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COMPARISON OF SEISMIC DEMAND OF THE BUILDING BY DISCRETE ANALYSIS AND ETABS

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ABSTRACT

Seismic analysis is a crucial aspect of earthquake engineering that aims to understand the response of structures to earthquake-induced ground motions. This research article is intended to compare the seismic demand of the residential G+2 RC frame building by discrete analysis and software results from ETABS as per the codal provisions of IS 1893(Part-1): 2016. The seismic analysis is carried out by using Equivalent Static Method and Response Spectrum Method and by considering seismic zone IV with a medium type of soil. The first section of the paper focuses on discrete analysis, which is used to estimate the seismic response of structures using mathematical equations. The second section discusses numerical methods, which involve the use of computer simulations to model the behaviour of structures under seismic loads. The third section covers the comparison of the results from both discrete analysis and software results. Responses like base shear, storey displacement, and storey drift are plotted on a graph and compared with the discrete analysis results.

Keywords: ETABS, Equivalent Static Method, Response Spectrum Method, Seismic Analysis.

I. INTRODUCTION

An earthquake is a natural phenomenon in which a building will experience extra stress and it can damage the building and structure. When the earthquake occurs the building will express high stress and it will damage the structure, which will result in loss of life, damage to the structure or property, and economic loss. Therefore, it is important to calculate the seismic performance of the building to ensure the safety of the occupant and to minimize the risk to the structure at the time of the earthquake. For structure to perform well in the earthquake it needed to be analysed as per the IS 1893 (Part 1) 2016. The analysis of the structure consists of a detailed assessment of the building under earthquake conditions. The assessment includes finding out how much seismic force a building can withstand and finding out the reactions caused due to these forces. The main aim of the analysis of the structure is to find out the building's seismic capacity, which refers to the overall ability of the building to withstand the seismic load without getting significant damage. The paper aims to analysed the residential G+2 RC frame building by Equivalent Static Method and Response Spectrum Method and compare the results with the discrete analysis results. The model was formed using the software ETABS and the responses like base shear, storey displacement, storey drift is calculated. The seismic zone for the analysis is considered as zone IV and the soil type is of medium type of soil.

A. Objectives of the Present Study.

1. To analysed a multi-storey RC building, by using different methods such as equivalent static analysis, response spectrum analysis and time history analysis.
2. To study the effect of earthquake of different magnitude and evaluate seismic demand on building using analytical approach, also termed as discrete analysis and compare the same using SAP2000 software.
3. To explore the effect of seismic zone, storey height, column orientation, vertical irregularity, column and beam stiffness, importance factor, response reduction factor on seismic demand of structure.
4. Better acquaintance with the codal provision related to earthquake analysis.

B. Equivalent Static Analysis

In equivalent static analysis the forces acting on the building and the effect of forces under static loading is calculated. In which the original dynamic loading is replaced by the equivalent static load which acts same as the original loads. Due to this the complexity in calculation is reduced and analysis becomes easier. Equivalent static method is useful for preliminary design of structure and to verify the adequacy of the structure. However, this method will not always give accurate results, in dynamic analysis for more precision in study another dynamic analysis method is used.

C. Response Spectrum Analysis

In response spectrum method, several modes of vibration are used in the frequency domains. The response of a multilevel structure is defined as a combination of different special modes i.e., corresponding to "harmonics" in a vibrating string. A computer program is used to determine the method of this special structure. For each mode, the response is recorded from the design response spectrum, based on the model mass and model frequency; They are then combined to estimate the overall response of the structure. In this study, the forces in all directions i.e., X, Y and Z were calculated and then the effect of the lateral forces on the building was analysed. The design acceleration coefficient for different soil types and response spectrum graph obtained from the IS 1893:2016 (part 1) used in the present study.

