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Comparison on Seismic Behaviour of RC Diagrid Structure with CFST Diagrid Structure

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Abstract: Due to increase in population and rapid urbanization, need of tall story buildings is increasing more than ever. Tall buildings are subjected to wind and seismic loads along with vertical loads. Modern methods are being used to counteract lateral forces like wind, earthquake.
Diagrid is one such type of building which has high lateral force resistance. In the present work an attempt has been made to use composite column as diagrid. The present work seeks to investigate the seismic behavior of RCC column with Concrete filled steel tube in a diagrid building. G+20 storey building and a regular floor plan of 24 m × 24 m size is considered for the study. ETABS software is used for modelling and analysis of structural members. The comparison of analysis of results in terms of top storey displacement, storey drift is presented here.
Keywords: RC Diagrid, CFST, ETABS, storey displacement, storey drift

I. INTRODUCTION

Civil engineers need to innovate earthquake-resistant design approaches and also have an obligation to decrease structural damage. Special techniques are required to design buildings such that they remain practically undamaged even in a severe earthquake. To make the earthquake structure resistant, it is vital to provide a lateral force resistant system.

Diagrid system absorbs lateral forces during the earthquake and improves the structure's rigidity. Diagonal members in diagrid structural systems can carry gravity loads as well as lateral forces owing to their triangulated configuration. Due to its structural effectiveness and aesthetic potential supplied by the system's distinctive geometric setup, the diagrid–diagonal grid structural system has recently been commonly used for high-rise structures. Diagrids are much more effective in minimizing shear deformation because they carry shear by axial action of the diagonal members, while conventional framed tubular structures carry shear by the bending of the vertical columns. Diagrid structures do not need high shear rigidity cores because shear can be carried by the diagrids located on the perimeter.

A steel-concrete composite column is a compression member consisting of either a concrete enclosed section of hot-rolled steel or a concrete filled tubular section of hot-rolled steel and is usually used as a load-bearing member in a composite-framed framework. Composite columns have more load carrying capacity than the bare strengthened column and the structural steel column included in the scheme. The composite columns are gaining popularity for use in multi-storey structures due to their outstanding static and earthquake-resistant characteristics such as reduced mass, high strength, rigidity and rigidity, considerably high toughness and ductility, high potential for energy dissipation. In addition to these benefits, simple site erection and assembly capacity can result in lower labour and foundation expenses compared to RCC columns and have great buckling strength, lower maintenance and fireproof costs compared to steel columns.

Members of Concrete Filled Steel Tubular (CFST) use both steel and concrete benefits. They consist of a circular or rectangular section of steel hollow filled with simple or strengthened concrete. They are commonly used as columns and beam columns in high-rise and multi-storey structures and as beams in low-rise industrial buildings requiring a solid and effective structural system. In terms of both structural performance and construction sequence, there are a number of distinct benefits linked to such structural systems.

Application of the CFST concept may result in total steel savings of 60 percent compared to conventional structural steel systems. Also used as a permanent formwork were steel tubes and the well-distributed reinforcement at the most efficient position. Due to the large shear capacity of concrete-filled steel tubular members, they predominantly fail in flexure in a ductile manner.

II. OBJECTIVES

The main aim of this projects to investigate the seismic behaviour of RC diagrid structure with CFST diagrid structure as per Indian Standard code. Specific objectives and aim of this work are listed below,

A. Modelling of RC diagrid structure and CFST diagrid structure of G+20 storey by using ETABS software.
B. To perform seismic analysis on the models and the effect of earthquake ground motions on these buildings has been studied.
C. To evaluate these modelled by response spectrum analysis and identify the effectiveness, performance level of buildings.
D. To carry out comparison between RC diagrid structure and CFST diagrid structure on the basis of their dynamic properties such as base shear, time period, storey displacement, storey acceleration, storey drift.

III.BUILDING CONFIGURATION

The 21-storey building is having 24m x 24m plan dimension and 73.5m total height of building. The storey height is 3.5m. The typical plan and elevation are shown in figure 1. There are two models for comparative study, one is for RC diagrid structure and another is for CFST diagrid structure. The building data is kept same for both models. The beam size and column sizes are as shown in table-1. The slab thickness is 200mm. The design dead load and live load for typical floor slab is 2.5 kN/m2 and 1.5 kN/m2.

