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Develop Approximate Analytical Models for Separated Seismic Analysis of Connected Buildings by SAP 2000

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ABSTRACT

In seismic analysis and earthquake-resistant design, a common assumption is that all supports within a structure will undergo the same earthquake motions. However, this assumption may lead to an inaccurate response, especially for elongated structures with extended lifelines. Since the 1960s, researchers have focused on investigating the impact of spatially varied ground vibrations on the seismic behavior of such structures, including long-span bridges (like cable-stayed bridges), multi-span continuous bridges, and similar architectural forms. During an earthquake event, seismic waves originate at the epicenter and traverse complex soil layers, encountering diverse conditions until they reach the earth's surface, which exhibits variable properties based on its location and composition. In this study, SAP2000 software was employed to create models for analysis. Three distinct types of trusses were utilized as connecting bridges within the models. Two structures, each consisting of 19 floors (G+19), were developed and linked by bridges constructed at the 7th and 14th floors of the buildings. The analysis involved conducting time history analyses on these models while varying the cohesion and friction parameters.

***Keywords* —** Multi Story, Connected Buildings, High Rise Building, Seismic Analysis, Structures, SAP 2000.

I. INTRODUCTION

Ensuring the structural reliability and safety of buildings holds immense significance, particularly in densely populated urban regions, especially those prone to seismic activity. The close proximity and interconnection of buildings present a distinctive challenge in seismic analysis and design. Understanding the dynamic behavior and potential risks associated with interconnected buildings during seismic events is pivotal for safeguarding public welfare, reducing destruction, and shaping effective urban planning and structural design strategies.

The seismic analysis of connected buildings involves a thorough evaluation of how interconnected structures respond to seismic forces. This assessment encompasses various factors, including the buildings' proximity, their structural interdependencies, and the dynamic interactions during seismic occurrences. Unlike isolated structures, interconnected buildings mutually influence each other's reaction to ground motion, either amplifying or mitigating the effects of seismic forces.

Skyscrapers, distinct from low-rise structures, stand tall and serve diverse purposes such as residences, offices, hotels, retail spaces, or a combination of functions. The term "multi-unit buildings" (MDUs) is typically used for multi-story residential structures, whereas "skyscrapers" specifically signify towering architectural marvels. Advancements in building materials and elevator technologies, such as the innovative DJF elevator design, have significantly enhanced the feasibility and cost-effectiveness of constructing high-rise buildings.

II. SOIL-STRUCTURE INTERACTION (SSI) AND STRUCTURAL RESPONSE

According to prevailing theory, the interplay between different soil types can potentially enhance the response of structures. However, in seismic structural analysis, several design codes often discourage considering the influence of Soil-Structure Interaction (SSI). These recommendations are based on an assumption lacking empirical support suggesting that SSIs could improve structural responses and increase safety margins. Analyzing the effects of landscape architectural relationships aids in strategic planning, thereby enhancing a structure's natural resilience. This approach offers a superior system compared to rigid structures of equivalent nature. Neglecting to incorporate the impact of SSI in the design process may limit the facility's overall performance. Unfortunately, this study faced limitations or disregarded certain design elements, resulting in a constrained analysis of SSI. Ignoring the complexity of SSI can oversimplify structural analysis, thus contradicting the notion that SSI positively impacts the system. In reality, SSIs might prove detrimental to organizational structures, and neglecting their effects can compromise the integrity and design of a structure, particularly in areas such as a vehicle's turret.

III. USED MODEL AND METHODOLOGY

In this chapter involves the creation of various models featuring buildings with G+19 floors. The analysis will employ the time history concept. Different types of trusses will be utilized in the building structures, and various types of soil structures will also be incorporated. The preparation of these models will be carried out using SAP2000 software. To modify the soil properties, the values of cohesion and friction will be adjusted. A total of nine models will be generated for the analysis process.

