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A DESIGN AND ANALYSIS OF TWIN-TOWER CONJOINED BUILDING WITH VIBRATION ABSORBER USING STMD-MR DAMPERS

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ABSTRACT: Buildings have been destroyed and there has been much instability throughout the ages due to earthquakes. Modern buildings are exposed to a gradually growing seismic force due to their increasing height and volume. This seismic design is now an essential component of the structure's analysis and design in order to prevent major damage and ensure safety. Increasing the building's stiffness is typically used in traditional seismic design to decrease the structure's response to an earthquake. The traditional approach is typically expensive and has an practical applicability, thus it is unable to significantly increase the structure's bearing capacity. Therefore, by using the hybrid system damage for tall building will be reduced. Using a hybrid model system (Shared Tuned Mass Damper (STMD) + Magneto-Rheological (MR) dampers), the transform functions and random seismic responses of the flexibly combined structures are obtained analytically. In addition to significantly reducing response times, this hybrid system control enhances the building's seismic performance.

KEYWORDS: seismic Design, Shared Tuned Mass Damper (STMD), Magneto-rheological (MR), Twin Towers

I. INTRODUCTION

Following September 11, 2001, after the tall buildings of the World Trade Center in New York were destroyed, many people instantly believed that skyscraper development would never take place again [1]. However, architects and engineers knew the history of tall buildings in cities, which realized that such large urban constructions did not simply happen to exist; as the world's population increased and more people started moving from rural to urban regions, they were required to address the problems associated with developing human habitation[2]. When the authors presented their papers on tall buildings in various contexts, the critics of these constructions were addressed, and in an effort to address the issue of growing urban density, an effort was made to understand the reasons behind the relentless construction of tall structures in the lack of practical alternatives. There are certain shortcomings to tall structures. However, if the wide and empty sky may be used to build a vertical scale of cities, urban sprawl and all of its related issues have no reason, would be generated or supported horizontally [3].

For example, a significant number of supertall (more than 300 m) and megatall (more than 600 m) buildings have been developed in the first two decades of the twenty-first century. More skyscrapers are being developed, As per the December 25, 2017/1 January 2018 issue of Time magazine and the Council on tall buildings and urban habitat (CTBUH), (greater than 200 meters in height) were constructed in cities in 2017 than in any previous year. The previous few decades have seen a global phenomena in the development of tall buildings, and the race for height is still continuing [4].

It's interesting to note that the concept of scale has been around for structures since Aristotle's time. They emphasized that size, proportion, and order that make an object beautiful. Galileo Galilei claimed that an object's size has a significant impact on its structure function, and provided precise observations of both animate and inanimate shapes and structures to support the suggestion [5]. It indicates that the load impact will eventually greater than the structural strength of any scaled-up structural system. Structural engineers and architects are aware that, in order to maximize horizontal spans, various structural elements such as beams, trusses, arches, cables, etc. must be used efficiently. The reasoning was applicable to vertical structures and claimed that different structural systems are required as structures get higher. The observation that higher structures place higher demands on the structural system and this concept developed from the fact that height is valued more due to lateral loads brought on by lateral wind loads [6].

Based on investigations, it was proposed that above 10 stories, the lateral wobbling begins to impact the design, stiffness gets importance over strength, the number of stories increases the premium for height significantly. This problem develops for the simple reality that the shear racking and cantilever movement cause the building's stiffness need to increase quickly, which provide the basis to total lateral movement and are caused by lateral weights being greatly increased with height. When lateral loads are not applied to the building, this means that it is able to support gravity loads, then the building's steel consumption with respect to height is represented by a straight line [7]. Reducing the shaded area and using a more suitable

structural system will help practical designers limit the amount of structural material used. The recognition that a building's synergistic arrangement of structural members are the first step toward implementing such a system into practice is to design it more effectively minimizes the internal forces and deformations that external loads create in the members, hence providing better strength and stiffness by design. This gives development to the concept of structural system variability to satisfy various loading needs as the dimensional constraints of the building [8].

