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Study of Seismic Analysis for Vertical Extension of Multi Storey Building - A Review

Neeraj Singh Saral[1], Rakesh Kumar Grover[2]
[1]*M.E. (Student), Department,* [2]*Associate Professor, Department of Civil Engineering, Jabalpur Engineering College, Jabalpur (M.P)*

Abstract: ***Expanding horizontally is impractical sometime because in this era where urban areas are rapidly developed, peoples have shortage of land due to financial aspect and limited space. In this situation vertical extension of building is more ideal solution then Horizontal expanding or construct the new building from the scratch. But due to lack or awareness and economical point of view house owner or developers may prioritize minimizing cost. As a result of sometime peoples are not designed our building for future extension, for that and due to revised seismic standard building need to redesign and check for seismic loading. In this study we are evaluate the importance of study in vertical extension with comparing the various research available for seismic analysis of multi storey building like Dynamic analysis (Time history method or Response spectrum method) with or without geometrical non linearity. This study suggests that for building more than seismic zone 2, dynamic analysis is required to get the proper response during seismic event, before extending any storey above it. Also suggested If requires do retrofitting of the building according to dynamic analysis of building before extension.***
Keywords: Vertical Extension, Dynamic Analysis, P-delta.

I. INTRODUCTION

Vertical extensions of existing multistorey buildings particularly in earthquake-prone regions is a critical aspect. For this evaluation dynamic analysis is very necessary, there are numerous of research has already been done for seismic analysis of building with different height, a lot of research has been done on different geometry, different slopes, etc but till now neither much attention has been paid to the research on vertical extension nor much research has been done on it. It is even a very common practice for middle-class people to extend their homes, with or without consulting professional (structural) engineers. Without thinking about what consequences it will have during an earthquake.

With a lot of research and modern machines today we can predict quite accurately how a building will behave during an earthquake and for that Dynamic analyse is one of the major factors. Dynamic analysis accurately predicts the modified structure's behaviour, with that we can also determine the reserve strength of the building.

The aim of the study is that we will take various research papers to compare that for know what kind of changes should take place in buildings and why we should work on this vertical extension area.

II. METHODOLOGY

The available research reports are categorized in four parts: -

1) A Comprehensive Review of Research on the significance of Dynamic Analysis for Buildings.
2) Comparative review on Research of the Application of Response Spectrum Analysis (RSA) and Time History (TH) Analysis Based on Building.
3) Systematic Review of Research on P-delta Analysis in Buildings.
4) Rational the Factors Driving the Need for Research in Vertical Extensions of Buildings.

III. LITERATURES REVIEW

Dr.M.S.V.K.V. Prasad1, Dr.K. R. Yoganathan2, Dr. A. Hemalatha3, Pallavi Hj4, Bairi Samatha5 (2022) – In this study deals with the behaviour of G+10 structure at different zones during seismic event by using STAADPRO. Configuration of seismic zones using in this study are zone II, zone III, zone IV and zone V. Response Spectrum Method is used.Base shear in zone III is 57.14% more then zone II, similarly Base shear in zone IV is 45.45% more then zone III and Base shear in zone V is 49.95% more then zone IV. Storey shear in zone III is 60% more then zone II. Storey shear in zone IV is 49.99% more then zone III. Storey shear in zone V is 49.9% more then zone IV.

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Hence approximately 50% of increment in base shear and storey shear in every single seismic zone increment. Similarly, displacement also increases with other percentage factor. But overall, we can say that the internal stress will become more with increment of seismic zone.

Gaurav Patidar1, Ankur Pandey2 (2022) – This study deals withs Dynamic Analysis of Multi Storey Buildings of Different Shapes. Using ETASB and STAADPRO in his research. This study found that the base shear in regular building having higher due to more stiffness then other. Stiffness value decreases when storey height increases. Displacement in irregular is less then regular building under seismic loading

D Sravya¹ and Dr V B Reddy Sudha2 (2021) – This study deals with the behaviour of rectangular and square RC framed buildings, using G+10, G+20 and G+30 storey buildings. Location of seismic zone V. All structures are analysis by Equivalent static method and dynamic analysis without considering the non linearity of the structures. India standard IS 1893:2002, IS 875:1987 and IS 456:2000 are used for all the loading calculations. This study shows that I rectangular model storey shear, storey displacement, storey drift and overturning moment is less then square model. Rectangular model has more story stiffness then square model against earthquake. Earthquake load effect increases with the height and static linear analysis is not enough to calculate the proper effect in high rise building.

