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Seismic analysis of RC regular and irregular frame structures

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Abstract - ***Reinforced concrete multi storey buildings are subjected to most dangerous earthquakes. It was found that main reason for failure of RC building is irregularity in its plan dimension and its lateral force resisting system. In this paper an analytical study is made to find response of different regular and irregular structures located in severe zone V. Analysis has been made by taking 15 storey building by static and dynamic methods using ETABS 2013 and IS code 1893-2002 (part1). Linear Equivalent Static analysis is performed for regular buildings up to 90m height in zone I and II, Dynamic Analysis should be performed for regular and irregular buildings in zone IV and V. Dynamic Analysis can take the form of a dynamic Time History Analysis or a linear Response Spectrum Analysis. Behavior of structures will be found by comparing responses in the form of storey displacement for regular and irregular structures. Different type of analysis methods such as equivalent static method and response spectrum method are adopted in order to study the storey displacement. Pushover curve is obtained, the main objective to perform this analysis is to find displacement vs. base shear graph and also time history analysis will be carried out taking BHUJ earthquake. In this present work two types of structures considered are reinforced concrete regular and irregular 15 storey buildings and are analyzed by static and dynamic methods. For time history analysis past earthquake ground motion record is taken to study response of all the structures. Presently there are six models. One is of regular structure and remaining are irregular structural models. This paper shows that behavior irregular structures as compared to regular structure***

Key Words: *RC building, regular, irregular, equivalent static, response spectrum, pushover, time history, ETABS 2013, IS 1893-2002 and BHUJ earthquake etc…*

1. INTRODUCTION

In actual practice, the structures will usually be built in having one of the irregularities i.e. stiffness, diaphragm, mass, re-entrant corner, and torsion irregularity. In the multistory buildings damages due to earthquake are usually at the weak points. This weakness is due to strength, variation in stiffness etc. So if a structure can perform well in earthquake means it should possess adequate strength, stiffness, ductility and simple configuration. Therefore these types of structures should be well designed under earthquake loading accounting the specified seismic design philosophies so that they can sustain moderate to strong earthquakes. The structures are analyzed by using methods Equivalent static method of analysis and Dynamic method of analysis. The dynamic analysis method can be performed by Time history method and Response spectrum method. And also nonlinear static analysis i.e. pushover analysis is also carried out.

In this present work two types of structures considered are reinforced concrete regular and irregular multistory buildings. Here 15 storey buildings are analyzed by above methods by using IS 1893-2002 (part1).