The premium for height increases as a result of the wind's lateral load effect, which increases with height and causes the pressure on the building's windward side to rise nonlinearly according to power law[9]. It is important that, even though Khan demonstrated the second-order effect of wind loading and described the key concepts of the premium for height, this phenomena makes extending constructions more prone to lateral sway have a larger height-to-width aspect ratio and are generally much slenderer than typical low-rise or mid-rise buildings. An additional overturning action is produced by the building's vertical gravity loads acting on the gradually larger deflected profile due to sway, which results in the second-order effect [10]. For the purpose of maintaining occupant comfort and avoiding damage to nonstructural components, wind-related lateral sways usually regulate the design, even for very tall buildings and in seismic zones, using low natural frequencies instead of seismic zones. At the maximum load level, where plastic hinges could develop, it is important to maintain continuity and take inelastic behavior into consideration, to ensure that the building has adequate ductility and energy-

dissipation capacity for seismic loads, structural components and connections need to be described properly. Since many supertall structures have been constructed in regions with frequent earthquakes in recent years, earthquake safety has been recognized as a significant structural design factor along wind resistance. However, for supertall and megatall buildings, wind is still typically taken consideration when designing the lateral load-resisting systems.

Generally, to determine the higher floors of tall buildings lateral acceleration, thin buildings, a wind-related dynamic study is required. By performing, it will be ensured that excessive building vibration will not impact occupant comfort, by changing the mass and stiffness parameters of the building, further active or passive control systems can be added to regulate the acceleration. Vortex-shedding-induced across-wind response must be given special care for supertall and megatall buildings since it may result in disastrous resonance. By designing special plan shapes with chamfered, rounded edges, non-prismatic forms can be added to the building to disrupt orderly vortex shedding over the building height either locally or globally, or two more useful techniques to manage wind-induced reactions of such buildings are notched corners and irregular external surfaces.

Utilizing the Twin Tower as a reference, a accurate scale model of the twin sky corridor that is symmetrical and has a sky corridor is created. A wooden structure model, mechanical analysis, seismic and structural design criteria have to be met by the high-rise twin-tower conjoined development, the two towers vibration characteristics with their flexibly combined parts are evaluated for vibration

loading. Energy dissipation and shock-absorbing devices, such as vibration absorbers, included into building structures by numerous scholars both domestically and abroad in recent times. The vibration absorber, it can effectively reduce earthquake damage to the main structure and is an improvement over the traditional structural design. In this work, the flexibly combined element is a vibration absorber, which increases its seismic performance in an earthquake, taking into consideration both economy and applicability.

II. LITERATURE SURVEY

T. Li, et.al [11] interactions due to the significance of these connections in the behavior of the seismically resistant construction between the precast structural members and the members at the base foundation. This research ultimately shows that, following an examination of the development and capabilities of seismically resistant precast concrete buildings, as well as a comparison of energy- and performance-based design approaches, performance-based design is used, accurate calculation methods are still required for the energy dissipation mechanisms at the local and system levels. R. Vargas, et.al [12] a different approach for seismic, in alternative to the lateral force method, was first recognized in the most recent version of the Republic of Panama's structural design code (REP-2014), performance-based design methodologies are used in the Los Angeles region for the analysis and design of tall buildings. In particular, this study presents the nonlinear static approaches for evaluating the structural performance of buildings. There will also be a description of nonlinear modeling used to create a building's seismic capacity curve, or pushover curve. In a similar manner, inelastic acceleration spectra will be used to characterize seismic demand for various

earthquake levels. Through the application of this process, the engineer can confirm if the demonstrated damage, or structural response, satisfies the acceptance requirements set out by design regulations.

Jacob S., Azam G., Siew W. H., Raina A., Peng Z. and Agyemang H. K., et.al [13] present implementation of the Lightning Protection System BS EN (British standard implementations of English language versions of European standards (ENs)) Standard for tall structures including glass facade architecture. The results demonstrate that the metallic frames of tall structures with glass facades are not protected from lightning current by the existing lightning protection systems since they are neither permanently linked to the ground. A thorough lightning protection system must be created for tall structures with glass façade architecture.

