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COMPARATIVE ANALYSIS BETWEEN RCC AND COMPOSITE COLUMN STRUCTURE ONSLOPING GROUND, WITH AND WITHOUT VIRTUALOUTRIGGER SYSTEM

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ABSTRACT

In the north and north-eastern sections of India, there is a huge area of hilly terrain that falls under seismic zones IV and V. There is a demand for development in this region as a result of growing urbanisation and economic expansion, as well as increased population density. The outrigger system with belt trusses are frequently used as one method of managing excessive drift caused by wind or seismic charges, during minor or medium lateral stress. In this paper, RCC and composite column structures are compared to the static and dynamic load cases in a G + 50 story tower, which is sloped at 20^0 . The structure is tested on the sloping ground with and without an outrigger system.

Keywords: Sloping ground, Outrigger system with Belt-Trusses, Response Spectrum, Storey Displacement, Storey Drift, Storey Shear Axial Force.

1. INTRODUCTION

When compared to buildings constructed in flat areas, buildings located in mountainous terrain are far more vulnerable to seismic and wind situations. Tall buildings have always been a symbol of aspiration and technological growth, resulting in global progress. Due to the scarcity of the city's land and the rising rates of urbanization in recent decades, high-rise buildings are an appropriate solution to the problem because of rapid population growth and the migration to urban areas by people from rural regions. With the rapid growth of urbanization, tall buildings have become a more practical option for residential and business space. Composite structures are defined as the two load-bearing structural components that are integrally connected and deflect as a single unit.As we know that, concrete and steel are good in compression and tension respectively. By structurally connecting the two materials, their characteristics can be leveraged to create a highly efficient and lightweight design.

II.REVIEW OF LITERATURE

Sachin Halemani et.al [1]:- "Influences of bracing system in RC structure on sloping ground under wind loads". The conclusions that are drawn from the study are, Displacement increases with respect to increase in sloping ground and height of a building, by using bracing it can be reduced, chevron brace reduces maximum displacement compared to a diagonal brace and x brace. Storey drift increases with increase in sloping ground and height of a building, by using bracing it can be reduced; chevron brace reduces maximum story drift compared to a diagonal brace and x brace.

Roy Shyam Sundar et al [2]:- delivered a paper on "A Study on Tall RC Structure with Outrigger System Subjected to Seismic and Wind Loading". On a slender tall RC structure, parameters such as story displacement, shear, drift, and time period were studied using finite element analysis. It is concluded that with an outrigger system, stiffness increases and makes the structure more efficient. Drift was reduced by more than half when an outrigger was installed, as did displacement and base moment, both of which increased the size and depth of the foundation.

K. Sathyamurthy et al [3]:- delivered a paper on "Dynamic Analysis of Outrigger Braced Systems in High Rise Steel Building". Parameters such as story drift, displacement and time period were examined for the behaviour, on the seismic zone II and IV frame structure. The G+40 storied structure with varying chevron bracing and diagonal bracing as well as varying the position of the belt was analysed and concluded that the controlled structure can be obtained by placing the belt on different levels with reduced lateral dilatation.

Sachin Kumar Dangi et.al [4]:- "Seismic analysis of an RC building on sloping terrain with variable shear wall positions". The study's findings show that placing shear walls on sloping terrain improves the building's seismic performance. The corner position of the shear wall is the best for counteracting axial loads.

III. RESEARCH METHODOLOGY

A.Objectives

• To conduct static and dynamic analysis of a G+50 multi-story tower with a RCC frame, with and without outrigger system using ETABS software.
• To conduct the seismic analysis of buildings located in seismic zone II (Bangalore) according to IS: 1893-2016.
• To conduct a wind analysis, according to IS 875 (part 3):2015.
• To compare the behaviour of RCC and composite column structure with and without virtual outrigger system on sloping ground, for the variables such as storey drift, storey displacement, storey shear, axial force.
• To recommend a suitable structure based on the structure's performance as measured by characteristics such as storey displacement, storey shear, storey drift, axial force.

