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(RESEARCH ARTICLE)

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A seismic behavior of RCC high rise structure with and without outrigger and belt truss system for different earthquake zones and type of soil

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Abstract

In the present era, there is more demand for high-rise buildings. The growing de- mand for high-rise buildings brings new difficulties and comes up with new safety precautions. With an increase in height of the structure, its rigidity reduces, making it difficult to withstand earthquake and wind effects, hence some preventative structural systems must be used. Some of them are bracings, shear walls, outrig- ger systems and belt truss systems etc. The outrigger and belt truss system is investigated in this study since it is the most effective method for high-rise buildings and skyscrapers. To prevent story drift and the rotational action of the core caused by seismic and wind forces, the external columns in an outrigger system are attached to the main inner or outer core using outrigger beams, walls, and trusses etc. at various floor levels. All external columns that are situated at the peripheral are connected together with truss elements in a belt truss system. This study investigates the comparison of the behavior of high-rise buildings with and without an outrigger system, and belt truss system for all seismic zones (zone II, III, IV and V) with different types of soil (hard, medium, soft). This study is carried out for 40 story buildings using response spectrum analysis. Analysis of the building is carried out by using ETABS 2018 software. The results are in the form of seismic responses like storey displacement, Storey drift, base shear are studied. Results show that the provision of an outrigger and belt truss system reduces the story displacement of the structure. After analysis and comparing the seismic responses of the structure, the building provided with the combination of outrigger and belt truss system perform better as compared to the only outrigger and belt truss system.

Keyword: Outrigger System; Belt Truss System; Seismic; Wind Loads

1. Introduction

Tall buildings are expanding quickly both in India and all over the world. Tall structures are a necessity in big cities where the population is increasing and there is a need for housing. It becomes increasingly challenging to regulate variables like storey drift and lateral displacement as the height of a building rises. The tall structure must therefore have mechanisms that can withstand the lateral loads. Outrigger and belt truss systems are an example of this kind of system (Daril John Prasad, Srinidhilakshmish Kumar, 2016).

1.1. Outrigger System

Although models of high buildings with horizontal and vertical load bearings have been developed recently systems with a shear wall system at the centre of the structure plan and columns at the exterior of the plan are recommended. Beams and flooring provide the interface between the central shear wall and the frame columns on the outer. To strengthen the collaboration and interaction between these two bearing elements, stiff horizontal elements, often made of steel or con- Crete are positioned between the shear wall and the columns at the specific level of the building. The

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main purpose of these structural components together referred to as the outrigger system, is to improve the mutual interaction between the frame columns and the shear wall, particularly by increasing the bending rigidity and lateral stiffness against horizontal loads. The outrigger system in a building can be used on one or more storeys (Yusuf Calayir et al. 2020).

1.2. Belt Truss System

Conventional outrigger concepts translate moments in the core into a vertical cou ple in the columns by using outrigger trusses that are directly attached to the core and outboard columns. Without a physical link between the outrigger trusses and the core, the ”virtual” outrigger concept achieves the same transfer of overturn- ing moment from the core to elements outboard of the core. Many of the issues posed by the usage of outriggers are avoided by removing a direct link between the trusses and the core. The fundamental idea behind the virtual outrigger concept is to transfer moment in the form of a horizontal couple from the core to trusses or walls that are not directly connected to the core using floor diaphragms, which are normally very stiff and resistant in their own plane. The horizontal couples are subsequently transformed into vertical couples in columns or other structural elements outside the core by the trusses or walls. Virtual outriggers can be effectively used with belt trusses and basement walls (Yusuf Calayir et al. 2020).

higher demands for railways traffic and short distance routes. The main objectives of the present study are to analyze and design truss bridge with railway loadings

1.3. Components of Outrigger and Belt Truss System

The outrigger, belt truss or panel, and core wall are the main parts of the outrigger system. The specifics of these parts are discussed below and illustrated in fig.1.2

1.4. Core Wall

The functional and service requirements for typical occupants are integrated with the main or artery component of a tall building. It is one of the principal lateral load-bearing structural elements and was primarily created to withstand earthquake and wind effects. The core wall, which is also used to install lifts and to accommodate services, is often created near the geometric centre of the building. Basically, it is a large shear wall cage.

