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Twin Tower High Rise Building Subjected To Seismic Loading: A Review

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Abstract**—** *The figurative tower which compliance all the structural state of affairs are in trend. These structures are not only constructed to deliver the present need but also to show the domination among all over the world which is also used as benchmark in the world. A number of structures were build till date and all of those are symbolic marvels like Petronas Tower in Kuala Lumpur, Huaguoyuan towers in China, Imperial Tower in India, Palm Tower in Doha and the list is myriad. Also a lot of twin towers are under construction not only across the world but also in India too. Such structures are made possible by bridging the gap between these two towers by various means like making the bridge or by RCC frame, steel connections, etc. In this paper various papers are studied to comprehend the concept and optimize the need. The study on various research papers along with existing towers help in deciding the objectives of the study and so the optimizing parameters.*

Keywords**— Connected structure, lateral loading, linked building, response spectrum analysis, Staad pro, Twin tower.**

I. INTRODUCTION

Conventional practices across the world to combat the seismic forces and wind effects as it is more important phenomenon now a days because of increasing construction of skyscraper are obsolete and need new practices and arrangements because the architectural and structural demand is poles apart from earlier construction. To full the increasing demand of living space along with commercial space various efforts are made to fulfill the need of hour.

Twin tower is the best example to rectify such kind of problem which not only comply the demand but also a mark of social and economic prosperity. The major aspect in these kind of building is to bridge the gap by providing a functional link which not only a architecture material but encompasses various functional allocation of the special structure due to a fact that the link proofs the critical fragment of the structure. It is also seen that without providing this link it is not structurally viable to support such kind of structure and contest seismic and wind loads.

To overcome such kind of problem it has been seen that only bridging is not a single solution but by connected by same means as the rest of building is made in bottom, middle or at the top of the structure. Earlier various efforts are made to accomplish the problem connected structure but nowhere the research is done on optimization of connecting part in the middle of building at varying height.

So a detailed review and study is required in the field of connected or linked structure for their stability analysis which helps in suggesting the recent situation the further need of research to optimize the suggested case contrary to various parameters. So a G+12 storied model is created with 13 different cases against several seismic parameters. They are as follows:-

CASE A= G + 12 (no floor twin)
CASE B= G + 12 (01 floor twin)
CASE C= G + 12 (02 floor twin)
CASE D= G + 12 (03 floor twin)
CASE E= G + 12 (04 floor twin)
CASE F= G + 12 (05 floor twin)
CASE G= G + 12 (06 floor twin)
CASE H= G + 12 (07 floor twin)
CASE I= G + 12 (08 floor twin)
CASE J= G + 12 (09 floor twin)
CASE K= G + 12 (10 floor twin)
CASE L= G + 12 (11 floor twin)
CASE M= G + 12 (12 floor twin)

Response spectrum analysis is performed and the building is analyzed for zone 4.

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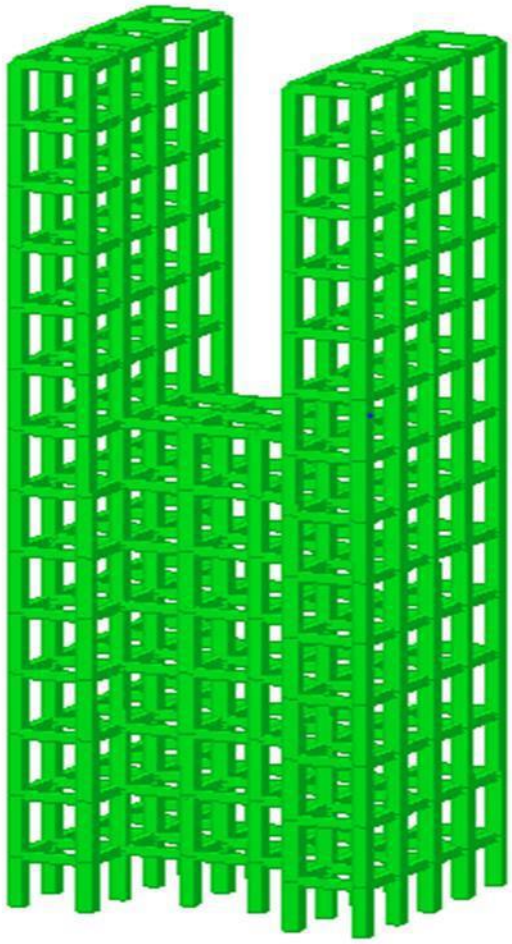

Fig. 1: Isometric view of connected tower having floor twin up to 6th floor.