II. LITERATURE REVIEW

[1] P. Chandrakar et.al [2015] evaluated the seismic behaviour of the G+10 multistorey building as per provision of IS 1893:2002. For time history analysis two earthquakes taken one is Nepal 2015 and El Centro 1940. The focus is to calculate base shear and maximum deflection in which the analysis is done by help of software ETABS. It is found that the base shear is overestimated by 15% to 20% and displacement by 10% to 15% in Response Spectrum Analysis. Comparing the results, it is concluded that the base shear calculated from Response Spectrum Analysis is slightly higher than Time History Analysis also the storey deflection is more in Response Spectrum Analysis then Time History Analysis.

[2] T. Subramani [2016] studied earthquake, parameters of seismic design, failure mechanism of structure and concept of earthquake resistant design. RC frame building with soft storey are known to perform poorly during a strong earthquake shaking. For a building that is not provided any lateral load resisting component like shear wall, bracing the strength is considered very weak and easily fail in earthquake for which investigation is performed and certain guidelines is to be developed for such type of buildings. It was concluded that numerically and by using different software like Staad Pro, ETABS, SAP2000, etc. The estimation of base shear is possible.

[3] S.R. Kangle et.al [2020] evaluated the response of the G+15 building with STAAD pro and ETABS. Focus was to compare the results from both the software. The model of G+15 RCC building is studied in both the software. When the modal mass participating factor is exceeding 75% then the structure is considered stiff for earthquake excitation. It was observed that the storey displacement in X- direction is more than Y-direction as the motion is applied in the X- direction. It was also observed that the base reaction of the structure is little bit different in both the software and concluded that the structure has good resistance to the smaller earthquake of moderate magnitude and intensity.

[4] K. V. Rathod et.al [2020] studied the ten storey RCC building by Time History Analysis method as per IS 1893:2002 (Part-1). For Time History Analysis time history of El Centro earthquake is used with the help of ETABS. In this study parameters like load carrying capacity, ductility, stiffness, damping and mass also the response parameters like base shear, storey drift and storey displacement are calculated. It is observed that the max base shear in x- direction is at 5.624 sec with 664.147 kN and on y- direction is at 3.5 sec with 565.974 kN. In this study base shear in x-direction and y-direction with respect to time history of El Centro was plotted in which max drift obtained in x-direction at storey 4 of 5.24 mm and in y-direction max drift at storey 6 of 7.01 mm. It is also observed that the maximum displacement 42.34 mm and 53.15 mm at X and Y direction.

III. METHODOLOGY

1. Calculation of forces and effect of forces on the building by manual method.
2. To model and calculate the effect of forces by equivalent static analysis method and response spectrum method by using ETABS.
3. To compare the results like base shear, storey displacement, storey drift from manual calculation with the software results.

IV. MODELING AND ANALYSIS

A. Structure Information

The model considered for the analysis is G+2 RCC multi-storeyed building. Building is modelled for seismic zone IV as per IS: 1893-2016. The dimension of the building in X and Y and Z direction is 7.20 m, 9.00 m, and 10.80 m respectively. The building has following dimensions,

- Column size – 300mm x 300mm
- All beam size – 230mm x 300mm
- Floor slabs are taken as 125 mm thick.
- The height of all floors is 3m.
- Soil type is medium.
- M20 grade concrete and Fe415, Fe250 steel is used.

B. Load assigned

For given structure dead load, live load and earthquake load are applied according to IS 875 part I, Part II and IS 1893:2016 respectively

1. Live Load

- Live load on 1st and 2nd floors = 2 kN/m^2

2. Dead Load

- Wall load = (unit weight of brickwork) x (thickness of wall) x (height of wall)
- Unit weight of brickwork = 20 kN/m^2
- Thickness of wall = 0.23 m
- Wall load on roof level = 20 x 0.23 x 1 = 4.6 kN/m^2
- Wall load on all other levels = 20 x 0.23 x 2.825 = 12.995 kN/m^2

3. Load Combination

All the required load combinations as per IS 456:2000 and IS 1893 (Part-1):2016 for static and dynamic analysis were applied to the modelled structures. The load combinations applied ensures adequate strength and serviceability to the structure.

