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Comparative Seismic Analysis of Irregular Shaped Multi Storied Structure With and Without Infill

***Zaker Baig*[1]**
[1] P.G. Student, Civil Engineering Department, P.E.S.College of engineering Aurangabad-431002, Maharashtra, India.(Email: zaker.baig051@gmail.com)

***D. N. Kakade*[2]**
Associate professor [2], Department of civil Engg., P.E.S.College of engineering. Aurangabad-431002, Maharashtra, India. (Email: deepak.kak06@gmail.com)

***Dr. A. P. Wadekar*[3]**
Principal[3], Department of civil Engg., P.E.S.College of engineering. Aurangabad-431002, Maharashtra, India.

Abstract

When a particular structure subjected to seismic forces, it experiences lots of effect and changes in the structure due to its plan irregularity and vertical irregularity, width to height ratio, located at which seismic zone, and so many. In this article we are focusing on the plan irregularity of structure with and without the contribution of infill. An actual fifteenth storey residential apartment type structure has been taken for our study which was initially L-shaped in plan. Further regular shape and T-shape structure is modelled with same area of actual plan and checked the effect of irregularity on the seismic performance of structure with and without the contribution of infill. The properties of infill are taken as the property of brick infill and the infill is assigned diagonally to the frame. The Linear direct integration time history analysis, imperial valley ground motions is used and analysis is performed to calculated the required aspects of structures and this dynamic analysis is performed by using programming software SAP 2000 and Etabs 16.

Keywords:- *Infill configuration, plan irregularity, time history analysis, axial forces, torsion moment, bending moment, base shear*

INTRODUCTION

A comprehensive review of past research on evaluation of lateral load behaviour of masonry infilled frames showed that when the strength and stiffness of infill is sufficiently large, local detrimental effect of infill may cause shear failure of columns.

Most of the past experimental studies reported shear failure of columns in frames not designed as per the recommendations of prevalent seismic standards. From the past studies, it was observed that there are several factors that had significant influence on failure mechanism of masonry infiled RC frames, which include aspect ratio, openings in the infill panels, column to beam stiffness ratio, axial load ratio on columns, type of infill and the construction methodology, number of stories and bays, etc. From the recommendations of the past studies, it is understood that infilled frames need to be designed to resist the excessive shear force from infill. It was also observed that most past studies used solid clay or fly ash bricks, hollow blocks or concrete bricks/blocks as infills. In the current study, frames were infilled with fly ash bricks, which were found to be significantly softer and weaker in comparison to the RC frame. Unfavourable torsional response is one of the important causes of damage of tall buildings during strong ground motion especially in seismic zones. The torsion effect can be determinate in elastic and inelastic analysis in earthquake engineering. In recent years some innovative ideas have appeared which complement the traditional approaches and which help to better understand the elastic and inelastic torsional response. A lack of symmetry produces torsional effects that are sometimes difficult to assess, and can be very adverse as studied in [1-3].

The preferred method for reducing the torque is to choose a floor plan often and quite compact. The behavior of buildings during earthquakes only be satisfactory if all steps are taken to establish a mechanism that promotes failure. It must create a special account so that torque does not affect or does not include a global elastic behavior of the structure. The building with the uneven distribution of hardness and strength in partnering plan side and torsion during an earthquake. As a twist, the seismic requirements symmetrical building their lateral stability, drift control and increase the duration and frequency of E.T. Structure It is made clear that the greater the eccentricity between the center of stiffness and the center of mass, the greater the effects of torque. An important aspect of behavior that can not be changed irregular structure is considered the level of control over the behavior of the vortex can not be changed. irregularity structure is an important reason to build a poor performance in severe seismic loading, irregularities plan contributed significantly to the potential for translational torsional coupling in the dynamic behavior of structures that tend to increase the lateral deflection collapsed increased power of Member and finally buildings.

LITERATURE REVIEWES

Bardia Khafaf et al [1]. High buildings with pyramidal general is use in the new development zone. It is seen that is also exposed in areas of high, there are many high buildings under construction and construction. In contrast, in the related seismic code has no specific criteria for any type of structural system. The structure of the building framed against time with or without frame or shear wall struts. Structural elements will usually consist of vertical beams and supports in the middle and I lean on the front of the building. Elements tend to split in this type of structure that make the behaviour of the structure in a different way. However, there are some aspects of the specific structure of the building, mainly caused by an earthquake; One of the main customs blur effect very lightning pyramid building structure symmetry is mainly in the bottom story. In this work, the results of many studies, the analysis for symmetrical, asymmetrical pyramid structure relative to a fixed structure and compare them with the requirements of the code are presented.

Dj. Z. Ladjinovic et al [2]. Building with asymmetrical distribution of force and power in the side and torsion coupled plan during an earthquake. In many buildings, the center of resistance do not coincide with the center of gravity. By reducing the distance between the center and the center of the torsional rigidity of the impact should be reduced. Features dynamic stiffness control structure. The choice of the stiffness characteristics of the structure is an important step in the conceptual design phase. The good behavior of the structure can be provided with a system of distributed lateral load resistance. Seismic behavior cannot be changed symmetrically designed building is calculated using stories base shear and torque (BST) is considered. It is proposed to construct BST-surface system with any number of elements of the resistance towards imbalance and ground movement. Surface BST describe the properties cannot change the system, however, inelastic deformation cannot be counted unless static or dynamic analysis of nonlinear done. Factors that determine seismic response, is the eccentricity of the force, side and plan Torsion distribution system stiffness and pleasure.

Dr. S. N. Tande et al [3]. Structural imbalance might be the main reason for the poor performance under seismic forces strong asymmetry for coupling the translation torsion into structural behavior of a dynamic to the potential contributes significantly to the increase of lateral deflection, In this article, the seismic behavior, which can not be altered and the design of buildings is studied symmetry. The impact of the torque on buildings studied. Building with obstacles torsion analyzed. The study also showed that there is an increase in shear, the column and the column in the outer frame requires special attention.

Romanbabu M. Oinam, et al [4] In this study, three geometrically similar frames, having different configurations of masonry infills, has been investigated. The frames have been modelled in *OpenSees* simulation platform, utilising material and section properties available in its library. This paper mainly focusses on studying the effect of masonry infills in the RC frames and its hysteretic response during an earthquake event, where it is expected to go into the non-linear range. Pushover analysis has been carried out to predict the seismic performance of the study frame, It has been observed that the lateral strength of the infill frame is significantly higher compared to bare frame and open ground frame. The bare frame and open ground frame started showing load degradation after 2.75% drift level, while fully infilled frame started degrading after 3.5% drift level. Overall performance of fully infilled frame is far better than that of the bare frame and open ground frame.

