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STATIC & DYNAMIC ANALYSIS OF MASONRY INFILLED R.C. FRAME

Shweta Laddha[1], Nikhil S. Agrawal[2], Prof. P. B. Kulkarni[3], Dr. P. D. Pachpor[4]

[1]P.G. Student, [2]Assistant Professor, [3,4]Professor, Civil Engineering Department,
[1,2,3,4] Shri. Ramdeobaba College of Engineering and Management Nagpur, Maharashtra, (India)

ABSTRACT

In the present study, it is attempt to access the performance of masonry infilled reinforced concrete (RC) frames with open first storey of with and without opening by performing its static and dynamic analysis.The static analysis is performed by using STAAD-Pro software whereas, dynamic analysis is performed with the help of ETABS software, because of some limitation in Staad-Pro.for dynamic analysis. In this research work, symmetrical frame of college building (G+5) located in seismic zone-III is considered by modeling of initial frame. Stiffness of infilled frames by modeling infill is calculated as diagonal struts. An investigation has been performed to study the behavior of the columns at ground level of multistoried buildings with soft storey subjected to static as well as dynamic earthquake loading.The present study compared the results of Equivalent Static Method and the Response Spectrum Method Analysis of frames modeled with and without infill. It shows that infill panels increase the stiffness of the structure. While the increase in the opening percentage leads to a decrease in the lateral stiffness of infilled frame.

Keywords: Masonry Infilled frame, Stiffness, Response Spectrum Method, Seismic Effect.

I. INTRODUCTION

Static and dynamic analysis can be used to design infilled frames subjected to a seismic loading. The static analysis involves the analysis of the frame for the equivalent static loads arising from seismic activity, while the dynamic analysis requires analysis in the time domain. It is widely accepted, by current codes of practice, that the equivalent static analysis will be sufficient for the seismic design of general multi storey structures. This is because the dynamic analysis, though accurate, is quite complex in nature and requires considerable skill, effort, and judgments.Accounting for the infills in the analysis and design requires the determination of the loads of the total composite system and the analysis of the entire infilled frame. Such an approach requires the knowledge of the various models.

As it is known, in many countries situated in seismic regions, reinforce concrete (RC)frames are infilled by brick or concrete-block masonry walls. For decades now, these infill walls were not taken into account when designing the bearing structures. However, an extensive experimental (Smith, 1966), (Smith et al., 1969), (Page et al., 1985), and analytical (Syrmakezis and Vratsanou, 1986), (Syrmakezis and Asteris, 1996)investigation has been made. Recently, it has been shown thatthere is a strong interaction between the infill masonry wall and the surrounding frame leading to:

1. Considerable increase of the overall stiffness (and, in many cases,higher base shear force).
2. Increase of dissipated energy.
3. Redistribution of action-effects and, sometimes, unpredictable damages along the frame.
4. Considerable reduction of the probability of collapse, even in cases of defective infilled frames, when they are properly designed.

The main goal of this paper is to establish the relationships between the parameters of a wall opening (such as position and opening percentage), as well as the comparison of different percentage of opening of plane infilled frames under earthquake loads. For the analysis,a equivalent diagonal strut method has been used. The static analysis has been performed as per IS: 1893-2002. For that college building (G+5) is considered by modeling of frame and Infills. Modelling of infills is done as per actual size of openings say 15%,20% and 25% for the various model such as bare frame ,infill frame and infill frame with centre and corner opening.Also the comparison of opening percentage has been made.The analysis and design is carried out out by software STAAD PRO and different parameters has been computed.

1.1 Soft Storey

A soft story building is a multi-story building with one or more floors which are “soft” due to structural design. These floors can be especially dangerous in earthquakes, because they cannot cope with the lateral forces caused by the swaying of the building during a quake. As a result, the soft story may fail, causing what is known as a soft story collapse. If you've ever seen pictures of massive damage after a major earthquake, you have probably seen a number of examples of soft story collapse, because it is one of the leading causes of damage to private residences. Soft story buildings are characterized by having a story which has a lot of open space. Parking garages, for example, are often soft stories, as are large retail spaces or floors with a lot of windows. While the unobstructed space of the soft story might be aesthetically or commercially desirable, it also means that there are fewer opportunities to install shear walls, specialized walls which are designed to distribute lateral forces so that a building can cope with the swaying characteristic of an earthquake. If a building has a floor which is 70% less stiff than the floor above it, it is considered a soft story building. This soft story creates a major weak point in an earthquake, and since soft stories are classically associated with retail spaces and parking garages, they are often on the lower stories of a building, which means that when they collapse, they can take the whole building down with them, causing serious structural damage which may render the structure totally unusable. Many earthquake-prone regions have building code which specifically define a soft story building, and prohibit the construction of such buildings. When builders apply for a permit to build a new structure, engineers may analyze the proposed plans to ensure that no soft stories are built in, and recommendations for improving the design may be included in the rejection letter, if the building department decides that the building will be structurally unsound in a quake. Older buildings are of great concern to building departments and emergency services in areas where earthquakes are common. These buildings are often in need of retrofits to make them safer in an earthquake, and such retrofits may be relatively inexpensive, especially when compared with the cost

