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Seismic Performance of RC Frame Building with Different Position of Shear Wall

Bharath V B[1], Kuldeep Singh Solanki[1], Aashutosh Raj Yadav[2]

[1]Assistant Professor, [2]Student,
[1,2]Department of Civil Engineering, Pratap University. Jaipur, Rajasthan, India

ABSTRACT

An earthquake force is a very strange force and behaves quite differently than Gravity and Wind loads, striking the weakest spot in the whole three dimensional structure. It's not earthquake that kills, in fact ignorance in design and poor quality construction results in many weaknesses in the structure that cause serious damage to life and property. Masonry Infill are frequently used to fill the gap between the vertical and horizontal resisting elements of the building frames with the assumption that these in fills will not take part in resisting any kind of load either axial or lateral. Hence, its significance in the analysis is generally neglected by the designer. In fact, infill wall and shear wall considerably enhance the rigidity and strength of the frame structure. Various researches suggest that the bare frame has comparatively lesser stiffness and strength than the infill frame and frame with shear wall, therefore their ignorance cause failure of many multistorey buildings when subjected to seismic loads. In the present study, the finite element analysis of RC frame models viz. a bare frame; a frame with shear wall considering infill; a bare frame with shear wall has been carried out and the number of storeys vary as G+3, G+5, G+7 and G+9. Linear analysis of all RC frame structures has been performed as per IS: 1893 (Part 1) - 2002 and IS: 456 - 2000. In this study only in-plane stiffness of masonry wall has been considered and infill panels modelled as equivalent diagonal strut elements. The behaviour of buildings subjected to Gravity and Seismic loads with the help of Response Spectrum Analysis using FEM based software and the effect on Time Period, Mass Participation factor, and Storey Drift has been observed. Strength and Rigidity of RC bare frame structures is found increasing after the inclusion of infill panels and shear wall.

KEYWORDS: *earthquake, Seismic, load, gravity, strenght, wall, FEM, RC Frame and structure*

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1. INTRODUCTION

1.1. GENERAL

Earthquake is one of the most scaring and causing phenomena of the nature and its very bad after-effects. Every year several million earthquakes occur on the earth. Many of these are of very small intensity and do not cause any harm. Still, earthquakes of maximum intensity in the surrounding of populated areas cause extent damage and loss of life. Much of the existing buildings in India and worldwide consists of structures designed without the we have to design the buildings according to the current seismic design procedures and, therefore, are vulnerable to damage during a seismic event.

1.2. IMPORTANCE OF THE STUDY

In the world structural system the unreinforced masonry contains a large number of Reinforced concrete and steel frame buildings. Unreinforced brickwork (masonry) is broadlyused in seismically energetic (active) places, specially as infill walls affecting both the structural and non-structural performance of buildings. Many buildings of this type have given very bad results during earthquakes. The Kircher (2006) suggested that concrete frames, including with and without infill, represent three major sources of seismic hazard in the earthquake prostrate zone. Because approximately 80% of the cost of damages of structures from earthquake.

a) Infill Compression and Shear Damages

b) Infill compression damages and Minor frame and minor frame

Fig: Partial collapse of RC frame building with masonry infill walls in Yingxiu during Wenchuan earthquake.

1.3. Objectives of the Study
The present thesis work is aimed at evaluating hypothetical existing RC framed building with the following objectives:
- Generation of 3D building model for both elastic and inelastic method of analyses.
- To study the effect of vertical irregularity on the fundamental natural period of the building and its effect on performance of the structure during earthquake for different building models selected.

1.4. Methodology
In the present study, using ETABS the masonry infill members and the reinforced concrete members both are modelled. The analytical macro models are modelled and analysed using ETABS software package for linear analysis. Equivalent static and response spectrum method in linear analysis are adopted for the analysis of seismic performance of RC frame building with different positions of shear wall and the methods are compared. Seismic forces are considered to act in one direction. Time period, base shear and the responses like storey drift and displacement are identified. Scope of the Study

1.5. Scope of the study
The scope of the present study pertaining to building and loading, modeling and analysis method, and different parametric studies are as follows:

A. Building and Loading
- The study is carried out by considering a RC frame office building resting on isolated

B. Modeling and Analysis Method
- 3D modeling for analyses using ETABS.
- Along the positive orthogonal directions the building models are pushed.
- The building is analyzed by Equivalent static method as well as Response Spectrum method.