1.5. Outrigger

Outrigger is a deep, rigid beam designed to increase building strength by connecting to the core shear wall from the external columns. It is utilized in both RCC and steel buildings and is often constructed from steel, concrete, or composite outrigger employed in the form of truss (X, V-Shaped, Inverted V-shaped bracings)

1.6. Belt Truss or Panel

To minimize overturning moments, a belt truss, also known as a virtual outrigger, is used to engage the outer columns of the building. It is comprised of steel or concrete beams. It also consists of the truss (X, V-Shaped, Inverted V-shaped bracings).

2. Problem statement

In the present dissertation work, it is proposed to carry out comparison of seismic analysis of 40 storied high-rise RCC structure provided with and without outrigger belt truss system and combination of outrigger with belt truss system for different seismic zones and different soil types to suggest the most effective system from all these system belt truss system and combination of outrigger with belt truss system for different seismic zones and different soil types to suggest the most effective system from all these systems.

Table 1 Properties RCC framed structure

Properties Of RCC Framed Structure	
Plan Size	29mX29m
Number of Stories	40
Floor to floor height	3.15M

Bottom story height	4 M
Size of column	0.8X0.8 m (31st 40th floor, M40) 1.0X1.0 m (Base 30th floor, M50)
Size of beam	0.5mX0.75m
Slab thickness	0.125M
Central shear wall core thickness	0.5 m
Wall Thickness	0.23m(External), 0.15(Internal)
Steel Outrigger	0.4mX1.0m(Box Section)
Earthquake load	As per IS:1893:2016
Wind load (WL)	As per IS: 875- 2015
Live load (LL)	3 KN/M2
Seismic zones	II, III, IV, V
Importance Factor	1.2
Response Reduction Factor	3,5
Type of soil	Soft, Medium, Hard
Basic Wind Speed	39
Terrain Category	II

