULAR	175
STIFFNESS IRREGULAR	171

Table 5:- Maximum Bending Moment for Various Structure Types

- *Time Period :*

STRUCTURE TYPE	TIME PERIOD (SECONDS)
RE-ENTRANT CORNER	3.8
VERTICAL GEOMETRIC IRREGULAR	3.1
STIFFNESS IRREGULAR	6
REGULAR	4

Table 6:- Time Period for Various Structure Types.

- *Base Shear :*

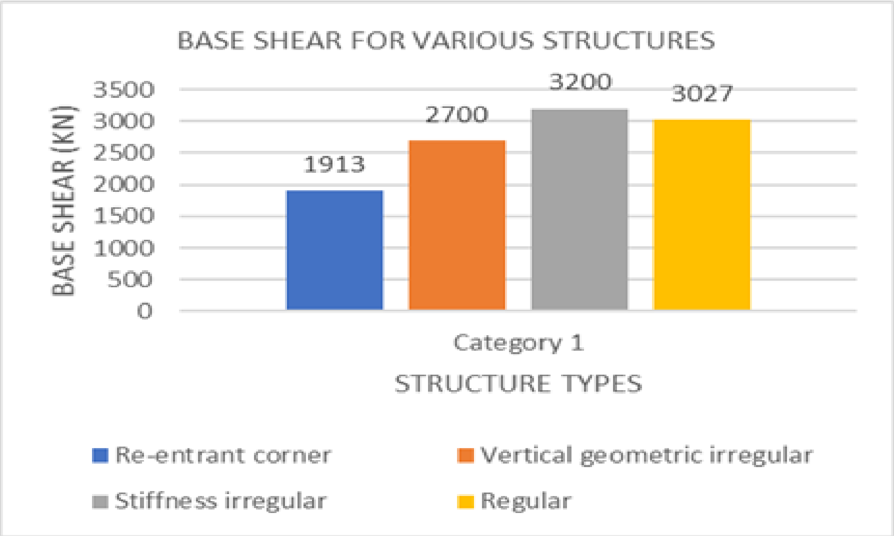


Fig.10:- Comparison of Base Shear among Various Structure Types.

- *Mode Period :*

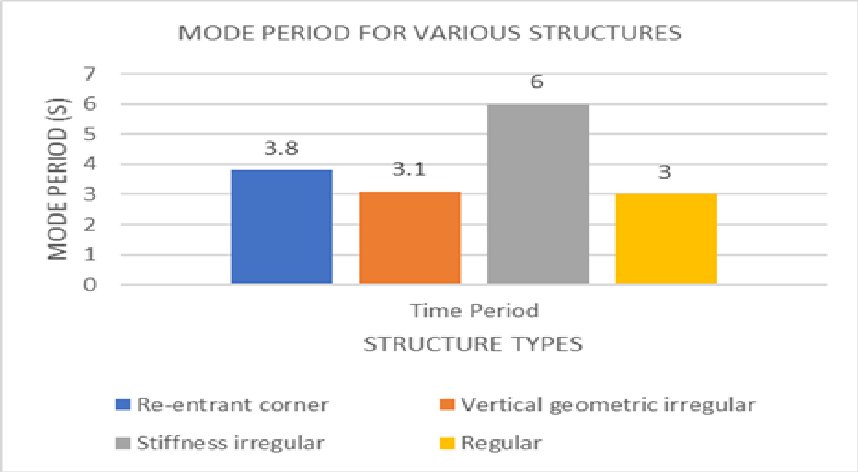


Fig.11:- Comparison of Mode Period among Various Structure Types.

- *Displacement :*

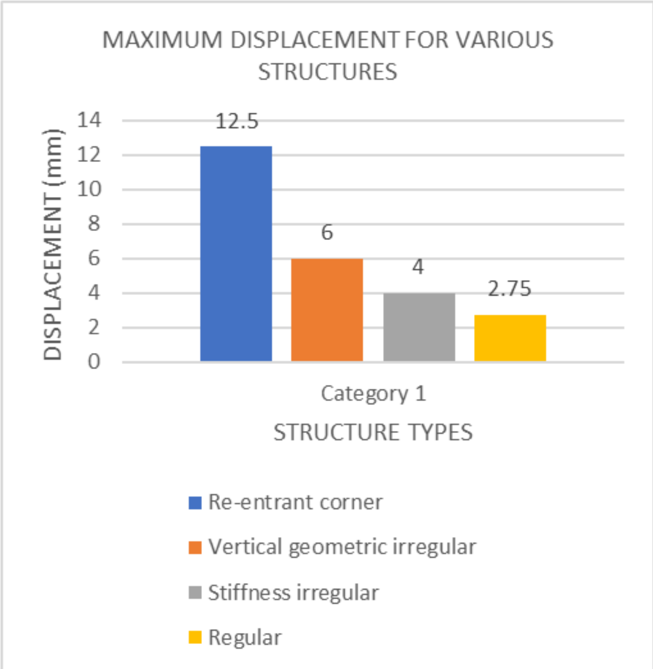


Fig.12:- Comparison of Maximum Displacement among Various Structure Types.