C. Parametric Studies
- When the seismic forces are subjected, that effect the infill masonry on the overall behavior of the structure.
- When the seismic forces are subjected, that effects of concrete corewall on the overall behaviour of the structure.

1.6. Scheme of Presentation
The report is organized into seven chapters, each dealing with Seismic behaviour infilled frame and infilled frame with shear wall and infilled frame with core wall .

2. LITERATURE REVIEW
2.1. General
Research works and studies experiments has been taken up since a long time all over the globe to understand or to evaluate the effect of seismic forces on existing RC building. On studying modeling and analysis techniques which is used for this purpose has also been getting improved with advancement of engineering and technology as well as with past experience.

2.2. Review of Literature
A work to study the effect of infill patterns [Arlekar et al, 2002][2] was carried out by performing linear elastic analysis on the building using ETABS analysis package. For this purpose a four storeyed reinforced concrete used, in this case of unreinforced brick and open first storey for moment resisting, the upper story has chosen. The building consisted of five bays in the horizantal direction and three bays in the longitudinal direction. Nine building models with different infill patterns were analyzed.

3. MODELLING OF STRUCTURE
3.1. Introduction
ETABS (2013) version 13.1.1. software packages from Computers and Structures, for member analysis and design patterns. Every packages are fully integrated system for modeling, analysing, designing, and optimizing structures of a particular type. In the present study, modeling of Infilled frame and the linear elastic analysis is carried out using the software ETABS

3.2. ETABS (V 13.1.1, 2013)
It is powerful software developed by Computers and Structures Inc, which can greatly enhance an engineer's design and analysis capabilities for members. Part of that power lies in an array of options and features. How simple it is to use is explained in the other part. In the program the basic approach is straight forward. The user invented define materials, structural properties and grid lines. All types of loads that the structure is subjected to, can be defined and assigned to the appropriate structural components. Dynamic analysis properties like mass source, total number of mode shapes and its directions can be defined. The following topics describe some of the important areas in the modelling.

3.2.1. Defining Material Properties
In the property name of material, data area, weight per unit volume, mass per unit volume, Poisson's ratio, modulus of elasticity should be specified for each type of material defined. The calculation of self-mass, mass per unit volume is used in the structure. To calculate the self weight of the structure we use weight per unit volume.

3.2.2. Defining Wall and Slab Sections

In ETABS, While defining the type of slab and wall section, on there behaviour, there are three options available, namely member type, plate type and shell type behaviour. Shell type behaviour means, The plate bending stiffness can provided in both out-plane membrane stiffness and in-of plane member stiffness. Membrane type behaviour mean, only in-plane covering stiffness is provided for the division. Plate type behaviour means, that only out-of-plane bending stiffness is allowed for the section.

3.2.3. Defining Frame Sections

Frame sections like beams, columns and diagonal struts are defined under this. In the present work the infill walls are modelled as diagonal struts and its width is calculated from the equation proposed by Mainstone (1971). The thickness of the strut and its material property is same as that of the masonry wall. Hinges were introduced (i.e. end moments were released) near the connecting ends of the strut.

3.2.4. Defining Diaphragms

In order to account for the in-plane rigidity of the structure, slab sections are modelled as rigid diaphragms by using the 'rigid diaphragm' option in the assign menu. By modeling the slabs as rigid diaphragms, the masses of the floors are automatically lumped at their centre of gravity (i.e. mass centre). However, for the buildings of irregular configuration (i.e. L-type, C-type, Y-type, narrow buildings etc.) slabs sections are modeled as 'semirigid diaphragms'.

3.2.5. Defining Loads

Dead load, live load, roof live load and seismic loading for the equivalent static analysis can be defined under the 'static load case'. The combinations of various load can be defined in the 'load combinations' option of the define menu.

3.2.6. Mass Source

In seismic analysis, mass of the structure is considered rather than the weight. In ETABS, by default it assumes self-mass of the structure as mass for the seismic analysis. To assign the correct mass, check the option from loads and add type of loads and its coefficients in the drop down menu. For example in the mass source obtained from the load combination DL+0.25LL according to IS 1893 (part1) -2002.

4. SYSMIC ANALYSIS METHOLOGIST

4.1. General

There are different methods available for the analysis of framed structures subjected to earthquake loads.

The methods of analysis can be broadly classified into the following types.

