STUDY ON CONVENTIONAL, SHEAR WALL AND HYBRID STRUCTURES IN DIFFERENT ZONES

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Abstract - *The rise in the demand and complexities of architectural aesthetics, conventional RC structures can no longer suffice. In the seismic design of buildings RC structural walls act as major earthquake resisting members. In the construction industry, conventional RC structures were generally adopted for residential and commercial building, owing to ease of design and construction. In recent times due to evolution in design and improved technology, there is a scope for the design of structures with ease. As a result, conventional structure, shear wall structure and hybrid structure have been proposed. The conventional structural system consists of frames, floor slabs, beams and columns. Such frames can carry gravity loads. In shear wall structures, all the vertical members are made of structural walls, generally called shear walls and are designed to carry both gravity loads and lateral loads. The hybrid structures consist of reinforced concrete frames interacting with reinforced concrete shear walls.*

In this study, responses of three types of structures when subjected to earthquake are compared in order to find the most effective structure in different seismic zones. A residential building is considered and modelled as conventional structure, shear wall structure and hybrid structure. The dynamic performance under different seismic zones (zone-III, IV, V) are evaluated using structural software ETABS incorporating response spectrum analysis. Also, to study the response of a structure for real time earthquake, abuilding structure is modelled as conventional and shear wall structure and is analyses for KOBE, Japan-1995 earthquake ground motion. The analysis incorporates the time-history analysis method. The load considerations and design conform to IS 1893: 2016 PART I. The storey stiffness, storey shear, maximum storey drift and maximum story displacement are the response parameters considered for the analysis. The responses of the three structural systems at different seismic zones obtained from response spectrum analysis and time history analysis are compared and it is observed that the shear wall structure is the most effective to resist the earthquake ground motion

Keywords: *shear wall structure, hybrid structure, seismic response, Storey Stiffness, response Spectrum method, time-history Analysis.*

I. INTRODUCTION

Elevated structures have consistently intrigued the psyches of individuals since the beginning of its development in the old occasions. There has been a significant increment in the development of tall structures both private and business and the advanced pattern is towards more tall and thin structures. There are numerous motivations to set up a tall structure venture and they are as per the following:

- Rapid growth of population in urban communities, and therefore the constant pressure of the limited land area affected the evolution of building.
- Expensive land prices.
- Restriction of random expansion in major cities adjacent to agricultural land.
- The high cost of setting up infrastructure for new cities. Reinforced concrete building structures can thus be classified as:

i.) **Conventional structure**: The structural system consists of frames, floor slabs, beams and columns are the basic elements of the structural system. Such frames can carry gravity loads while providing adequate stiffness.

ii.) **Shear wall structure**: In this type of structures, all the vertical members are made of structural walls, generally called shear walls.

iii.) **Hybrid structure:** The system consists of reinforced concrete frames interacting with reinforced concrete shear walls.

In the construction industry, conventional RC structures were generally adopted for residential and commercial building, owing to ease of design and construction. In recent times, evolution in design and improved technology, as a result there is a scope for the following type of structures: shear wall structures and hybrid structures and are evaluated.

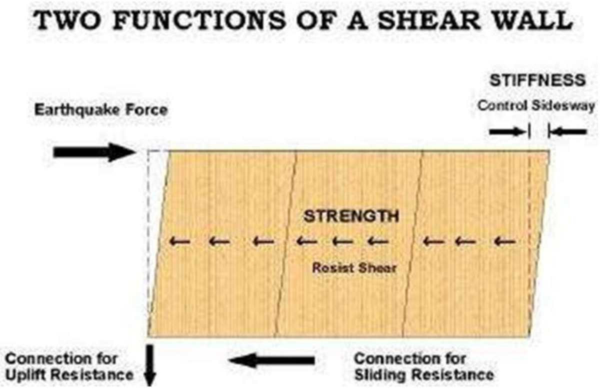

Figure 1 Showing the Functions of Shear Wall

Behavior of shear wall under seismic loading : Shear walls have a rectangular cross area. At the point when a wall is given solidly between two segments, a free weight shape result. The segments that are available at either finishes of the wall are named as limit components. They increment the strength of the wall in flexure and shear fundamentally . Flanged wall areas result because of meeting walls. Contingent upon the tallness to-width proportion, a shear wall may carry on as a slim wall, a squat wall, or a mix of the two. Slim shear walls typically have a tallness to-width proportion more noteworthy than 2. They act like a vertical slim cantilever beam. The essential method of misshapening is twisting; shear distortions are little and can be dismissed. Flexural strength for the most part oversees the structure of such walls. Squats shear walls normally have a stature to-width proportion not exactly half. They show huge measure of shear disfigurement when contrasted with twisting distortion. Shear strength for the most part oversees the structure of such walls.