II. REVIEW OF LITERATURE

Wensheng LU and Xilin LU, in this paper various scaled and connected multistoried high rise tower are modeled tested on shaking table. In this analysis a new concept is taken in to consideration that the effect of flexible transfer floor. Dynamic behaviors of various models are compared between theoretical analysis and tested results. For shaking table test the models of following buildings are made comprises of Guangzhou International Commercial and Trade Plaza, Shanghai Kaixuanmen Mansion, Shanghai BOCOM Financial Tower, Shanghai Chongshou Commercial Plaza and Shanghai Pudong Reception Center. All the models are made up of micro concrete and fine reinforcement. Furthermore theoretical analysis is done by using various models contains multi tower with rigid podium, multi-towers with rigid podium, rigid plate mass spring model and a new multi rigid block model. The results of the study concluded that dynamic behavior of connected tower with respect to conventional multistoried building is usually different. The seismic resistant ability is lower for building with door shape. Large podium shows the significant behavior against the couple action of high rise building between transfer floors. Drift action generated due to increasing height is controlled by flexible connections between linked buildings. In U shape building the seismic response is very crucial.

Ji Dongyu and Li Xiaofen, in this paper an effort is made to analyses 23 storied high rise building in which the bottom three floors are made for commercial housing and the rest of 20 floors are two symmetrical towers connected at 20th story by connecting plates. The study is carried out by finite element analysis in ANSYS software in which the aforesaid high rise twin tower is analyzed by time history analysis for seismic response. The building is connected by RCC plates and pile foundation is adopted at base. Building is analyzed for seismic intensity of 7degrees. Model is tested against various seismic parameter like horizontal displacement, horizontal acceleration, etc. in this analysis is focused on third floor and twenty third floor of the building to find the behavior of seismic parameters against seismic action. The results of the study shows the maximum horizontal displacement at twenty third floor is 0.078m at 2.26sand the horizontal acceleration for the same level is 1.90m/s2 at 1.64s. Similarly for third floor the maximum value recorded of horizontal displacement is 0.006m at 4.20s also horizontal acceleration is found 0.69m/s2 at 4.45s. These numerical value obtained by time history analysis in ANSYS suggest that the assumed connected structured model is safe for seismic action taken for consideration also economic and reasonable as per engineering practices.

Diagoro Isobe, Li Thi Thai Thanh and Zion Sasaki, this study presents the performance against collapse behavior of connected high rise tower by numerical simulations. In this study numerous simulations are done for to analyses the actual cause of collapse of World Trade Center tower in terrorist attack dated on 9/11. To examine the impact forces of dynamic unloading in the core columns a fully scaled structure of World Trade Center is modeled to analyze aircraft impact assessment. Several numerical codes are assumed and analyzed to assess the cause of that havoc. For analysis a linear Timoshenko beam element is taken for consideration. The results of the study suggests that whole collapse in World Trade Center is not only because of reduction of strength of members due to increase in temperature and buckling but because of the fact that the connections in the members is very weak and also due to impact caused by aircraft which creates havoc in column section by destruction of its splices. It is also observed that out of the two towers of World Trade Center one were remained stand for a longer

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time with respect to another one due to reason of symmetrical structural deficiency.

