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Research Paper

Comparative Analysis of G+12 MS Building Introducing with Belt Truss & Outrigger System using Software Approach

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Abstract:
Rapid growth of infrastructure to accommodate modern civilization is demanding tall structures in cities. As the buildings are becoming taller the problem of their lateral stability and sway has to be tackled by engineering judgment. Structural system development has evolved continuously to overcome the problems related to lateral stability and sway, There are many ways developed and adopted now these days to overcome this. One such structural system is outrigger and belt truss structural system also in this project we are adopting Shear wall method.
The outrigger and belt truss structural system has proved to be most promising structural system in resisting problem related to lateral stability and sway. The present study is conducted for 12 storied high rise building with shear wall in central of building outer periphery. High rise building with floor plan of 35m x 28m in addition with shear wall of 5 m x 42 m is considered with both side of building. Static Earthquake analysis is carried out to study parameter's maximum storey displacement, Base shear, Base moment, Axial Force and Bending Moment to compare building with application of concrete and steel outrigger at various position varying with the height of building and the software used for this analysis is Staad-pro V8i version.
Key Words: Tall building, outrigger, belt truss, shear wall, lateral stability, sway, Storey displacement, Base shear, Base moment, Axial Force and Bending Moment.

I. Introduction

In today's modern era it has become need to undertake development in tall structure to accommodate the present population as the cities are growing fast and land availability is becoming lesser for human beings, so there is need for development of tall structures, but with development of tall structures there is need to tackle the problems related to it .Outrigger and belt truss structural system has proved to be efficient and economical solution for the problems related to tall structure development.Ductility towards lateral deformation refers the ratio of the maximum deformation and the idealized yield deformation. Ductility of a building is its capacity to accommodate large lateral deformations along the height. It is quantified as the ratio of maximum deformation that can be sustained just prior to collapse (or failure, or significant loss of strength) to the yield deformation. Thus, a ductile building exhibits large inelastic deformation capacity without significant loss of strength capacity. In a ductile building, the structural members and the materials used therein can stably withstand inelastic actions without collapse and undue loss of strength at deformation levels well beyond theelastic limit. Ductility helps in dissipating input earthquake energy through hysteretic behavior. Earthquake-resistant design of buildings relies heavily on ductility for accommodating the imposed displacement loading on the structure.

1.1. Outrigger and belt truss structural System

The outrigger and belt truss system comprises of a main concrete core connected to exterior columns by relatively stiff horizontal memberssuch as bracings termed as outriggers. The bracing can be of different shape. The basic structural response of the system is based on very simple concept. When structure is subjected to lateral loads, the columns on which the outriggers rest combining the column restrained by outrigger resist the rotation of the core, causing the mitigation in magnitude of lateral deflections and moments in the core in comparison to the freestanding core alone resisted the loading. The external moment is now resisted by combined action of the bending of the core and the axial tension and compression of the exterior columns connected to the outriggers.

1.2 Concept of Outrigger

Outriggers have been effectively used in the sailing ship industry for long time which were used to resist wind. The outriggers like the spreaders and the exterior columns like the shrouds or stays. Engineers had observed this behavior of sail boats in resisting wind and so it was implemented in buildings which further was studied and used as outrigger and belt truss system in building especially in high rise buildings. The basic concept of outrigger and belt truss system was found out from the arrangement of mast, spreaders and shrouds in sail boats.

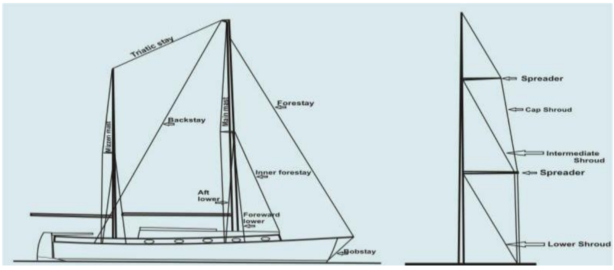

Fig.1.2.1 Sail boat with mast, spreader and shroud.

1.3 Classification of Outrigger structural system

On the basis of connection to the core there are two types of outrigger truss;

1. Conventional Outrigger system
2. Virtual Outrigger system

Conventional Outrigger System

In the conventional outrigger system, the outrigger bracings are connected directly to shear walls at the core and with columns at the periphery of the building. The intermediate columns between the external columns and the shear walls are connected with outrigger bracings. The outrigger can be applied simultaneously at multiple floors simultaneously. The outrigger bracings connected to the core and external columns converts the moment in core to vertical couple in columns. Problem of axial shortening and elongation of the columns and deformation of the trusses causes rotation of the core at the outrigger in minor level, maximum times it is found that there is reverse curvature due to small rotation in core.