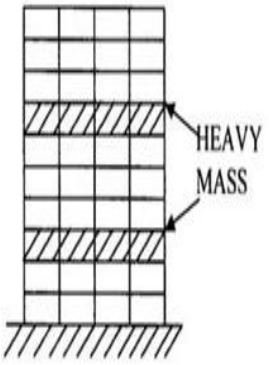

Fig -1: Mass irregularity

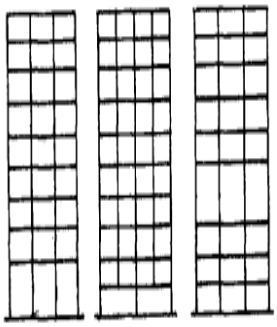

Fig -2: Stiffness irregularity

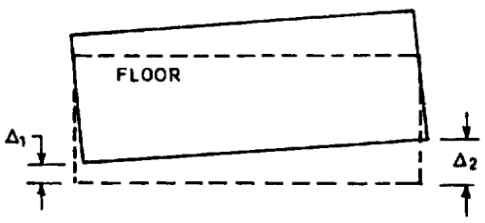

Fig -3: Torsion irregularity

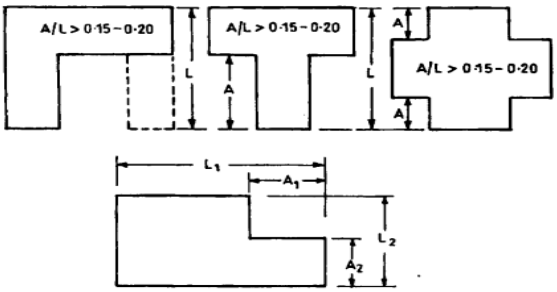

Fig -4: Re-entrant corner irregularity

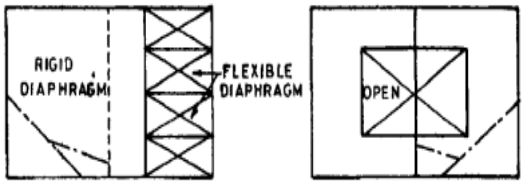

Fig -5: Diaphragm irregularity

2. METHODS OF ANALYSIS OF STRUCTURE

The seismic analysis should be carried out for the buildings that have lack of resistance to earthquake forces. Seismic analysis will consider dynamic effects hence the exact analysis sometimes become complex. However for simple regular structures equivalent linear static analysis is sufficient one. This type of analysis will be carried out for regular and low rise buildings and this method will give good results for this type of buildings. Dynamic analysis will be carried out for the building as specified by code IS 1893-2002 (part1). Dynamic analysis will be carried out either by Response spectrum method or site specific Time history method. Following methods are adopted to carry out the analysis procedure.

1.1 Equivalent static analysis

The seismic design of buildings fallows the dynamic nature of the load. But equivalent static analysis would become sufficient for simpler, regular in plan configuration and it will give more efficient results. This analysis will flow in a manner with the calculation of design base shear and its distribution to all storey's by using the formula as given in code.

1.2 Response spectrum method

The representation of maximum response of idealized single degree freedom system having certain period and damping, during earthquake ground motions. This analysis is carried out according to the code IS 1893-2002 (part1). Here type of soil, seismic zone factor should be entered from IS 1893-2002(part1). The standard response spectra for type of soil considered is applied to building for the analysis in ETABS 2013 software. Following diagram shows the standard response spectrum for medium soil type and that can be given in the form of time period versus spectral acceleration coefficient (Sa/g).

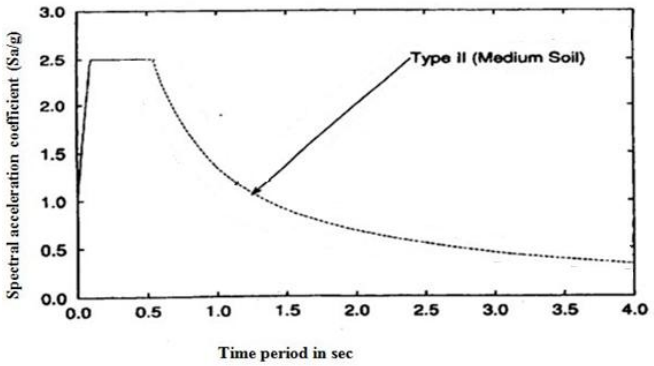

Fig -6: Response spectrum for medium soil type for 5% damping

1.3 Time history analysis

In this analysis dynamic response of the building will be calculated at each time intervals. This analysis can be carried out by taking recorded ground motion data from past earthquake database. This analysis overcomes all disadvantages of response spectrum analysis if there is no involvement of nonlinear behavior. Hence this method requires greater efforts in calculating response of buildings in discrete time intervals. In this project work BHUJ earthquake of magnitude 7.7 with ground acceleration 0.106g is taken for the time history analysis.

1.4 Pushover analysis

This is a performance based analysis and has aim in controlling the structural damage. In this analysis several built in hinge properties are included from FEMA 356 for concrete members. This analysis will be carried out by using nonlinear software ETABS 2013. This software is able to predict the displacement level and corresponding base shear where first yield of structure occurs. The main objective to perform this analysis is to find displacement vs. base shear graph.

3. DETAILS OF THE MODELS

The buildings that are considered for the analysis have been modeled in ETABS 2013 software. Here buildings with regular and irregular configuration having 15 storey are modeled in ETABS 2013.