HYBRID STRUCTURE:- The structure is a combination of framed and shear wall structure. This includes structural elements of columns and beams along with shear wall panels at places to provide required stiffness to the structure. In this system RCC frame is braced with concrete shear wall.

OBJECTIVES

The main objectives of this study are

- To model the building frame as conventional structure, shear wall structure, hybrid structure and to perform dynamic analysis using response spectrum method and time history analysis using real ground motion

- To compare the seismic response of conventional structure, shear wall structure and hybrid structure in order to find the most effective structure to resist the earthquake ground motion

II. METHODOLOGY

DESCRIPTION OF MODEL :-For the given architectural plan, the building is modelled as three different structural forms. The frame work of the study follows the procedure of structural analysis and design. The positions of the structural elements for all the structural forms are placed aesthetically in accordance to the architectural plan. The property assignment for the structural elements and the load imposition on the structure are carried out as recommended by the IS codes.

A tall structure, considered for the analysis has stilt + ground + nine floors with storey height of 3m each. The structure is modelled as a conventional frame structure, shear wall structure, and hybrid structure. The modelling and the analysis of the structure is carried out by ETABS ULTIMATE 2016 which uses the FEM analysis. The performance of structures is evaluated for seismic zone-III, IV and V. The analysis incorporates the response spectrum method conforming to IS 1893-2016 Part-I and the load considerations conforming to IS 875 corresponding parts. The design of the structure conforms to IS 456 and ductile designing incorporated as per IS1893. Also, aims at analyzing and evaluating the structural performance of multi-storey conventional structure and shear wall structure for a particular earthquake. In this study the considered architectural plan consist of stilt+ground+fifteen floors with a floor height of 3m each with 1.2m parapet wall and is modelled as conventional structure (framed structure designed with columns and beams as structural elements) and shear wall structure (designed as shear panels to counter both gravity and seismic loads).The analysis is carried out by ETABS. Here earthquake considered is KOBE, Japan-1995. The analysis incorporates the time-history analysis method. The assumed buildings are fixed at the base and the floors act as rigid diaphragm.

MODELLING

The structures are modeled using ETABS software package. Beams and columns are modelled using frame elements in conventional structure, shear walls are modelled as shell elements in shear wall structure and in hybrid structure both shell elements and frame elements are modelled.

The following are the three type of structures considered to study the response of the multi storey building when subjected to earthquake. The length in transverse direction is 47.62m and in Y direction is 13.87m with number of bays in horizontal X direction is fourteen and vertical in Y is three.

RESPONSE SPECTRUM METHOD

A reaction range is a plot of pinnacle or consistent state reaction (relocation, speed or increasing speed) of a progression of oscillators of fluctuating regular recurrence, that are constrained into movement by a similar base vibration or stun. This is likewise be utilized in surveying the reaction of linear frameworks with different methods of motions (multi-level of opportunity frameworks), in spite of the fact that they are just precise for low degrees of damping.

In this investigation reaction range of dynamic analysis is utilized to locate the best structure among ordinary structure, shear wall structure and crossover structure when exposed to the earthquake. Reaction spectra are valuable apparatuses of earthquake for breaking down the presentation of structures. On the off chance that the characteristic recurrence of the structure is known, at that point the pinnacle reaction of the structure can be assessed by perusing the incentive from the beginning range for the suitable recurrence.

The principle impediment of reaction spectra is that they are just generally appropriate for linear frameworks. Reaction spectra can be produced for non-linear frameworks, however they are just appropriate to frameworks with the equivalent non-linearity, in spite of the fact that endeavors have been made to create non-linear seismic plan spectra with more extensive basic application. In the event that the info is utilized in figuring a reaction range is consistent state occasional, at that point the consistent state result is recorded. Damping must be available, or, in all likelihood the reaction will be unending.