Belt Trusses as Virtual Outriggers

The floor diaphragm action restrict the rotation of the core is resisted by the floor diaphragms at the top and bottom of the belt trusses which results in conversion of moment in core into a horizontal couple in the floor, which in turn is transferred to the inclined bracings which then shift their forces to the vertical columns supporting it. Three dimensional elastic analysis is used to determine forces and moments created in all components. The lateral load resisting system consists of shear wall core, external columns, belt truss bracings and floor diaphragm action. The belt truss is connected to the external columns; belt truss is bracing that are connected to the external column which tie down the periphery of the building.

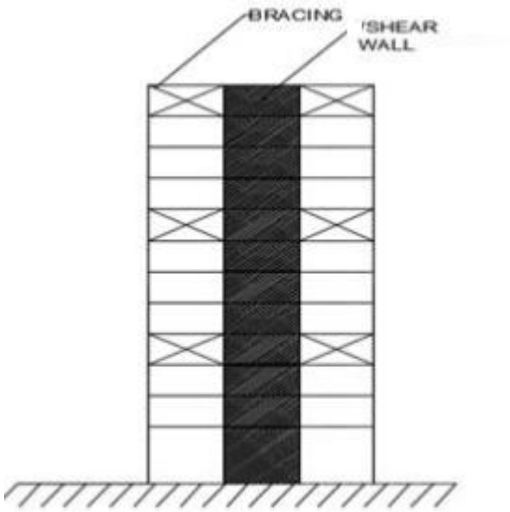

Fig. 1.3.1. Tall building with conventional outriggers.

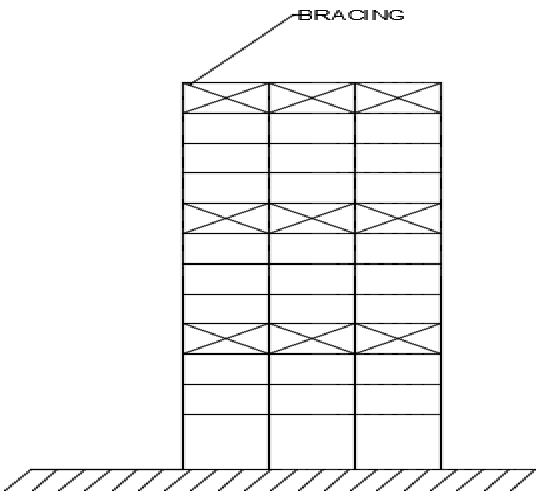

Fig.1.3.2. Tall building with belt trusses as “virtual” outriggers

Simplified mathematical model of outriggers

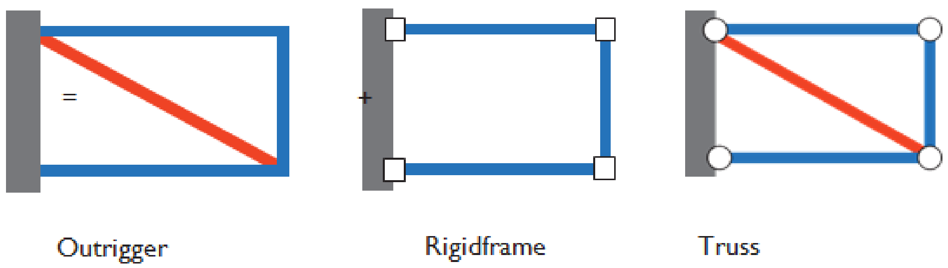

FIGURE 1.3.3: Simplified mathematical model of outriggers.

1.4 Shear Wall

Shearwall is a structural member positioned at different places in a building from foundation level to top parapet level, used to resist lateral forces i.e. parallel to the plane of the wall. When lateral displacement is large in a building with moment frames only, structural walls, often commonly called shear walls, can be introduced to help reduce overall displacement of buildings, because these vertical plate-like structural elements have large in-plane stiffness and strength. There are different materials by

