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# Dynamic Analysis of High Rise Flat Plate Building with Different Retrofitting Systems

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**Abstract:**

*Nowadays the world is going towards the implementation of performance based engineering analysis. However in some metropolitan cities like Bangladesh multi-storied flat plate buildings are still constructed in conventional ways. Those ordinary buildings designed without proper seismic consideration could be vulnerable to damage even under low level of ground shaking from distant location. This research paper intended to investigate the lateral stiffness increment of five types of cases based on whether they are retrofitted or not under dynamic loading. Among the cases four cases consisted of dual systems i.e. that retrofitted by shear wall and diagonal bracing only at exterior or exterior and centre frame. Valid results are obtained by Finite Element Analysis of a 15 storied flat plate garments building modeled using software package SAP 2000 for earthquake zone II in Bangladesh. The paper also deals with the structural response of the shear wall and diagonal bracing. Dynamic responses of our model under earthquake, El-Centro, have been investigated. This paper demonstrates the accuracy and exactness of Time History analysis in comparison with the most commonly adopted Response Spectrum Analysis and Equivalent Static Analysis.*

**Key words**: Flat plate, Response Spectrum Analysis, Equivalent Static Analysis, Time-history Analysis

## I. Introduction:

Through the years flat plate attracts the eye of architects for its beautiful view and of engineers for its reduced floor height. But its demands get down because of its weakness to lateral forces. Because it does not allow any beam at its edge so necessarily due to deflection control, slab thickness needs to be increased. On the other hand, the world is becoming congested, so sky is the limit and the modern trend is towards taller and slender structures. But in Bangladesh engineers often don't consider seismic behavior of those structures. So there should be much more detailed analysis to assure acceptable seismic performance beyond the elastic range. Time History and Response Spectrum analysis should be performed in high rise structures because it predicts the structural response more accurately in comparison with Equivalent Static analysis.

## II. Methods of Dynamic Analysis:

The difference between static and dynamic analysis principally in acceleration is created by loads with time or as per response of the structure. Dynamic analysis is a type of structural analysis which covers the behavior of structures subjected to dynamic loading which include people, wind, waves, traffic, earthquakes, and blasts. Dynamic analysis can be used to find dynamic displacements, time history, and modal analysis which can also be called response spectrum analysis. Dynamic analysis is important for high-rise building and very effective in today's philosophical analysis of structure against Earthquake Loading. A dynamic analysis is also related to the inertia forces developed by a structure when it is excited by means of dynamic loads applied suddenly (e.g., wind blasts, explosion, and earthquake). Dynamic analysis for simple structures can be

carried out manually, but for complex structures, the finite element analysis can be used to calculate the mode shapes and frequencies.

**Time History Analysis***:* It is an analysis of the dynamic response of the structure at each increment of time, when its base is subjected to a specific ground motion. Alternatively, recorded ground motions database from past natural events can be a reliable source for time histories but they are not recorded in any given site to include all seismological characteristics suitable for that site. Recorded ground motions are randomly selected from three main parameters in time history generation- analogous magnitude, distance and soil condition category.

**Response Spectrum Analysis**: It gives the maximum response of idealized single degree of freedom system having certain period and damping during earthquake ground motion. Here terms like maximum absolute acceleration, maximum relative velocity or maximum relative displacement can be described by plotting maximum response against un-damped natural frequency condition and various damping values.

## III. Retrofitting Methods:

Retrofitting methods are systems of adding extra structural elements to provide resistance especially against earthquake. Its basic principle is to strengthen slab-column joints, wall connections etc. Practically it is called seismic retrofitting of structures. There are few types as follows: Conventional Strengthening Method, Traditional Method of Seismic Retrofitting, Retrofit of Structures Using Innovative materials, and Base Isolation.

## IV. Objectives of the Study:

The main objectives of present study include:

1. To analyze the dynamic effect of loads on building.
2. Dynamic analysis for seismic loads on framed structures using Time History Method, Response Spectrum Method and Equivalent Static Method.
3. To investigate the dynamic response under El–Centro earthquake.

