Comparative Study of Static and Dynamic Method of Seismic Analysis of RCC Multistoried Building

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***Abstract** - Reinforced concrete (RC) building frames are most common types of constructions in urban India. Thought their lifetime, these are subjected to various types of forces during such as static forces due to dead loads, live loads and dynamic forces due to earthquake. In the present study, one tall RCC building of 15 stories is assumed to be situated in seismic zone II is analyzed using two different methods i.e. Equivalent static method and response spectrum method, using ETAB software. From analysis, the parameters like storey displacement, storey drift, base shear and time period and frequency are determined and also comparative study is done for both the methods.*

***Key Words*: Equivalent static method, response spectrum method, storey displacement, storey drift, Base shear, time period, frequency.**

1. INTRODUCTION

Over the days, high rise structures are evolving so much popularity. The improvement in the technology has given the power to improve the construction technology, quality of construction and high-rise structures accuracy. High rise towers can be nowadays made used for multi utility such as residential tower, office building, apartment, flats, commercial, trade centres and many more. This situation leads to the effect called Vertical city development. This is due to increase in the urban density and to accommodate more no. of people in lesser available space. This system will be a landmark and unique.

1.1Reinforced Cement Concrete

The external forces will be resisted by 2 materials whi ch will act together. The materials are bonded by frictional forces. The materials are reinforcing steel embedded inside the concrete material. Since concrete is strong in compression forces alone, reinforcing steel is provided to take care of tensile forces.

The plain cement concrete (PCC) alone cannot be sufficient to resist tensile forces due to horizontal forces such as wind and seismic. Hence reinforcing steel will be provided to handle the tensile developed due to externally applied loads. From 19th century onwards, industrial revolution happened and hence the concrete gains its world level market.

1.2 Multi-Storey Buildings:

There is no correct or exact term to defining a high rise building but it can be defined based on the comparisons with other structures. Different specialist calls the high-rise structure on the basis of their convenience. From the point view of the structural engineer, however, it will be purely based on its height. This is due to failures caused by external factors such as wind and seismic forces.

1.3 How to make A building Earthquake-Proof:

It is based on the designer's efficiency and idea. The earthquake pushes the structure due to earthquake force. The following are the few methods to make the building stable.

- Providing Flexible footing: Most of the cases, the building foundation will experience lift in the structure. In other way, the base isolation systems are provided, which will isolate the structure. This flexible isolator consists of flexible pads it will be layers of steel and rubber. If the structure experience earthquake, the waves creates the building to slide due to the presence of isolators.

- Providing various Dampers.

Dampers works like shock absorbers. It can be adopted in high rise buildings to resist earthquake forces. It is similar as works in bikes and cars. It absorbs the shock waves and slow down the energy. This can be adopted in two ways, such as pendulum dampers and vibration control devices.

- Vibration shield

The actual building is modelled and experimented which will deflect due to earthquake forces. The plates are placed at ground levels which will separates when earthquake forces occur.

- Reinforce the building's structure

The building redistributes the forces when the earthquake forces travel through them. There are many interconnecting members such as shear walls, diaphragm, and moment resisting frames and cross bracings to avoid collapse of the structure.

Shear walls is a panel of RCC walls which helps in transferring earthquake forces to ground. The bracings help to increase the ability of carrying tension in the structure.

Diaphragms are the slabs which provide lateral stability by connecting beams and columns. Diaphragm will transfer the horizontal flat plate will transfer force to column and beams laterally. The flexibility in a building can be achieved by moment resisting frames. The joint between column and frame will be rigid and the member will be flexible. Hence the building can resist larger earthquake forces.

- Earthquake-Resistant materials

There are many materials which can be used efficiently to reduce the effect of earthquake. The many of the materials will even dissipate the energy absorbed by the structure such as base isolator, dampers, shock absorber, and many.

2. OBJECTIVES AND METHODOLOGY

2.1 Objectives:

The objectives are as listed below:

- To prepare 3D model of multi-storey RCC building using ETABS software.
- Analyse building for seismic analysis and Dead load, Live load and Earthquake load using static equivalent method and response spectrum method structure.
- Comparison of displacement, story drift, base shear, time period and frequency.