Model Geometry

Table 1: 9 Different Cases of Soil and Truss

Model	Name of Models	Cohession	Fricition Angle	Cases
1	Pratt truss with C-soil	20	0	Pratt truss case-1
2	Pratt truss with ϕ-soil	0	30	Pratt truss case-2
3	Pratt truss with C-ϕ soil	20	30	Pratt truss case-3
4	Warren truss with C-soil	20	0	Warren truss case-1
5	Warren truss with ϕ-soil	0	30	Warren truss case-2
6	Warren truss with C-ϕ soil	20	30	Warren truss case-3
7	Virendeel truss with C-soil	20	0	Virendeel truss case-1
8	Virendeel truss with ϕ-soil	0	30	Virendeel truss case-2
9	Virendeel truss C-ϕ soil	20	30	Virendeel truss case-3

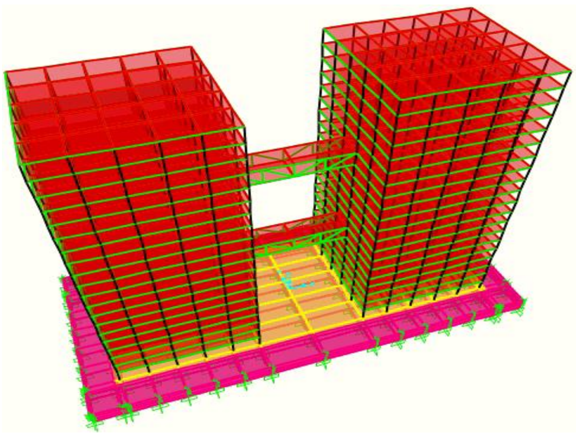

Fig. 1: Three-dimensional Visualization of Bareframe Featuring Pratt Truss - Case 1

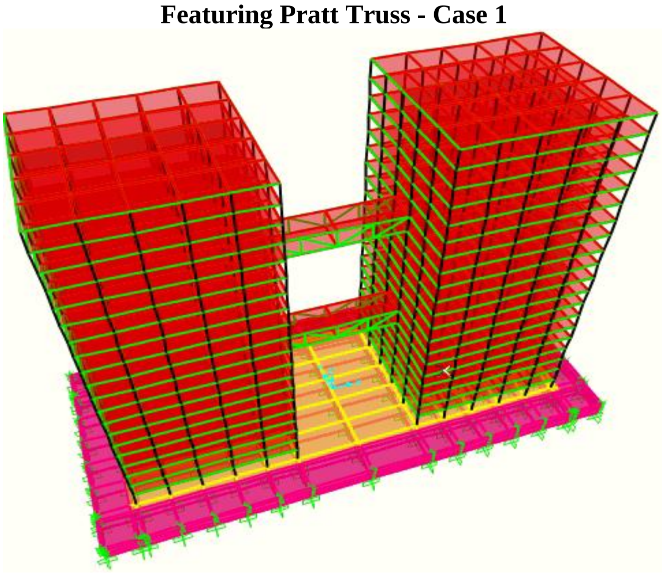

Fig. 2: Three-dimensional Visualization of Bareframe Featuring Pratt Truss - Case 2

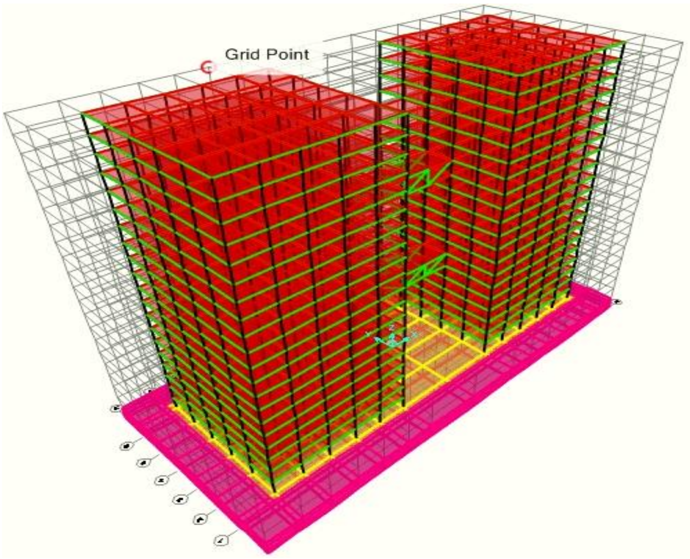

Fig. 3: Three-dimensional Visualization of Bareframe Featuring Pratt Truss - Case 3

