International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 02| Feb 2020 www.irjet.net p-ISSN: 2395-0072

"To study the Torsional Effect on Multistory Building with Plan and Vertical Irregularity."

Ms. Komal A. Kedge [1], Prof. M.S Kakmare[2]

[1]PG Student, Padmabhooshan Vasantraodada Patil Institute of Technology, Budhgaon, Sangli
[2]Professor & P.G Cordinator, Padmabhooshan Vasantraodada Patil Institute of Technology, Budhgaon, Sangli

---

Abstract - *The buildings are still damage due to someone or the other reason during earthquake. Regular buildings configurations are almost symmetrical about the axis and have uniform distribution of the lateral force resisting structure such that it provides a continuous load path for both gravity and lateral loads. The irregular building configuration may cause interruption of force flow and stress concentrations. Asymmetrical arrangements of mass and stiffness cause large torsional force. Where the center of mass does not coincide with the center of rigidity. It observed that during earthquake in plan and vertical irregular building measure damage is occur at re-entrant corner. A building having plan and vertical Asymmetry is modeled in finite element analysis. Accendibility torsional load is applied with reference to 1893(Part-1)-2002.*

Key Words: Asymmetrical building; Earthquake; Response Spectrum; Torsion; Remedies on torsion &Better solution.

1. INTRODUCTION

Earthquake Engineering is most important field in the structural engineering research field. Traditionally structures were analyzed for the gravity loading and designed accordingly. The destruction caused by earthquakes to such structures gave rise to a thought of designing such a structure that would safely withstand and resist earthquakes which are expected to occur during the design life time of the structure. Earthquake analysis utilizes the basics of the Structural dynamics. Several simplified methods are available to evaluate the seismic Performance of the building.

In present scenario many buildings are asymmetric in plan and/or in elevation based on the distribution of mass and stiffness along each storey throughout the height of the building. However, an accurate evaluation of the seismic behavior of irregular buildings is quite difficult and a complicated problem. Due to the variety of parameters and the choice of possible models for torsional unbalanced systems, there is as yet no common agreement or any accurate procedure advised by researchers on common practice in order to evaluate the torsional effects. Seismic damage surveys and analyses conducted on modes of failure of building structures during past severe earthquakes concluded that most vulnerable building structures are those, which are asymmetric in nature.

Asymmetric building structures are almost unavoidable in modern construction due to various types of functional and architectural requirements. Torsion in buildings during earthquake shaking may be caused from a variety of reasons, the most common of which are non-symmetric distributions of mass and stiffness Modern codes deal with torsion by placing restrictions on the design of buildings with irregular layouts and also through the introduction of an accidental eccentricity that must be considered in design. The lateral-torsional coupling due to eccentricity between centre of mass (CM) and centre of rigidity (CR) in asymmetric building structure generates torsional vibration even under purely translational ground shaking during seismic shaking of the structural systems, inertia force acts through the centre of mass while the resistive force acts through the centre of rigidity as shown in Fig.1.1.

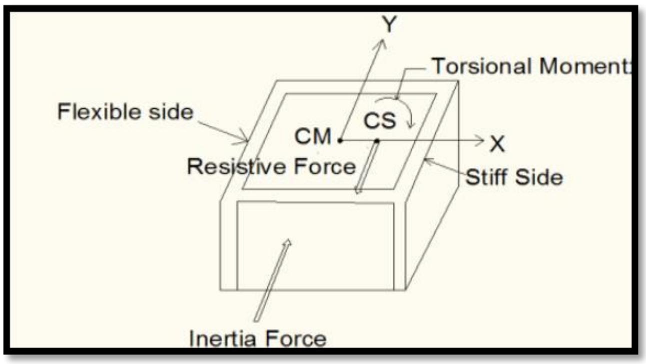

Figure 1.1 Generation of Torsional Moment in Asymmetric Structures

In the Figure 1.1 shows that center of mass and center of rigidity are not coincides with each other which create torsional moment at center of rigidity.