Mohaiminul Haque, et al [6] Bangladesh is one of the most earthquake prone areas in South-Asia and Sylhet is the most seismic vulnerable region in Bangladesh. Seismic performance analysis is highly recommended to ensure safe and sound building structures for this region. For effective performance of reinforced concrete (RCC) structure, new seismic design provisions require structural engineers to perform both static and dynamic analysis for the design of structures. In this study four different types of models are selected namely W-shaped structure, L-shaped structure, and rectangular shaped and square shaped structure. And all these models are analysed under dynamic analysis, by using programming software etabs 15 and SAP2000

METHODOLOGY

TIME HISTORY ANALYSIS

LINEAR DIRECT INTEGRATION TIME HISTORY ANALYSIS

Direct integration of the full equations of motion without the use of modal superposition is available in SAP2000. While modal superposition is usually more accurate and efficient, direct-integration does offer the following advantages for linear problems:

• Full damping that couples the modes can be considered

• Impact and wave propagation problems that might excite a large number of modes may be more efficiently solved by direct integration For nonlinear problems, direct integration also allows consideration of more types of nonlinearity that does modal superposition. Direct integration results are extremely sensitive to time-step size in a way that is not true for modal superposition. You should always run your direct-integration analyses with decreasing time-step sizes until the step size is small enough that results are no longer affected by it. In particular, you should check stiff and localized response quantities. For example, a much smaller time step may be required to get accurate results for the axial force in a stiff member than for the lateral displacement at the top of a structure.

FAST NUMERICAL ANALYSIS (FNA) TIME HISTORY ANALYSIS

The method of nonlinear time-history analysis used in SAP2000 is an extension

of the Fast Nonlinear Analysis (FNA) method developed by Wilson (Ibrahimbegovic and Wilson, 1989; Wilson, 1993). The method is extremely efficient and is designed to be used for structural systems which are primarily linear elastic, but which have a limited number of predefined nonlinear elements. For the FNA method, all nonlinearity is restricted to the Link/Support elements. A short description of the method follows.
The dynamic equilibrium equations of a linear elastic structure with predefined nonlinear Link/Support elements subjected to an arbitrary load can be written as:
KL ***u***(*t*) +***C*** ***u***&(*t*) + ***M*** ***u***&&(*t*) + ***r****N* (*t*) = ***r*** (*t*)
where ***KL*** is the stiffness matrix for the linear elastic elements (all elements except the Links/Supports); ***C*** is the proportional damping matrix; ***M*** is the diagonal mass matrix; ***r****N* is the vector of forces from the nonlinear degrees of freedom in the Link/Support elements; ***u***, ***u***&, and ***u***&& 2. are the relative displacements, velocities, and accelerations with respect to the ground; and ***r*** is the vector of applied loads.

MODELLING

1. In the structural designing world, most of the structural engineer as in my observation use bare frame method for to analyse and design a multi-storied structure, either it may be regular or irregular. So many authors as given in literature reviews and references performed analysis on some particular models and concluded their results and they concluded that after assignment of infill which non structural element, it contributes efforts in the performance of structural under seismic action. We took a residential apartment of fifteen stories with all its components and configuration and assign brick infill as a single diagonal strut. as shown in Fig. 1 and Fig. 1.1

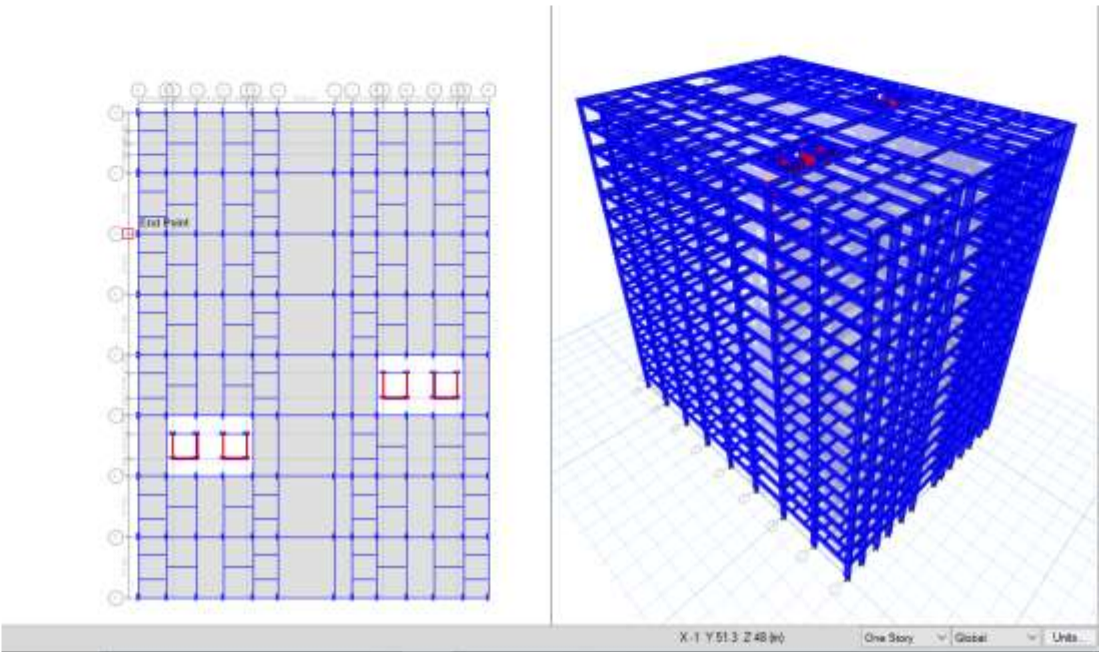

Fig 1 *Regular plan structure without infill*

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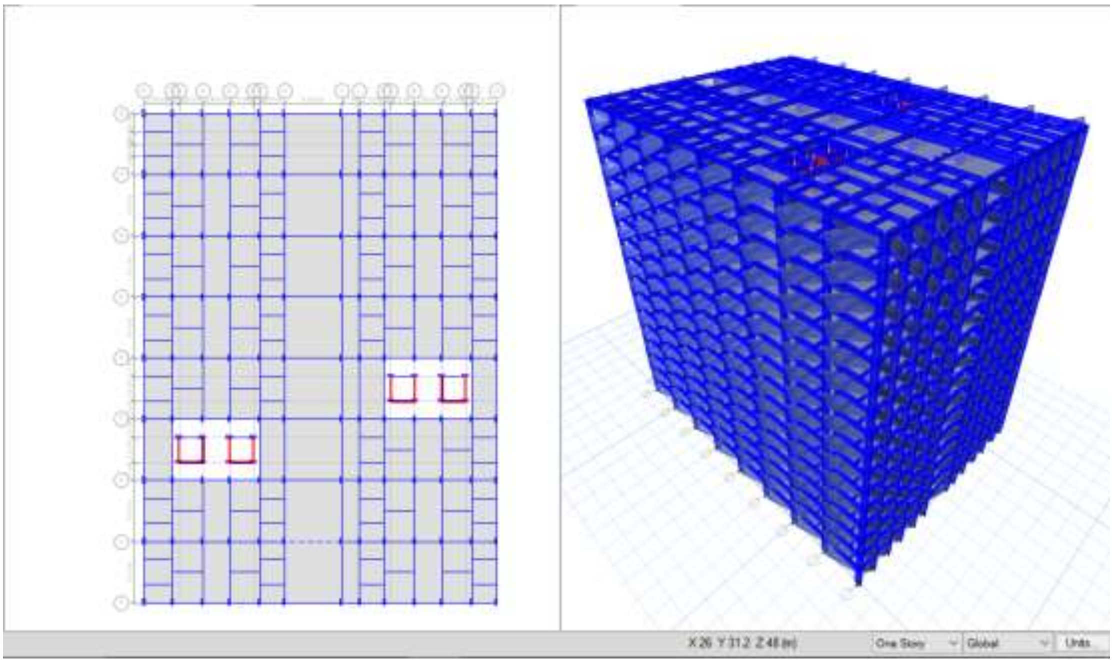