Krishna Prasad Chaudhary1, Ankit Mahajan2 (2021) – This study intends to analysis the response of irregular shaped high-rise buildings by Response spectrum analysis using ETABS. Using G+12 and G+16 storey building with plan (L, O and H shaped) and vertical irregularities. This study found that H shaped building response better then other (L and O shaped) buildings. 12 storey building response better then 16 storey building. 16 storey L shaped building found the maximum displacement.

Aditesh Thakur1, Er. Charanjit Singh2 (2019) – This study investigates the behaviour of multi storey building during seismic event with or without struts. In this study G+16 and G+20 storey building is used. Dynamic analysis is performed by STAADPRO. Taking seismic zone V, seismic loading data is taking as per IS 1893:2016. The end result reveals that the maximum displacement in single cross strut is reduced 54% and 67% reduced for double cross sturts. Hence using struts in high rise building can reduced displacement very well, these techniques can be used for flexible buildings.

V. Rajendra Kumar1, Ranga Rao.V2 (2017) – This study investigates the comparison between Equivalent Static Method & Response Spectrum Method with considering the regularity and irregularity in the structure. Analysis and compare results of structure in different zone II, zone III, zone IV, and zone V using STAADPRO. Using Indian standard IS 1893:2002 is used for earthquake load calculation. Form linear static method for regular structure compares to zone II, it is observed that lateral displacement is increases 38%, 59% and 72% in Zone III, IV and V respectively. Similarly for irregular structure with linear static method lateral displacement in Zone IV and V is increased 49% and 64% from zone II. From dynamic analysis method it is observed that lateral displacement in regular building is increased 38% in zone III, 59% in zone IV and 72% in zone V then the zone II. Similarly for irregular building with dynamic analysis lateral displacement increments are 59% and 73% for zone IV and V compare to zone II. Hence this study proves that for irregular building with higher zone dynamic analysis give more accurate results.

Prakriti Chandrakar1, Dr. P. S. Bokare2 (2017) – This study investigates the comparison between Response Spectrum analysis and Time History analysis for buildings. End result of this study is show that the total displacement in Time History analysis is 10% - 20% less then Response Spectrum analysis. Both show almost same result but for important structure should be analysis by Time History analysis because it predicts more accurate behaviour of building. On the other hand, Response Spectrum analysis is faster than Time History analysis but uneconomical. For low rise and mid-rise buildings Response Spectrum analysis can be a good option.

Nikunj Mangukiya1, Arpit Ravani2, Yash Miyani3, Mehul Bhavsar4 (2016) – This study investigates the behaviour of RC structure with considering P Delta effect. G+25 storey building is used for this study. Considering of seismic load according to IS 1893:2002. All the analysis are done on ETABS software. Results of this study shows that the 12% to 20% increment in displacement and 5% to 20% variation in bending moment. Hence for better estimation of structure behaviour P Delta analysis is also important.

Dr. S. K. Dubey1, Prakash Sangamnerkar2, Deepak Soni3 (2014) – The present study deals with the analysis of RC framed Symmetric and Asymmetric buildings in Zone-III and IV using inelastic method (P-Delta Analysis).The objective of present study is to find out the effect on Response quantities (Story Drift, Story Displacement and Nodal Displacement) due to “P-Delta” analysis on the RC framed structure and also find out the effect of asymmetry on this analysis. “P-Delta” Analysis is Non-Linear Static Analysis, so the structural response is including the additional response produced due to simultaneously action of lateral and gravity load on undeformed as well as deformed geometry. After doing the whole analysis it is found that the Response quantities are higher if “P-Delta” analysis is performed.

A. Bahrami1, S. Deniz2, H. Moalin3 (2022)– This study investigates the behaviour of RC building after vertical extension. Vertical extension is very helpful where shortage of house land. StruSoft structural analysis software is used for this investigation. Eurocodes and Swedish national annex standards are used in this study. A building from Gavle is used for references for detailed specifications of structural component. This analysis considered various load like snow, dead, imposed and wind load as program oriented. End results shows that the load bearing elements are experienced higher utilization ratio due to this it requires more reinforcement to prevent failure. Strengthening for increased reinforcement are also introduce in this study. Vertical forces and deflection is also increases after vertical extension.

Parth Shailesh Patel1, Vasudev Tulsi Patel2, Romil Jatin Shah3, Qureshi Mohammad Naved4 (2022) – In this research the structural design to be adopted for the proposed structure covers the minimum design requirement. Design load wind and earthquake loads are taking. In order to offset the load of the added floor, the following was done: the loft slabs on both the first and second floors were removed, and the terrace waterproofing was also taken off.