B. Statement of the Problem

To perform the static and dynamic analysis of RCC and composite column structure on sloping ground with a 20^{o} slope, with and without the use of virtual outrigger system.

IV.OUTRIGGER SYSTEM WITH BELT-TRUSSES

A hybrid load-resisting lateral system with outriggers and belt trusses. Outriggers are rigid and horizontal components that connect the external systems to the internal structures and belt-trusses are another rigid horizontal component connecting the external structural system to the columns of the perimeter. To control storey drifts, the fundamental approach of this system is to establish strengthening stories with belt-truss outriggers system at appropriate heights. This technology is commonly employed in towering structures all around the world. Outriggers system with belt-trusses are used in the structural systems of most tall structures in China, both completed and under construction.

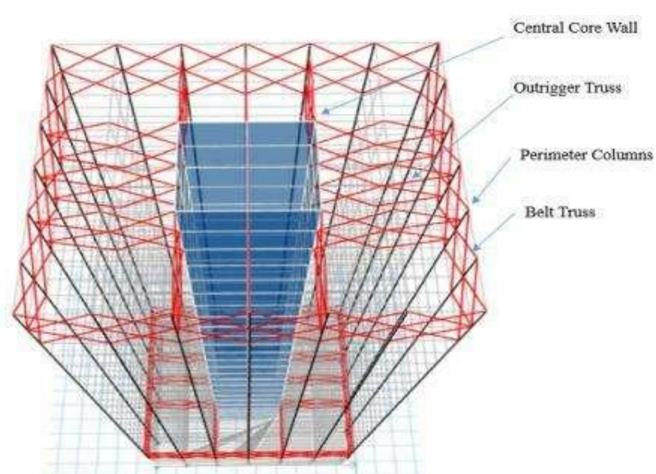

Fig 1: Outrigger system with Belt-Trusses

V. MODELLING AND ANALYSIS

To perform static and dynamic analysis of G+50 multi-story building structure on sloping ground.

Table 1: Building Data

Plan size	30mX30m
Height of building	178.50m
Slab thickness	150mm
Floor to floor height	3.5m

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Table 2: Material Properties

f_{ck}	50N/mm^2 (Column, Shear wall) 40N/mm^2 (Beam, Slab)
f_y	HYSD500 (Longitudinal bars) Mild250 (Confinement bars)

Table 3: Details of Loads

Live load	3.0 kN/m^2
Floor finish	1.5 kN/m^2
Wall load	2.254 kN/m^2

Seismic load as per IS: 1893-2016	
Seismic zone	II
Seismic zone factor	0.1
Response factor(R)	3.0
Importance factor	1.5
Wind load as per IS:875(Part 3)- 2014	
Wind speed	33m/s
Importance factor	1.5
Terrain category	4
Soil category	II (medium soil)
Class	C
Damping	5%
Risk coefficient	1.05
Terrain coefficient	1.115
Topography coefficient	1.36
Windward coefficient	0.80
Leeward coefficient	0.25

Table 4: SectionProperties:-

RCC column	1000X1000mm
CFST(Concrete Filled Steel Tube) Composite column	800X800mm
Beam	B1 – 500x300mm B2 – 600X400mm B3 – 700X500mm B4 – 800X600mm B5 – 900X700mm B6 – 1000X800mm B7 – 1100X900mm B8 – 1200X1000mm
Slab	150mm
Shear wall	SW1 – 350mm SW2 – 450mm SW3 – 500mm SW4 – 600mm SW5 – 700mm SW6 – 800mm

Table 5: Configurations to be Analysed:-

Model. No	Configuration
M1	RCC frame with core.
M2	RCC frame with core and outrigger system with belt-trusses.
M3	A composite column with core.
M4	A composite column with core and outrigger system with belt-trusses.

Table 6: Outrigger Location:-

Outrigger location	Storey 4
	Storey 5
	Storey 23
	Storey 24

The effectiveness of the structure with outrigger system depends on its position. The above table represents the position of outrigger system, for which the good performance of structure is obtained.defined either in the caption or in a legend provided as part of the figure. Figures should be placed at the top or bottom of a page wherever possible, as close as possible to the first reference to them in the paper.

