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Seismic and Wind Response Analysis of High-Rise and Low-Rise Buildings: A Comprehensive Study

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ABSTRACT –

This abstract provides a concise overview of several studies focusing on different aspects of structural dynamics and performance evaluation. The first study investigates the seismic assessment of a 21-story building with an asymmetrical plan, utilizing in-situ measurements to evaluate the structure's seismic performance. The second study delves into soil-structure interaction effects on the dynamic response of linear structures, presenting response spectra to assess analysis accuracy across various parameters. The third study examines the dynamics of building-soil interaction with embedded foundations and damping mechanisms, revealing how natural frequency and damping increase with embedding, thereby influencing earthquake response, while effective damping is shown to rise with internal friction in the soil. Additionally, the abstract highlights research on wind effects on super-tall buildings during Typhoon Nesat in 2011, analyzing wind fields, structural properties, and wind-induced responses to enhance understanding of building resilience in extreme weather conditions. Lastly, the abstract discusses dynamic properties of low-rise reinforced concrete buildings during construction stages, emphasizing the integration of measurement and numerical analysis for rational outputs in structural engineering practices.

Keywords: Seismic assessment, Dynamic characteristics, Frequency Domain Decomposition, Soil effect, Fixed-base structure, Soil-structure interaction, Single-degree-of-freedom systems, Response spectra, Dimensionless parameters, Building-soil interaction, Foundation embedding, Material damping, Earthquake response, Dynamic behavior, Vibration test, RC building, Infill wall, Foundation flexibility, Wind effects, Structural vibrations, Damping ratios, Serviceability performance, Super-tall buildings.

I. INTRODUCTION

In this study, we undertake a comprehensive assessment of the seismic vulnerability of a 21-story building situated in Guadeloupe, with a particular focus on evaluating its seismic performance and dynamic characteristics. Central to our investigation is an exploration of soil-structure interaction effects on the dynamic response of linear structures, wherein we compare the behavior of buildings on soft soil versus firm ground. This comparative analysis sheds light on the influence of soil conditions on structural dynamics under seismic loading, aiding in the optimization of designs for enhanced seismic resilience. Moreover, our study extends to examining the earthquake response of buildings on flexible soil, incorporating factors like embedment and internal friction effects to elucidate the complex dynamics governing the interaction between buildings and their foundations, particularly crucial for accurate seismic vulnerability prediction and mitigation.

Additionally, we delve into the impact of wind on super-tall buildings during typhoons, recognizing the growing importance of understanding dynamic responses to wind loading for structural integrity and occupant safety. Employing empirical formulas and numerical analyses, we quantify the dynamic properties of buildings, crucial for determining their lateral forces and responses to external loads. Through empirical observations and analytical methods, our study aims to provide valuable insights that inform the development of more resilient and sustainable structural designs, ultimately enhancing the safety and resilience of built environments in regions prone to seismic and wind hazards like Guadeloupe.

II. REVIEW OF LITERATURES

In their 2000 publication on the "Dynamic Behavior of Building-Foundation Systems," Anestis Veletsos, Jethro Meek, and Bauunternehmung Prien present a comprehensive investigation into the intricate dynamics of soil-structure interaction in building systems. Utilizing Discrete Fourier Transform techniques, the study meticulously evaluates system responses, with a specific emphasis on the harmonic response of foundations isolated from superstructure mass effects. Through rigorous analysis, the research elucidates the profound impact of soil-structure interaction on dynamic responses, offering insights into response spectra under diverse earthquake motion inputs. Delving further, the study explores the frequency-dependent properties of equivalent springs and dashpots, providing crucial insights into the behavior of linear structures subjected to dynamic loads. Anticipating future directions, the authors propose advanced studies to deepen understanding of soil-structure interaction effects across various foundation types and soil conditions. Highlighting the significance of soil-structure interaction, the research identifies maximum structural deformation as a pivotal factor governing internal forces within these systems. Additionally, comparative analyses between structures on soft soil and firm ground underscore the importance of soil conditions in dynamic response assessment, contributing valuable knowledge for structural design and analysis practices.

Jacob Bielak's 2000 study, "Dynamic Behaviour of Structures with Embedded Foundations," delves into the intricate dynamics of building-soil interaction, foundation embedding, material damping, and earthquake response. Bielak's research primarily focuses on deriving earthquake response formulas tailored specifically for scenarios involving building-soil interaction, paying particular attention to problems associated with embedded foundations and formulations concerning hysteretic damping. While specific problems are not explicitly outlined in the provided context, the study meticulously examines system parameters crucial for comprehending responses within building-foundation systems. Additionally, Bielak suggests potential future research avenues, hinting at the exploration of rotational components and further investigation into earthquake response dynamics. The research delves deeper into the dynamics of building-soil interaction by considering embedded foundations and damping mechanisms, revealing how natural frequency and damping increase with embedding, thereby significantly impacting earthquake response dynamics. Noteworthy is the study's emphasis on the role of internal friction within the soil, which contributes to the enhancement of effective damping. Expanding its scope, the research also analyzes the earthquake responses of buildings situated on flexible soil, incorporating factors such as embedment and internal friction to provide insights into the intricate dynamics of soil-structure interaction during seismic events.