Gillott, C.1, Densley-Tingley D.2 and Davison, B.3 (2021) – This study intends to determine the Sustainable housing provision. This study proves that the vertical extension is very important for various reasons. Compare urban to suburban area vertical extension is more sustainable for densify city. It helps people to live in city centre. Also help construction industry to minimize construction waste and lowering the carbon emissions for whole life of building.

Rikard Sundling1, Åke Blomsterberg2, Anne Landin3, (2018) – This study was conducted on six similar buildings in Gothenburg. Sweden. Need immediate renovation. Aim of this study is to determine the energy efficient renovation of existing building for vertical extension economical and environment sustainable. Analysis and compare the life cycle profit analysis and life cycle impact assessment. The authors claim that renovations based on low-energy plus vertical extensions would increase the number of apartments without expanding the urban footprint, and at the same time, lower energy dependency and environmental impact. This study has addressed the matter of whether or not vertical extension could increase the financial viability of energy-efficient renovation and further reduce its environmental impact. As the renovation will lower the energy use from 178 to 57 kWh/m2, it will contribute with a yearly energy saving of almost 6 GWh.

M. Kyakula1, S. Kapasa2, E. A. Opus3 – A study considerations in vertical extension of reinforced concrete structures. this paper explains how the buildings designed using the older codes based on elastic analysis have reserve strengths when extensions designed based on limit state design codes such as BS8110 and Eurocode 2 are added. It sets out considerations that have to be taken into account. These include: determining the strength of existing structures and of the soil. Investigating the capability of the existing structure to carry increased load and effecting the modification in the slabs, beams, columns and foundation design. The composite action of the new concrete that is added onto the old concrete is also considered. their load-bearing capacity might appear greater when assessed with modern limit state methods (up to 37% greater). However, even with this seemingly higher capacity, the existing reinforcement might not be sufficient, option like adding more reinforcement or increasing the size of structural members may need to be considered. Increasing the size of member will increase the bending moment capacity, like 33% increase in Slab depth, 42% increase in moment capacity, net increase of just 9%.

Joan Artés1, Gerardo Wadel2, and Núria Martí3 (2017) – In this study investigates the vertical extension and improving of existing building. They identified a substantial amount of buildable space (around 800,000m2) on rooftops in the Example district of Barcelona. The research indicates that vertical extensions can improve existing buildings and provide new, high-quality homes, ultimately enhancing the community's quality of life. The methodology developed by the authors has been applied in several projects, demonstrating its potential. However, they acknowledge that the methodology requires ongoing adjustments to address various challenges and should be seen as part of an evolving innovative process. The use of industrialized and lighter construction methods for vertical extensions on older buildings is considered an innovative approach.

Bayan S. AL-Nu'man1 (2016) – This is carried out for strengthening scheme existing building due to extension by adding floors. In this study 14 storey building is used then extended to 16 storeys by adding 2 stories of normal weight concrete. End results shows that some of the columns could not carry the additional load due to extension, as a result of strengthening of columns is requires. Lateral loads like wind does not show that much effect on the structure after extension. Reinforcement percentage for strengthening in interior columns is 16.9% while strengthening in edge columns is 11.83%.

IV. CONCLUSIONS

Based on the findings of several studies, the following conclusions have been reached:

1) An existing building strength and soil capacity is crucial factor to considered in analysis before proceeding with vertical extensions.

2) Earthquake load effects increase significantly with extension because seismic weight of the building also increases.
3) Generally, for mid rise building, Wind load does not show significant effect after extension of building.
4) Vertical extensions increase loads on existing structural elements. Due to which load bearing elements experience higher utilization ratio, as a result of more reinforcement.
5) Even modern codes may reveal strengthening of building due upgradation of zone with extension. But reinforcement adequacy must still be verified.
6) The composite action of new concrete with existing concrete must be considered.
7) Lightweight and industrialized construction methods are recommended for vertical extensions on older buildings.
8) The removal of unnecessary weight from lower floors can help offset the added load of the extension.
9) Rectangular building exhibit better seismic performance, so for future extension plans use rectangular building shape then other.
10) Dynamic analysis methods (Response Spectrum and Time History) provide more accurate results than static linear analysis (Equivalent Static Method), especially for high-rise and irregular buildings.
11) Time History analysis is considered the most accurate but is computationally intensive and less economical than Response Spectrum analysis.
12) Response Spectrum analysis is a good and fast option for low to mid rise building. Also used for determine the behavior of building during earthquake before and after extension.
13) Considering P-Delta effects in analysis significantly increases displacement and bending moments, indicating its importance for accurate structural behavior prediction.
14) Vertical extensions are a viable solution for increasing housing capacity, especially in urban areas with limited land. Densifying cities, reducing urban sprawl, and minimizing construction waste.
15) Vertical extensions can be used to improve the energy efficiency of existing buildings.