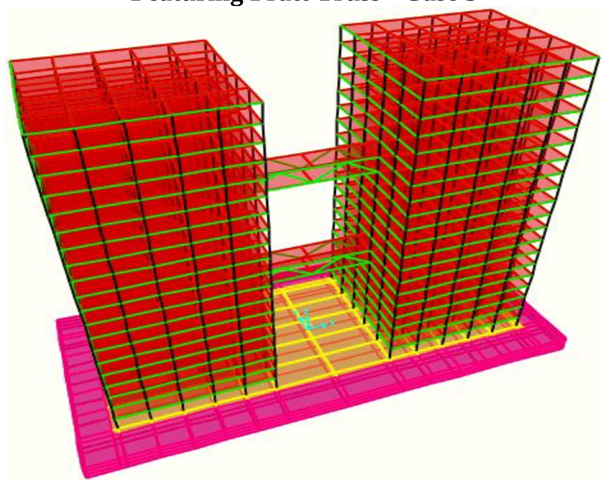

Fig. 4: Three-Dimensional Display of Bareframe Incorporating Warren Truss - Case 1

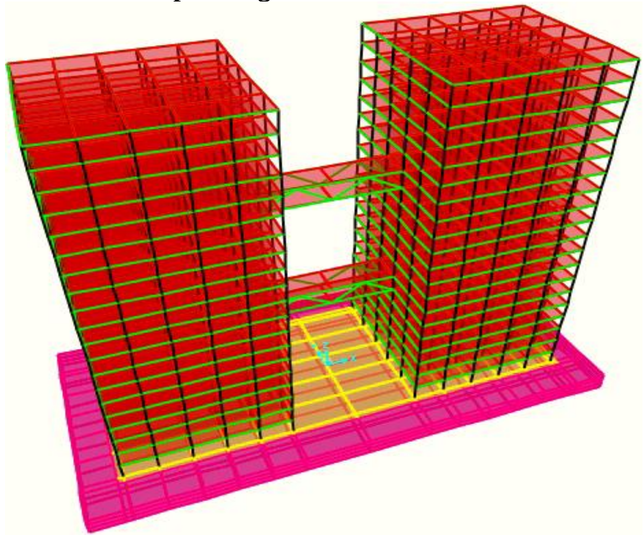

Fig. 5: Three-Dimensional Display of Bareframe Incorporating Warren Truss - Case 2

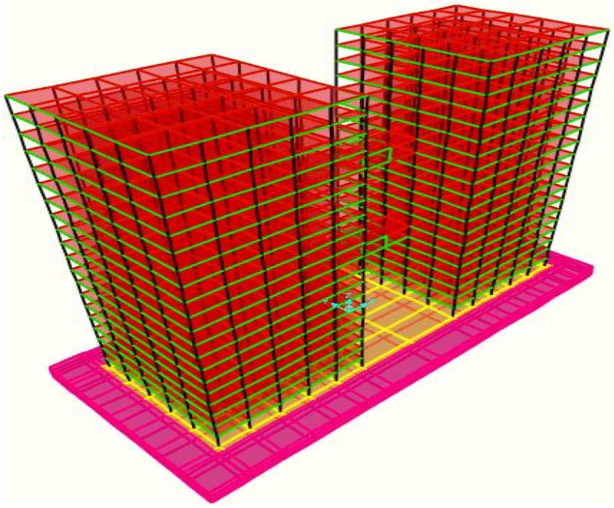

Fig. 6: Three-Dimensional Display of Bareframe Incorporating Warren Truss - Case 3