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of replacing a soft story building after it collapses. In the San Francisco Bay Area, a region notorious for its earthquakes, an estimated one in six structures are soft story buildings, which means that many neighborhoods could experience catastrophic building collapses in a major earthquake if property owners refuse to retrofit. Some insurance companies which offer earthquake insurance refuse to insure if a building is classified as a soft story building, due to the increased liability.

1.2 Objectives

The primary objective of this work is to study the seismic response of RC frame building using the role of infill wall. And also check the behavior of building with soft storey. The effect of earthquake forces on five storey building with and without the effect of brick infill with different percentage of opening for various parameters is proposed to be carried out with the help of static and dynamic analysis. The various parameters are computed. The major objectives of the research work are as follows:

1. To study the behavior of frame with brick masonry infill by modeling masonry infill as a diagonal strut.
2. To check the stiffness, strength and ductility of building With & Without Openings for different analytical model.
3. Dynamic analysis of Soft Storey Frame.
4. To check the building model by providing opening variations with the method of response spectra on ETABS and comparing it with equivalent diagonal strut method.
5. To compare area of steel obtained from the result of dynamic analysis with static.
6.To compute parameters of model with and without infill wall, with different % of opening with the help of structural analysis software ETABS.

1.3 Analytical Methods

Static or dynamic analysis can be classified into three broad categories, namely elastic analysis, plastic analysis and nonlinear analysis. Elastic analysis refers to the analysis where a linear elastic behavior is assumed for the frame and the infill, and geometric and material nonlinearities are not included. In the case of a plastic analysis, an elastic-plastic stress-strain relationship is assumed for the materials, and the failure load of the infilled frame corresponding to collapse stage is determined. In the nonlinear analysis, the different sources of nonlinearity are included, and the response of the structure is traced in the entire loading range, from pre cracking to collapse. For most applications, codes of practice recommend an elastic analysis, because of the inherent complexity of a nonlinear analysis.

The different models available for the elastic analysis of infilled frames can be classified into four groups based on their complexity. They are the stress function method, the equivalent diagonal strut method, the equivalent frame method and the finite element method.

1.3.1 Equivalent Diagonal Strut Methods

The simplest equivalent strut model includes a single pin-jointed strut. Holmes who replaced the infill by an equivalent pin-jointed diagonal strut made of the same material and having the same thickness as the infill panel suggest a width defined by,

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$$\frac{w}{d} = \frac{1}{3}$$

Paulay and Priestley suggested the width of equivalent strut as,

$$w = 0.25d$$

Where,

d = Diagonal length of infill panel

W = Depth of diagonal strut

However, researchers later found that this model overestimates the actual stiffness of infilled frames and give upper bound values. Another model for masonry infill panels was proposed by Mainstone in 1971 where the cross sectional area of strut was calculated by considering the sectional properties of the adjoining columns. The details of model are as shown in Fig. 4.2. The strut area A_s was given by the following equation.

$$A_{e} = W\, t$$

$$W = 0.175\,(\lambda H)^{-0.4}\, D$$

1.3.2 Response Spectrum method

The objective of response spectrum analysis is to obtain the likely maximum response of the systems. The response spectrum is a plot of the maximum response (maximum displacement, velocity, acceleration or any other quantity of interest) to a specified load function for all possible single degree-of-freedom systems. The abscissa of the spectrum is the natural period (or frequency) of the system and the ordinate is the maximum response. It is also a function of damping. The design response a spectrum given in IS 1893:2002 for a 5% damped system.

The representation of the maximum response of idealized single degree freedom systems having certain period and damping, during earthquake ground motion. The maximum response is plotted against the undamped natural period and for various damping values, and can be expressed in terms of maximum absolute acceleration, maximum relative velocity, or maximum relative displacement.