The figure number and caption should be typed below the illustration in 8 pt and left justified [***Note:*** one-line captions of length less than column width (or full typesetting width or oblong) centered]. For more guidelines and information to help you submit high quality artwork please visit:http://www.elsevier.com/wps/find/authorsview.authors/ authorartworkinstructions. Artwork has no text along the side of it in the main body of the text. However, if two images fit next to each other, these may be placed next to each other to save space. For example, see Fig. 1.

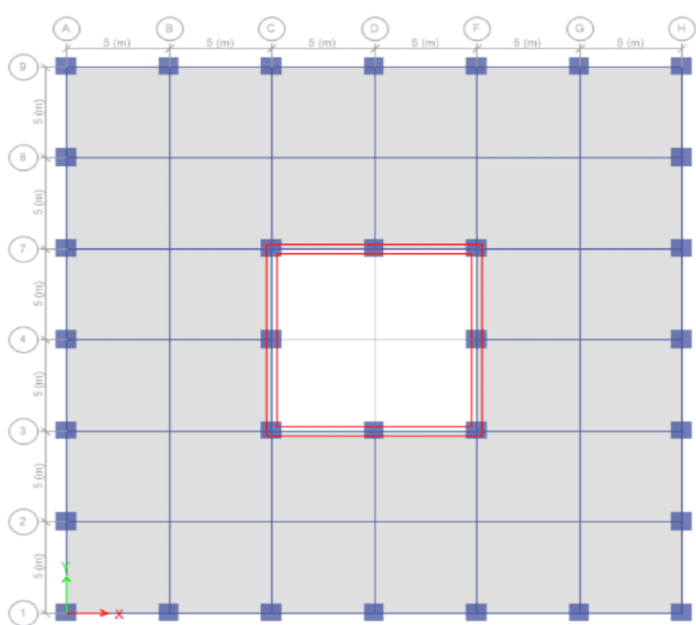

Fig 2: Plan

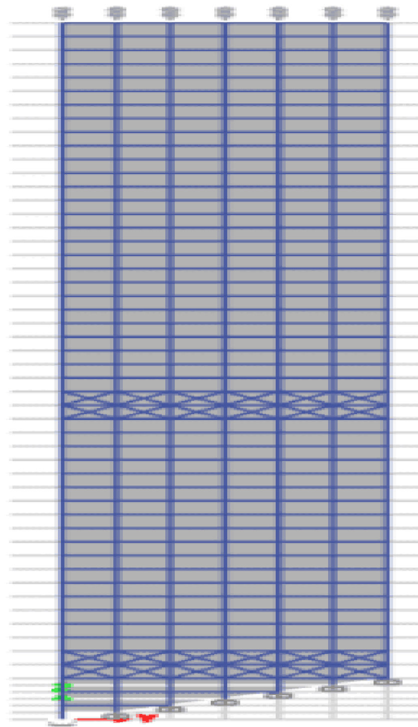

Fig 3: Elevation

VI RESULTS AND DISCUSSIONS

1. STATIC ANALYSIS

The goal of structural analysis is to figure out how a structure reacts to a given action. This activity can manifest as a burden created by the weight of objects such as people, furniture, wind, snow, and so on, or as another type of excitation such as an earthquake, ground shaking induced by a nearby blast, and so on. A distinction is made between dynamic and static analysis based on whether the applied action has enough acceleration in proportion to the structure's natural frequency. If a load is applied slowly enough, inertia forces (Newton's second law of motion) can be ignored and the analysis simplified to a static analysis.

a) STOREY DISPLACEMENT:-

The entire displacement of any storey in relation to the ground is referred to as storey displacement. The maximum permitted storey displacement, according to IS regulation, is H/500 = 178500/500 = 357mm. Where H is the structure's overall height.