3. Modeling

3.1. Structural Plan

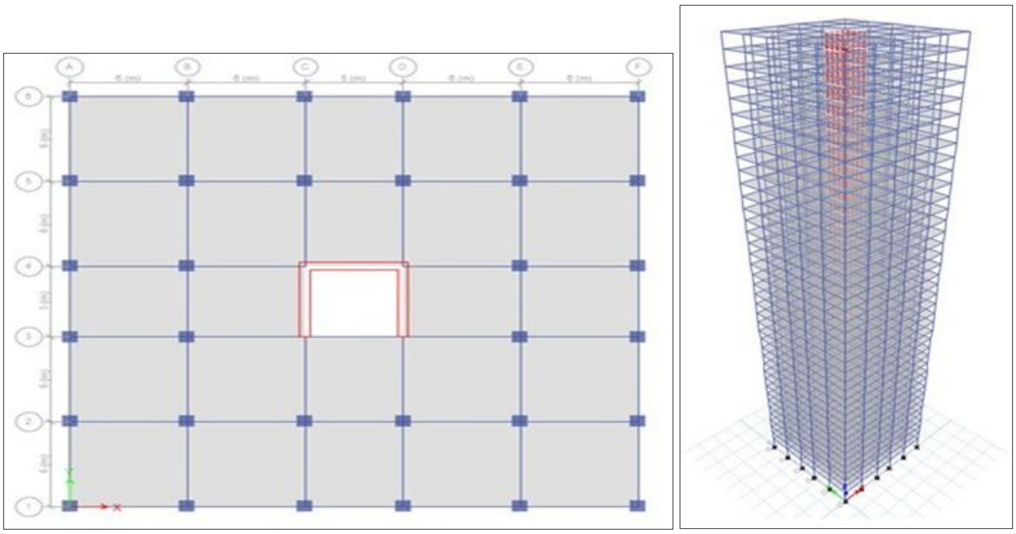

Figure 1 3D MODEL

4. Results for story displacement

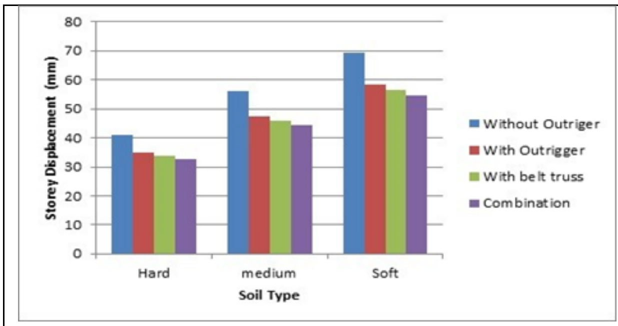

Figure 2 Storey displacement for Zone II spec-X

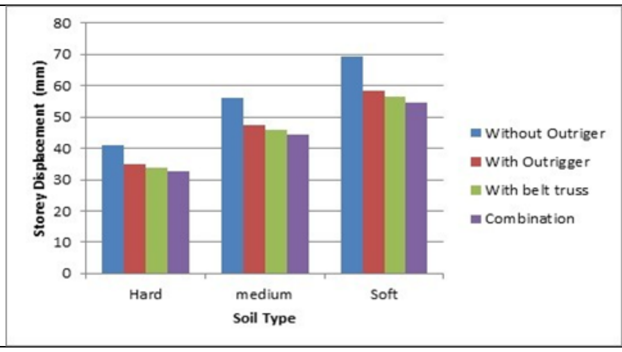

Figure 3 Storey displacement for Zone IV spec-X

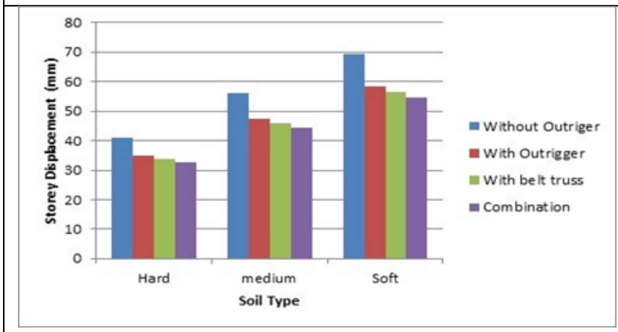

Figure 4 Storey displacement for Zone II spec-Y

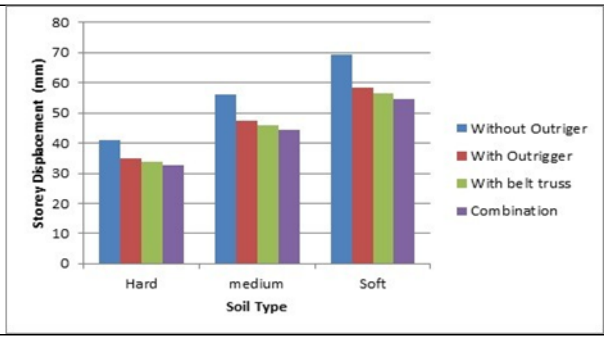

Figure 5 Storey displacement for Zone IV spec-Y

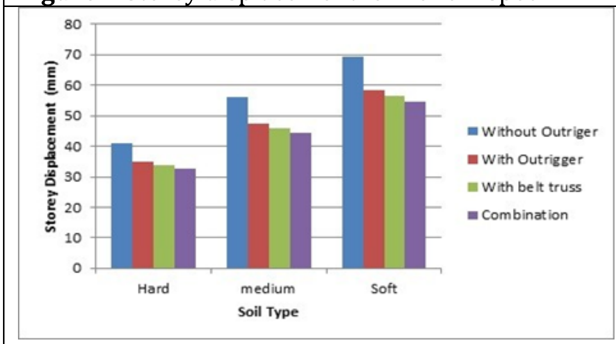

Figure 6 Storey displacement for Zone III spec-X

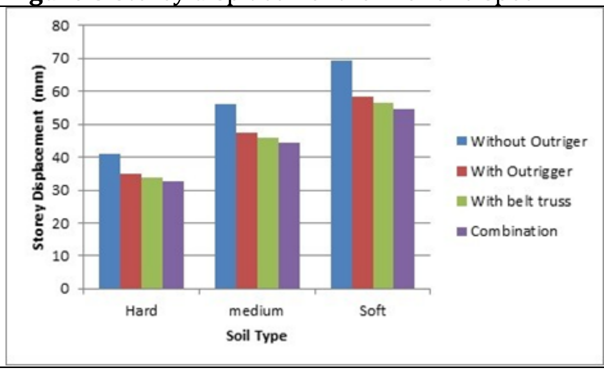

Figure 7 Storey displacement for Zone V spec-X

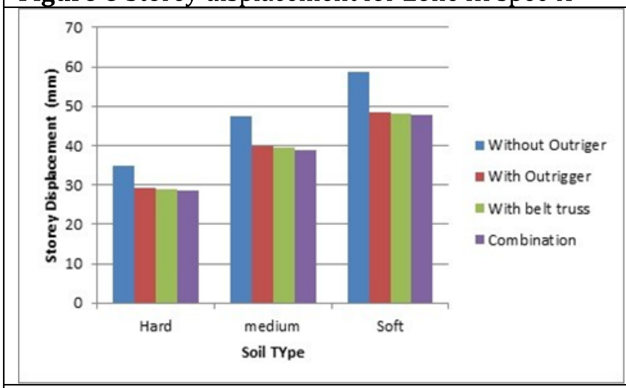

Figure 8 Storey displacement for Zone III spec-Y

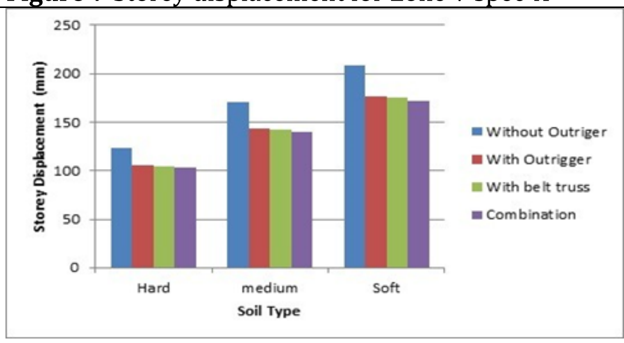

Figure 9 Storey displacement for Zone V spec-Y

5. Results for storey drift

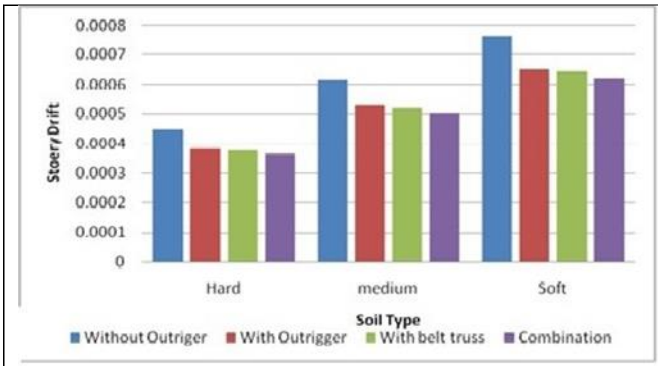

Figure 10 Storey drift for Zone II spec-X

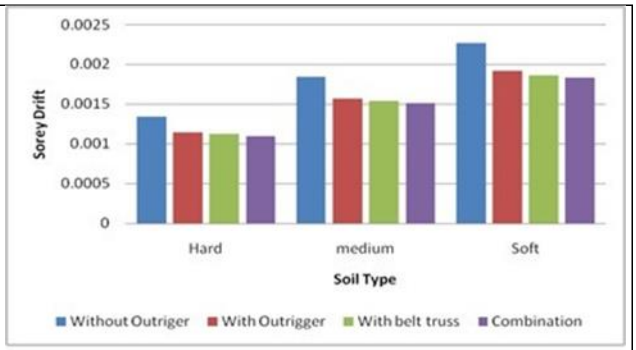

Figure 11 Storey drift for Zone V spec-X