For the present work, (G+15) storey building with storey height 3 meter for all, with plan 16mx16m is taken. Building has five bays of 4m in both X and Y directions. For irregular buildings the modeling has been made according to IS code. Details of the Building are given in table-1 below.

Table -1: Building Description

Particulars	Reinforced concrete building
Plan dimension	16mX16m
Height of buildings considered	30m,45m
Grade of steel	Fe415
Grade of concrete	M25
No. of storey	10,15
Beam size	300mmX600mm
Column size	500mmX500mm
Soil type	Medium(II)
Seismic zone	V

All the six models are modeled in ETABS 2013. Irregular models are created in ETABS 2013 software according to the codal provisions.

3.1 Building models

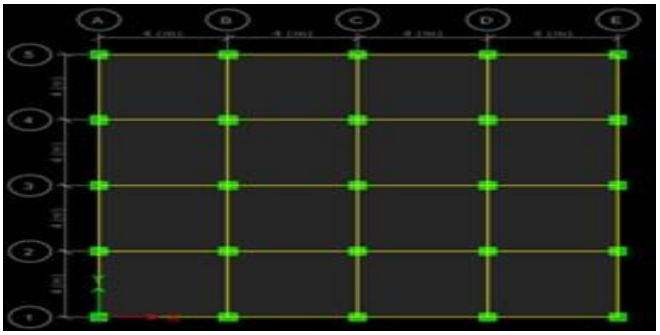

Fig -7: Model of 15 storey regular building

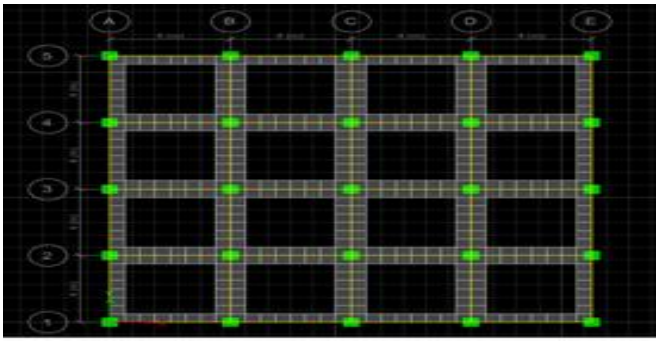

Fig -8: Model of 15 storey Diaphragm irregular building

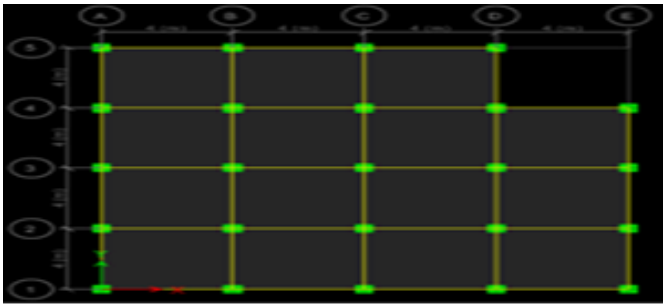

Fig -9: Model of 15 storey Re-entrant corner irregular building

Live load on all the structures is taken as 3 KN/M^2 on floor levels and roof level 1.5 KN/M^2. And slab thickness as 150mm. stiffness irregularity is created by rising bottom storey height to 6m with respect to regular building. Mass irregularity and torsion irregularity are created according to the procedure given in IS code.

4. RESULTS

1) From equivalent static analysis storey displacement for all structural models are obtained from ETABS 2013 and the results are graphically presented below

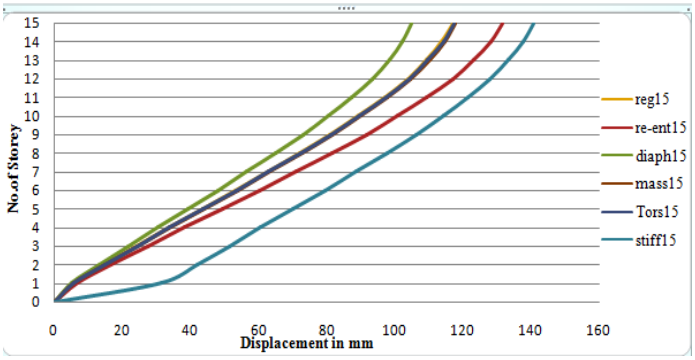

Chart -1: Storey displacement due to EQ load for 15 storey

2) From response spectrum analysis storey displacement for all regular and five different irregular structures are obtained.