Xiaohan Wu, Jun Wang and Jiangyong Zhou, in this paper author perform research on four multistory tower interconnected on the top floor by a sky corridor bridge. In this analysis seismic action is controlled by tuned mass damper. Corridor is taken as friction pendulum tuned mass damper. The connecter bridge used to bake for path between four towers is connected by flexible links. Perform 3-D software is used to analyze the 3-D model of the framed multistoried connected tower developed by Nosa CAD, Elastoplastic time history analysis is used to analysis the model in Perform 3-D and the seismic parameters are haul out from software and compared against nonlinear response obtained in the result. The model is compose of 8 multi storey framed structure in which 6 storey is used for commercial purposes and bottom three storey is used for basement. All the building specifications are taken as per Chinese Code like C30 concrete is used in RCC members and C60 is used for core tube wall. The result of the study shows that the concept of frequency pendulum tuned mass damper is found successful which reduce not only seismic action and also deformation along with damage extent. When the tower and corridor are connected by rigid connections then the relative displacement developed in the tower is resisted by isolation devices.

S Radhakrishnan, Dr K g Selvan, Dr S Senthil Kumar, author raises an serious issue with this paper regarding poor contruction practices and and negligence of primary conditions like soil report etc. in this paper the case study is done on an under construction 11 storied building that is a twin tower that is swallowed by collapse located at Moulivakkam, porur. The major issue raised is that one building is fallen by itself during its own construction and the other tower that was half built was devastated by imploding. There is very extensive research work is carried out by the author to find out all the possible reason of this havoc. Actually the main reason of all this incident is the death of 61 workers in the construction site by collapsing of building by its own which bring this media and finally to court. To analyze the case study the authors firstly identify the builder with all of its qualification with all the proper approvals released by the state authority. Later the architectural and structural plans are again assessed according to building requirements. After that the soil study is carried out. Timeline is also presented in the paper as evidence to show the exact details chronologically. The results of the study shows that lack of knowledge and construction practices adopted by builders are the primary reason of this havoc. The team selected for this kind of construction right from labor to architect and engineers is not adequate and qualified for this type of construction. Also the material should be chosen for these types of structures are not as per specification. Soil testing is not performed in proper manner as foundation plays important role in this type of structure. Also the structural drawings are not completely tested and the work is not executed in the site as per instruction. Similarly various loopholes are found in this construction work which results in happening of such perilous disaster.

M. R. Willford and R. J. Smith, here author presents the design of two multistoried connected tower situated in manila, which is a susceptible area confined by typhoon winds and affected by seismic forces evaluated as UBC-97 and zone 4. The building height is 210m and 30m in plan. The building is designed for both wind and seismic forces by performance based method. Both the towers are made up of reinforced concrete and random arrangement of columns and walls at the perimeter of the structure along with an outrigger system that is 2 stories deep for 50 percent height of tower. Vertically acting fluid viscous dampers are used to connect outrigger with the adjacent column. The damping system used in the tower is termed as Arup damped outrigger system which is a non-tuned system and utilizes much lower space as compared to tuned devices. The result of the study shows that with the use of this non tuned damping system wind action is considerably controlled. Other than that seismic forces are resisted by the adopted performance based design which not only make structurally viable but also economical. In this design method 30% concrete is saved as compared to conventional code based design procedure. Also the steel density is controlled by a proportionate amount of 100 kg/m^3 that is not possible by code's analysis and design.

Andrew Luong and Michael Kwok, in this study authors makes an attempt to the solution of vertical irregularity of structures by connecting towers. Various key aspects are taken into consideration comprises of wind tunnel action, resistance against vertical earthquake loading, comfort under vibration and wind action and lastly diaphragm action in critical members. One storey deep steel trusses are used to support the connecting portion of tower at the lowest floor. Belt trusses are used to counter lateral forces. The building is spread in a very large area of 4,50,000 m^2. The results of the study shows that simply the linking of top part of the cantilever linked path is not simple but made possible by steel bracing system, external continuous dia-grid tube system. The wind and seismic action is resisted by reducing the floor plates in the east-west direction and upper half portion of the

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structure. Also the building make economically feasible by using composites i.e. steel and RCC members wherever required along with small outriggers which helps in reduction of structural steel to a considerable amount and approximately 250kg/m^2 is utilized which is about 50-100 kg/m^2 lesser from conventional methods.