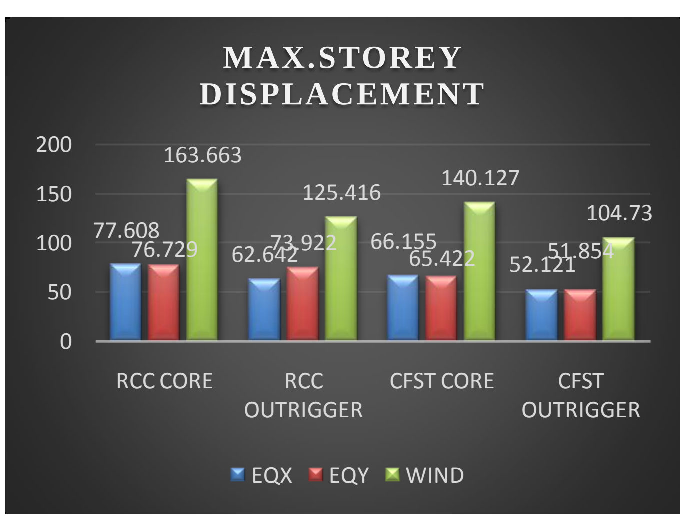

Fig 4: Maximum Storey Displacement under static load case

The minimum storey displacement is observed for CFST outrigger structure under seismic and wind load case

b) STOREY DRIFT

The ratio of displacement of two subsequent floors to floor height is known as storey drift. The maximum permissible storey drift, according to IS regulation, is 0.004 h = 0.04*3500 = 14mm. The storey height is denoted by the letter h.

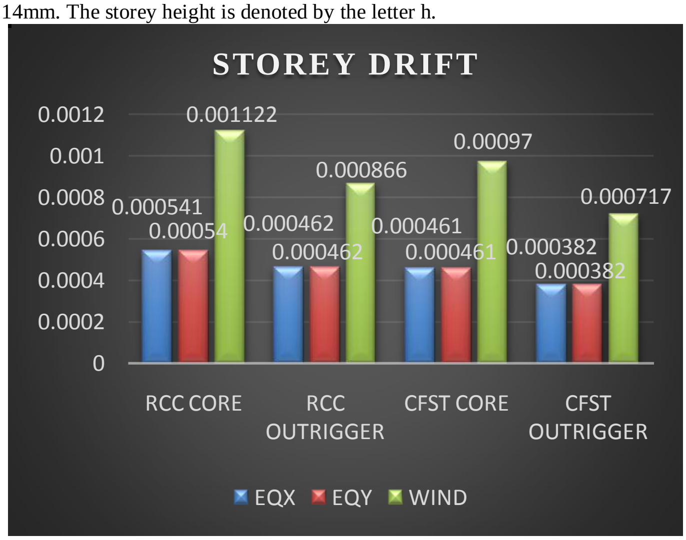

Fig 5: Maximum Storey Drift under static load case

The minimum storey drift is observed for CFST outrigger structure under seismic and wind load case.

c) STOREY SHEAR

The reactive force in each storey fluctuates as a result of lateral pressure, and this reactive force is known as storey shear. The lateral stress is delivered along the height of the building, and the building has varied stiffness and masses along its height. The reactive force owing to lateral load differs in each storey, and this reactive force is known as storey shear.

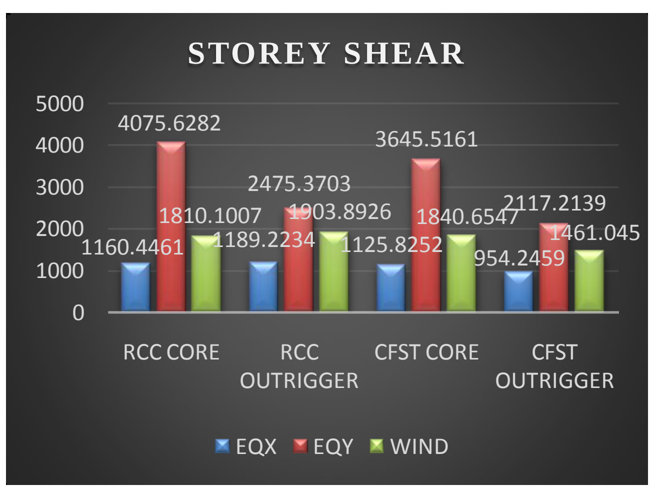

Fig 6: Maximum Storey Shear under static load case

Storey shear is overall less in structures with outrigger, for static load case, but application of outrigger satisfies the criteria of resisting lateral loads.

d) AXIAL FORCE

Force acting through the centroid or geometric axis of a structure and is applied along its length or perpendicular to its cross section, is referred to as the axial load.