Dynamic analysis shall be performed to obtain the design seismic force, and its distribution to different levels along the height of the building and to the various lateral load resisting elements, for the following buildings:

a) Regular buildings - Those greater than 40m in height in Zones IV and V, and those greater than 90 m in height in Zones II and III.

b) Irregular buildings- All framed buildings higher than 12m in Zones IV and V, and those greater than 40 m in height in Zones n and III.

The analytical model for dynamic analysis of buildings with unusual configuration should be such that it adequately models the types of irregularities present in the building configuration.

NOTE - For irregular buildings, lesser than 40 m in height in Zones II and III, dynamic analysis, even though not mandatory, is recommended.

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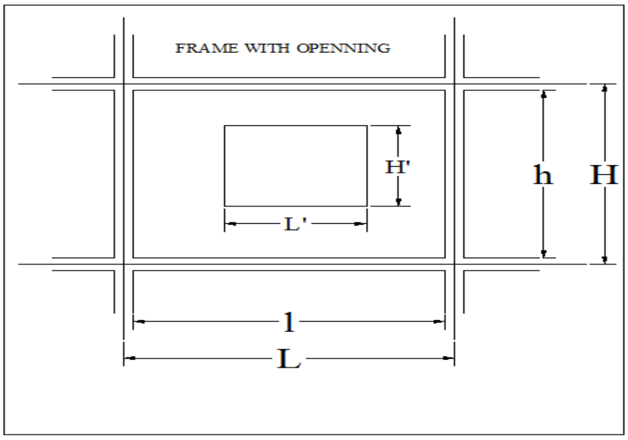
$$\text{Opening percentage (\%)} = \frac{\text{Area of openning } (A_{op})}{\text{Area of infill} (A_{infill})}$$

Dynamic analysis may be performed either by the Time History Method or by the Response Spectrum Method. However, in either method, the design base shear (*VB)* shall be compared with a base shear

(VB) calculated using a fundamental period *Ta*, Where *VB* is less than *VB'* all the response quantities (for example member forces, displacements, storey forces, storey shears and base reactions) shall be multiplied by *Va* / *Va'* .The value of damping for buildings maybe taken as 2 and 5 percent of the critical, for the purposes of dynamic analysis of steel and reinforced concrete buildings, respectively

II. INFILLS FRAME WITH OPENING

Area of opening, A_{op} is normalized with respect to area of infill panel, A_{infill} and the ratio is termed as opening percentage (%)



$$\text{Opening percentage (\%)} = \frac{\text{Area of openning } (A_{op})}{\text{Area of infill} (A_{infill})}$$

III. STRUCTURAL DETAIL

Type of structure	College building (G+5)
Zone	III
Foundation level to ground level	1 m
Floor to floor height	4 m
External wall	230 mm
Internal wall	230 mm

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Live load	2 kN/m^2
Material	M20 AND Fe415
Seismic analysis	EQUIVALENT STATIC METHOD (IS 1893 (Part I) - 2002)
Size of column	C1= 300mmX700mm, C2= 400mmX750mm
Size of beam	B1=300mmX500mm, B2=300mmX400mm
Depth of slab	150mm
Design philosophy	LIMIT STATE METHOD CONFORMING (IS 456-2000)
Ductile detailing code	**IS 13920-1993**