TIME HISTORY ANALYSIS

This is a step by step analysis of the dynamic response of a structure to a specified loading that may vary with time. This is used to determine seismic response of a structure under dynamic loading of representative earthquake. To perform this analysis, a representative earthquake time history is required for a structure being evaluated. In this study, a residential building with regular plan is modelled as conventional Frame structure and Shear wall structure. It is evaluated for its dynamic performance under one particular earthquake - KOBE, Japan-1995 using ETABS. The time history data is collected from PEER. The analysis incorporates the time-history analysis method. The load considerations and design conform to IS 1893: 2016 PART I. The storey stiffness, maximum storey drift and maximum story displacement of the two different models under KOBE seismic forces are compared. This method is applicable for both elastic and inelastic analysis.

LOADS AND FORCES CONSIDERED :-The various types of loads acting on the structure are as follows:

Dead load: Dead loads consist of the weight of the complete structure with finishes, fixtures, wall panels and all equipment of permanent nature including tanks, partitions etc. as Per IS: 875 (Part-I)-1987.

Live loads: Imposed loads in different areas include live loads which will not be less than those specified in IS: 875 (Part-II). The loads listed here under are the minimum loads for the areas involved.

Wind loads: Wind load on structure is calculated as per provisions of IS: 875 (Part-III)-1987. Wind is assumed to blow in any direction and the most unfavorable condition will be considered for design. The computation of wind loads is based on IS: 875 (Part-III) - 2015.

Design wind speed Vz = Vbk1 k2 k3 k4 Where

k1 = Risk coefficient factor (Table 1 of the IS: 875-2015 (Part 3)) k2 =Terrain, height factor (Table 2 of the IS: 875-2015 (Part 3))

k3 =Topography factor (as per Clause 6.3.3. of the IS: 875-2015 (Part 3))

Design wind pressure (Pz) = Design wind pressure in N/sq.m at a height 'z'

= 0.6*Vz2 N/m^2

Earthquake forces: The project considered falls in Zone-V, Zone-IV and Zone III. The base shear force will be computed for building depending on total height, no of stories, type of construction, type of foundation, dead loads and live loads.

Load considerations:

- 100% DL+ 25% LL for Live Load up to 3 kN/m^2
- 100% DL+ 50% LL for Live Load above 3 kN/m^2 As the site is in Zone III, Zone IV and Zone V.

Response spectrum method (dynamic analysis method) is used for analysis and considered load is 100%DL+25%LL since the live loads didn't exceed $3kN/m^2$

SOFTWARE PLATFORM – ETABS:-ETABS (Extended Three-dimensional Analysis of Building Systems) is general-purpose civil-engineering software developed by computer and structures Inc. (CSI), Berkeley, California. It is ideal for the analysis and design of any type of structural system. Basic and advanced systems, ranging from 2D to 3D, of simple geometry to complex, may be modeled, analyzed, designed, and optimized using a practical and intuitive object-based modelling environment that simplifies and streamlines the engineering process. The software is capable of performing both static and dynamic analysis as well as design. It is used in the present study to analyses the structures.

ETABS can also perform time history analysis. It has the capability of showing results graphically and it is also possible to export these results.

III. RESULTS

The response of eleven story regular buildings conventional structure, shear wall structure and hybrid structure when subjected to earthquake are compared in different seismic zones in terms of storey displacements, storey shear, storey drift and storey stiffness. For each model, the response due to earthquake are obtained in different seismic zones. Two types of structures are considered under hybrid structures, hybrid structure-I and hybrid structure-II. In hybrid structure-I, shear walls are placed at the corners of the building and in hybrid structure-II shear walls are placed in intermediate positions in the building to find the effective position of placing a shear wall in multi-storey building. Also, the response of fifteen storey building modelled as conventional structure and shear wall structure are also analyzed for real earthquake ground motions (data collected for ground motion is from PEER) for earthquake-KOBE-1995 and are compared in order to find the most effective structure using time history analysis.

RESPONSE OF BUILDINGS OBTAINED FROM RESPONSE SPECTRUM METHOD OF ANALYSIS:

In this study the response of the structures obtained using response spectrum method when subjected to earthquake for different seismic zones are discussed. The various responses considered for the study are storey displacements, storey drifts, storey shear and storey stiffness for conventional structure, shear wall structure, hybrid structure-I and hybrid structure-II.