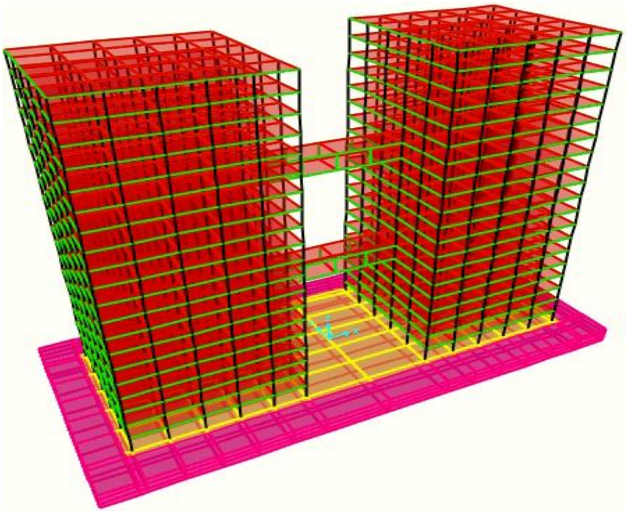

Fig. 7: Three-Dimensional Perspective of Bareframe Employing Vierendeel Truss - Case 1

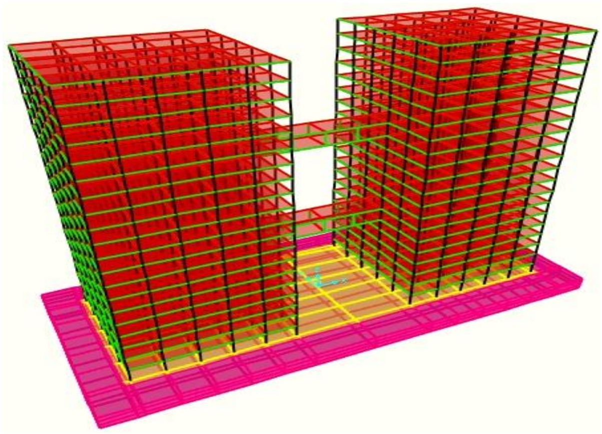

Fig. 8: Three-Dimensional Perspective of Bareframe Employing Vierendeel Truss - Case 2

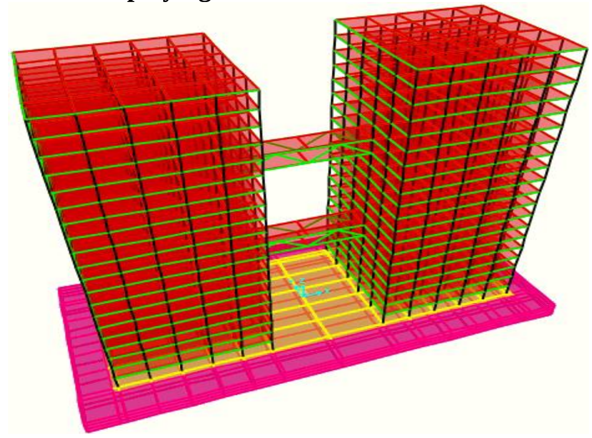

Fig. 9: Three-Dimensional Perspective of Bareframe Employing Vierendeel Truss - Case 3