- *Bending Moment :*

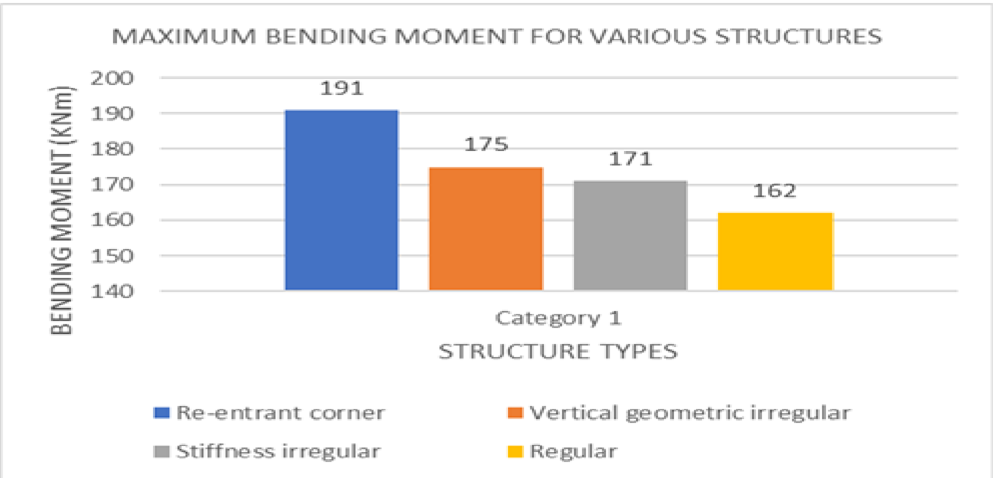


Fig.13:- Comparison of Maximum Displacement among Various Structure Type

- *Storey Drift :*

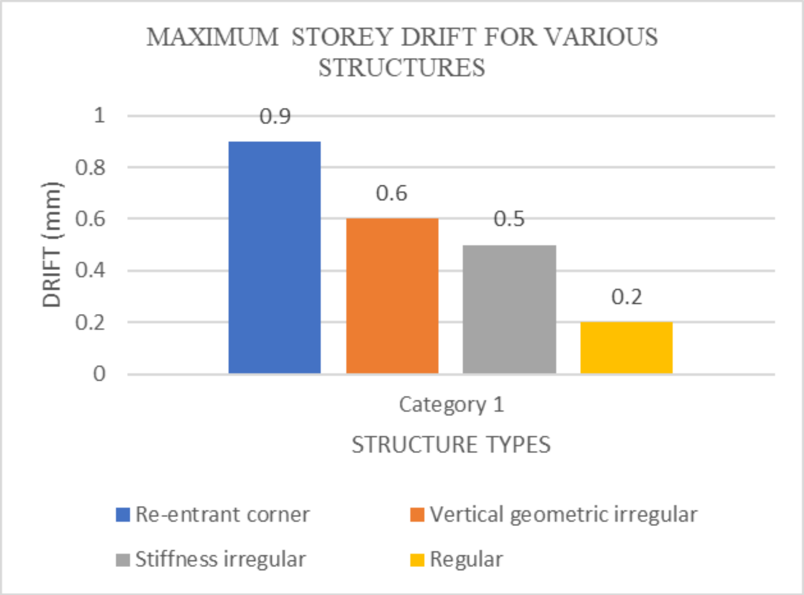


Fig.14:- Comparison of Maximum Storey Drift among Various Structure Types.

VI. CONCLUSIONS

From the results obtained, it is clearly shown that the seismic response of regular building is highly good and satisfactory when compared to the seismic response of all the irregular structures (Re-entrant corner irregularity, Vertical geometric irregularity and Stiffness irregularity).

- ➢ However when a comparison is made between the three irregularities considered, it can be concluded that the seismic response of stiffness irregular structure is far better than the vertical geometric irregular, and the re-entrant corner irregularity.
- ➢ Re-entrant corner irregularity shows the worst seismic performance among the considered irregularities.
- ➢ The base shear is found very high for stiffness irregular structure compared to other irregular structures (62.7% higher than re-entrant corner irregularity, 18.5% higher than vertical geometric irregular structure and 5.1% higher than regular structure).
- ➢ The lateral displacement is found very high for re-entrant corner structure compared to other irregular structures (52.1% higher than vertical geometric irregular structure, 68% higher than stiffness irregular structure and 78.4% higher than regular structure). This is due to change in geometry of the structure and the inertial forces are more and hence displacement is more.
- ➢ The bending moment is found to be maximum in re-entrant corner irregular structure. It is 8.4% higher than vertical geometric irregularity, 10.4% higher than stiffness irregularity and 15.2% higher than regular structure)
- ➢ The storey drift is very high for re-entrant corner structure compared to other irregular structures (33% higher than vertical geometric irregular, 44% greater than stiffness irregular structure and 77.2% higher than regular structure). This is due to change in geometry of the structure, thereby leading to the reduction in stiffness of the structure.
- ➢ Response spectrum method provides a clear interpretation of the contributions of different modes of vibration. It is useful for the seismic evaluation of structures.
- ➢ From the above conclusions it is clear that the regular structure with RC moment resisting frame and with masonry walls, perform better under the action of seismic load, compared to irregular structure.
- ➢ The irregular structures, especially the re-entrant corner structure shows the worst performance when subjected to seismic excitation compared to other type of irregular structures compared to other irregular structures (mass irregular, mass irregular, vertical geometric irregular structures).However, stiffness irregular structure has the better seismic performance when compared to the other types of considered irregularities.

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