C. Calculation of Seismic Weight and Base Shear.

We need to calculate base shear in X and Y direction by manually as per IS 1893:2016 provision.

1. Dead load calculation

- Total self-weight of 1st floor slab = 253.125 kN
- Total self-weight of 2nd floor slab = 253.125 kN
- Total self-weight of beams at 1st floor= 111.78 kN
- Total self-weight of beams at 2nd floor= 111.78 kN
- Total self-weight of 0.23 m thick wall at 1st floor= 842.076 kN
- Total self-weight of 0.23 m thick wall at 2nd floor = 842.076 kN
- Total self-weight of all column of 1st floor = 162 kN
- Total self-weight of all column of 2nd floor= 108 kN
- Total floor finish load of 1st floor slab = 1kN/m2
- Total floor finish load of 2nd floor slab = 1kN/m2
- Total dead load of 1st floor = 1449.981kN

- Total dead load of 2nd floor = 1395.981 kN
- Total self-weight of 0.23 m thick wall at roof= 149.04 kN
- Total self-weight of all column at roof = 90 kN
- Total dead load of Roof slab = 684.945 kN

2. Live load calculation

- Live load on Roof = 0
- Total Live load on 1st and 2nd floor = 162 kN/m

3. Seismic weight calculation

- Seismic weight of Roof = 720.94 kN
- Seismic weight of 2nd Floor = 1436.481kN
- Seismic weight of 1st Floor = 1490.481 kN

Total seismic weight of building: = Seismic wt. of 1st floor + Seismic wt. of 2nd floor + Seismic wt. of Roof = 720.94+1436.481+1490.481 = 3647.907 kN……. Total Seismic weight of building

4. Calculation of base shear

As per Clause 7.6.1, of IS 1893 (part-1): 2016, the total lateral force or design seismic base Shear is given by, VB = Ah X W

Where, W= Seismic weight of the building = 3647.907KN

Along X-direction, VBx = Ahx X W = 0.060 X 3647.907 = 218.874 KN

Along Y-direction, VBy = Ahx X W = 0.060 X 3647.907 = 218.874 KN

From IS 1893 (Part 1): 2016 Cl. 7.6.3, we have, $Q_i = \frac{W_i h_i^2}{\sum W_i h_i^2}$

Where, Qi = Design lateral force at floor i.

Wi= Seismic weight at floor i.

hi = Height of the floor measured from base,

Storey shear calculation is shown in following table:

Table 1. Storey Shear Calculation

FLOOR	W_i (kN)	h_i	h_i^2	$W_i h_i^2$	$\frac{W_i h_i^2}{\sum W_i h_i^2}$	$V_{Bx} = V_{By}$	Q_i (kN)
First	720.94	10	100	72094.5	0.43	218.874	94.86
Second	1436.48	7	49	70387.52	0.42	218.874	92.62
Roof	1490.48	4	16	23847.68	0.14	218.874	31.38
$\sum W_i h_i^2$ = 166329.7					$\sum Q_i$ = 218.874		

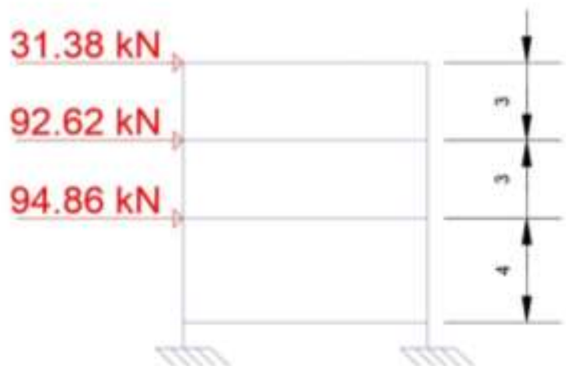

Figure 1: Design seismic force on the building from x-direction and y-direction.