IV. RESULTS AND DISCUSSION

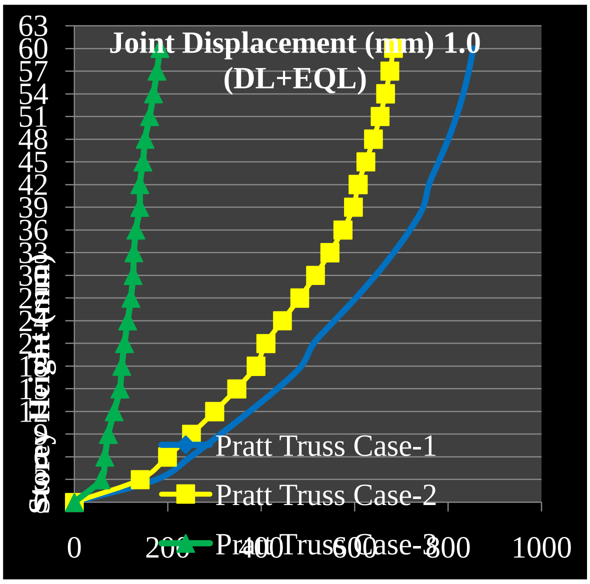

Fig. 10: Joint Displacement 1.0 (DL+EQL) of Pratt Truss in Different Cases

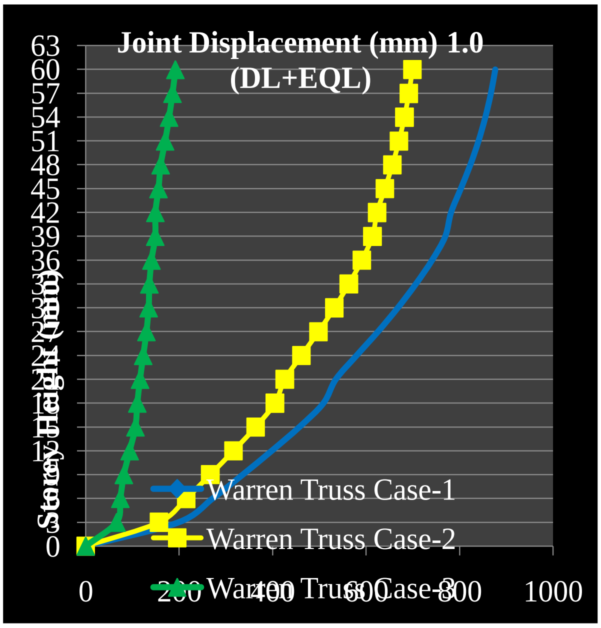

Fig. 11: Joint Displacement 1.0 (DL+EQL) of Warren Truss in Different Cases

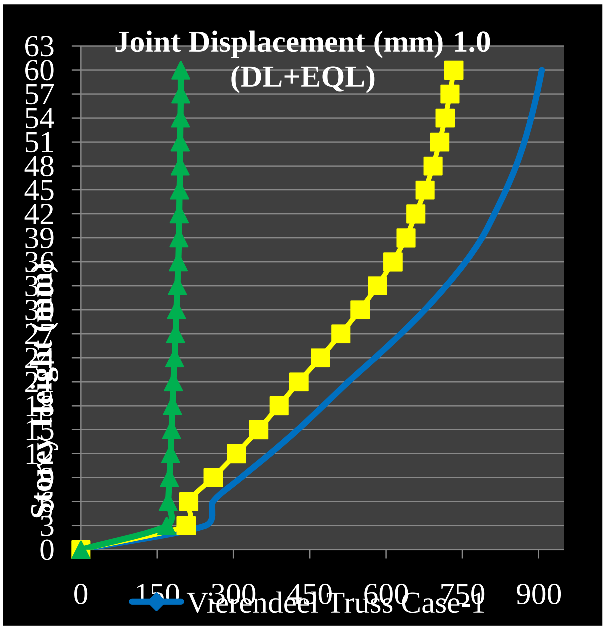

Fig. 12: Joint Displacement 1.0 (DL+EQL) of Vierendeel Truss in Different Cases

V. CONCLUSIONS

The In conclusion, seismic analysis and earthquake-resistant design commonly assume uniform earthquake motions across all supports within a structure. However, this assumption might not accurately represent the response, particularly for elongated structures with extended lifelines. Since the 1960s, researchers have been investigating how spatially varied ground vibrations impact the seismic behavior of such structures, including long-span bridges like cable-stayed bridges, multi-span continuous bridges, and similar architectural forms.

During seismic events, waves originating at the epicenter travel through intricate soil layers, encountering diverse conditions until they reach the earth's surface, which exhibits variable properties based on location and composition.

This study utilized SAP2000 software to develop models for analysis. Three distinct truss types were employed as connecting bridges within these models. Two structures, each featuring 19 floors (G+19), were interconnected by bridges constructed at the 7th and 14th floors of the buildings. The analysis involved conducting time history analyses on these models, varying cohesion and friction parameters to explore their impact.

This comprehensive investigation sheds light on the importance of considering spatially varied ground vibrations in seismic analysis, particularly for structures spanning significant lengths. Incorporating such variations into analysis methodologies is crucial for accurately predicting and enhancing the seismic resilience of elongated structures. The utilization of advanced software and varied truss designs in this study offers valuable insights into addressing these complexities for more robust earthquake-resistant design and structural planning in the future.

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