Fig 1.1 *Regular plan structure with infill*

3. The second model structure is of rectangular shape but having the same area approx. 1700 sq. metre. This model also consist the same components which ever is defined for L-shaped structure. We are going to see the effect of torsion moment in whole L-shaped structure comparing with its regular shape structure. And see what ever be the results from the comparison, this results will be compared with the structure containing brick infill as a diagonal strut. The rectangular shape plan is as shown in Fig. 2 and Fig. 2.2

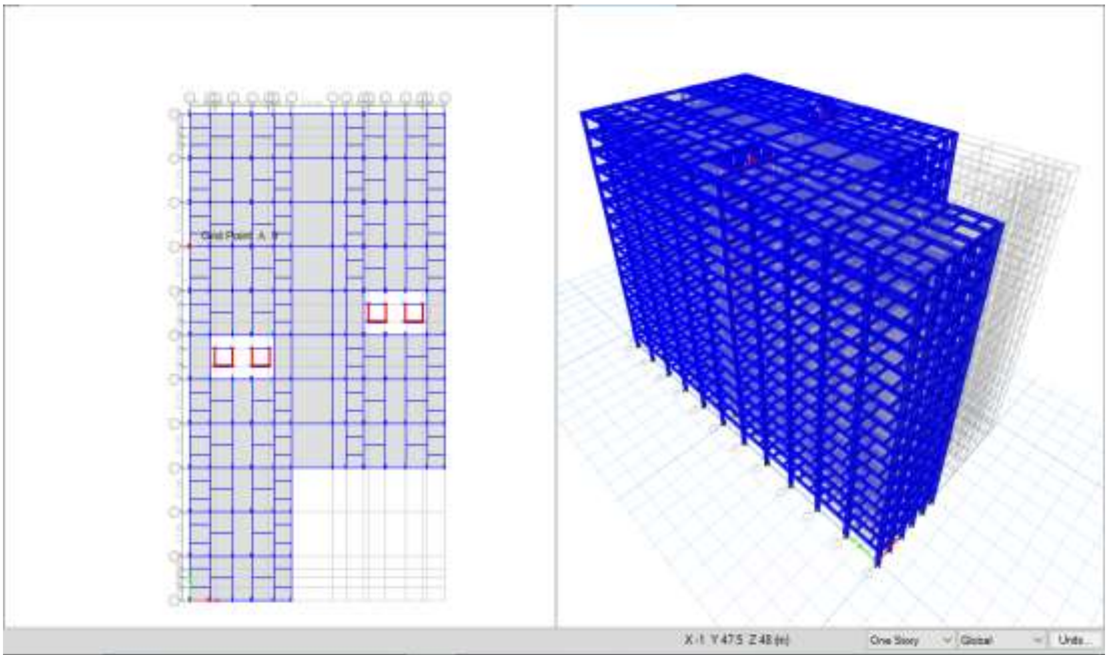

Fig 2 *Irregular L-shaped plan without infill*

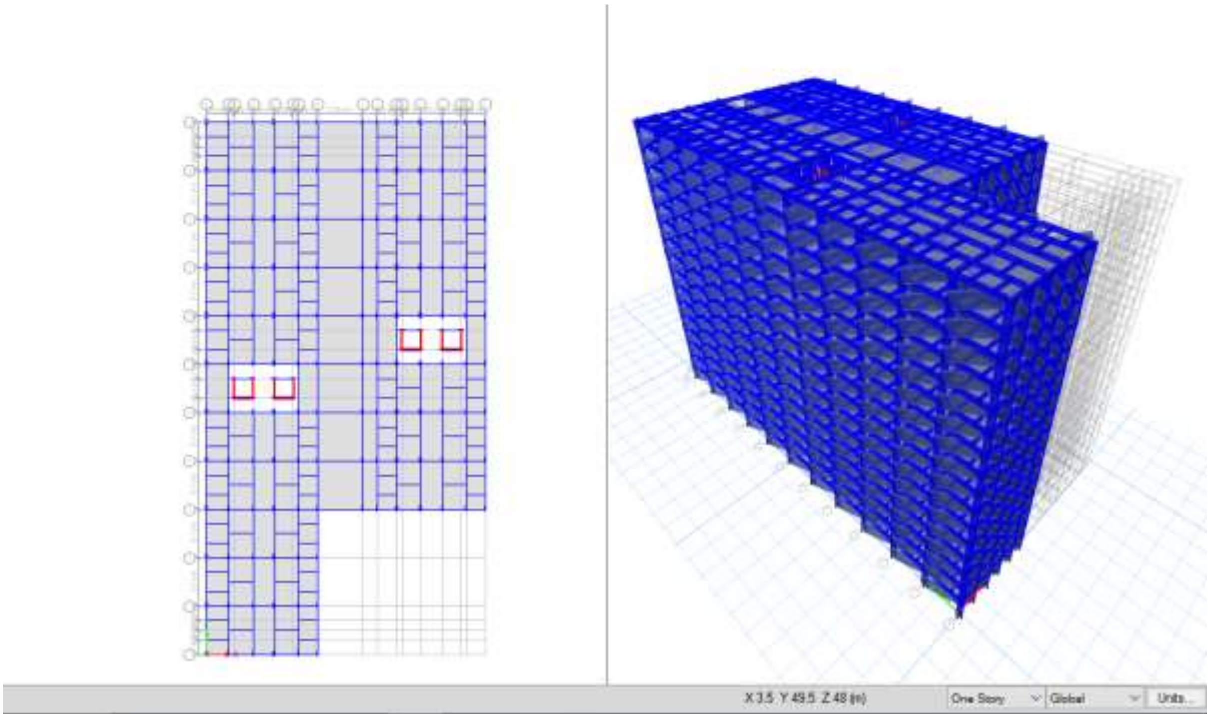

Fig 2.2 *Irregular L-shaped plan with infill*

4. Third project model structure is of T-shaped with two re-entrant corners, having the same plan area approx. 1700 sq. metre. T-shaped structure is as shown in Fig. 3

