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Response Spectrum and Time History Analyses- A Review

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ABSTRACT

This review article thoroughly examines the methodologies and applications of response spectrum and time history analyses within the realm of structural engineering. It consolidates and assesses the current state of knowledge, methodologies, and advancements concerning these widely employed approaches for evaluating seismic performance in structures. The paper systematically investigates the principles that underlie response spectrum analysis, addressing crucial parameters like spectral accelerations, damping ratios, and modal participation. Additionally, it explores the historical evolution and contemporary uses of this method. The focus then shifts to time history analysis, providing a detailed exploration of its intricacies, advantages, and challenges. Through a critical review of pertinent literature and case studies, the article clarifies the strengths and limitations of both methods and underscores emerging trends in research and practical applications. By synthesizing this extensive information, the review aims to be a valuable asset for researchers, engineers, and practitioners in the structural engineering community, promoting a deeper comprehension of the complexities associated with response spectrum and time history analyses. Furthermore, it seeks to guide future research and applications in seismic design and assessment.

Keywords: Response spectrum, Time history, Analysis, Seismic Analysis, STAAD PRO, ETABS, SAP2000.

I. INTRODUCTION

The evaluation of seismic performance in structural engineering is a crucial aspect, demanding the use of advanced analytical tools to ensure the safety and resilience of constructed environments. This research report aims to explore the complexities of response spectrum and time history analyses, two prominent methods employed to assess the dynamic behavior of structures under seismic forces. Response spectrum analysis provides a comprehensive overview of a structure's response to seismic excitations, considering modal characteristics. On the other hand, time history analysis offers a detailed examination of dynamic responses over time, utilizing actual seismic records. Given the substantial threat that seismic events pose to global infrastructure, a thorough understanding of these analytical techniques is essential for designing structures capable of withstanding and mitigating the impact of earthquakes. This research seeks to contribute to this understanding by reviewing the principles, methodologies, and applications of response spectrum and time history analyses, ultimately advancing knowledge in earthquake engineering and informing improved design practices for resilient structures.

II. LITERATURE REVIEW

Bahador Bagheri, Ehsan Salimi Firoozabad, Mohammadreza Yahyaei(2012) The article conducts a comparative analysis of static and dynamic evaluations for multi-storey irregular buildings located in seismic zone V in India. It assesses the precision and accuracy of time history analysis in contrast to commonly used response spectrum analysis and equivalent static analysis. The research employs software packages ETABS and SAP 2000 v.15 to model 20-storey irregular buildings, examining their dynamic responses during actual earthquakes, namely EL-CENTRO 1949 and CHI-CHI Taiwan 1999.The findings indicate that, within the initial five stories, there is negligible disparity in displacements calculated by various methods. However, as the building's height increases, the differences in displacements gradually become more pronounced. The paper delves into various aspects, including storey displacements, center of mass displacement, bending moments and shear forces of beams and columns, top story deflection, and support reactions.In summary, the article offers valuable insights into the seismic behavior of concrete-reinforced buildings, emphasizing the significance of employing dynamic analysis methods for irregular structures situated in high seismic zones.

Jiuyang Li, Fangqi Li, Zhiru Cai(2021) The paper, titled "Seismic Analysis of Multi-Story Frame Office Building Based on SAP2000," investigates the seismic performance of a multi-story reinforced concrete frame office building using the finite element software SAP2000. The analysis encompasses model analysis, response spectrum analysis, and time history analysis of the structure. The results indicate that the overall seismic performance of the frame aligns with design specifications, suggesting the building's capability to withstand seismic events. Notably, the y-pillar structure exhibits elastic and non-yield characteristics during significant earthquakes, affirming its seismic resilience. Leveraging SAP2000 software facilitates a comprehensive examination of the structure's response to seismic forces, providing valuable insights for the design and construction of similar buildings. In summary, the paper offers a detailed analysis of the seismic performance of a multi-story frame office building, emphasizing the effectiveness of the design and structural elements in withstanding seismic events.