2.2 Methodology

The method of modeling and analysis involves the following process, listed below:

- Literature survey is carried out of various papers and objectives of the project are finalized.
- A G+15 RCC Storey building is selected and Modelling is carried out using ETABS software.
- Framing layout is finalized with loads acting on it as per latest available IS codal provision.
- The Analysis such as Static and dynamic is carried out for the models.
- The results are extracted and tabulated for comparison.
- The results are discussed and conclusions are drawn.

3. MODELLING

3.1 Building Description

The proposed model is purely conventional RCC structure. The model is 15 storey heights with irregular in plan shaped structure. The below Table 4-1 shows material properties and design parameters used in this project.

Table-1 Material Properties and Design Parameters

	Description	Data
1.	Seismic Zone	II
2.	Seismic Zone Factor (Z)	0.10
3.	Importance Factor (I)	1.0
4.	Response Reduction Factor (R)	3
5.	Damping Ratio	0.05
6.	Soil Type	Medium Soil (Type II)
7.	Height of the building	45m (15Storeys)
8.	Story to story Height	3.0
9.	Span Length	Varies
10.	Column Size used	300x300 & 450x450mm
11.	Thickness of Slab	125mm
12.	Floor Finish	1.5KN/m^2
13.	Live Load	2.0, 3.0, 4.0KN/m^2(As per IS875-P2)
14.	Grade of Concrete (f_{ck})	M 25 for Beams Slabs. M 40 for Columns.
15.	Grade of Steel (f_y)	Fe 500

4. RESULTS AND DISCUSSION

The model is analysed for Gravity loads to check the adequacy of model. Later same model is analysed for Static i.e., Equivalent Static Analysis and Dynamic Analysis i.e., Response Spectrum Analysis. The results are extracted and furnished in the section.

4.1 Equivalent Static Analysis (ESA)

4.1.1 Displacement

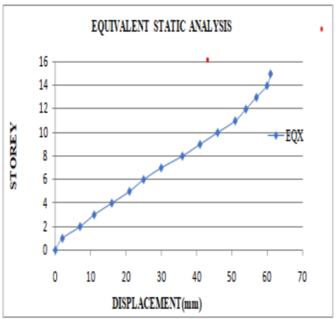

Chart-1: Displacement vs Storey ESA

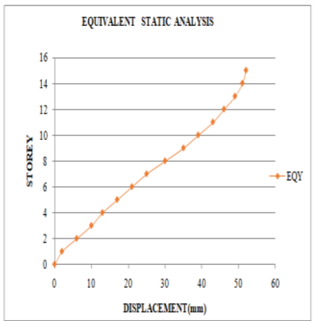

Chart-2: Displacement vs Storey ESA

The Above graph shows the displacement vs Storey's for Equivalent Static Analysis. The displacement is higher at the top storey and lesser in bottom storey for both X & Y Direction. However, the displacement in Y directions seems to be higher than X Direction. This is due to more stiffness in X Direction.

4.1.2 Storey Drift

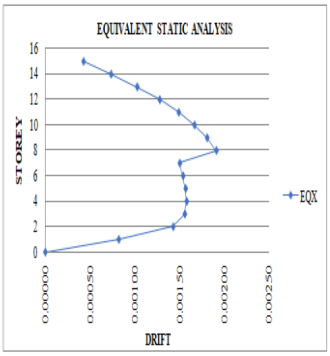

Chart-3: Storey Drift vs Storey ESA

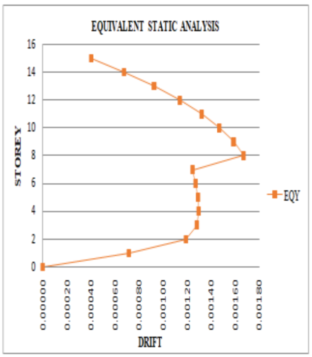

Chart-4: Storey Drift vs Storey ESA

The Storey drift is the difference of the displacement of successive storey. However, the drift values are increasing with increase in storey level. It keeps on increases up to some height and later it reduces again. The drift values are slightly higher in X direction compared with Y Direction.