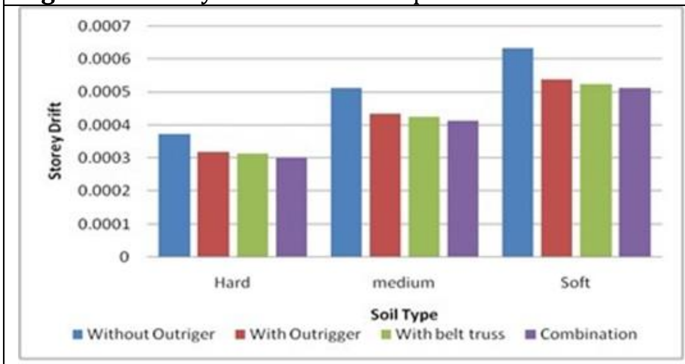

Figure 12 Storey drift for Zone II spec-Y

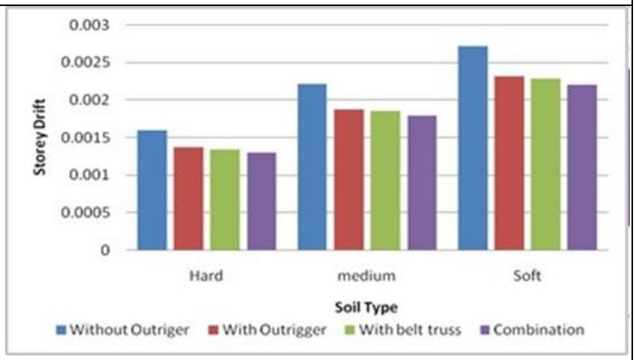

Figure 13 Storey drift for Zone V spec-Y

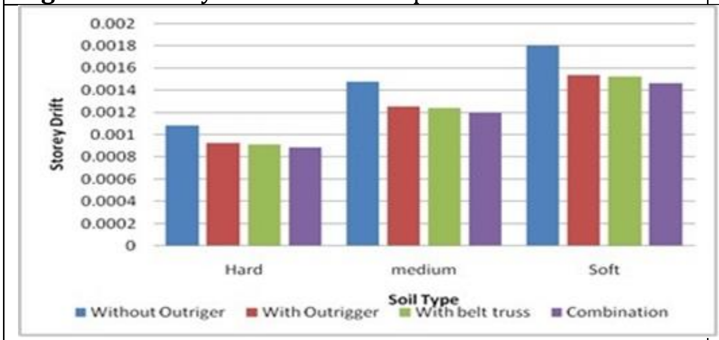

Figure 14 Storey drift for Zone III spec-X

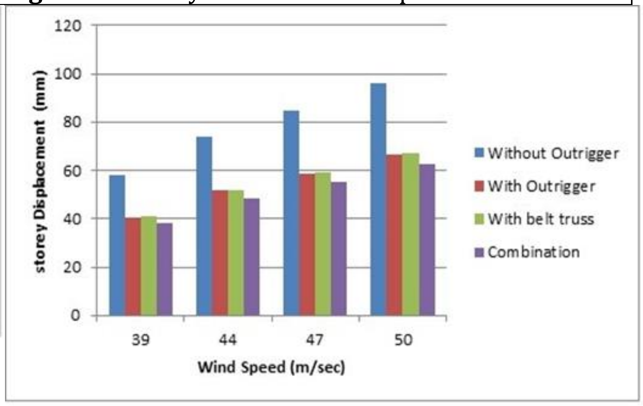

Figure 15 Storey Displacement for wind load in X direction

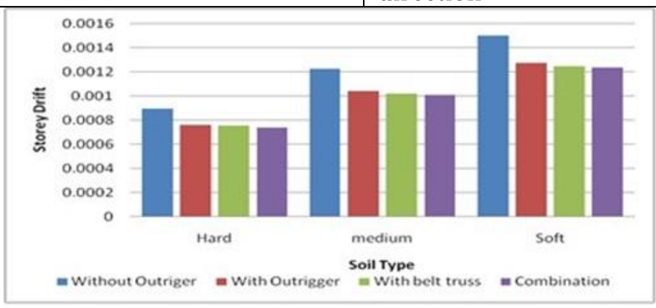

Figure 16 Storey drift for Zone III spec-Y

6. Conclusion

- From the software analysis, it is observed that the maximum reduction in storey displacement due to seismic forces for combination of outrigger with belt truss system is obtained as up to 21%, for outrigger it is obtained as up to 16.5% and for belt truss system it is obtained as up to 18%.
- From the software analysis, it is observed that the maximum reduction in storey displacement due to wind load for the combination of outrigger with belt truss system is obtained as up to 35%, for outrigger it is obtained as up to 31% and for belt truss system it is obtained as up to 30%.
- From the software analysis, it is observed that the maximum reduction in storey drift due to seismic forces for combination of outrigger with belt truss is obtained as up to 19%, For outrigger it is obtained as up to 15% and for belt truss system it is obtained as up to 17%.
- From the analysis results, it is observed that the outrigger system and belt truss are more efficient in resisting the wind load as compared to the seismic forces.
- From analysis results, it is concluded that the combination of the outrigger with belt truss system is more efficient in reducing displacement than only outrigger and belt truss system.

Future scope

- Study of behavior building with outrigger and belt truss system of varying depth.
- Study of outrigger system with a combination of energy dissipating devices like dampers and base isolations.
- Study of the outrigger system with different materials.
- Study of building behavior with outrigger and belt truss system provided with different shapes of truss element.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest.

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