RESPONSE OF CONVENTIONAL STRUCTURE OBTAINED FROM RESPONSE SPECTRUM METHOD:- The conventional structure is analyzed for the parameters: storey displacement, storey drift, storey shear and storey stiffness for various zones. The results obtained from the analysis are discussed in the following sections.

RESPONSE OF CONVENTIONAL STRUCTURE FOR STOREY DISPLACEMENT:

The variation of maximum storey displacements with storey height for conventional structure subjected to earthquakes of zone-III, zone-IV, and zone-V is shown in fig .45.Storey displacement is the ratio of displacement of two consecutive floor to height of that floor. It is observed that storey displacement values are increasing along with storey height. Also, the displacements are increasing from zone-III to zone-V.

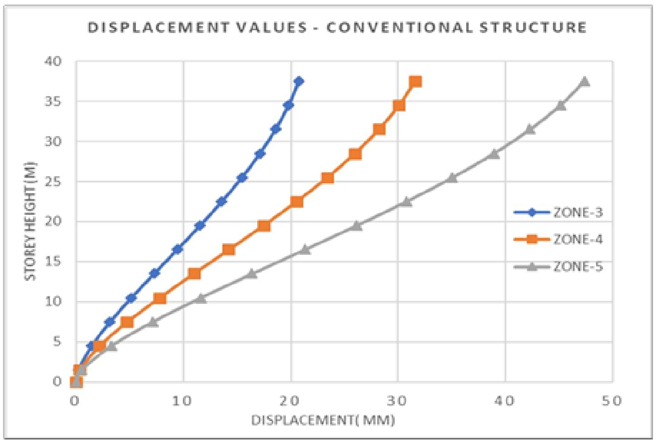

Figure 1 Variation of displacements in conventional structure

RESPONSE OF CONVENTIONAL STRUCTURE FOR STOREY DRIFT:-The variation of maximum storey drifts with storey height for conventional structure subjected to earthquakes of zone-III, zone-IV, and zone-V is shown in fig. 4.6.Storey drift is the displacement of displacements between two consecutive stories divided by the height of the storey. It is observed that storey drift values are increasing gradually till the storey height equal to 14m and decreases when the storey height is larger than 14m for all seismic zones. Also, drift ratios are increasing from zone-III to zone-V.

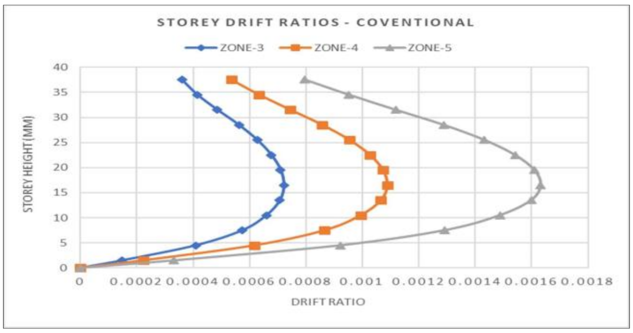

Figure 2 Variation of storey drift ratios in conventional structure

CONCLUSIONS

The seismic response of building structures modelled as conventional structure, shear wall structure, hybrid structure and are compared in order to find the most effective type of structure to resist earthquake loads. Response spectrum and time-history method of dynamic analysis is used. From the study the following conclusions are drawn

- Shear wall structure is found to be the most effective when compared to conventional structure and hybrid structure to reduce storey displacements and storey drift ratios for earthquake
- Stiffness of shear wall structure is found to be largest compared to conventional structure and hybrid structure. It is observed that stiffness variation is slightly varying (decreasing) from stilt to parking floor in case of shear wall structure due to a high percentage of openings in stilt and parking floor
- Storey shear of shear wall structure is lesser compared to conventional structure and hybrid structure
- The responses of shear wall structures are lesser compared to conventional structure when they are subjected to real earthquake KOBE-1995.
- Shear wall structure performs well even in high seismic cases than conventional structure and hybrid structure with minimum drift values and lower displacement values. Among the hybrid structure-I and hybrid structure-II it is observed that hybrid structure-II is found more effective when subjected to earthquake. Providing a shear wall in a building is more effective to reduce lateral displacement. This is because in shear wall structure, the whole structure is composed of the RC wall, where strength, stiffness, and load-bearing capacity are uniform throughout the structure.

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