## V. Details of the Present Study:

### General

Whenever we talk about a structure we always think about the loads it carries and its resistivity against it. For that, we have to know about the axial force, shear force, moment, stress and displacement of that structure. As we will try to know the behavior of our structures under dynamic loads, in this segment of our work we will show our data about displacement which is obtained by SAP2000 software analysis.

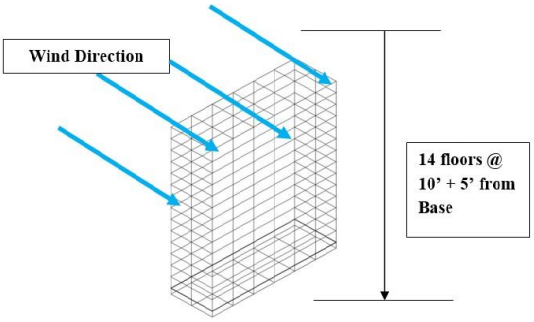


**Figure 01: Conceptual Frame View (Grid Division)**

### Details of the Models

The model which has been adopted for the study is a 15 story regular garments building. The building consists of four different types of square columns with the dimensions 30 in x 30 in, 27 in x 27 in, 24 in x 24 in and 20 in x 20 in. The floor

slabs are taken as .791 ft thick. The modulus of elasticity and shear modulus of concrete have been taken as E = 2.48×107 kN/m2 and G = 1.03 ×107 KN/m².

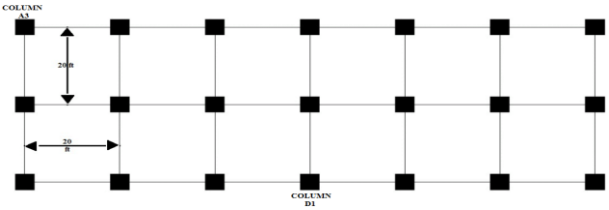


**Fig 02: General plan view of a 15 story garments building**

Here we studied 4 different cases. Case 01 has diagonal bracing only at exterior, in Case 02 there is bracing at both interior and exterior, in case 03 there is Shear Wall at exterior whereas in case 04 there is Shear Wall at both interior and exterior. In this study Shear wall section are taken as 8 inch thick and diagonal bracing are taken as 12 in x 12 inch.

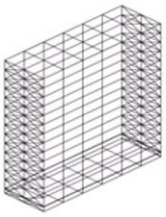

Fig 03: Case01: Diagonal Bracing at Exterior

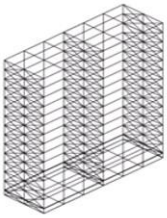

Fig 04:Case02: Diagonal Bracing at Exterior and Mid

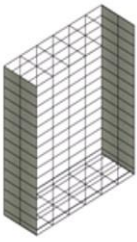

Fig 05:Case03 (Shear Wall at Exterior)

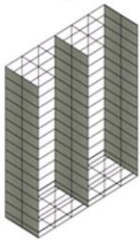

Fig06:Case04 (Shear Wall at Exterior and Mid)

## V. Result and Discussion:

### Comparison between Equivalent Static Method and Time History Method:

Equivalent static method is a linear static method for the seismic analysis whereas time-history method is a linear dynamic method. Fig. 01,02,03,04 illustrate the comparison of storey drift using equivalent static method and time-history method for fifteen store flat plate building with different retrofitting systems. The percentage variation between the two methods of analysis for the above cases are 54.7%, 48%, 54.60%, 66.4% respectively. A detail of percentage variation in storey drift of different models of shear walls is illustrated in Table 1.