Eldemery Ibrahim, in this paper author marks an impact of high rise multistory building its necessity in the present developing world and the effect they imposed. With an example it is explained that high rise is not only solution especially for every part of the world like In Egypt its whole population chosen only 4% of land space out of entire Egypt. In the present time it is assumed that tall skyscraper is the landmark and new pride figure for any country. In this paper author explaining the effect of multistoried structure and the requirement of setting limit by the respective government while using these tall buildings as a tool of urban development and need of making guidelines to control the alarming situation produced by this. Various facts are analyzed its requirement and so its impact in the society, how sustainable are these buildings, their influence in developing countries and developed countries where the effective available land share is a big constraint whether to use it as assets or ignoring in the crowd and name of urbanization. In the conclusions is demonstrated that this skyscraper phenomenon is gobbling the world. By comparing two countries one is developing i.e. Egypt and another one is developed i.e. Japan the situation is very differ for both the cases because in the previous case the land resources are present in adequate amount but in later case land scarcity proofs the use of high rise structure is the only solution left for their present and upcoming population increment. In the former we have option to utilize desserts as option but in the second case we do not have any option left other than multistory concept.

Ji Dongyu, Li Lamei, in this paper the study presents the vibration model for a structure to analyze the impact and finding probable options to bear dynamic actions. In this exploration Simulation is done by Finite element method. The building is used for teaching purpose which is spread in a vast area of 8425 m2 where ground floor is kept slightly lofty with a height of 7m in 6 storey building and in rest of building is floor height is kept constant for 4.2m. The building is analyzed as per Chinese building code and all the input parameters are set as per their standards. C40 concrete is used in construction, modulus of concrete is 32.5 GPa whereas Modulus of elasticity for foundation is kept 0.261 GPa. To perform the real time simulation Saint-Venant's principle is used in which the length of foundation taken as 100m, width is taken 30m and the depth of foundation is taken as 2m. The result of the study shows that the required dynamic characteristics are found to be more complex for assumed framed structure of teachers building. While taking about deciding parameters the vibration mode of first and second order proven to be of higher importance than transitional vibration mode. Finally the stiffness of the building is found minimum in case of transverse direction and maximum in case of vertical direction whereas longitudinal direction comes at middle in between these two directions.

Niels H. Harrit et. al., In this paper author presents the study in which a new material is accidentally discovered from dust generated from 9/11 terrorist attack. While checking the various samples after destruction of huge twin tower some specific red/grey chips were found in every sample collected for detailed analysis. Overall 4 samples are collected from different locations. One of those samples is collected from Manhattan, just after 10 minute of collapse, on the very next day two samples are taken and finally after one week last sample is collected. The red/grey chips found in all the samples collected from different sources and on different dates. Various modern techniques are used to analyze these chips consists optical microscopy, scanning electron microscopy, X-ray energy dispersive spectroscopy and differential scanning calorimetry, in the red material granular particles are found of 100nm mostly composed of oxides of iron and some very small plate like structure is found in which traces of aluminum is identified. When tested by ignition they shows a different exothermic behavior that is much lower than normally found thermites. Based on various conclusion drawn from chemical analysis it is concluded that the red/grey chips found in the dust is unreacted thermitic material, also the material is chemically active, nanotechnology is incorporated in this material and the most important is that this material is explosive in nature and highly energetic pyrotechnic.

III. CONCLUSIONS AND OUTLINE OF PROPOSED WORK

So far by reviewing and studying numerous research papers it has been analyzed that in the field of stability of multistoried twin tower against seismic and wind loads it is required to analyze the connected structure with various possibilities of structural stability by various means and its optimum location in the building. Here we come at conclusion drawn from studying the above review the position location of connector in the building is optimized so as to resist seismic loading.

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The conclusive outcomes drawn from the study are enlisted below:

1. A multistoried building is taken for analysis with 13 floors in which floor twins is modeled up to 12th floor. Total of 13 cases are proposed with floor twins are varies floor height and the optimum condition is identified to resist seismic action. The tower is analyzed for zone 4 against medium soil type.
2. The study is conducted for both the directions viz. lateral and longitudinal direction.
3. Study is completed against various seismic parameters consists maximum displacement and storey drift in bot X & Z direction.
4. Conclusively the optimum case out of various cases is suggested with the help of above numerical data and Staad analysis.

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