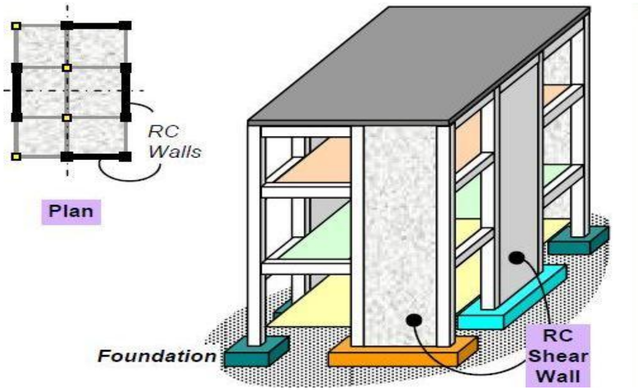

Figure 1.4:- Reinforced concrete shear wall

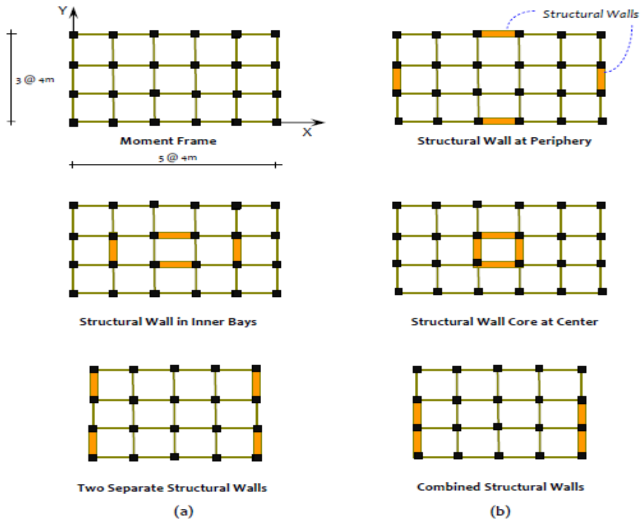

Figure 1.4.1:- Position of shear walls in a moment resisting frame building

Which shear wall can be constructed but reinforced concrete (RC) buildings often have vertical plate-like Reinforced concrete walls (Figure 1.4) in addition to slabs, beams and columns. Their thickness can be as low as 150mm, or as high as 400mm in high rise buildings. Shear walls are usually provided along both length and width of buildings.

Shear walls are like vertically-oriented wide beams that carry earthquake loads downwards to the foundation. Therefore, the structural system of the building consists of moment frameswith specific bays in each direction having structural walls (Figure 1.4.1).

Classification of shear walls:-

- Simple rectangular types and flanged walls (bar bell type)
- Coupled shear walls
- Rigid frame shear walls
- Framed walls with in filled frames
- Column supported shear walls
- Core type shear walls

Types of shear walls based on the materials used for construction:-

Based on materials used for construction shear walls are classified as follows,

1) RCC Shear Wall.
2) Plywood Shear Wall.
3) RC Hollow Concrete Block Masonry Wall.
4) Steel Plate Shear Wall.

II. NEED OF THE PROJECT

Accumulation of growing population especially in developing countries has resulted in an increased tallness of buildings, this need creating impact on structural improvement of tall building. As building increases in tallness there is effect of wind and earthquake forces, to increase stiffness of building against lateral load extra structural system such as belt truss and outriggers is required. The reviewed approach for the outline and improvement of tall building using outrigger and belt truss is helpful to provide a potential arrangement. The study in turn is helpful for various research persons involved in outline the tall buildings by using outrigger and belt truss system also in this project we are adopting Shear wall method. The principle objectives of this project are comparison between the results of Conventional concrete building, Steel Structure Building & Composite building using STAAD Pro. The design involves load calculations and analyzing the whole structure by STAAD Pro. The design methods used in STAAD Pro analysis are Limit State Design conforming to Indian Standard Code of Practice. These involve Staad Modeling, Analysis the members due to the effect of Seismic load &Compare them for Axial force, Bending Moment, Base Shear, Base Moment & Nodal Displacement parameters.The proposal structure is a G+12 storied building with 3.00 m as the height of each floor. The overall plan dimension of the building is 35 m x 28 m.

III. OBJECTIVE OF THE STUDY

a) To study the effect of introduction of Outriggers in tall structure subjected to Static seismic loading.

b) To study the influence of Concrete Outrigger, Shear wall and braced core divider with X braced outrigger in all seismic zone.

c) Analysis the different configuration of the building under Conventional concrete method, the same building configuration with the Belt Truss and Outrigger system also introduced another model with the Shear Wall.

d) Various Static checks are applied on the results.

e) Analysis the results of all models as their Axial force, Bending Moment, Base Shear, Base Moment & Nodal Displacement parameters.

f) Discuss the comparative results and Find the conclusion.

Composite structure

In past structural engineer has d the choice of masonry building and multi stories building with RCCframed structure or steel structure. Recently trend of going towards composite structure has started and going.

Now a days in India to fulfill the requirements and needs of high rise buildings the composite is best suited forinfrastructural growth other than the RCC and steel structures, and steel concrete composite system have becomequite popular in recent time because of their advantages against convention construction, composite constructioncombines the better properties of both material such as concrete and steel

Advantages of Composite structure

i. Increased strength for a given cross sectional dimension.

ii. Increased stiffness, leading to reduced slenderness and increased buckling resistance.

iii. Good fire resistance in the case of concrete encased.

iv. Corrosion protection in encased member.

Review of literature papers:

In most of the reviewed research studies, the foundations were assumed to be fixed foundations. However, non-fixed foundations were also considered in some studies such as T.Subramani1study. In this study, the foundations under exterior columns such as piled foundations, which act in a vertical direction only, were modeled as linear springs with a translational linear stiff ness. While the foundation of the core is only subjected to a bending moment under lateral loads.