Milad Faiz, Rajesh Kumar (2023) The paper undertakes a comparative analysis of the efficacy of equivalent static analysis and response spectrum analysis in extreme seismic zones, employing the ETABS software. The study involves three structures of varying heights (5-Storey, 10-Storey, 15-Storey) located in seismic zones IV and V. The key findings from the analysis reveal that equivalent static analysis yields higher maximum story displacements in comparison to response spectrum analysis. Specifically, the disparities are noted as 36% in the 15-Storey building, 38% in the 10-Storey building, and 34% in the 5-Storey building.Furthermore, the study identifies that the fundamental time period remains consistent between both analysis methods, with a decrease of 9.5% from the 15-Storey to the 10-Storey structure and a 29% reduction from the 10-Storey to the 5-Storey building. Additionally, equivalent static analysis exhibits higher maximum drift ratios compared to response spectrum analysis, showing differences of 27%, 33%, and 30% in the 15, 10, and 5-Storey buildings, respectively. In summary, the overall trend indicates that values derived from equivalent static analysis tend to be generally higher than those obtained through response spectrum analysis, emphasizing the importance of careful consideration when selecting analytical methods in extreme seismic zones.

Mudassir Ahmed, G Kishore (2018) The paper explores the applicability of time history analysis for multi-story buildings in seismic zone II in India, advocating its economic viability compared to the response spectrum method. Using the ETabs software, the study models a 10-story regular building, calculating story displacement and drift. Notably, it identifies maximum story drift at the first floor (zero at the base) and minimum story displacement at the base (maximum at the top floor). Emphasizing the significance of seismic evaluation and dynamic analysis in earthquake-prone regions, the research aims to enhance multi-story buildings' resistance to seismic forces.The analysis of displacement and acceleration graphs reveals an increase in values with story height, and variations exist between floors. The paper underscores the cost-effectiveness of time history analysis over the response spectrum method for dynamic analysis of multi-story buildings. Overall, the findings provide valuable insights into multi-story building behavior under seismic forces and underscore the efficacy of time history analysis in seismic design.The seismic analysis of structures, considering parameters such as load carrying capacity, ductility, stiffness, damping, and mass, utilizes both linear and nonlinear methods. The current version of the IS: 1893-2002 code mandates three-dimensional analysis for multi-story buildings due to plan or elevation irregularities and heightened seismic intensities in weaker zones.

Chen Qing-jun(2009) The paper addresses the dearth of research on the attenuation relationship of long-period ground motion and the corresponding long-period response spectrum for high-rise structures exposed to such seismic conditions. Through a comparative study, it explores three classic long-period seismic waves and compares them with conventional seismic waves. Employing finite element analysis software and the time-history analysis method, the research investigates the seismic responses of a high-rise structural model subjected to both types of seismic waves. The findings reveal that the model experiences larger base shear forces, displacement responses, and acceleration responses under long-period seismic waves compared to general seismic waves. The study concludes that high-rise structures exposed to long-period seismic waves are predominantly controlled by displacement. This contributes valuable insights into the behavior of high-rise structures in the context of long-period ground motion, addressing a notable gap in current research.

Kintali Sai, Anirudh and Dr. Shaik Yajdhani (2015) In one of his research endeavors, Dr. Shaik Yajdhani delves into the influence of earthquakes on multistoried buildings. Employing both dynamic and static analysis methods, he assesses a structure with a (G+9) pattern using STAAD-PRO software. The study meticulously examines various parameters, including beam stresses, axial forces, torsion, displacements, moments at different nodes, and beams. The research outcomes reveal that dynamic analysis produces notably higher values for moments, displacements, and nodal displacements in the Z direction compared to static analysis. Intriguingly, the axial force values in both analysis methods closely align. Additionally, the study observes that torsion exhibits negative values in static analysis and positive values in dynamic analysis. In summary, the research underscores that under seismic excitation, nodal displacements and bending moments are significantly larger than under static loads, underscoring the indispensable role of dynamic analysis in comprehending the seismic behavior of multistoried structures.