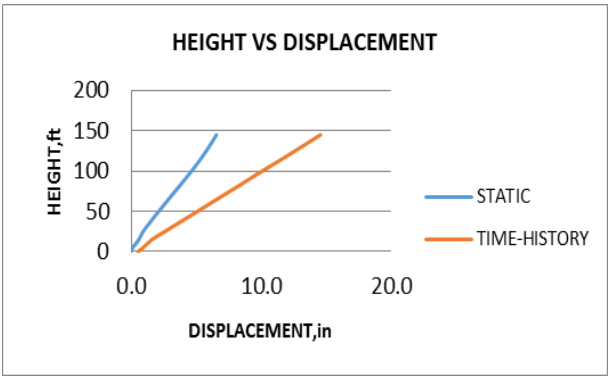


**Fig 01: The comparison of storey drifts using equivalent static method and time-history method for case 01**

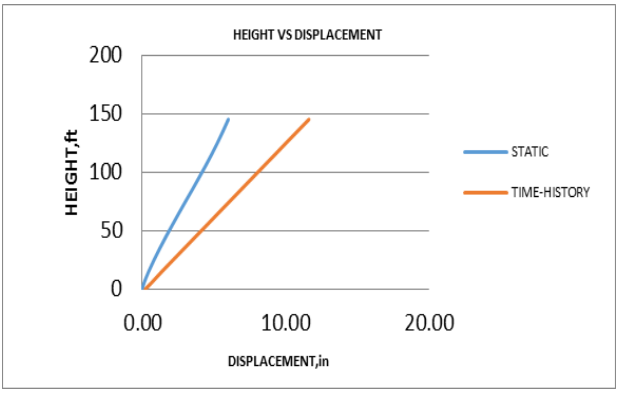


**Fig 02: The comparison of storey drifts using equivalent static method and time-history method for case 02**

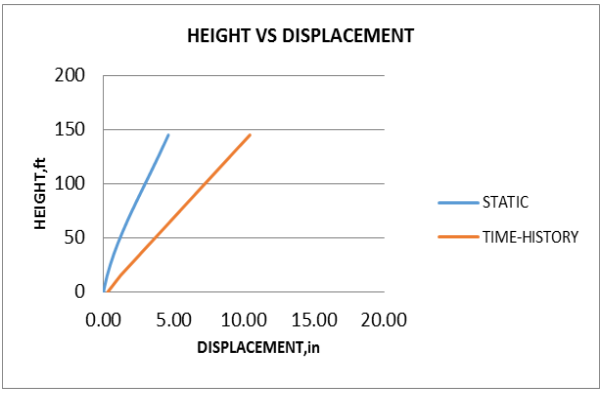


**Fig 03: The comparison of storey drifts using equivalent static method and time-history method for case 03**

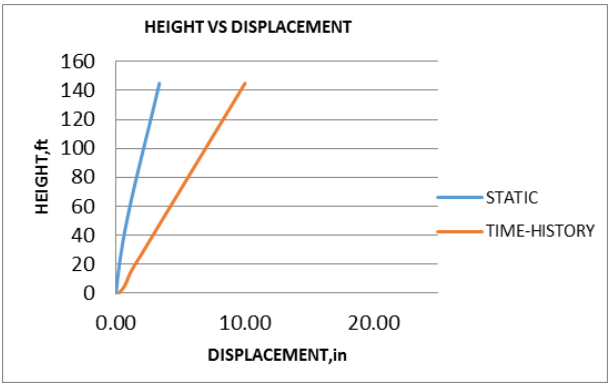


**Fig 04: The comparison of storey drifts using equivalent static method and time-history method for case 04**

| CASE TYPE | PERCENT VARITION |
|---|---|
| CASE 01 | 54.7 |
| CASE 02 | 48.2 |
| CASE 03 | 54.6 |
| CASE 04 | 66.1 |

**Table 1 Percentage Variation in Storey Drift between Equivalent static and Time-history Method for Different type of cases.**

## Comparison between Equivalent Static Method and Response Spectrum Method:

We know that the Equivalent static method is a linear static

method for the seismic analysis whereas response spectrum method is a linear dynamic method. Fig.05, 06, 07, 08 illustrate the comparison of storey drift using equivalent static method and response spectrum method for fifteen storey flat plate building with different retrofitting systems. The percentage variation between the two methods of analysis for the above cases are 16.77%, 27.7%, 25.68%, 44.4% respectively. A detail of percentage variation in storey drift of different models of shear walls is illustrated in Table 2.