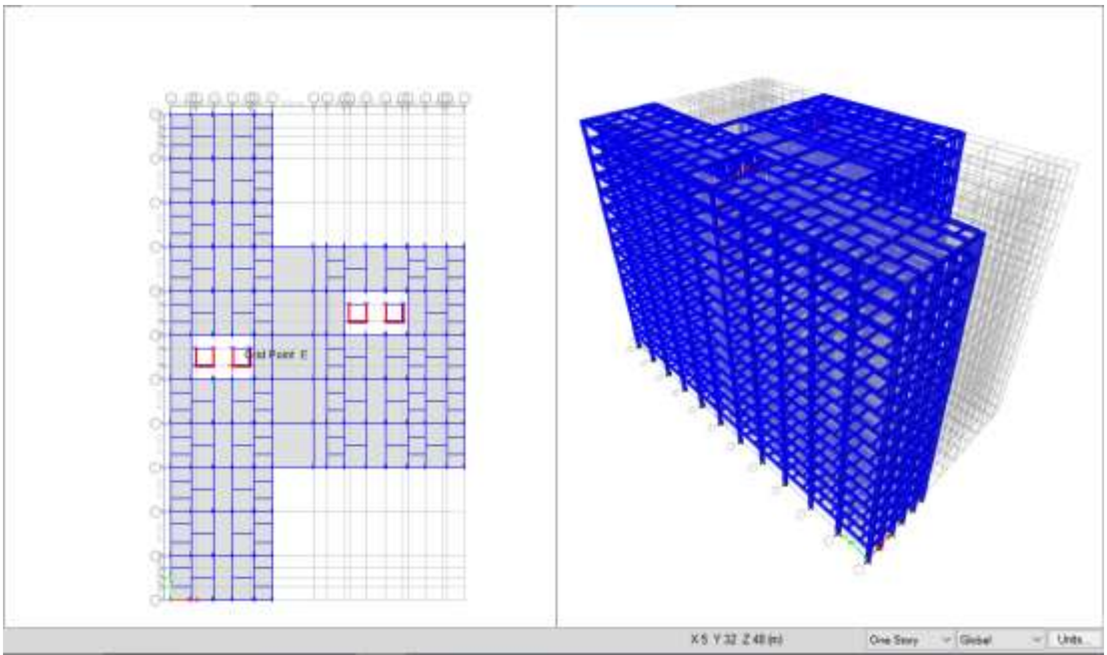

Fig 3 Irregular T-shaped plan without infill

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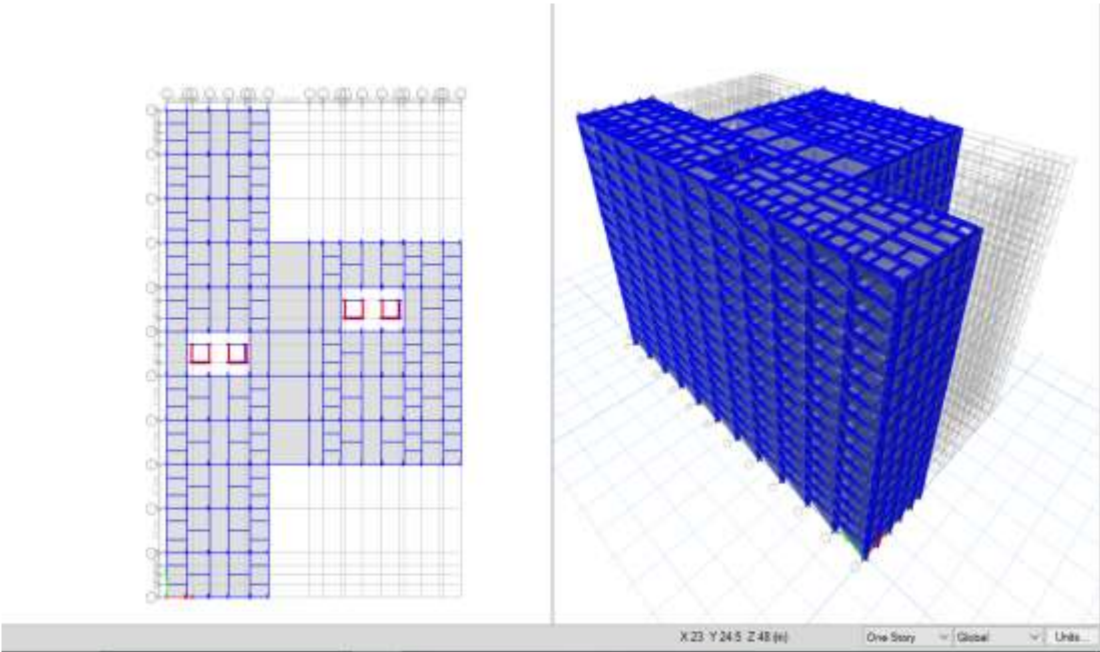

Fig 3.3 *Irregular T-shaped plan with infill*

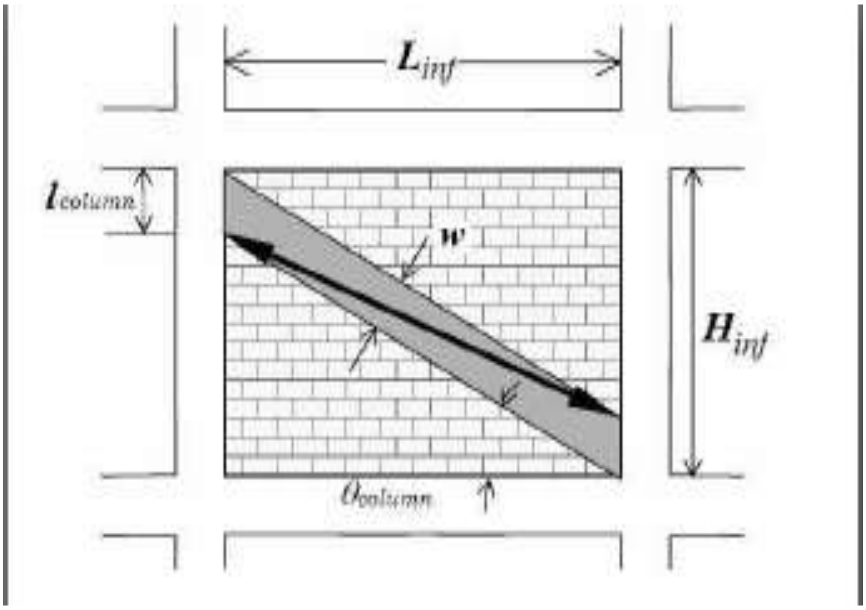

Fig 4 *Placement of diagonal strut*

RESULT AND DISCUSSION

In the comparison analysis of all these types of structure, we compares the axial forces, bending moments, torsion moments, base shear story drift and time periods of all models. These results are in the manner that all type structure with and without contribution of infill. And also the results are separately compared like regular structure with its irregular structure and also with infill.

