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Review Paper Seismic Analysis of High - Rise Building by Response Spectrum Method

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Abstract: *Reinforced Concrete Frames are the most commonly adopted buildings construction practices in India. With growing economy, urbanization and unavailability of horizontal space increasing cost of land and need for agricultural land, high-rise sprawling structures have become highly preferable in Indian buildings scenario, especially in urban. With high-rise structures, not only the building has to take up gravity loads, but as well as lateral forces. Many important Indian cities fall under high risk seismic zones, hence strengthening of buildings for lateral forces is a prerequisite. In this study the aim is to analyze the response of a high-rise structure to ground motion using Response Spectrum Analysis. Different models, that is, bare frame, brace frame and shear wall frame areconsidered in Staad-Pro. and change in the time period, stiffness, base shear, storey drifts and top-storey deflection of the building is observed and compared.*

Keywords: Reinforced Concrete Frames

I. INTRODUCTION

Earthquake has always been a threat to human civilization from the day of its existence, devastating human lives, property and man-made structures. The very recent earthquake that we faced in our neighbouring country Nepal has again shown nature's fury, causing such a massive destruction to the country and its people. It is such an unpredictable calamity that it is very necessary for survival to ensure the strength of the structures against seismic forces. Therefore there is continuous research work going on around the globe, revolving around development of new and better techniques that can be incorporated in structures for better seismic performance. Obviously, buildings designed with special techniques to resist damages during seismic activity have much higher cost of construction than normal buildings, but for safety against failures under seismic forces it is a prerequisite.

Earthquake causes random ground motions, in all possible directions emanating from the epicentre. Vertical ground motions are rare, but an earthquake is always accompanied with horizontal ground shaking. The ground vibration causes the structures resting on the ground to vibrate, developing inertial forces in the structure. As the earthquake changes directions, it can cause reversal of stresses in the structural components, that is, tension may change to compression and compression ma change to tension. Earthquake can cause generation of high stresses, which can lead to yielding of structures and large deformations, rendering the structure non-functional and unserviceable. There can be large storey drift in the building, making the building unsafe for the occupants to continue living there.

Reinforced Concrete frames are the most common construction practices in India, with increasing numbers of high-rise structures adding up to the landscape. There are many important Indian cities that fall in highly active seismic zones. Such high-rise structures, constructed especially in highly prone seismic zones, should be analyzed and designed for ductility and should be designed with extra lateral stiffening system to improve their seismic performance and reduce damages. Two ofthe most commonly used lateral stiffening systems that can be used in buildings to keep the deflections under limits are bracing system and shear walls The use of steel bracing system is a viable option for retrofitting a reinforced concrete frame for improved seismic performances. Steel braces provide required strength and stiffness, takes up less space, easy to handle during construction, can also be used as architectural element and is economic. Steel

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braces are effective as they take up axial stresses and due to their stiffness, reducedeflection along the direction of their orientation.

Fig.1 RC building with exterior bracing system as lateral stiffener [1]

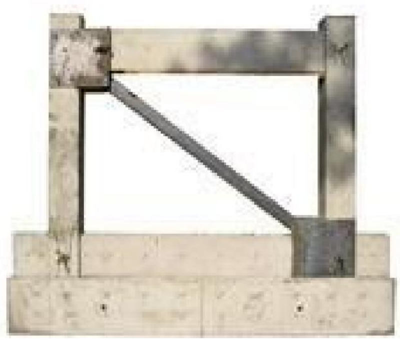

Fig.2 Connection of steel brace to concrete member [2]

Shear wall is a vertical member that can resist lateral forces directed along its orientation. Shear walls are structural system consisting of braced panels, also known as Shear Panels. Concrete Shear walls are widespread in many earthquake-prone countries like Canada,
Turkey, Romania, Colombia, Russia. It has been in practice since 1960's, used in buildings ranging from medium- to high-rise structures. Shear walls should always be placed symmetricallyin the structure and on each floor, including the basement. Reinforced concrete Shear walls transfer seismic forces to foundation and provide strength and stiffness

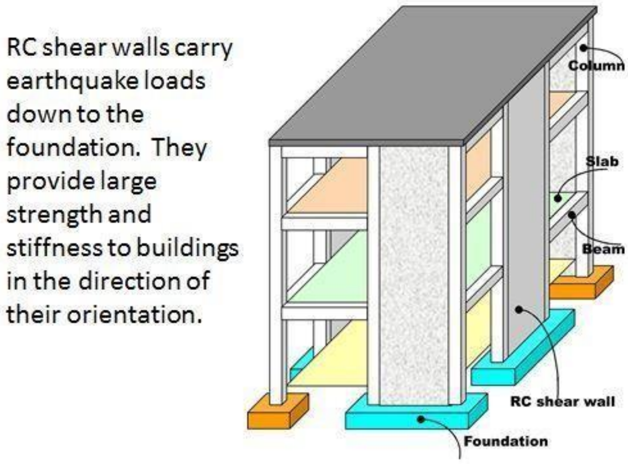

Figure 3: Building showing a Shear Wall [3]