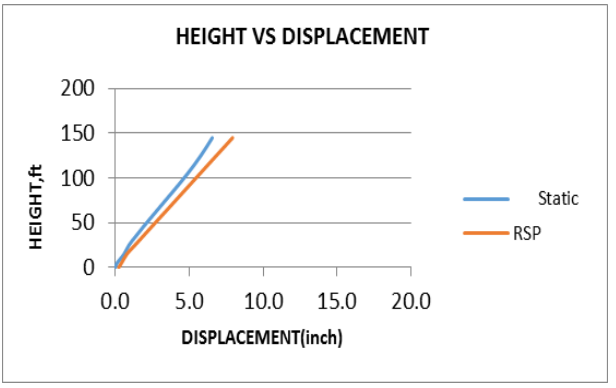


**Fig 05: The comparison of storey drifts using equivalent static method and response spectrum method for case 01**

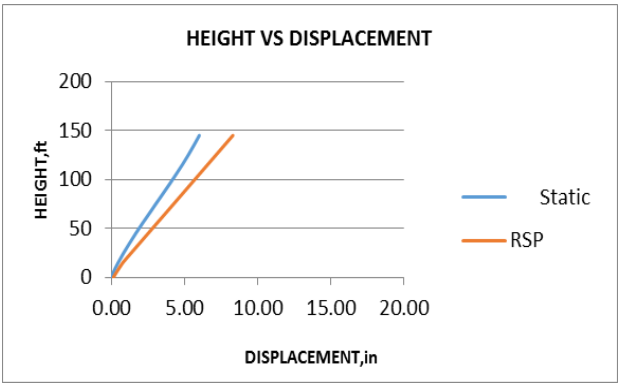


**Fig 06: The comparison of storey drifts using equivalent static method and response spectrum method for case 02**

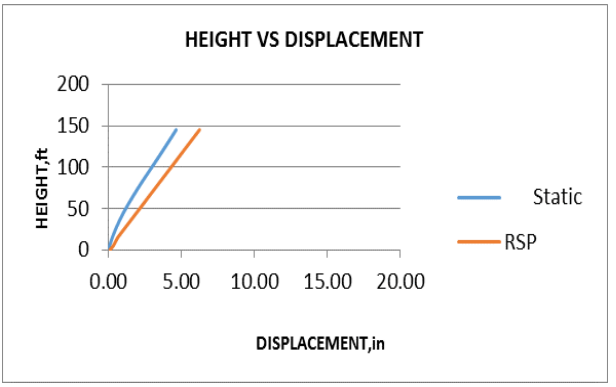


**Fig 07: The comparison of storey drifts using equivalent static method and response spectrum method for case 03**

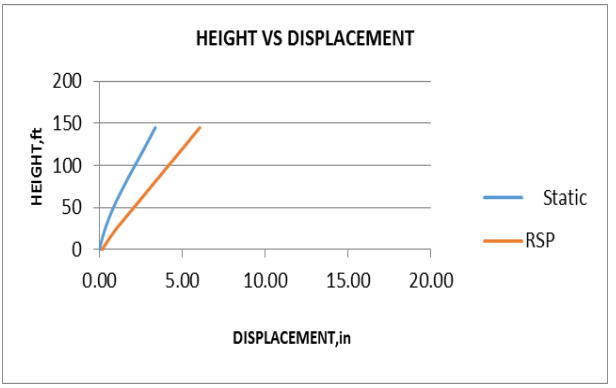


**Fig 08: The comparison of storey drifts using equivalent static method and response spectrum method for case 04**

| CASE TYPE | PERCENT VARITION |
|---|---|
| CASE 01 | 16.77 |
| CASE 02 | 27.7 |
| CASE 03 | 25.64 |
| CASE 04 | 44.4 |

**Table 2 Percentage Variation in Storey Drift between Equivalent static and Response Spectrum Method for Different type of cases**:

## Comparison between Response Spectrum Method and Time History Method:

The Time History analysis is used if it is important to represent inelastic response characteristics or to incorporate time

dependent effects when computing the structure's dynamic response. A comparison for storey drift between responses Spectrum method and time history analysis is carried out for fifteen storey flat plate building with different retrofitting systems. Fig. 09,10,11,12 illustrates the comparison of storey drift using response spectrum method and time history method. The percentage variation between the two methods of analysis for the above cases is 45.6%, 28.78%, 40.00%, 39.5% respectively. A detail of percentage variation in storey drift of different models of shear walls is illustrated in Table 3.

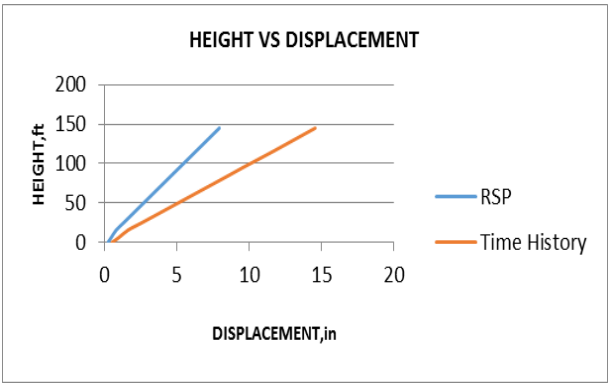


**Fig 09: The comparison of storey drifts using response spectrum and time-history method for case 01**

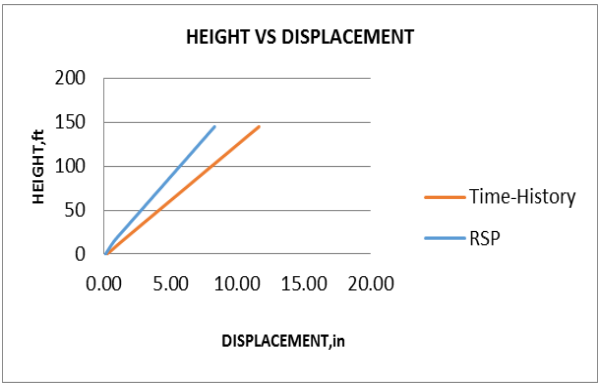


**Fig 10: The comparison of storey drifts using response spectrum and time-history method for case 02**

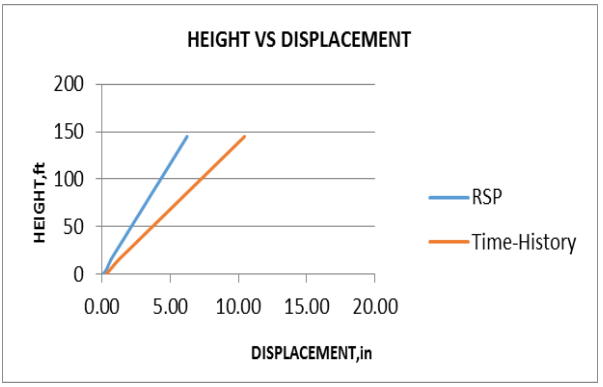


**Fig 11: The comparison of storey drifts using response spectrum and time-history method for case 03**

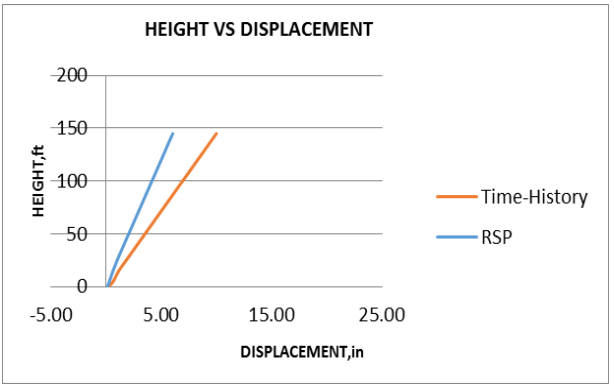


**Fig 12: The comparison of storey drifts using response spectrum and time-history method for case 04**

| CASE TYPE | PERCENT VARITION |
|---|---|
| CASE 01 | 45.6 |
| CASE 02 | 28.78 |
| CASE 03 | 40.01 |
| CASE 04 | 39.5 |

**Table 03 Percentage Variation in Storey Drift between Time-History and Response Spectrum Method for Different type of cases**

## VI. Conclusions:

After doing all these experiments it can be concluded that Equivalent Static Method can be used effectively for low rise

buildings. For higher buildings, Response Spectrum method should be used. For important structures Time History Analysis should be performed because it predicts the structural response more accurately in comparison with other two methods since it incorporates p - Δ effects and material non linearity which is true in real structures.

On the other hand flat plate is good from the perspective of gravity load. But it has been experienced that flat plate building can't stand strongly against wind, seismic or other lateral forces. As a result, more than any other structural components, the lateral force-resisting structure has significant impact on space planning. Therefore, it is essential for a structure to have lateral resistance to withstand dynamic load. To do the initial schematic design in the right way it is important to recognize that it is critical to consider lateral forces from the very start and to integrate lateral force – resisting structure.