AXIAL FORCE

Table 1 *Axial forces*

TYPE	R	IR.L	IR.T
INFILL	680028.832	1305985.867	2569026
WITHOUT INFILL	670992.549	29763335	864043

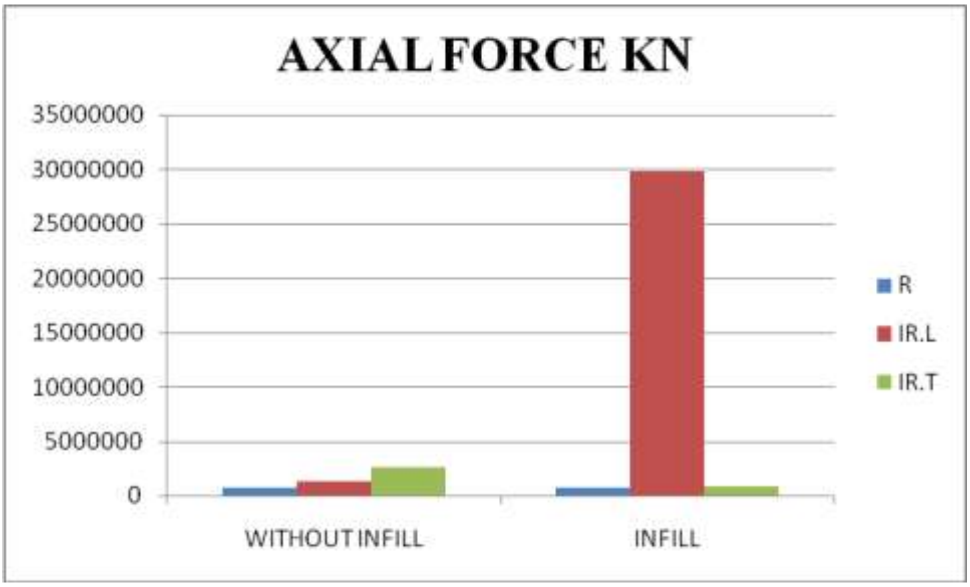

Fig 5 *Axial forces of all models with and without infill*

Table 2 *Axial forces of L-shape model*

R	IR.L	IR.L.IF
680028.832	1305985.867	29763335

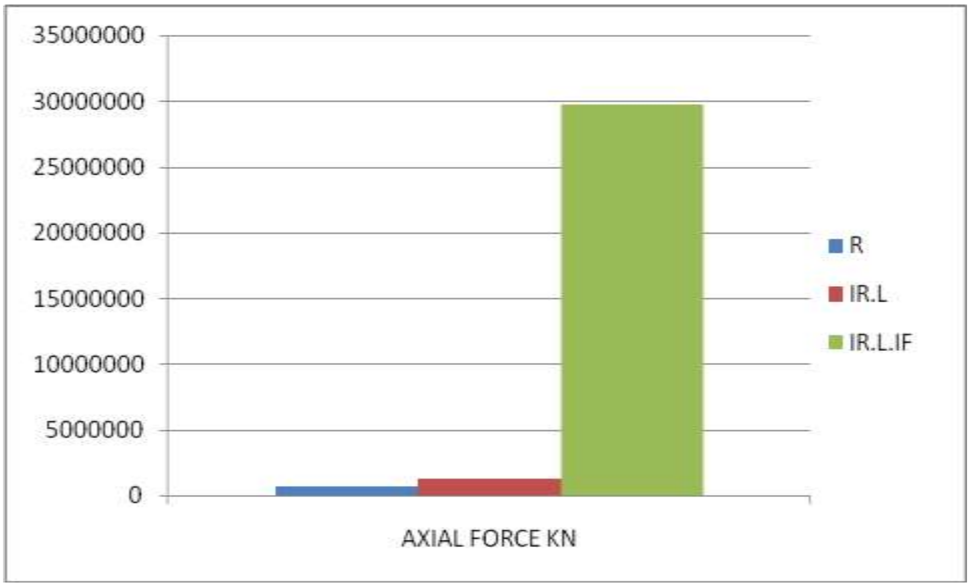

Fig 6 *Axial force of regular, irregular L-shape and irregular L-shape with infill*

Table 3 *Axial forces of T-shape model*

R	IR.T	IR.T.IF
680028.832	2569026	864043

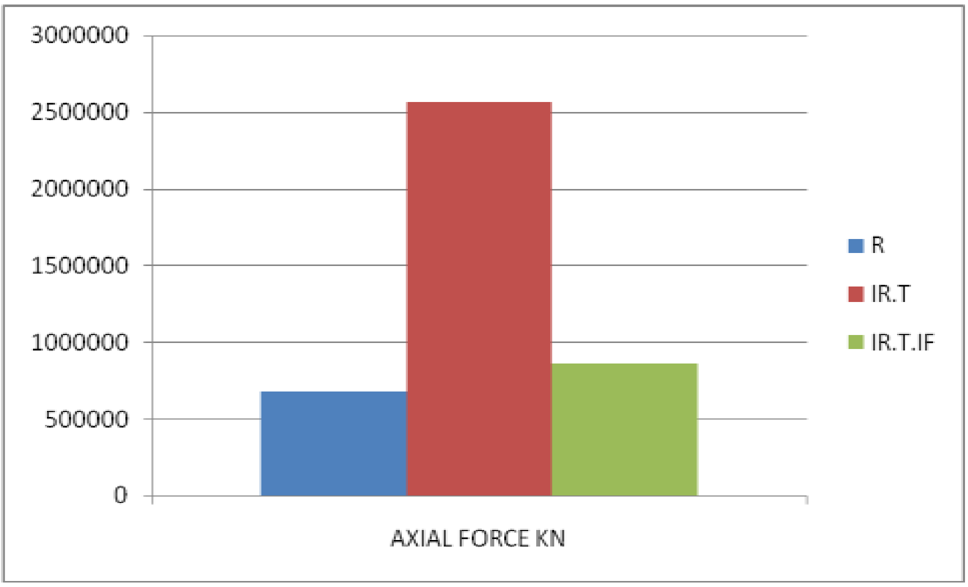

Fig 7 *Axial force of regular, irregular T-shape and irregular T-shape with infill*

An axial force has been calculated as story wise manner instead of individual columns axial forces, and for results comparison the base story has taken. In that all regular structure, irregular L-shaped structure and irregular T-shaped structure with and without infill is compared. We found that without infill, the structure facing consistently low axial forces in all types model whereas after assigning brick infill as a diagonal strut then the axial forces came higher in regular shape structure and irregular L- shape structure otherwise the T-shape structure experiencing equivalent axial forces as compares to its same model without infill as shown in Figure 1.