J. Cai, et.al [14] Two well-known methods for determining wind loads are the wind load determination method through the Load Code for the Design of Building Structures and the wind load determination method through ASCE 7. These techniques attempt to identify which more careful course of action offers a higher level of surety for safety in connection to wind loads. All things considered, wind loads applied to structures can be calculated using the complex and widely applicable system provided by the load code for the design of building structures. It can offer a high level of safety for buildings that are resistant to wind loads. Although there is certainly need for improvement, the ASCE 7 wind load estimation method is another reliable approach for calculating wind loads.

M. AlHamaydeh, M. E. Elkafrawy, F. M. Amin, A. M. Maky and F. Mahmoudi, et.al [15] the use of ultra-high performance concrete for shear walls in tall buildings

while maintaining structural efficiency and environmental sustainability. When analyzing and creating structures that are 20 or 40 stories, the implementation of the coupled special reinforced concrete shear walls system formed the lateral force-resisting system. The compressive strength of normal strength concrete was 60 MPa, though the compressive strengths of ultra-high performance concrete varied depending on the designer. The results demonstrated that the lateral load resisting system's layout had effectively improved stress distribution inside the buildings while also reducing torsional impacts. Consequently, there is less need for ultra-high-performance concrete when a well-designed and verified configuration is used. Additionally, using ultra-high-performance concrete might negatively impact building performance and increase the cost of construction in the case of relatively large, very effective lateral load resisting devices.

Azizi M., Talatahari S. and Giaralis A., et.al [16] Fuzzy logic controllers (FLCs) with optimal rule bases and membership functions are developed using an Upgraded grey wolf optimizer (UGWO) in an effort to reduce seismic structural damage. The latter is stated on the ends of structural members in terms of the maximum curvature ductility ratio. By taking into consideration FLC-based optimal seismic active management, a twenty-story steel benchmark building with nonlinear behavior and more than 400 design elements is used to demonstrate the capabilities of the UGWO. The efficiency of the UGWO is evaluated by comparing its output with the results of five different, utilizing state-of-art metaheuristic optimization techniques, such as the basic Grey Wolf Optimizer, in addition to nine different structural performance measures. Comparisons show that UGWO can

provide better seismic performance, this minimizes structural reactions and damages for the construction being evaluated as a benchmark.

D. M. Sahoo and S. Chakraverty, et.al [17] suggests using Functional Link Neural Networks (FLNNs) to predict that the tall structural responses will be affected by seismic loads. The input for this study is the ground acceleration data, and the output is the structural responses of the various levels of the multistory shear buildings. It is important to note that managing large amounts of seismic data has become to be a significant difficulty in the construction of tall buildings, including shear buildings. Therefore, combined with effective Chebyshev and Legendre polynomials, in FLNN a functional expansion block has been used. When the output of an FLNN and a Multilayer neural network (MNN) are compared, it is discovered that the FLNN performs more efficiently computationally than the MNN and provides more accuracy.

S. Nilnond, N. Chinthaned, P. Sanposh, J. Rungrangpitayagon, J. Rohlfing and K. Phuvoravan, et.al [18] For the Active Mass Damping (AMD) system, in order to modify Proportional-Integral-Derivative (PID) PID gains in a three-floor scale model with Loma Prieta Earthquake excitation, a fixed-structure H_{∞} (specified energy) control technique was proposed. The results demonstrate that effective the proposed approach. Compared to the AMD system without the AMD system and under PID- Particle Swarm Optimization (PSO) PSO tuner control, the maximum deflection of the third floor under seismic excitation may be significantly reduced by the AMD system with the fixed-structure H_{∞} control.

Vincenzi L., Bassoli E., Bovo M. and Mazzotti C., et.al [19] Dynamic tests were

conducted both prior to the strengthening in order to examine the bell tower's model features and evaluate potential modifications in dynamic behavior brought about by the intervention. An advanced MEMS (Micro-Electro-Mechanical System) MEMS-based system was used to record accelerations during ambient vibrations. Its primary characteristics include digital data transmission and the ability to do some system evaluations directly on-board the sensors. 11 biaxial MEMS units were used to acquire accelerations. The first eight modes, whose natural frequencies range between 0.5 and 9.0 Hz, are readily identifiable. Finally, a traditional analog (piezoelectric) system and the installed MEMS-based system are compared in terms of performance, with critical comparisons of the results.