4.1.3 Time Period

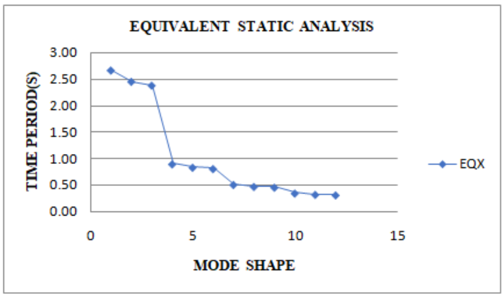

Chart- 5: Mode Shape vs. Time Period ESA

The time period seems to be more in first three modes compared to other modes. However, after first three modes it decreases suddenly.

4.1.4 Frequency

Frequency indicates the number of times the activity is happening per second. The results are extracted and tabulated as below.

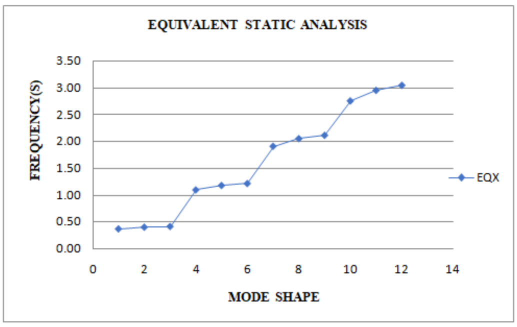

Chart- 6: Mode Shape vs. Frequency ESA

Frequency is inversely proportional to time period. The Frequency will be lesser for starting modes, where as it reduces for ending modes.

4.1.5 Base Shear

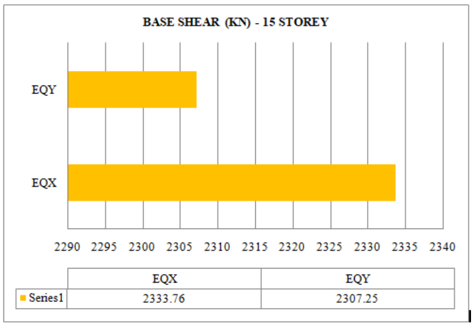

Chart- 7: Base Shear ESA

4.2 Response Spectrum Analysis (RSA)

4.2.1 Displacement

The Displacement of model is extracted in both X & Y Direction and tabulated in the below table:

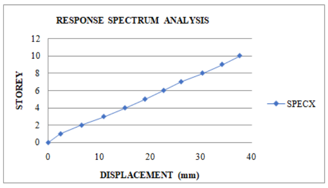

Chart- 8: Displacement vs Storey RSA

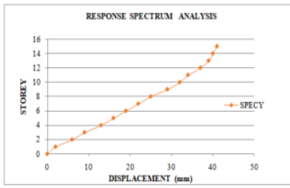

Chart-9: Displacement vs. Storey RSA

The Above graph shows the displacement vs Storeys for Response spectrum Analysis. The displacement is higher at the top storey and lesser in bottom storey for both X & Y Direction. However, the displacement in Y directions seems to be higher than X Direction. This is due to more stiffness in X Direction.

4.2.2 Storey Drift

The storey drift of the model is extracted for model in both direction and presented as below.

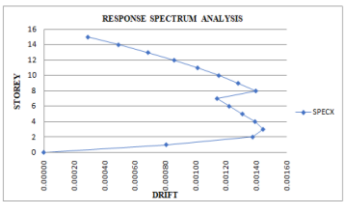

Chart-10: Storey Drift vs Storey RSA

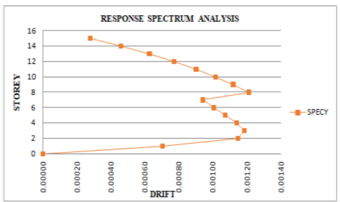

Chart- 11: Storey Drift vs Storey _ RSA

The Storey drift is the difference of the displacement of successive storey. However, the drift values are increasing with increase in storey level. It keeps on increases up to some height and later it reduces again. The drift values are slightly higher in X direction compared with Y Direction.

4.2.3 Base Shear

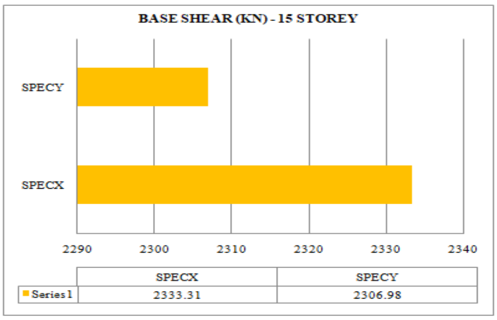

Chart-12: Base Shear RSA

The base shear is the shear force acting at the support level of the structure. It is the sum of equivalent shear acting at particular floors. The Base shear is more in X direction comparatively. It is mainly due to more stiffness in X direction compared to Y Direction. More the stiffness more will be the base shear attracted.