When regular bare frame structure got compared with its irregular L and T-shaped bare frame structures and irregular L and T-shaped infill structure then L-shaped model with infill experiencing more axial forces as compared to its without infill model as shown in Figure 2. At the same time T-shaped infill model experiencing less axial forces as compared to its without infill model as shown in Figure 3.

TORSION MOMENTS

Table 4 *Torsion Moment*

TYPE	R	IR.L	IR.T
INFILL	814483205	788421027	90066781
WITHOUT INFILL	122521301	138791587	90079787

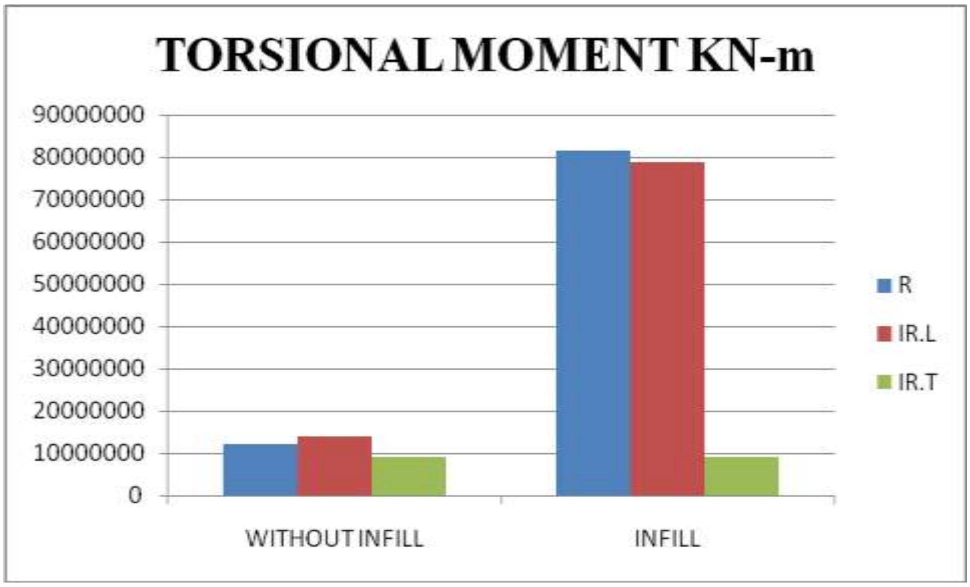

Fig 8 *Torsion moment of all models with and without infill*

Table 5 *Torsion moment of L-shape model*

R	IR.L	IR.L.IF
1.23E+08	1.39E+08	1.23E+08

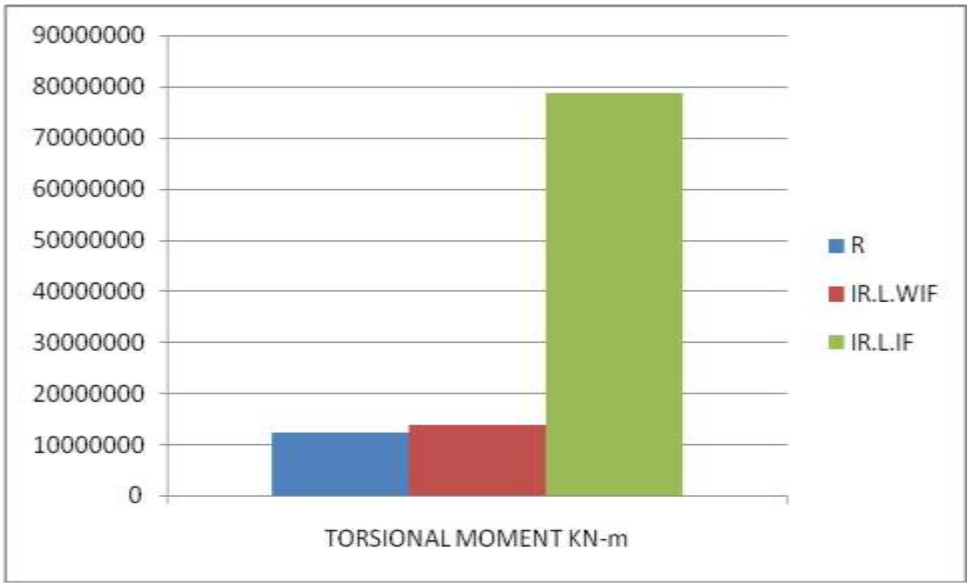

Fig9 *Torsion moment of regular, irregular L-shape and irregular L-shape with infill*

Table 6 *Torsion moment of T-shape model*

R	IR.T	IR.T.IF
1.23E+08	90079787	90066781

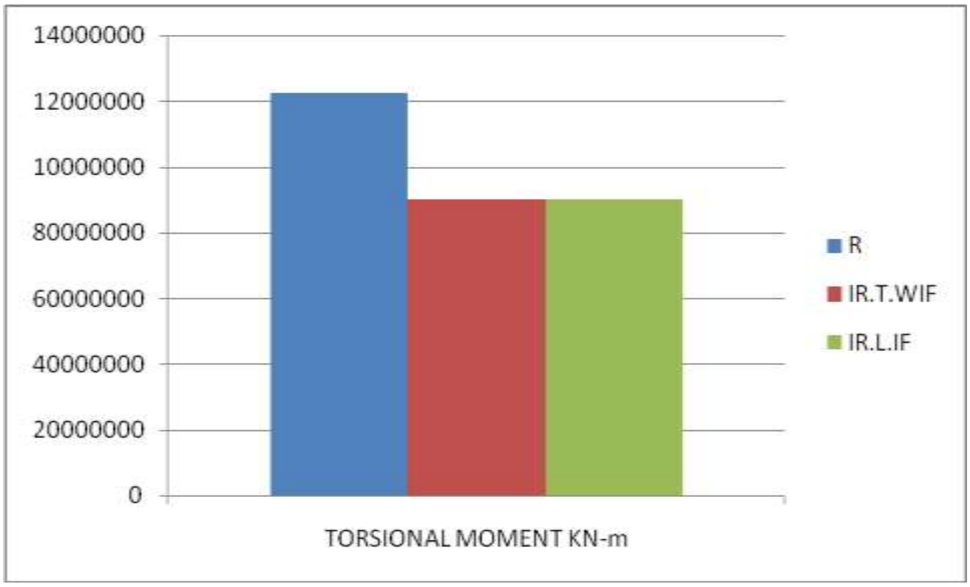

Fig 10 *Torsion moment of regular, irregular T-shape and irregular T-shape with infill*

Torsion is that aspect of structure that should be kept seriously during analysis and design of particular structure by the structural designer. As per IS-1893 2002 part I provision the re-entrant corners increases in the structure then the torsion of that structure will increase. Out of three models of our research, second model is of L- shape in plan having one re-entrant corner and the third model is of T-shape in plan having two re-entrant corners, all models have the same area but of different plan shape.