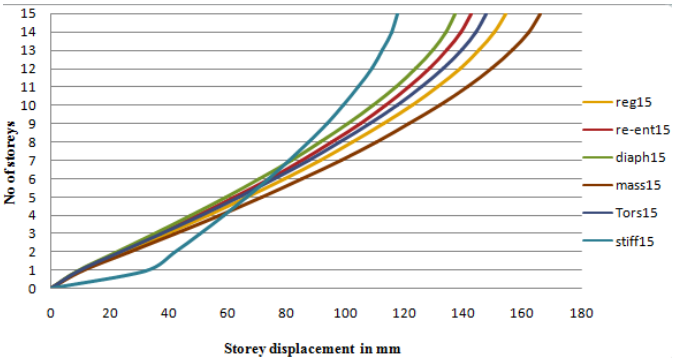

Chart -2: Storey displacement for 15 storey building using response spectrum method

3) From pushover analysis displacement vs. base shear graph is obtained.

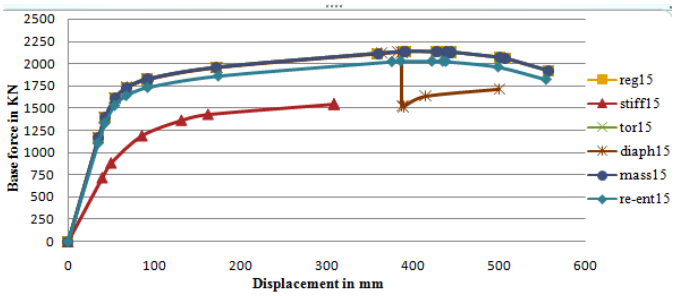

Chart -3: Displacement vs. base shear for 15 storey building using pushover analysis

3) Time history analysis has been carried out taking BHUJ earthquake and behavior of all the structural models are recorded in the form of time period vs. base force.

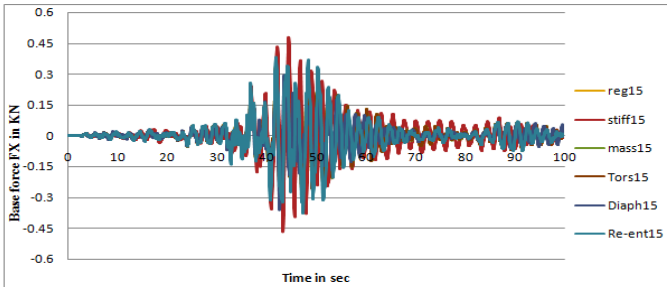

Chart -4: Time period vs. base force for 15 storey building using time history analysis

5. CONCLUSIONS

1) The results obtained from static analysis method show lesser storey displacement values as compared to response spectrum analysis. This variation may be due to nonlinear distribution of force.

2) In diaphragm irregularity, storey displacement and storey drift found to be less as compared to regular structures in both static and response spectrum method
.

3) As seen from pushover curve, stiffness irregularity shows nonlinear behavior at earlier stage as compared to all other structures. Therefore earthquake is more enhanced in stiffness irregularity structure.

4) From time history analysis it was found that for 15 storey stiffness irregularity shows least base force as compared to all other structures

So in overall it can be concluded that structure built-in with stiffness irregularity will be on non conservative side and as seen from time history analysis, as storey increases behavior of stiffness irregularity and diaphragm irregularity becomes reverse.

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BIOGRAPHIES

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