The torsion will be developed at Re-entrant corners in L-shape and T- shape Building .the Re-entrant corner, lack of continuity corner is the common characteristic of overall building configuration that in plan .L-shape and T-shape occurs due to lack of tensile capacity and force concentration. According to IS-1893(Part1)-2002, Plan configurations of a structure and its lateral force resisting system contain re-entrant corners, where both projections of the structure beyond the re-entrant corner are greater than

15 percent of its plan dimension in the given direction. Re-entrant corner

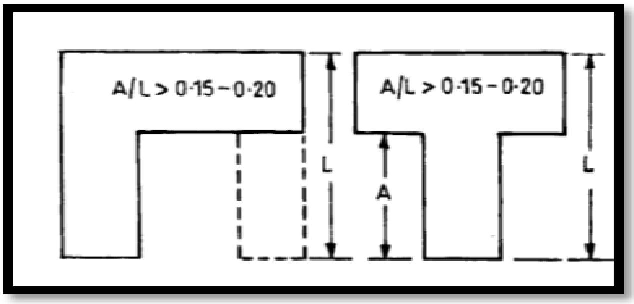

Figure 1.2 Examples of Building with Plan Irregularities

In figure 1.2 shows differential motion between different parts of building, resulting local stress concentration at the notch of the re-entrant corners.
There are many remedies to avoid the torsion irregularity are as follows
a) By providing shear wall.
b) By providing uniform box
c) By providing Architectural Relief
d) By providing Diagonal Reinforcement

There are many researches carried out on the torsional behavior of building. They give the better solution to avoid the torsion. But they didn't apply it on actual building.

1.1 Asymmetric Buildings

To perform well in an earthquake, a building should possess four main attributes, mainly, simple and regular configuration, and adequate lateral strength, stiffness and ductility. Buildings having simple regular geometry and uniformity distributed mass and stiffness in plan as well as in elevation, suffer much less damage than with irregular configuration. A building shall be considered as irregular as per IS 1893(Part I)-2002 if it lacks symmetry and has discontinuity in geometry, mass or load resisting elements. These irregularities may cause interruption of force flow and stress concentrations. Asymmetrical arrangement of mass and stiffness of elements have increase in shear forces on lateral force resisting elements resulting from the horizontal torsional moment arising due to eccentricity between centers of centre of rigidity.
There are main two types of irregularities:
1. Vertical Irregularity
2. Plan Irregularity

1.2 Vertical Irregularity

It is referring to sudden change of strength, stiffness, geometry and mass results in irregular distribution of forces and deformation over height of Building.

1.3 Vertical Geometric Irregularity

A vertical setback is a geometric irregularity in a vertical plane. It is considered, when the horizontal dimension of the lateral force resisting system in any storey is more than 150% of that in an adjacent storey. The setback can also be visualized as a vertical reentrant corner. The general solution of a setback problem is the total seismic separation in plan through separation section, so that portions of the building are free to vibrate independently. When the building is not separated, check the lateral-force-resisting elements using a dynamic analysis.

1.4 Plan Irregularities

Horizontal Irregularities which refers to asymmetrical plan shapes (e.g.-L,T,U,F.) or discontinuities in the horizontal resisting elements(diaphragms) such as cut-outs, large openings, reentrant corners and other abrupt changes resulting torsion, diaphragm deformation and stress concentration.

1.5 Torsion Irregularities

Torsion irregularity shall be considered when floor diaphragms are rigid in their own plan in relation to the vertical structural elements that resist the lateral forces. Torsion irregularity is considered to exist when the maximum storey drift, computed with design eccentricity, at one end of the structure transverse to an axis is more than 1.2 times of the average of the storey drifts at the two ends of the structures.

The lateral-force-resisting elements should be a well-balanced system that is not subjected to significant torsion. Significant torsion will be taken as the condition where the distance between the storey's centre of rigidity and storey's centre of mass is greater than 20% of the width of the structure in either major plan dimension. Torsion or excessive lateral deflection is generated in

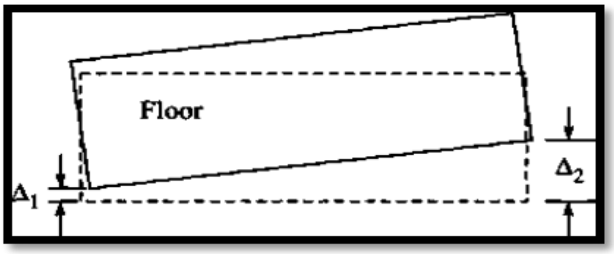

Figure 1.3 Torsion Irregularities With Stiff Diaphragm [3]

asymmetrical buildings, on eccentric and asymmetrical layout of the bracing system that may result in permanent set or even partial collapse. Figures show the example of building failure due to torsion in Alaska earthquake, 1964 and Mexico earthquake, 1985 respectively. Torsion is most effectively resisted at point farthest away from the centre of twist, such as at the corners and perimeter of the buildings.