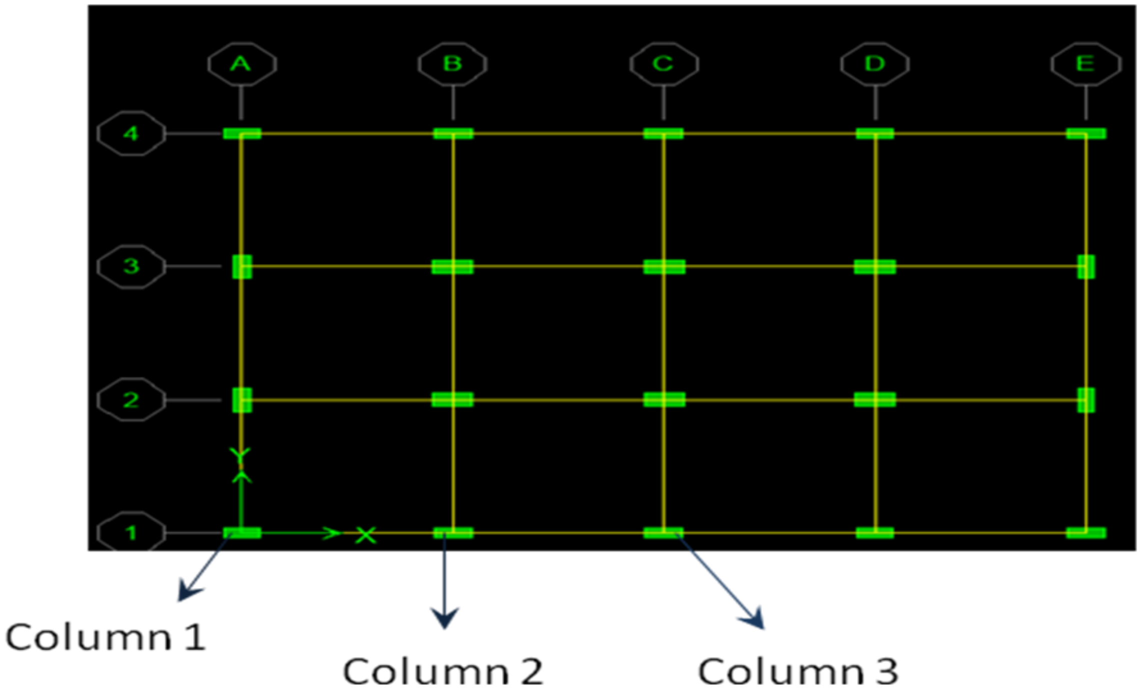

Figure.3.1 View of example building (Symmetric plan)

IV. CONCLUSION

4.1 For (G+5) building analyzed by Equivalent Static Method

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- The Maximum deflection in bare frame for (G+5) is 105.05mm and in strut frame it is minimum which 17.84mm at highest storey level. If the effect of infill wall is considered then the deflection has reduced drastically.
- The Maximum Deflection infilled frame for (G+5) with 15% centre opening is 21.05mm and 18.44mm in 15% corner opening. Thus the deflection in centre opening is more than the corner opening.
- In column, considering infill wall effect, the value of Axial force, bending moment ,AST is less compared to bare frame.
- Axial force in case of strut frame is 2159.40 KN and in Infilled Frame with 15% centre opening is 2217.03KN.because of infill wall effect, there is drastic decrease in the value of axial force in column.
- Due to reduction of axial force and bending moment there is drastic reduction in requirement of steel in fully infilled frame and infilled frame with 15% opening model.
- The increase in the opening percentage leads to a decrease on the lateral stiffness of infilled frame.
- It is found that stiffness increases in fully infilled frame compared to infilled frame with opening.

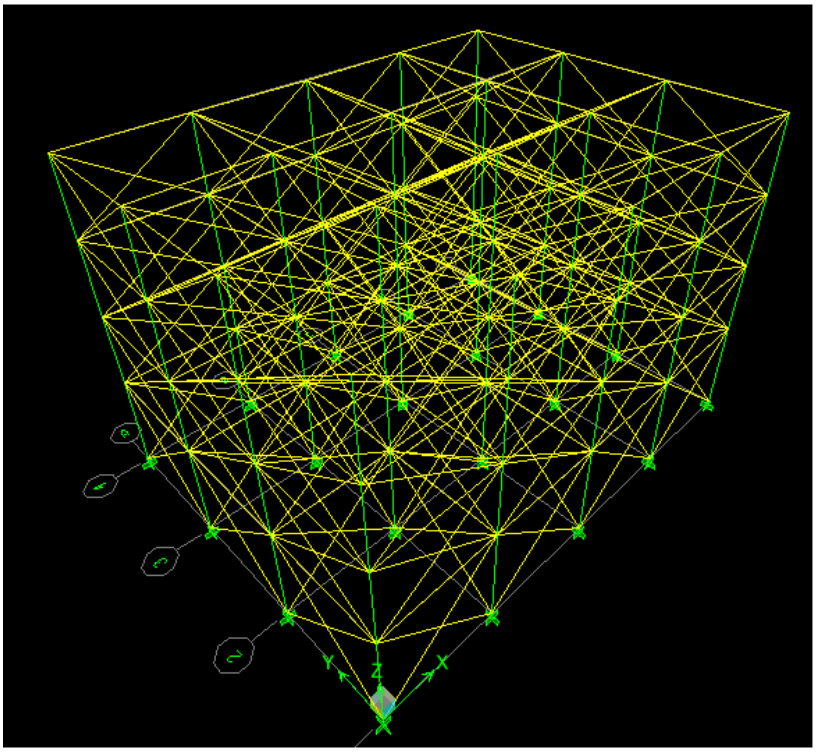

Figure 3.1: Sample 3D Model of buliding in ETABS

4.1 Conclusions for (G+5) building analyzed by Response Spectrum Method.

- The base shear of infilled frame is 1269.75 kN which is more than the base shear of bare frame i.e. 550.72 kN. Thus, the calculation shows that, when RC framed buildings having brick masonry infill on upper floor with soft ground floor is subjected to earthquake loading, base shear can be more than twice to that predicted by response spectrum method when no infill in the analysis model.