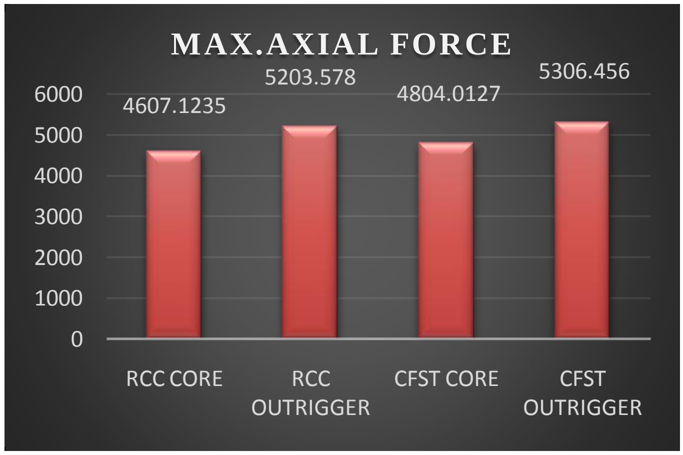

Fig 7: Maximum Axial Force under static load case

CFST outrigger structure has more axial force as compared to other structures.

2. DYNAMIC ANALYSIS

The goal of structural analysis is to Fig out how a structure reacts to a given action. A distinction is made between dynamic and static analysis based on whether the applied action has enough acceleration in proportion to the structure's natural frequency. As a result, structural dynamics is a form of structural analysis that studies the behaviour of structures under dynamic (high-acceleration) loads. Dynamic loads include people, wind, waves, traffic, earthquakes, and blasts, all of which change over time. For determining modal analysis, time histories and dynamic displacements, dynamic analysis is useful.