Asymmetrical buildings, on eccentric and asymmetrical layout of the bracing system that may result in permanent set oreven partial collapse. Figures show the example of building failure due to torsion in Alaska earthquake, 1964 and Mexico earthquake, 1985 respectively. Torsion is most effectively resisted at point farthest away from the centre of twist, such as at the corners and perimeter of the buildings.

1.6 Re-Entrant Corners

The re-entrant, lack of continuity or "inside" corner is the common characteristic of overall building configurations that, in plan, assume the shape of an L, T, H, + or combination of these shapes occurs due to lack of tensile capacity and force concentration (Vukazich, 1998). According to IS 1893 (Part 1): 2002, plan configurations of a structure and its lateral force resisting system contain re-entrant corners, where both projections of the structure beyond the re-entrant corner are greater than 15% of its plan dimension in the given direction. The re-entrant corners of the buildings are subjected to two types of problems. The first is that they tend to produce variations of rigidity, and hence differential motions between different parts of the building, resulting in a local stress concentration at the notch of the re-entrant corner. The second problem is torsion. In Fig. an L-shaped building is subjected to a ground motion of Alaska earthquake, 1964 in north-south direction; attempt to move differently at their notch, pulling and pushing each other. So the stress concentrations are high at the notch. The magnitude of the induced forces will depend on mass of building, structural system, length of the wings and their aspect ratios and height of the wings and their height/depth ratios. To avoid this type of damage, either provides a separation joint between two wings of buildings or tie the building together strongly in the system of stress concentration and locates resistance elements to increase the tensile capacity at re-entrant corner.

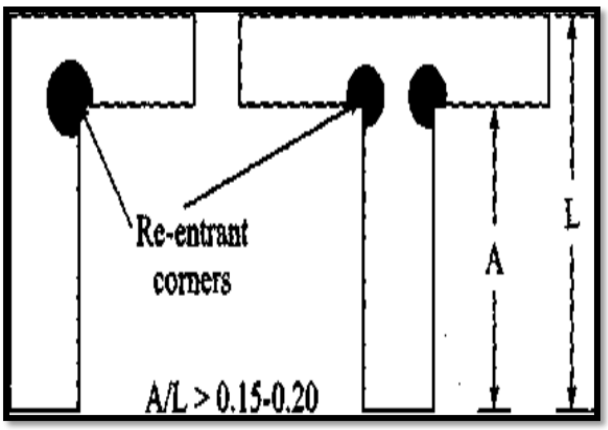

Figure 1.4 Buildings with Plan Irregularities

2. LITERATURE REVIEW

Gupta, et al. (2015) "Torsional Behavior of Asymmetrical Building" International Journal of Modern Engineering Research (IJMER), Vol.3 (2), 1146-1149 [1]: has studied on the torsional behavior of multi-storey buildings with different structural irregularities. Such as plan irregularity and vertical irregularity. This paper represents a review about the investigation done on torsional behavior of multi-storey buildings with plan as well as vertical irregularities. It also focuses on codal provision made for torsion. This paper concludes that torsion is the most critical factor leading to major damage or completes collapse of building; therefore, it is necessary that symmetric buildings should also be analyzed for torsion. While designing the building design eccentricity and accidental eccentricity should be considered. It was observed that the irregular profile buildings got larger forces and displacement as compared to symmetrical buildings. Structures are never perfectly regular and hence the designers routinely need to evaluate the likely degree of irregularity and the effect of this irregularity on a structure during an earthquake.