In their 2010 research on the "Identification of Dynamic Properties of Low-Rise RC Building," N. Poovarodom and K. Charoen pong meticulously examine the dynamic characteristics of reinforced concrete (RC) buildings, with a focus on vibration testing, infill walls, and foundation flexibility. Employing a combined approach of measurement techniques for accuracy and numerical analysis for comprehensive insights, the study delves into dynamic testing and numerical analysis of a six-story building, particularly scrutinizing masonry walls and foundation flexibility through ambient vibration measurements. Through their investigation, the research elucidates the significant impact of soil-structure interaction on natural frequencies, alongside the influence of masonry walls on the building's dynamic properties. Moreover, it unveils that foundation flexibility plays a crucial role in determining natural frequencies, showcasing soil-structure interaction effects, while damping ratios exhibit increases correlating with mass and stiffness components within the structure. Looking ahead, the authors suggest further exploration into the dynamic properties of taller buildings across different construction stages and the examination of various foundation types' impact on building dynamics. Additionally, the study broadens its scope by presenting insights into wind effects on super-tall buildings during Typhoon Nesat in 2011, analyzing wind fields, structural properties, and wind-induced responses of buildings, thus providing valuable knowledge on the resilience of tall structures during extreme weather conditions.

In their 2014 publication in Case Studies in Nondestructive Testing and Evaluation, Q.-B Bui, S. Hans, and C. Boutin delve into the seismic assessment and dynamic characteristics of buildings, with a particular emphasis on structures featuring asymmetrical plans and the influence of soil dynamics. Through meticulous in-situ dynamic measurements employing accelerometers or velocimeters, the study unveils the natural frequencies of buildings, crucial for understanding their behavior under seismic stress. Utilizing the Frequency Domain Decomposition (FDD) method, the research dissects the complex vibration modes of such buildings, while also accounting for the soil effect on their behavior. Notably, the study meticulously calibrates concrete modulus and masonry values to ensure the accuracy of its models. By isolating building behavior from soil effects, the research pioneers a more precise approach to seismic assessment, validated through numerical models that both verify dynamic characteristics and fine-tune soil properties. This comprehensive methodology is exemplified through a detailed case study of a 21-story building with an asymmetrical plan, providing valuable insights into the dynamic behavior of such structures and the interplay of soil dynamics in seismic scenarios. Looking forward, the study hints at future research avenues, suggesting the introduction of simulated excitations to further enhance assessment techniques.

In their 2015 study on the "Monitoring of dynamic behavior of super-tall buildings during typhoons," Qiusheng Li and Jun Yi meticulously explore wind effects, structural vibrations, damping ratios, and serviceability performance in super-tall buildings. Employing Fourier transform for energy distributions in the frequency domain and wavelet transform for time-frequency energy distributions of structural vibrations, the research uncovers novel insights into tall structure dynamics during extreme weather events. Challenges posed by multipath effects on GPS displacement records are effectively addressed through high-pass filtering techniques, revealing variations in damping ratios correlated with amplitude and nonlinear energy dissipation phenomena. Additionally, the investigation examines typhoon-generated wind characteristics and resulting structural responses, estimating wind speeds at the building's apex and aligning measured natural frequencies with existing empirical formulas. Advocating for further exploration into wind effects on tall buildings, the authors emphasize the importance of investigating natural frequencies and acceleration responses under varying wind conditions. The study also extends its scope to analyze typhoon effects on super-tall buildings in Hong Kong, providing insights into wind-induced responses and dynamic properties to enhance understanding and resilience of high-rise structures in adverse weather conditions. Through a comprehensive approach integrating measurement techniques and numerical analysis, the research contributes to understanding dynamic properties crucial for accurately estimating lateral forces and responses, utilizing both empirical formulas and numerical analysis to enhance property estimation methodologies.

III. CONCLUSION

The conclusion emphasizes the crucial role of considering soil effects in seismic design, utilizing methods such as in-situ measurements, FDD, and FE modeling for accurate assessment. It underscores that neglecting soil dynamics may lead to underestimating natural frequency and damping, impacting structural safety. Additionally, the interaction between buildings and soil is highlighted as crucial for seismic considerations, with three key parameters influencing the foundation-structure system response. Furthermore, wind effects on super-tall buildings during extreme weather events were analyzed, revealing variations in damping ratios correlated with vibration amplitude. The studies also identified natural frequency changes during construction stages, emphasizing the importance of monitoring structural dynamics throughout the building process. Lastly, the impact of masonry walls on building stiffness compared to mass was noted, contributing to a comprehensive understanding of structural behavior.

IV.REFERENCES

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