BENDING MOMENT

Table 7 *Bending moment*

TYPE	R	IR.L	IR.T
INFILL	10218382478	1150464458	5589969153
WITHOUT INFILL	1097184526	6603015589	760830596

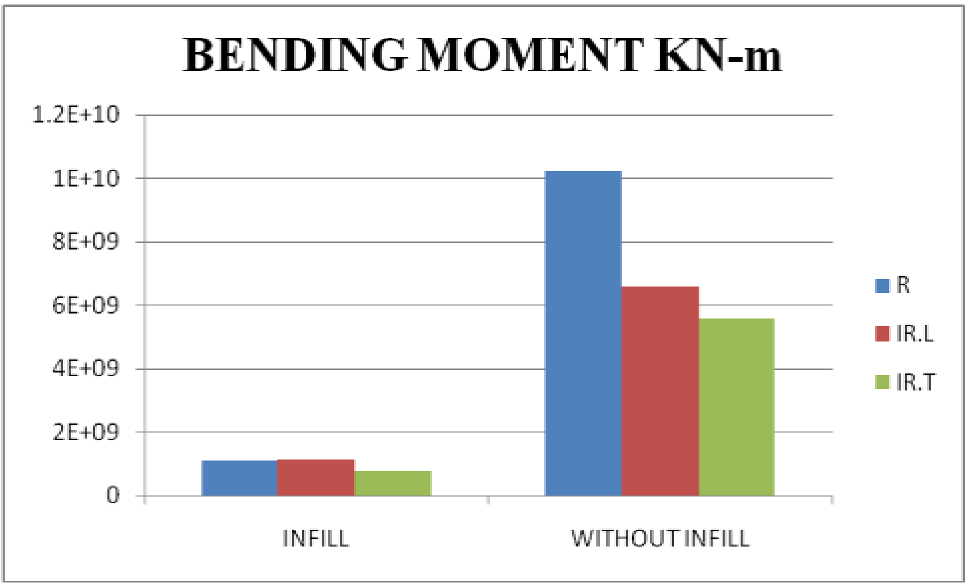

Fig 11 *Bending moment of all models with and without infill*

***Table 8** Bending moment of L-shape model*

R	IR.L	IR.L.IF
1097184526	1.15E+09	6.6E+09

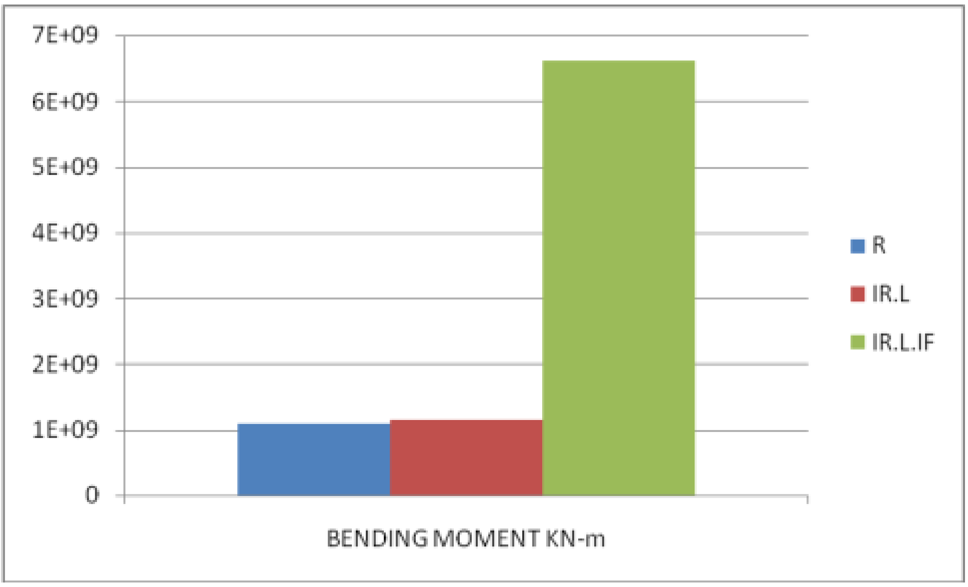

***Fig 12** Bending moment of regular, irregular L-shape and irregular L-shape with infill*

***Table 9** Bending moment of T-shape model*

R	IR.T	IR.T.IF
1097184526	7.61E+08	5.59E+09

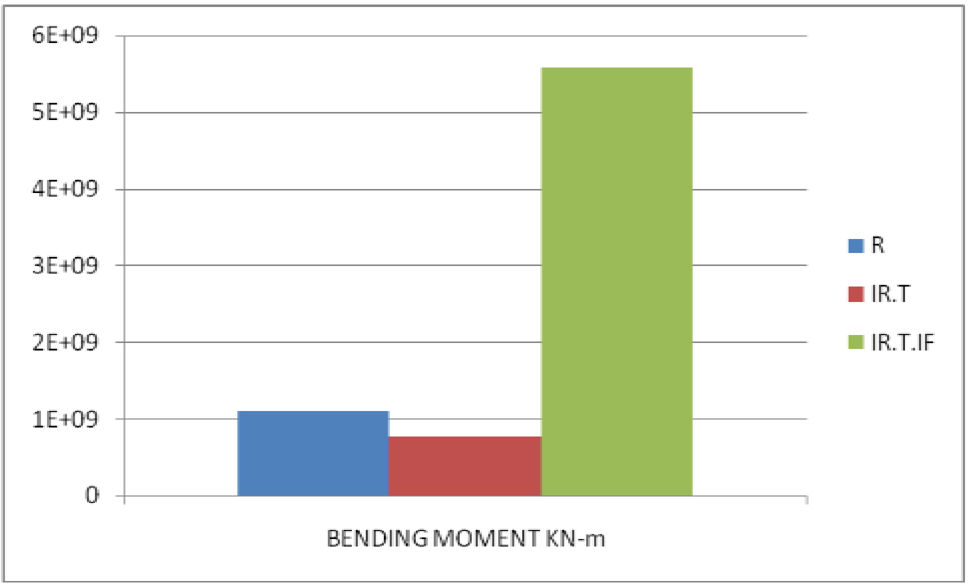

***Fig 13** Bending moment of regular, irregular T-shape and irregular T-shape with infill*

In without infill models, the dead load of wall is directly assigning as uniformly distributed load on the span length of beam then bending moment will be created in respect of that uniformly distributed load. When diagonal strut infill got assign to the frame in an addition then the bending moment will increases. We need to see in which modal will bending moment will increase or decrease with respect to regularity and irregularity.