From the above studies it is evident that MODEL 4 is the most effective and MODEL 1 is the least effective under dynamic loading. It is found that displacements in dynamic analysis are higher in comparison to equivalent static method analysis. Therefore, in addition to equivalent static method analysis, detail dynamic analysis (Time history and Response spectrum analysis) should be performed for important high rise structures.

## BIBLIOGRAPHY:

Chopra, A. K. 1995. *Dynamics of structures theory and applications to earthquake engineering*. Englewood Cliffs: N.J. Prentice-Hall.

Biswas, R.K., Meraj Uddin, Arman Chowdhury, Khan Al-Imran. "Comparative Analysis of a 15 Story Flat Plate Building with and Without Shear Wall and Diagonal

Bracing Under Wind and Seismic Loads". *Journal of Mechanical and Civil Engineering* 9(2): 97-101.

Bungale, S. T. 2005. *Wind and Earthquake ResistantBuildings Structural Analysis and Design* Monticello, New York 12701, U.S.A.

Chowdhury, Arman, Biswas, R.K, M.N. Nazmul Hoq, and S.M. Iskander. 2013. "Evaluation of the structural implication of Incorporating Base Isolator as Earthquake Protection Device." *International Organization of Scientific Research (IOSR)-International Journal of Mechanical and Civil Engineering* 8(1): 27-30.

Dinar, Y., N. Alam, and S. C. Paul. 2013. "Performance Based Analysis of RC building consisting Shear wall and varying infill percentage." *European Academic Research* 1(10): 260-268.

Dinar, Y., N. U. Rahi, and P. Das. 2013. "Variation of Deflection of Steel High-Rise Structure Due to P- Delta Effect considering Global Slenderness Ratio." *International Journal of Emerging Technology and Advanced Engineering* 3(12): 250-256.

Mohan, Romy. C. Prabha. 2011. "Dynamic Analysis of RCC Buildings with Shear Wall." *International Journal of Earth Sciences and Engineering* 4(6): 659-662.

Nanduri, P.M.B. Raj Kiran, B. Dean Kumar, Y. Chandrasekhar, B.L.P. Swami. 2012. "Comparative Study of Wind Load Analysis of Flat Plate Multistoried Frames With and without Reinforced Concrete Infilled Walls". *International Journal of Emerging Technology and Advanced Engineering* 2(8): 177-182.