1. Linear Static Method (Equivalent Static Method)
2. Linear Dynamic method (Response Spectrum and Linear Time History Method)
3. Non-Linear Static Method (Pushover Analysis)
4. Non-Linear Dynamic Method (Non-linear Time History Analysis) In linear static method,

4.2. Equivalent Static Method

In the equivalent static method the force depends upon the code based fundamental period of structures because it is simplest method for analysis with some empirical modifiers. As the whole design base shear is to be computed , and then distributed the stiffness and mass for a building based on the some appropriate simple formulae along the height of the building.

4.3. Response Spectrum Method of Analysis

In order to carry out the seismic analysis and design of a construction to be built at a meticulous location, It required the actual time history record. However, we cant records at each and every place. Further, the seismic analysis of constructions cannot be passed out simply based on the maximum value of the ground increase of velocity as the response of the structure based upon the frequency substance of ground motion and its own dynamic properties. To beat the above difficulties, earthquake reaction spectrum is the a large amount popular tool in the seismic analysis of constructions.

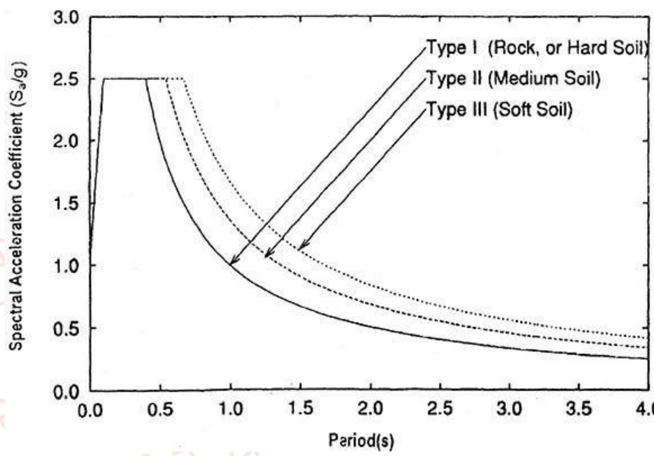


Fig. Design spectrum as per IS:1893-2002

4.3.1. Modes to be considered

The code IS 1893(Part 1): 2002 suggests that for all the modes total modal masses analysis by using the number of modes to be considered is at least 90% of the total seismic mass. If the lower frequency is considered more than 10% than the natural frequency when the modes are considered as closely spaced. The peak response quantities used by combining both such as square root of sum of square method as well as complete quadratic combination of scheme to be used for the methods which are not locked-space. If there were few closely-spaced modes, thus it considered the use of sum of absolute values (ABS) method and rest of the modes could be combined using CQC method.

5. ANALYTICAL MODELLING

5.1. Introduction

Most building codes prescribe the method of analysis based on whether the building is regular or irregular. Almost all the codes suggest the use of static analysis for symmetric and selected class of regular buildings. For buildings with irregular configurations, the codes suggest the use of dynamic analysis procedures such as response spectrum method or time history analysis.

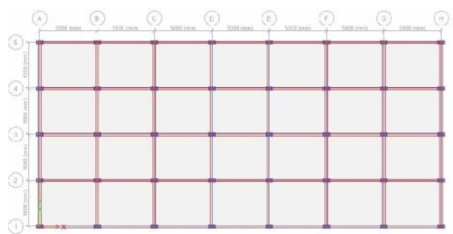


Figure: Plan layout of model (G+7)

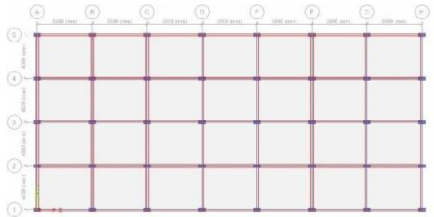


Figure: Plan layout of model (G+15)