V. FUTURE SCOPES

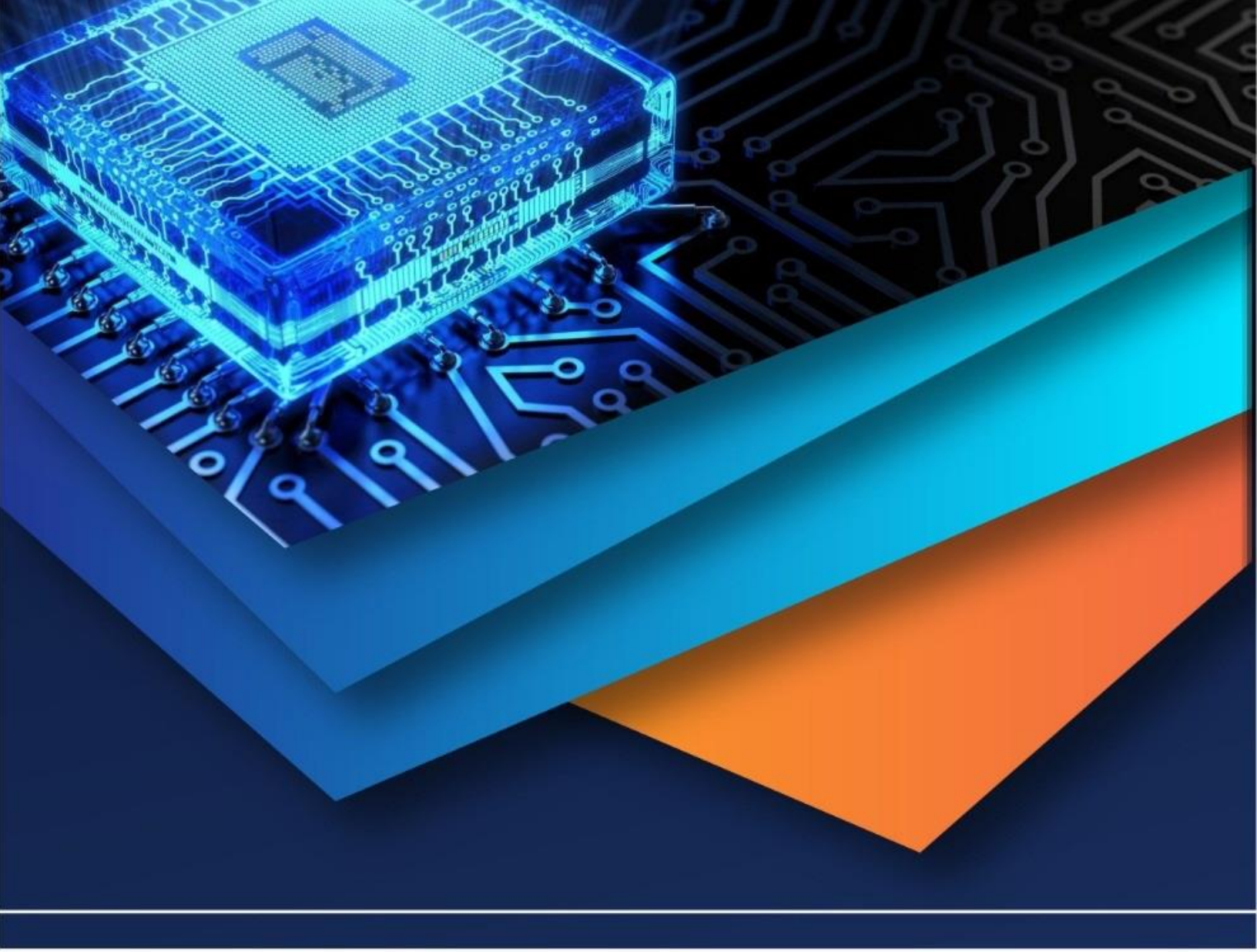
Future study could be focus on following area:

1) A Study can be conduct on checking behaviour of buildings with each increase in floor.
2) Determine the impact of extension floor on high rise buildings.
3) Study to calculate the action of old concrete with new concrete after extension.
4) Study for mass irregularity if any due to extension of storey.
5) Study for analysis of existing building strength and soil capacity.

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