1.1 Objective:

The objectives of present work are as follows:

1. To analyze the building with different ground motions, namely, IS code compatible ground motion, Imperial Valley ground motion and San Francisco ground motion.
2. To perform dynamic analysis of the building using response spectrum method.
3. To model building with different lateral stiffness systems and study the change in response of the building
4. To compare and get a better and efficient lateral stiffness system

1.2 Scope of Project

1. This study concerns analysis of reinforced concrete moment resisting open frame, open frame with braces and open frame with shear walls only, using Staad Pro program. The effect of brick infill is ignored.
2. This study involves a theoretical 12 storey building with normal floor loading and no in fill walls.
3. The comparison of fundamental period, base shear, inter-storey drift and top-storey deflection is done by using Response Spectrum analysis, which is a linear elastic analysis

II. LITERATURE REVIEW

Chandurkar, Pajgade (2013) evaluated the response of a 10 storey building with seismic shear wall using ETAB v 9.5. Main focus was to compare the change in response by changing the location of shear wall in the multi-storey building. Four models were studied- one being a bare frame structural system and rest three were of dual type structural system. The results were excellent for shear wall in short span at corners. Larger dimension of shear wall was found to be ineffective in 10 or below 10 stories. Shear wall is an effective and economical option for high- rise structures. It was observed that changing positions of shear wall was found to attract forces, hence proper positioning of shear wall is vital. Major amount of horizontal forces were taken by shear wall when the dimension is large. It was also observed that shear walls at substantial locations reduced displacements due to earthquake.

Viswanath K.G (2010) investigated the seismic performance of reinforced concrete buildings using concentric steel bracing. Analysis of a four, eight, twelve and sixteen storied building in seismic zone IV was done using Staad Pro software, as per IS 1893: 2002 (Part-I). The bracing was provided for peripheral columns, and the effectiveness of steel bracing distribution along the height of the building, on the seismic performance of the building was studied. It was found that lateral displacements of the buildings reduced after using X-type bracings. Steel bracings were found to reduce flexure and shear demand on the beams and columns and transfer lateral load byaxial load mechanism. Building frames with X- type bracing were found to have minimum bending as compared to other types of bracing. Steel bracing system was found to be a better alternative for seismic retrofitting as they do not increase the total weight of the building significantly.

Chavan, Jadhav (2014) studied seismic analysis of reinforced concrete with different bracing arrangements by equivalent static method using Staad Pro. software. The arrangements considered were diagonal, V-type, inverted V-type and X-type. It was observed that lateral displacement reduced by 50% to 60% and maximum displacement reduced by using X-type bracing. Base shear of the building was also found to increase from the bare frame, by use of X-type bracing, indicating increase in stiffness.

Esmaili et al. (2008) studied the structural aspect of a 56 stories high tower, located in a high seismic zone in Tehran. Seismic evaluation of the building was done by non-linear dynamic analysis. The existing building had main walls and its side walls as shear walls, connected to the main wall by coupling of beams. The conclusion was to consider the time-dependency of concrete. Steel bracing system should be provided for energy absorption for ductility, but axial load can have adverse effect on their performance. It is both conceptually and economically unacceptable to use shear wall as both gravity and bracing system. Confinement of concrete in shear walls is good option for providing ductility and stability.

Akbari et al. (2015) assessed seismic vulnerability of steel X-braced and chevron-braced Reinforced Concrete by developing analytical fragility curve. Investigation of various parameters like height of the frame, the p-delta effect and the fraction of base shear for the bracing system was done. For a specific designed base shear, steel-braced RC dual systems have low damage probability and larger capacity than unbraced system. Combination of stronger bracing and weaker frame reduces the damage probability on the entire system. Irrespective of height of the frame, Chevron braces are more effective than X-type bracing. In case of X-type bracing system, it is better to distribute base shear evenly between the braces and the RC frame, whereas in case of Chevron braced system it is appropriate to allocate higher value of share of base shear to the braces. Including p-delta effect increases damage probability by 20% for shorter dual system and by 100% for taller dual systems. The p-delta effect is more dominant for smaller PGA values.

Kappos, Manafpour (2000) presented new methodology for seismic design of RC building based on feasible partial inelastic model of the structure and performance criteria for two distinct limit states. The procedure is developed in a format that can be incorporated in design codes like Eurocode 8. Time-History (Non-linear dynamic) analysis and

Pushover analysis (Non-linear Static analysis) were explored. The adopted method showed better seismic performance than standard code procedure, at least in case of regular RC frame building. It was found that behaviour under "life-safety" was easier to control than under serviceability earthquake because of the adoption of performance criteria involving ductility requirements of members for "life-safety" earthquake.