X. Zhou, T. Tian, J. Bai, Y. Luo, X. Yang and T. Yang, et.al [20] maximum allowable value of each safety index of tower grounding device under the condition of power frequency short circuit lightning strike, calculates the actual value of safety index of grounding device under typical design by grounding simulation software. Through comparison, it is found that the over-standard power frequency step voltage is a key problem in the safety of grounding devices. The spiral grounding module is proposed to replace part of the vertical grounding electrode to balance the step voltage, and the structural parameters are optimized. The design method of 220kV(Kilovolt (kV)) urban transmission steel pipe tower linear radiation grounding device combined with spiral grounding module and the safe grounding design scheme of transmission steel pipe tower are given, which provides a reference for the safe design of transmission tower grounding.

III. METHODOLOGY

The systems of two adjacent buildings are described. A STMD-MR that was precisely adjusted for mass, rigidity, and damping in accordance with the dynamic characteristics of the building it had been placed on mounted in every structure. A hybrid STMD-MR that was adjusted for the building's dynamic characteristics are been placed in the structure. A dashpot was used to share the STMD-MR throughout the building.

The displacement response of both structures exhibits a decreasing trend that is followed by an increasing trend as the frequency ratio is increased. The cost function also exhibits this pattern. The optimal frequency ratio decreases with increasing damping. If they take the minima (least) (based on the cost function) at a higher frequency ratio as the global minimum cost. This results in more efficient optimal solutions. These optimal solutions are associated with extremely stiff springs in the STMD-MR.

In consideration of the symmetrical, conjoined twin tower's durability, practicality, and safety, a more thorough examination of its bearing capacity is required. The symmetrical, linked twin tower is modelled physically. Since it is impossible to directly get the load-displacement relationship curve, the analysis mostly depends on the bearing capacity and the results of the experiment. Based on the initial loading and further vibration absorber reinforcement, the physical model's simulation of the structure's bearing capacity is predicted to be as high as 6.5 kg, indicating a high safety factor. With a 6 kg bearing capacity, the vibration absorber goes through a considerable force, and its safety margin is limited. The vibration absorber successfully reduced the total vibration amplitude following the application of

seismic force, and there was finally no structural damage. The structural bearing capacity analysis leads to the following results. By reducing the structure's natural vibration period, the twin tower's sky corridor could increase overall stiffness. When there is a sky corridor present, the twin tower structure's vibration is more complex, because the sky corridor enhances the diversity of vibration at intermediate and higher levels while changing the directional aspects of the structure's total vibration. Only a small amount of the structure's natural vibration period is affected by the sky corridor, but the top floor's displacement and the difference between tower levels are significantly impacted.

A vibration absorber could efficiently use energy, increasing the structure's carrying capacity. The amount of material utilized in the structure can be reduced while maintaining bearing capacity by adjusting the vibration absorber. Because of this, structural performance and cost can be coordinated and unified, hence lowering the structure's overall cost. A vibration absorber could successfully lower the vibration's amplitude. When taking into consideration the economics element, when the structure is designed with one or two vibration absorbers, its dampening function can be fully utilized and good results can be achieved.

In case that the vibration absorber swings past a particular point, the wood block will prevent the wood strip was connected under the platform from moving. If the swing goes over the limit, the wood strip below the platform will secure it and give it restoring force, limiting the vibration absorber's displacement. The greatest displacement under a seismic wave determined by several testing is the displacement limit.

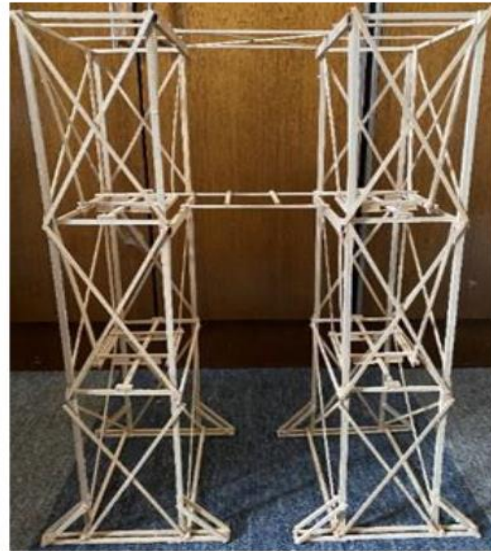


Figure 1. Physical model of the conjoined twin tower

This limit is then reduced in order to get the smallest and most optimal displacement limit, which may successfully limit displacement while also utilizing the vibration absorber to its greatest extent possible.