4.3 Comparison of Static and Dynamic Analysis

4.3.1 Displacement

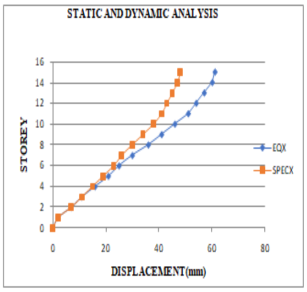

Chart-13: Displacement vs Storey

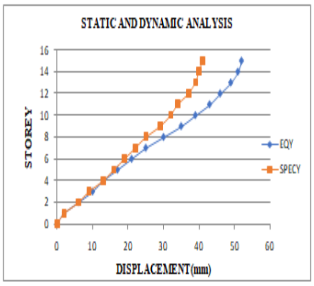

Chart-14- Displacement vs Storey

From the results, it is found that the static analysis gives more displacement values compared with dynamic analysis and it is found that increase is about 21%. The displacement values in X direction is higher in case of both static and dynamic analysis. And the difference in the displacement in X & Y direction remains constant irrespective of type of analysis and it about 14.5%.

4.3.2 Storey Drift

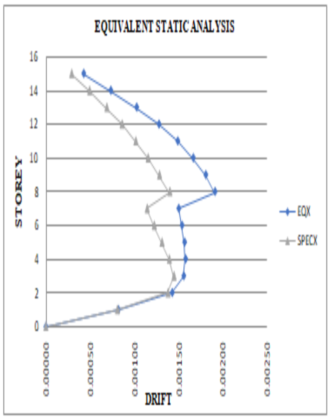

Chart-15: Storey

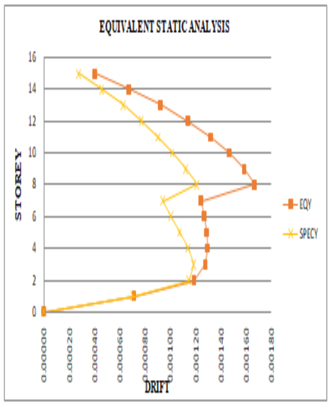

Chart-16: Storey Drift vs Storey

The Storey drift is the difference of the displacement of successive storey. The between static and dynamic, drift values are higher in static analysis. From the results, it is found that the static analysis gives more displacement values compared with dynamic analysis and it is found that increase is about 21%.

5. CONCULSION

5.1 Conclusions

The Model is analyzed for both static and dynamic analysis. The results are extracted and compared; from the overall comparison following conclusions are listed.

- The maximum horizontal displacement with equivalent static method shows more by 27% analysis don by response spectrum method.
- The maximum story drift with equivalent static method shows more by 36% analysis done by response spectrum method.
- The maximum value of storey drift is 0.0019 which is lesser and is within allowable limit. i.e., 0.004*H = 0.004*3.00 = 0.012m and 12mm. Hence the drift is not a major governing factor in this kind of building.
- The displacement values in X direction is higher in case of both static and dynamic analysis. And the difference in the displacement in X & Y direction remains constant irrespective of type of analysis and it about 14.5%.
- In comparison between static and dynamic, drift values are higher in static analysis.
- The time period for static and dynamic analysis is same. This is due to the fact that, time period only depends on model geometry other than type of analysis.
- The fundamental time period calculated was an approximate value, however, ETABS, FEM based software provides exact results.
- The base shear values should be same for static and dynamic analysis is almost same as per IS1893

Seismic Code, however, it is again proved from the results.

- From the overall analysis, it can be easily concluded that, for high rise structure, the static analysis gives higher results comparatively. And hence dynamic analysis should be carried out to design the structure effectively and economically.

5.2 Future Scope

- Further analysis can be carried out for a greater number of storeys with vertical irregularity.
- The time history analysis can be used to assess the exact behaviour of particular zone.
- Steel structure can be compared with RCC for cost and stability comparison.

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