BASE SHEAR

Table 10 Base shear

TYPE	R	IR.L	IR.T
INFILL	2.2E+08	1.92E+08	1.74E+08
WITHOUT INFILL	20048802	23374633	19131455

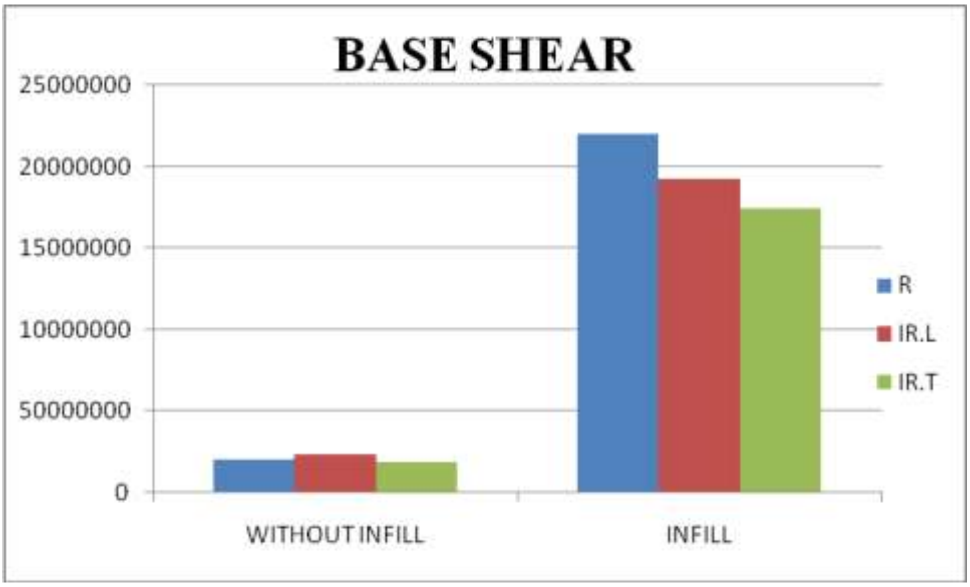

Fig 14 *Base shear of all models with and without infill*

R	IR.L	IR.L.IF
20048802	23374633	1.92E+08

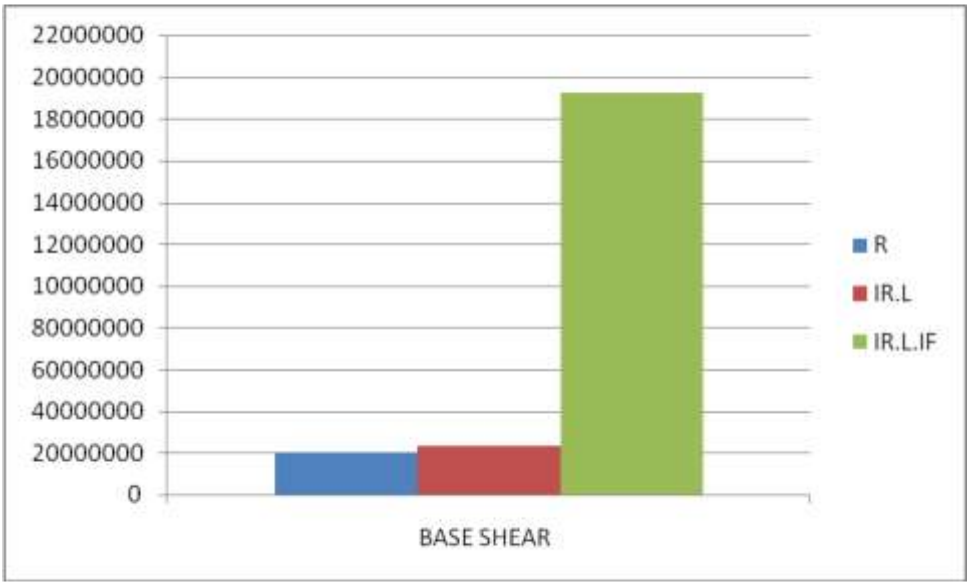

Fig 15 *Base shear of regular, irregular L-shape and irregular L-shape with infill*

R	IR.T	IR.T.IF
20048802	19131455	1.74E+08

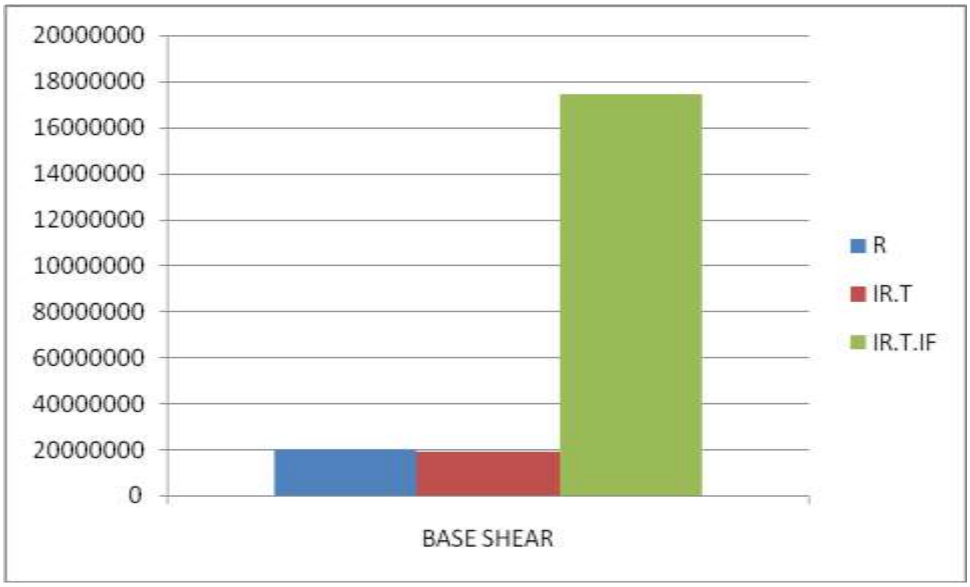

Fig 16 *Base moment of regular, irregular T-shape and irregular T-shape with infill*

Base shear is the lateral forces coming over the structure due to application of seismic forces. Either base shear is the lateral resistivity of structure during the seismic application of seismic forces during earthquake.

In case of our three research models the base shear is increase in all models after application of infill as diagonal strut mostly T-shape model experiencing the large base shear and other two models doesn't have much difference in base shear value before and after application of infill.

CONCLUSION

From above analytical results and observation it is concluded that

- Axial forces of structure after the assignment of infill as a diagonal strut, increases mostly in L-shaped structure which is having one re-entrant corner. Where as in T-shaped infill plan having two re-entrant corners, the axial forces are considerably lower from its bare frames axial forces value. T-shaped without infill plan was having much value of axial forces but after assignment of infill the axial forces values got reduced to much considerable value. It will affect the economical and ductile design of structure.
- Torsional moments were near about same in all bare frame models but after assignment of infill torsion got much increased in all models except T-shaped model. Even T-shaped model having torsion slightly lower form its bare frame torsion value. Bending moment got increase after infilling the models. There for beams must be design as per the bending moment requirements.
- Base shear increases as the all models got infilled. Since due to infilling the models, models become more stiff and base shear value is more in stiff structures.

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