Another paper of Mohd Parvez Affani1, Shaik Mohd Javeed2 Mohd Farrukh Anwar3 "comparative study of RC tall buildings between symmetrical and unsymmetrical shapes in consideration of non-ductile using with and without outrigger and belt truss system" study the effect of introduction of Outriggers intall structure subjected to dynamic wind loading. Along with the influence of core divider and braced coredivider with X braced outriggers. In this paper study influence of concrete outrigger&effect ofOutriggers with Peripheral Belt Truss. They focused on symmetrical andUnsymmetrical Buildings (Rectangular and Yformed building, C formed Building).

Design & Analysis of Multi Storied Building(G+10) By Using Stadd Pro V8i, In this paper Mr. A. P. Patil1et.al focused on comparison between Staad-pro software and manuallycalculations and design a multi-storied building usingSTAAD Pro. The design involves load calculations andanalyzing the whole structure by

STAAD Pro. The designmethods used in STAAD Pro analysis are Limit StateDesign conforming to Indian Standard Code of Practice.These involve Staad Modeling, Analysis the members dueto the effect of Wind & Seismic load.

Lateral Stability Analysis of High Rise Building with the Help of STAAD-PRO. Researched by Pramod Kumar Sharma1et.al, In this thesis G+40, G+60, G+80 storied regular buildingmodal has been analyzed by static & dynamic analysis. Thisbuilding has the plan area of 42.30 m x 18.05 m with astorey height 3.0m and depth of foundation is 2.0 m. Thestatic & dynamic analysis has been done on computer withthe help of STAAD-Pro software using the parameters forthe designing as per the IS-1893- 2002-Part-1 for the zone(V) and the post processing result obtained has beensummarized in succeeding tables.

Analytical Study of Tall Building with Outtrigger System with Respect to Seismic and Wind Analysis Using ETABS, T.Subramani1, K.Murali2 are targeted at the performance of multi outrigger structural system for a ten storey constructing with static and dynamic analyses of various fashions were examined the use of ETABS software program. The performance analysis of the tall building for distinctive fashions are performed to discover the surest function of outrigger gadget and belt truss with the aid of the usage of lateral loads. Time history analysis for floor movement statistics of the ten storey building version are carried out. The evaluation includes lateral displacement; storeys go with the flow and base shear for static and dynamic loading.

Deflection Control in Composite Building by Using Belt Truss and Outriggers Systems, S. Fawzia and T. Fatima wrote,

This paper investigates deflection control by effective utilization of belt truss and outrigger system on a 60-storey composite buildingsubjected to wind loads. A three dimensional Finite Element Analysisis performed with one, two and three outrigger levels.

Comparative Study of Usage of Outrigger and Belt Truss System for High-Rise Concrete Buildings, C. Bhargav Krishna, V. Rangarao, The building framewas fortified horizontal way by givingOutrigger and Belt support framework at each 9 to 10 story level.Two methods of analysis have been considered for lateralstability analysis viz linear static and linear dynamic for bothseismic and wind. The various parameters like (1) Lateraldisplacement, (2) Maximum storey drift, (3) Storey shear forces,(4) storey moments and (5) Storey overturning moments wereConsidered for better comprehension of Tall building, when itwas exposed to substantial seismic and wind powers. The Seismicanalysis was carried out according to the Indian measures.

THE USE OF OUTRIGGER AND BELT TRUSS SYSTEM FOR HIGH-RISE RCC BUILDING,Akash Kala, Madhuri Mangulkar, Indrajeet Jain,This study aims to identify the optimum outrigger location in high rise concrete building under horizontal load.

Thus, 60-story reinforcedconcrete building is studied in order todetermine theoptimum location to construct the outrigger to minimize the drift due to wind load. Buildings with different location of outriggers are analyzed by a structural analysissoftware ETABS. Results from the analysis shows that the optimum location to construct the outriggers is one third of the height of the building. It has been shown from this study that the structure is optimized when the outrigger is placed at 20^{th}level.

IV. CONCLUSION

The various methods and techniques used to investigate uses of belt truss and outrigger in tall buildings structural system were discussed in this paper. It is found that many researchers focused on to obtain position of belt truss and outrigger to control deflection of building, controlling core moment and column reaction are the secondary need of research. Optimum position of structural system for deflection criteria is different than bending moment criteria. Although the optimum location suggests by researchers in the mid height of building, location of the system differs significantly as per design criteria. Manual methods studied to obtain location of structural system gives nearly accurate result as that of by software. Outrigger and belt truss is active and cost effective structural system which is most developing structural systems. The present study in turn is useful for various research persons involved in design the tall buildings by using outrigger and belt truss system.

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