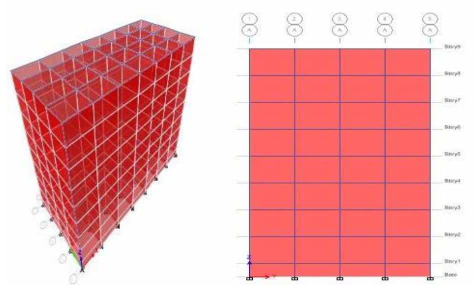


Figure-3D view and elevation of eight storeyed building

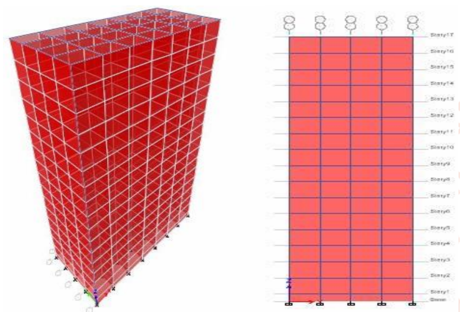


Figure:3D view and elevation of sixteen storeyed building

5.2. Example Buildings

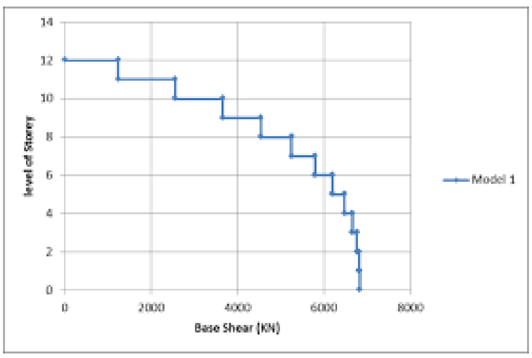
The building studies that, the plan layout of eight storey and sixteen storey building of the RC moment resisting frame. The bottom storey height is kept 1.5 m and a typical height of 3.5m is kept for all the upper storeys in both the buildings. The building is considered to be located in the seismic zone V. In the seismic weight calculations only 50% of the floor live load is considered

5.3. Performed Analysis in ETABS

The analysis and design of the building is carried out using ETABS computer program. The some of the important topics are discussed below in the modeling.

Defining of the wall and slab sections:

In the present analysis all the walls and slab are given membrane type behavior to provide in plane stiffness. The slab sections are modeled as rigid diaphragms by using the rigid diaphragm option in the assign menu. By modeling the slab as rigid



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6.1. Introduction

The structure is analyzed as per Indian standards, for the load combination and seismic loads IS-1893-2002(PART1), about Seismic zone = V zone, Importance factor = 1, Soil type = II, Live load = 3.5KN/m^2 and design is considered as per IS-456-2000. For the full dead load and 50% of live (Imposed) load constitute the seismic weight.

6.2. Natural Periods

The codal (IS 1893-2002) and natural periods of the building models in horizontal and vertical direction are shown in tables-6.1 and 6.2. From tables codal and modal analysis is obtained by the time periods, they do not agree where the percentage difference of the fundamental time periods between the modal method and codal methods is maximum for model-2 along longitudinal & transverse direction for eight story models and for sixteen storyed building model 2 and for model 1 buildings.

6.3. Base Shear (KN) and Displacement (mm) at Yield Point

Base shear and displacement for eight and sixteen storey models along transverse and longitudinal directions

6.4. Lateral Displacements

With respect to the ground the maximum lateral displacements for every floor level discussed in the below Tables-6.4.1 to 6.4.15 for Response spectrum and Equivalent static method. For better comparability the lateral displacement for every models along the both ways of ground motion are designed in the graphs

6.5. Storey Drifts

The premissible storey drift is limited to 0.004 times of the storey height, so that, during earthquake minimum damage would be considered and fake less psychological horror(fear) in the brains of public.

7. Summary

The present work attempts to study the seismic response RC buildings located in seismic zone-V. In this study all important components of the building that influence the mass, strength and stiffness of the structure are included in the analytical model. The study leads to the following conclusions.

7.1. Conclusions

A. Fundamental natural period decreases when effect of infill wall and concrete core wall is considered.
B. As per specified by code, the Storey drifts are found within the permissible limit (IS 1893-2002 Part-1).
C. The shear wall is efficient and result in the high rise

structure.

D. The provision of shear wall it has a lateral stiffness has a more significant than the lateral strength in taller buildings.
E. The frame with masonry infill exhibited both strength and stiffness but when the frame is considered without shear wall.

7.2. Scope For Future Study

Further studies can be done on high rise buildings (sky-scrapers) by providing shear walls at the corners. By conducting further studies we can provide shear wall at the ground storey and also dual system, its also consists of shear and moment resisting frame so that both systems are designed, at all the floor levels by considering the lateral stiffness of dual system which resist the total design force. To design moment resisting frames independently we may resist at least 25% of design seismic base shear.

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