K. Veera Babu, S. Siva Rama Krishna, Venu Malagavelli (2022) The study focused on the nuanced structural dynamics that render buildings constructed on sloping land more susceptible to seismic pressures compared to those on level ground. Rigorous analysis was conducted on the behavior of a multistory building situated on sloping terrain, drawing comparisons with structures on flat surfaces. The investigation took place within the seismic context of Earthquake Zone II, examining crucial factors such as storey shear, drifts, moments, and displacement through Response Spectrum Analysis. The resulting examination revealed distinct trends, shedding light on the heightened vulnerability of buildings located on sloping terrain to seismic stresses. These findings offer practical insights for the design and construction of resilient structures in hilly areas, where seismic risks necessitate specific considerations for enhanced safety and stability. Moreover, they provide valuable information regarding the structural performance of buildings in such challenging topographical conditions.

S. Sharma ans A. K. Tiwary (2022) The Chandigarh University Faculty of Engineering is conducting a comprehensive analytical study to assess the impact of various factors on the lifespan of structures, specifically those without infill walls. The study aims to understand the remarkably long lifespan of these structures by considering elements such as soil type, storey height, seismic zone, number of storeys, number of bays, base dimension, and column size. Recognizing the inadequacy of the current code statement to encompass all variables affecting the structure's period, the analysis focuses on a reinforced concrete skeleton without partition walls, as indicated by the IS code. Modal analysis of exceptional models is undertaken using various parameters, and the impact of each parameter on the building's fundamental period is thoroughly examined. The study reveals that the type of soil, seismic zones, bay length, and storey height significantly influence the building's fundamental period, contributing to its extended lifespan. Interestingly, the column size also plays a role, albeit in the opposite direction, shortening the structure's time period. These findings shed light on the importance of these factors in determining the structural longevity of buildings without infill walls, offering valuable insights for future design considerations and code improvements.

Wahane and Phuke (2017) The paper delves into the unique responses of reinforced concrete buildings under three distinct analysis methods: equivalent static, response spectrum, and time history. With a focus on measuring displacement values in each method, the study employs a multi-story building with frames as the analytical model.The findings underscore that the static approach yields higher displacement values compared to the other two methods. Furthermore, the study concludes that time history analysis proves to be the most accurate and precise method for calculating acceleration values. It suggests that the linear dynamic method is particularly well-suited for taller buildings, while linear static analysis remains viable for structures with regular configurations and limited height. Additionally, the paper notes variations in base shear values depending on the chosen approach, though all results are considered satisfactory.In summary, the research advocates for the adoption of more precise methods, such as time history analysis, especially for buildings with more complex structures. This insight contributes to refining the understanding of the nuanced responses of reinforced concrete buildings under different analysis techniques.

Ajay Singh Gulshan (2016) The paper under consideration delves into the seismic response of buildings that incorporate setbacks, comparing their behavior to that of regular buildings during earthquakes. The analysis involves a comprehensive examination of seven distinct building types, consisting of one regular structure and six irregular structures with setbacks at different storey heights.The research findings reveal significant variations in the behavior of these structures. Specifically, irregular buildings with setbacks exhibit a substantial increase in the axial force within beams and columns compared to their regular counterparts. This heightened axial force suggests an elevated risk of failure in irregular structures during seismic events. On the other hand, the values of shear force and bending moment in irregular structures experience a decrease. This decrease is attributed to the reduction in mass resulting from the introduction of setbacks.The paper concludes by emphasizing the potential negative impact of incorporating setbacks in buildings during earthquakes, characterizing them as potentially disastrous. As a practical recommendation, the paper suggests avoiding such irregularities in structural design to enhance seismic resilience. Overall, the paper provides valuable insights into the complex behavior of buildings with setbacks, shedding light on the importance of considering irregularities in the structural design process, especially in seismic-prone regions.

M. V. Landge, R. K. Ingle (2021) The primary goal of the study was to identify and quantify the acceleration floor amplification in models of low-rise buildings. The paper aimed to capture both elastic and inelastic acceleration responses in regular buildings and those with irregularities, including mass and stiffness irregularities situated at various storeys, along with buildings featuring vertical geometric irregularities.The research findings highlighted that the characteristics of the input ground motion played a crucial role in governing the response of the lower storey. The floor response spectra exhibited distinct peaks corresponding to contributing modes influenced by the dynamic characteristics of the building.An interesting observation was made regarding the floor accelerogram, which intensified concerning the base due to a dynamic filtering effect. This intensification was particularly notable for periods near the modal time periods of the elastic model, contributing to an extensive frequency content in the floor accelerogram. Overall, these insights contribute to a better understanding of acceleration floor amplification in low-rise building models under various irregularities and dynamic conditions.