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- It is observed that frames with infill produce much smaller deflections as compared to frames without infill. The maximum displacement of fully infilled frame is 4.342 mm and that of bare frame is 10.324 mm.
- It is also observed that there is increase in the displacement of 15% centre and corner opening as compared to fully infilled frame.
- The maximum storey drift of bare frame is 6.237 mm, fully infilled frame is 7.808 mm, 15% centre opening is 7.777 mm and 15% corner opening is 7.8336 mm.

  Thus the storey drift of all the structural members are within the code prescribed limit of 0.004. Since the structure becomes stiffer with the decrease in height of structure. By increasing the opening percentage the storey drift also increases.
- The time period of bare frame is 1.6942 secs which is 51.59% more than fully infilled frame i.e. 0.8741 sec and it is also observed that the time period increases as there is increase in the opening size.
- By considering the infill wall the roof displacement of the structure reduces and the stiffness of the structure increases. The masonry infill wall is more significant in small structures as the height of the structure increases the effect of masonry infill wall reduces.
- In all the analyses, it is observed that the infill helps in the increase of ductility and the flexural strength of the members.
- Dynamic Analysis is more complicated than Equivalent Static Analysis, manually as well as by using software and it takes much time for the calculation of results.
- But it is also observed that Dynamic Analysis gives more accurate values than Equivalent Static Method, thus it is feasible to incorporate these values as they are more realistic.

REFERENCES

[1] Nikhil Agrawal, Prof.P.B.Kulkarni "Static Analysis of Masonry Infilled R.C.Frame With &Without Opening Including Soft Storey of Symmetric Building" in IOSR, Vol. 7, Issue 6 July-August 2013

[2] C V R MURTY And SUDHIR K.JAIN ,"BENEFICIAL INFLUENCE OF MASONRY INFILL WALLS ON SEISMIC PERFORMANCE OF RC FRAME BUILDINGS"

[3] Nikhil Agrawal, Pooja Raut, Prof.P.B.Kulkarni "Static Analysis of R.C.Frame With &Without Opening Including Soft Storey by using "Equivalent Diagonal Strut Method" in IJSRP, Vol. 3,Issue 9 August-September 2013

[4] A S Patil and P D Kumbhar, "TIME HISTORY ANALYSIS OF MULTISTORIEDRCC BUILDINGS FOR DIFFERENT SEISMIC INTENSITIES" 2013, Int. J. Struct. & Civil Engg. Res. 2013 , Vol. 2, No. 3, ISSN 2319 – 6009, August 2013

[5] Prof. P.B Kulkarni1, Pooja Raut2 , Nikhil Agrawal3 'LINEAR STATIC ANALYSIS OF MASONRY INFILLED R.C.FRAME WITH &WITHOUT OPENING INCLUDING OPEN GROUND STOREY' International Journal of Innovative Research in Science, Engineering and Technology Vol. 2, Issue 6, June 2013

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

[6] Seismic Analysis and Design of Vertically Irregular RC Building Frames"PG Conference 2015, Held at MAEER's MIT, Pune-411038, 24-25 April 2015

[7] Tushar Agrawal,Prof.P.B.Kulkarni, Nikhil Agrawal, "Review Paper on Structures of Blast Loading and Blast Effects on Structures."IJREST, Vol. 01 ,Issue 08, December 2015, International Journal of Research in Engineering, Science and Technologies

[8] Pooja Raut ,Nikhil Agrawal ,Prof.P.B.Kulkarni "Analysis of Masonry Infilled Frame With &Without Different Percentage Of Opening" in IJAERD, Vol. 01 ,Issue 08, August 2014, International Journal of civil Engineering

[9] Goutam Mondal and Sudhir K. Jain, M.EERI , "Lateral Stiffness of Masonry Infilled Reinforced Concrete (RC) Frames with Central Opening", Volume 24, No. 3, pages 701–723, August 2008; © 2008, Earthquake Engineering Research Institute.