a) STOREY DISPLACEMENT

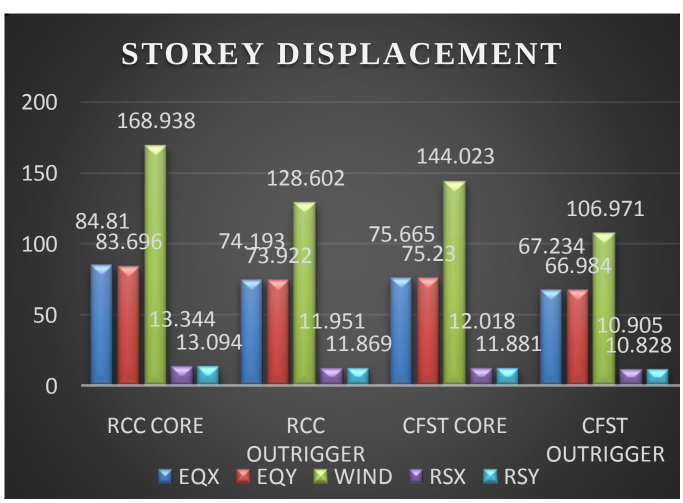

Fig 8: Maximum Storey Displacement under dynamic load case

The minimum storey displacement is observed for CFST outrigger structure

b) STOREY DRIFT

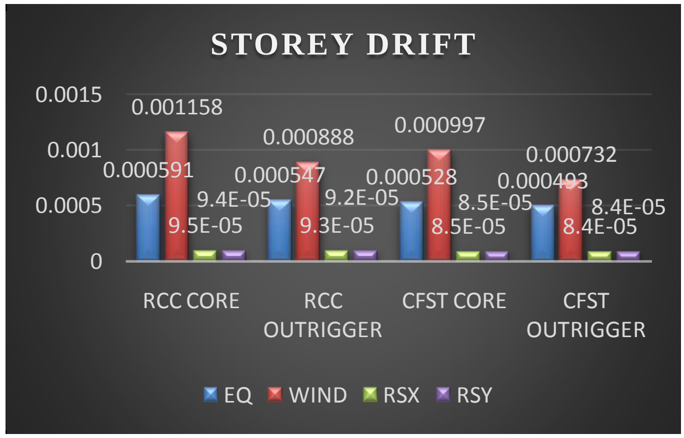

Fig 9: Maximum Storey Drift under dynamic load case

The minimum storey drift is observed for CFST outrigger structure

c) STOREY SHEAR

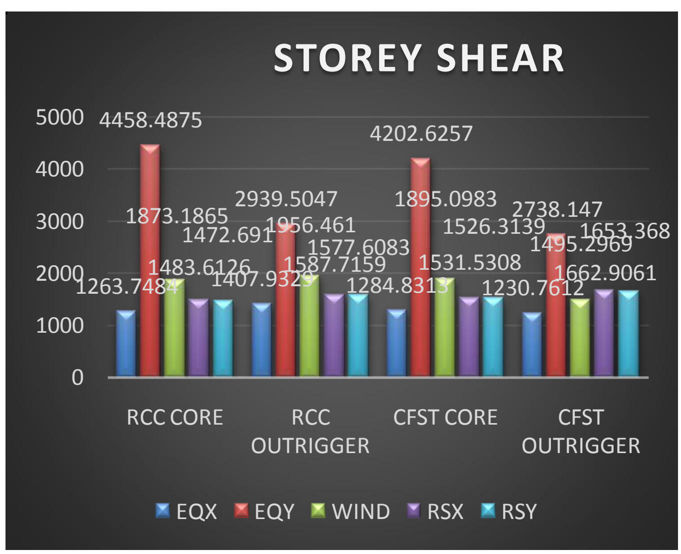

Fig 10: Maximum Storey Shear under dynamic load case

The outrigger structure has more storey shear as compared to other structures for response spectrum load case

d) AXIAL FORCE

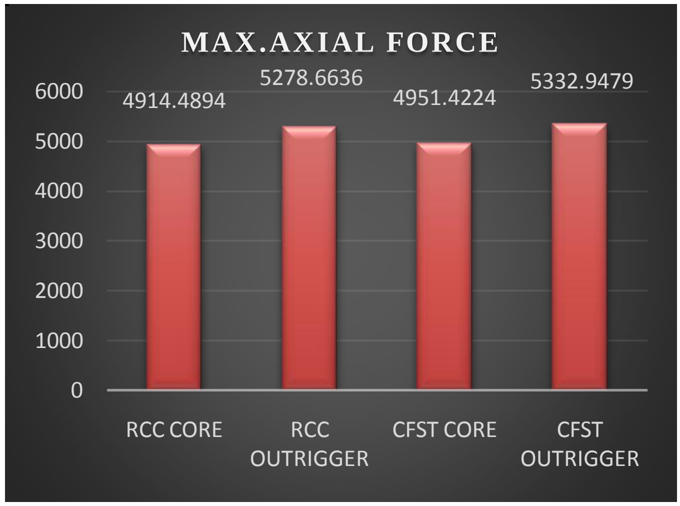

Fig 11: Maximum Axial Force under dynamic load case

CFST outrigger structure has more axial force as compared to other structures.

VII. CONCLUSION

1. It is observed that CFST outrigger structure has less storey displacement and storey drift as compared to other structures for static and dynamic load cases.
2. For static load case, CFST outrigger system has 16.5% less storey displacement and 17.2% less storey drift when compared with RCC outrigger system.
3. For dynamic load case, CFST outrigger system has 8.7% less storey displacement and 9.1% less storey drift when compared with RCC outrigger system.
4. Storey shear is overall less in structures with outrigger, for static load case, but application of outrigger satisfies the criteria of resisting lateral loads.
5.It is observed that the outrigger structure has more storey shear as compared to other structures for response spectrum load case.
6. CFST outrigger structure has more axial force as compared to other structures.
7. It can be concluded that, the Concrete Filled Steel Tube (CFST) column structure with belt truss outrigger system is more efficient in resisting lateral loads on sloping ground, when compared with other structures.

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