IV. RESULT ANALYSIS

This section examines the Design and analysis of a twin-tower conjoined building with a vibration absorber utilizing STMD-MR dampers.

Table.1: Performance Comparison

Parameters	STMD-MR	TMD
Gap	05.63	09.7
Flexibility	6.42	4.91
Strength	8.74	6.38

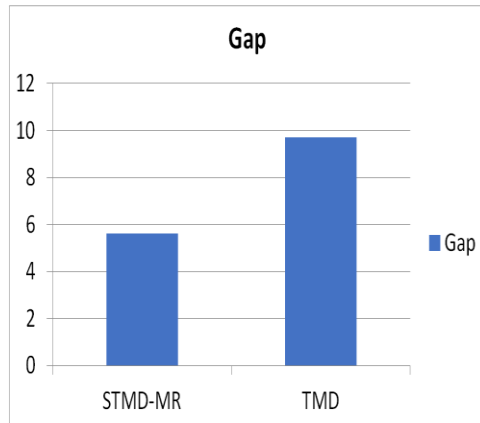


Figure 2. Gap Comparison Graph

Figure 2. shows a gap comparison between the Tuned Mass Damper (TMD) and the Shared tuned mass damper- magneto-rheological (STMD-MR).

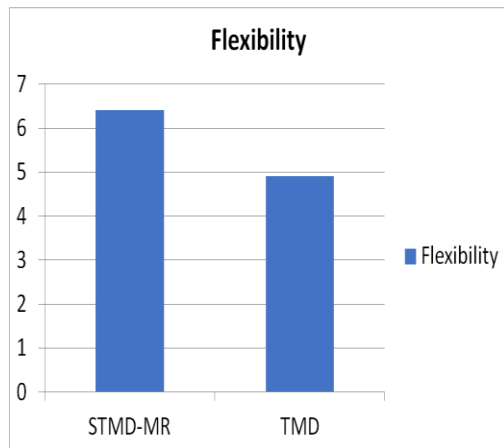


Figure 3. Flexibility Comparison Graph

The flexibility for Shared Tuned Mass Damper- Magneto-rheological (STMD-MR) shows high when compared Tuned Mass Damper (TMD). The graphical representation is observed in Figure 3.

A comparison of the strengths of the Shared tuned mass damper- magneto-rheological (STMD-MR) and Tuned mass damper (TMD) is shown in Figure 4. When the STMD-MR technology is used, the tower's strength increases.

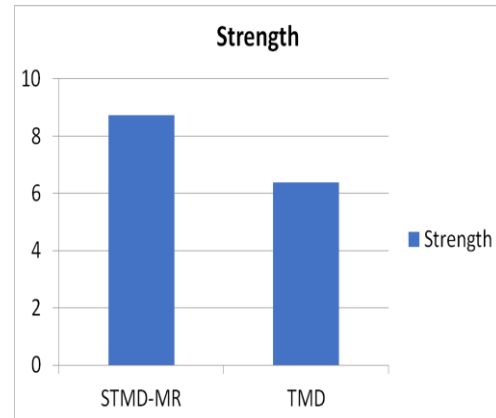


Figure 4. Strength Comparison Graph

V. CONCLUSION

This section concludes the Design and analysis of a twin-tower conjoined building with a vibration absorber utilizing STMD-MR dampers. From one structure to another, a TMD's effects might shared. Therefore, a decrease is possible in both buildings, signifying an economical strategy to managing two adjacent structures using a single shared device. Through integrating a common TMD and an MR damper, a hybrid system can be used to achieve sharing. But the results from the hybrid system are more important than the ones from the TMD. The seismic gap was significantly decreased because sharing between two adjacent structures can clearly reduce the pounding hazard. The hybrid system always achieves its effectiveness with respect to the earthquake predominant frequencies over a wide range of neighboring building frequencies.

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