Suryawanshi, et al. (2014) "Torsional Behaviour of Asymmetrical Buildings in Plan under Seismic Forces" International Journal of Emerging Engineering Research and Technology, Vol.2(4), PP 170-176 [2]: has studied on the torsional behavior of asymmetric building subjected to ground motion using Response Spectrum method. Then he used the non-linear push over analysis has been used to find the structural description. In this paper the gravity load analysis & lateral load analysis as per the seismic code IS 1893(part-1):2002 is carried out for three building one is symmetric and other two are asymmetric in plan for variation in building height. Determining the torsional moment, Base shear, displacement & time period by Response spectrum method & their capacity & demand is equivalent using non-linear push over analysis. This paper concludes that time period and base shear calculation by using equivalent static method is approximately equal with response spectrum method in SAP.
It also concluded that torsional moment is more in the asymmetry building so beam and column are necessary to design considering torsional moment. The base shear and roof displacement of asymmetry building is more than symmetrical building. By using push over analysis performance of symmetrical building is better than asymmetrical building.

Wakchaure, et al. (2013) "Effect Of Torsion Consideration In Analysis Of Multi Storey Frame"", International Journal of Engineering Research and Applications, Vol.3(4), 1828-1832 [3]: has studied on the influence of the torsion effects on the behavior of structure is done. In this paper two building are considered one is without considering torsion and other is considering the torsion. The building is analyzed and design using method and as per IS1893 (part1): 2002.the result are compared in terms % Ast in column. This paper concluded that in the asymmetric building second building, that is without considering torsion, it was observed that the area of steel in the beams at critical stage are much smaller than those obtained in the case of first building, that is with considering torsion. The bottom bars should be more critical, because they seem to be subjected to more tension than the top bars therefore torsional behavior of asymmetric building is one of the most frequent sources of structural damage and failure during strong ground motions. He also concluded that the torsion is the most critical factor causes damage in building, so the irregular buildings are analyzed for torsion.

Bensalah, et al. (2012) "Assessment of The Torsion Effect in Asymmetric Buildings Under Seismic Load" 15 WCEE, LISBOA [4]: has presented the influences of torsional effect on the behavior of the structure. In this paper two buildings are considered one symmetrical and other un-symmetrical building in terms of rigidity. Some parameters such as displacement, ductility, reduction factor and dynamic non-accidental eccentricity are focused in this paper. This paper concludes that lateral yielding strength in terms of capacity of asymmetric structure is higher than symmetrical structure. The ductility increases with increasing input motion (Arias intensity) and decrease with increasing predominant period with significant variation in asymmetrical structure than those symmetrical structures. The reduction factor decreases when the dominant period of the earthquake increases. Unlike the reduction factor increase with decreasing input motions.

Maramaee, (2011) "The Effects of Torsion on Steel Structures Under Seismic Analysis" Middle-East Journal of Scientific Research, Vol.10 (6), 764-767 [5]: has studied about the torsional effect on steel structure under seismic analysis. Due to architectural condition and structural application, mass source and stiffness source are not coinciding. The structure also might be asymmetric as an asymmetric bracing in plan which leads to unbalance distribution of stiffness or because of unbalance distribution of the mass. In this paper five storied building with different percentage of asymmetric which is because of stiffness changes have been designed. The static and dynamic nonlinear analysis under three acceleration recording has been done. Finally, performance level of the structure has been evaluated. Steel bracing is provided at different position in building.

3. OBJECTIVES AND PROPOSED WORK

3.1 OBJECTIVES

i. To study the torsional effect due to plan and vertical irregularity on L-Shape Multi-Storied Building at Re-entrant corner.

ii. To study the torsional effect due to plan and vertical irregularity on T-Shape Multi-Storied Building at Re-entrant corner.

iii. To discuss remedies for torsion irregularities and giving optimum solution for cases as per IS 1893(Part-I)-2002

3.2 METHODOLOGY

i. Analyzing the structure under the loading using Linear Static Method.

ii. Analyzing the structure using the FEM base software

iii. Analyzing the structure under the torsional effect using FEM base software

iv. Analyzing the structure for Push over analysis using FEM base software

4. Result and Discussion of 10 and 15 Storey Buildings

4.1 Result

T Shape Building (X Direction)

By using software ETABS Response Spectrum Method	Seismic weight (KN)	Time Period	Base Shear
With SW at Corner (15 floor)	501028	.58SEC	18675KN
Without	516170	.58SEC	18767KN

SW at Corner (15 floor)			
With SW at Corner(10 floor)	330797	.26SEC	13231
Without SW at Corner(10 floor)	340967	.26	13638

T Shape Building(Y Direction)