III. METHODOLOGY

3.1 Literature Review

To gather various types of work on seismic analysis of high-rise structures and increasing lateral stiffness of thesystem various papers, thesis and research articles were tudied thoroughly and referred. The idea behind doing literature review was to collect data and have understanding on different methods anapproaches that can be used, to clear understand the software requirement of the project. Literature review was done to have a thorough guidelines during the entire project work.

3.2 Data Collection

Various Indian standard codes were collected from the department of civil engineering Agce satara The earthquake data' s were obtained from the site Peer.berkeley.edu. The earthquakes considered in this work are time history of ground motion as per IS 1893:2002 (Part-I), Imperial Valley and San Francisc

3.3 Methodology Adopted

As discussed in the scope of the work, the entire work is divided into three parts: Analysis of bare frame in all the above three mentioned ground motions Analysis of the braced frames. For Analysis of the frame with shear wall. For analysis a 12stories high building is modeled in Staad Pro as a space frame. The building is does not represent any real existing building. The building is unsymmetrical with the span more along Z direction than along X direction. The building rises up to 42m along Y direction and spans 15m along X direction and 20 m. along Z direction .The building is analyzed by Response Spectrum Analysis, which is a linear dynamic analysis. Dynamic Analysis is adopted since it gives better results than static analysis. The specification of the frame are given in Table 1 and the plan and the model of the building is shown in

Specifications	Data
Storey Height	3.5m
No. of bays along X direction	3
No. of bays along X direction	4
Bay Length along X direction	5m
Bay Length along Z direction	5m
Concrete grade used	M 30
Columns	0.45m X 0.25m
Longitudinal Beams	0.40m X 0.25m
Transverse Beams	0.35m X 0.25m
Slab Thickness	0.1m
Unit Weight of Concrete	25 kN/m3
Live Load	3.5 kN/m3
Zone	IV
Soil Conditions	Hard Soil
Damping Ratio	5%

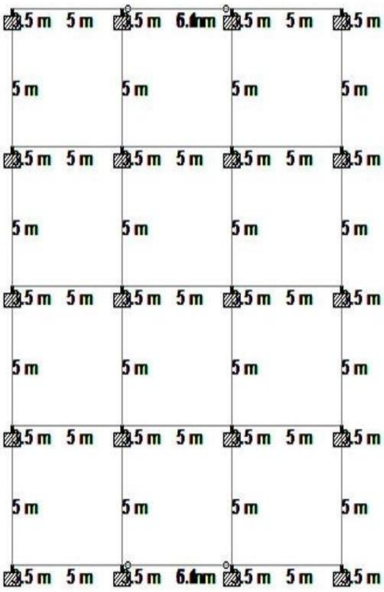

Fig. 4 Plan of the building

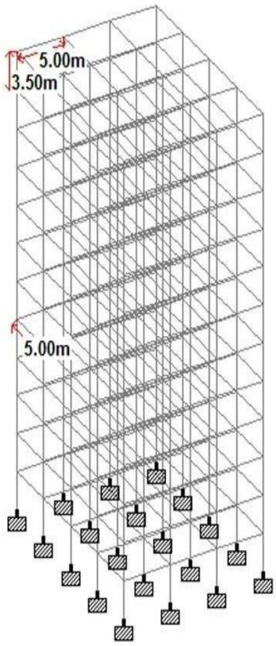

Fig. 5 Model of the building

3.4 Response Spectrum Analysis

Response Spectrum is a linear dynamic analysis. Response spectrum is a plot of the maximum response of a SDOF system to a ground motion versus time period. It is derived from time history analysis of ground motion by taking the maximum response for each time period. The time periods of the bare frame up to 12th mode calculated from MATLAB program is So, by IS code time period of the bare frame =

1.237 s In Staad Pro, Response Spectrum Analysis is done as follows:

1. After preparing the bare model, seismic definition for IS 1893-2002 was created by giving the required input of time period, zone factor, R factor, etc. Then under seismic definition self-weight and floor weights of 2.5kN/m2 and 3.5 kN/m2 were given.
2. Under Load Definition Earthquake load, Dead load, Live load and various load combinations were created.
3. Under Earthquake load, after assigning self-weight, floor load and live load in X, Y and Z directions, Response Spectra was defined. For Indian Code compatible earthquake already defined IS 1893-2002 is chosen. For Imperial Valley Earthquake and San Francisco Earthquake the response spectrum values are entered. Acceleration values for the corresponding time periods of the building for Imperial Earthquake and San Francisco earthquake has been taken by multiplying 9.81* Sa/g of their respective response spectrum. The Sa/g is the response spectrum values that were taken from the results of MATLAB progra for generating Response Spectrum from time history of ground motion of the earthquake considered. The time period and their corresponding
4. The load combinations that were considered were according to IS 1893-2002 (Part-l and are as follows:

1.5(DL+LL)
1.2 (DL+ LL+EL)
1.2 (DL+ LL-EL)
1.5 (DL+EL)
1.5 (DL-EL) 0.9DL + 1.5 EL 0.9DL -1.5 EL

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