III. SUMMARY

In conclusion, the array of research studies examined provides valuable perspectives on seismic analysis of structures, emphasizing the critical role of method and software selection based on structural complexity and seismic zone considerations. The comparative analyses conducted by different researchers underscore the intricate nature of seismic behavior, with dynamic analyses, notably time history analysis, emerging as crucial for comprehending structural responses to seismic forces. These studies contribute significantly to ongoing endeavors in refining design practices, emphasizing the necessity for precise modeling and careful consideration of factors such as building height, irregularities, and seismic zone characteristics. The collective findings reinforce the dynamic and evolving landscape of seismic analysis, advocating for continuous research to enhance structural resilience and ensure safety in earthquake-prone regions.

IV. REFERENCES

1. Mudassir AhmedM.M.D & Kishore.G .(2018), Time histroy analysis of multi sorey building for highrise structures, Vol. 6, Iss: 6, pp 8970-8972.
2. Jiuyang Li, Fangqi Li &Zhiru Cai.(2021) Seismic analysis of multi-story frame office building based on SAP2000. Vol. 768, Iss: 1, pp 012124
3. Chen Qing-jun.,(2009) A Comparative Study on Long-Period Seismic Responses for High-Rise Structures, Vol. 20, pp 1341–1353.
4. Bahador Bagheri, Ehsan Salimi Firoozabad, Mohammadreza Yahyaei. (2012) Comparative Study of the Static and Dynamic Analysis of Multi-Storey Irregular Building. World Academy of Science, Engineering and Technology, International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering-Vol. 6, Iss: 11, pp 1045-1049
5. Milad Faiz, Rajesh Kumar, (2023) Comparative Effectiveness of Equivalent Static Analysis & Response Spectrum Analysis in Extreme Seismic Zones .IOP conference series.Vol.1110,Iss:1,pp 01231-012013.
6. Rajendra Kumar, V., & Ranga Rao, V. (2017). Comparative study on regular & irregular structures using equivalent static and response spectrum methods. International Journal of Civil Engineering and Technology, 8(1), 615–622.

7. Anirudh, Kintali Sai, Dr. Shaik. (2015). Comparative Study of Static and Dynamic Seismic Analysis of a Multistoried Building. IJSTE - International Journal of Science Technology & Engineering,2(01)

8. K. Veera Babu, S. Siva Rama Krishna, Venu Malagavelli(2022)Seismic analysis of Multi storey Building on Sloping Ground and Flat Ground by using ETABS, IOP conference series-Vol. 1130, Iss: 1, pp 012004-012004.

9. S. Sharma & A. K. Tiwary (2022). Influence of Distinctive Parameters on Fundamental Time Period. 699–710

10. Wahane, R. M., & Phuke, R. M. (2017). Comparative Study of Various Seismic Analysis Methods for RC Structure. 7(6), 30–36

11. Ajay Singh Gulshan (2016) Response Spectrum Analysis of Response of Building with Setbacks, IOSR Journal of Mechanical and Civil Engineering-Vol. 01, Iss: 01, pp 01-07

12. M. V. Landge, R. K. Ingle (2021) Comparative study of floor response spectra for regular and irregular buildings subjected to earthquake, 01 Jan 2021-Vol. 22, Iss: 1, pp 49-58

13. M.Bello, A.A Adedeji, R.O.Rahmon, M.A.Kamal, (2017), Dynamic Analysis Of Multistory Building And Seismic Excitation By Response Spectrum Method Using Etabs, Journal of Research Information in Civil Engineering, Vol.14, No 4, 2017

14. B.F.Maison, C.F.Neuss, K.Kasai, (1983), The Comparative Performance Of Seismic Response Spectrum Combination Rules In Building Analysis,

15. S.S.Patil, S.Aghadge, C.G.Konapure, C.A.Ghadge, (2013), Seicmic Analysis Of High Rise Building By Response Spectrum Method,IOSR Journal of ENGINEERING,vOL. 3,iSSUE 9,pp 01-09.