By using software ETABS Response Spectrum Method	Seismic weight (KN)	Time Period	Base Shear
With SW at Corner (15 floor)	501028	.4SEC	19911KN
Without SW at Corner (15 floor)	516170	.4SEC	1990KN
With SW at Corner(10 floor)	330797	.34	13231
Without SW at Corner(10 floor)	340967	.34	13638

L Shape Building(X Direction)

By using software ETABS Response Spectrum Method	Seismic weight (KN)	Time Period	Base Shear
With SW at Corner(15 floor)	359393	.51SEC	14286KN
Without SW at Corner(15 floor)	360459	.51SEC	14330KN
With SW at Corner(10 floor)	237348	.31SEC	9523KN
Without SW at Corner(10 floor)	238096	.31SEC	9523KN

L Shape Building(Y Direction)

By using software ETABS Response Spectrum Method	Seismic weight (KN)	Time Period	Base Shear
With SW at Corner(15 Floor)	359393	.51SEC	14286KN
Without SW at Corner(15	360459	.51	14330KN

Floor)			
With SW at Corner(10 floor)	237348	.31	9523KN
Without SW at Corner(10 floor)	238096	.31	9523KN

L Shape Building Drift

By using software ETABS Response Spectrum Method	Max Story Drift (Spec X)	Max Story Drift (Spec Y)
With SW at Corner(15 floor)	.00177	.0024
Without SW at Corner(15 floor)	.002127	.002718
With SW at Corner(10 floor)	.00117	.001595
Without SW at Corner(10 floor)	.001274	.0018

5. CONCLUSIONS

In this research modeling of multistoried building with plan irregularity is done. In accordance with IS1893-2016 for simulation purpose finite element analysis ETABS is used following conclusions are formed after studying T-shape and L-shape Building with Providing the Architectural Relief in form of Shear Wall at the Corner of the Building.

1) Providing the Shear Wall at the Corner decreases the relative displacement & stress at re-entrant corners.
2) Architectural Relief is given for L-Shape & L-Shape building relatively considerable decrease in displacement and also decrease in stresses at re-entrant corners.
3) A T-shape building with shear wall and without shear wall at corner is analyzed and it is observed that nodal displacement and stresses reduced at re-entrant corners.
4) In T- shape & L-Shape building shear wall must be provided at re-entrant corners.
5) There is reduced in drift of the building when we have provided the shear wall at the corner of the buildings.
6) Architectural Relief is the better solution on the re-entrant corner on which maximum earthquake damage is done.
7) The torsional moment is reduced in when we have provided the Shear wall at the corner of the Building.

REFERENCES

1) Gupta.V.N & Pajgade. P. S. (2013) "Torsional Behavior of Asymmetrical Building" International Journal of Modern Engineering Research (IJMER), Vol.3 (2), 1146-1149.

2) Suryawanshi S. N, Kadam.S.B, Tande.S.N.(2014), "Torsional Behaviour of Asymmetrical Buildings in Plan under Seismic Forces", International Journal of Emerging Engineering Research and Technology, Vol.2(4), PP 170-176.

3) Wakchaure M. R, Nagare Y U (2013) "Effect Of Torsion Consideration In Analysis Of Multi Storey Frame", International Journal of Engineering Research and Applications, Vol.3(4), 1828-1832.

4) Bensalah.M.D, Bensaibi.M., Modaressi.A. (2012) "Assessment of The Torsion Effect In Asymmetric Buildings Under Seismic Load" 15 WCEE, LISBOA

5) Maramaee Soleiman (2011) "The Effects Of Torsion On Steel Structures Under Seismic Analysis" Middle-East Journal of Scientific Research, Vol.10 (6), 764-767.

6)Jarernprasert, E. Bazan, J. Bielak (2008) "Inelastic Torsional Single Story Systems" The 14 World Conference on Earthquake Engineering, Beijing, China.

7) Kumar Naresh. Gornale.B.G, Abdullah.A.M (2012) "Seismic Performance Evaluation of R c-Framed Buildings - An Approach to Torsionally Asymmetric Buildings" IOSR Journal of Engineering (IOSRJEN), Vol.2 (7), 01-12

9) P.Agarwal,M.Shrikhande(2004) "Earthquake Resistant Design Of Structures", PHI Publication.