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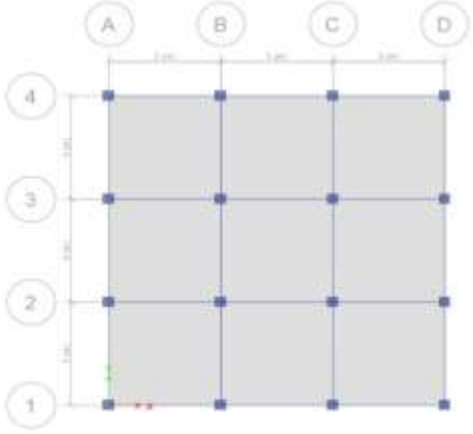


Figure 2: Plan

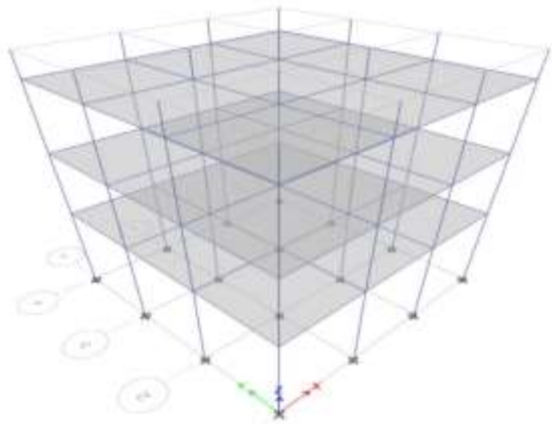
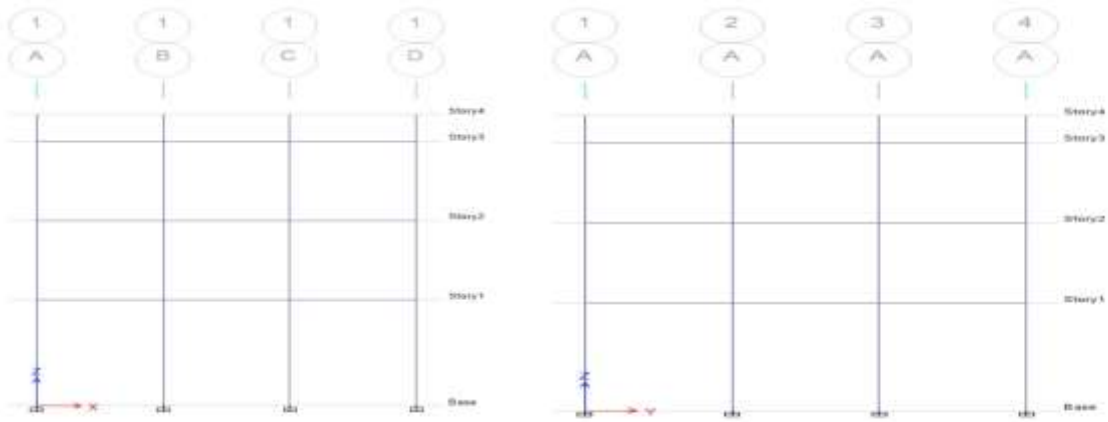


Figure 3: 3D Model



X-Z View Y-Z View

Figure 4: Floor to floor line diagram.

V. RESULT AND DISCUSSION

Response of G+2 RCC multi-storeyed residential building subjected to dynamic loading were computed. Equivalent static analysis, response spectrum analysis was performed using software. ETABS is used to compute the response for equivalent static analysis and response spectrum analysis. Results from different methods of analysis were used to observe and compared the floor response.

Figure 5: Storey Forces of Manual and Equivalent Static Method

VI. CONCLUSION

From the above charts and tables following conclusions are made:

1. The values in both Equivalent static method and manual calculations are near to the same.
2. As the Equivalent analysis is computed by software the results are more precise.
3. Better accuracy of the analysis can be obtained using software.
4. Better understanding of codal provision is possible.

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