TABLE I

Building parameter	Details
Type of diagrid	RC
Number of storeys	G+20
Plan dimension	24mx24m
Height of typical floor	3.5m
Spacing of frame	6m c/c
Size of core column	750x750mm
Size of Diagrid	550x550mm
Size of beam	300x600mm
Size of beam	230x550mm
Slab thickness	200mm
Grade of concrete	M 30
Grade of steel	Fe 345
Type of structure	Special moment resisting frame
Seismic zones	II, III, IV, III
Soil type	Hard soil, Medium soil, Soft soil
Importance factor	1

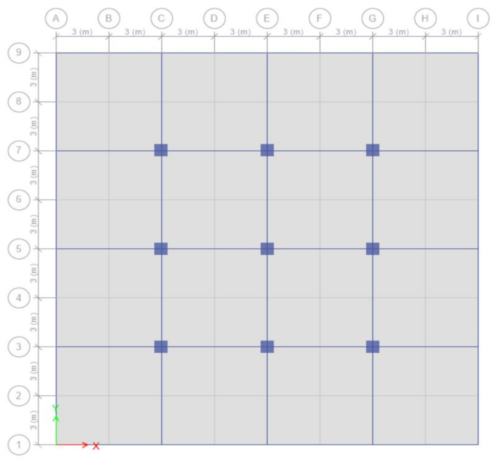
Fig1 : plan

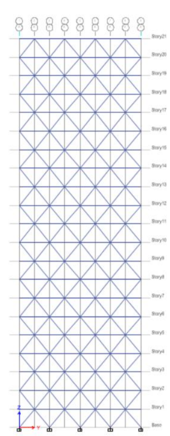
Fig2:elevation

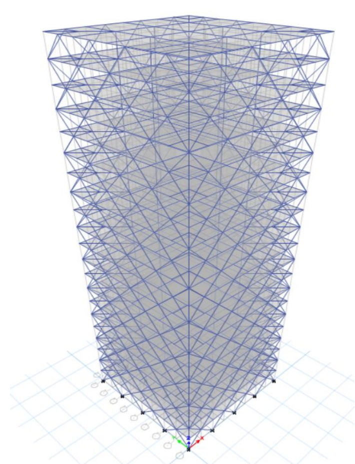
Fig3:3d model

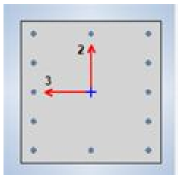

Fig4:RC diagrid

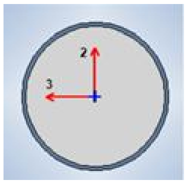

Fig5:CFST diagrid

IV. RESULTS AND DISCUSSION

A. Time Period

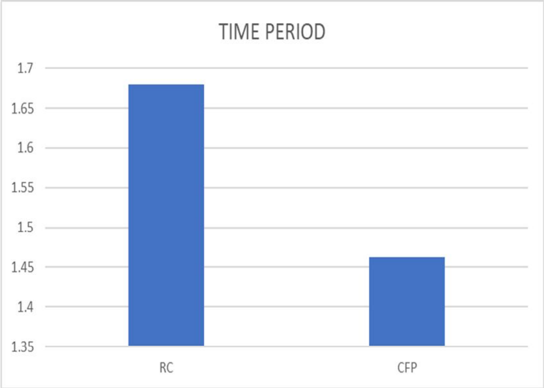

Fig 6: Time period of RC Diagrid and CFST diagrid structures

The time period reduces with the use of CFST composite diagrid than RC diagrid is shown in above fig. As the time period reduces the stiffness of the building increases because the time period is inversely proportional to the stiffness of the structure. The time period is reduced by 13.09% with the use of CFST composite diagrid than RC diagrid. Hence the multi-storey building with RC diagrid has less stiffness due to increase in the time period.

B. Storey Displacement

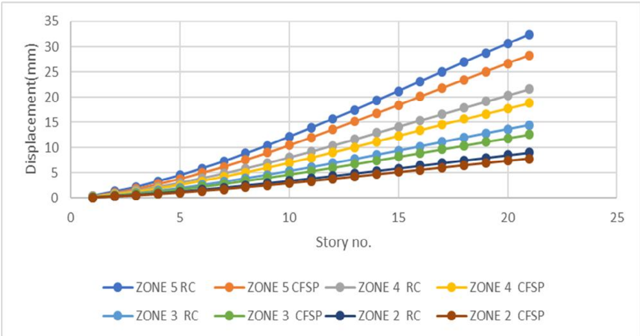

Fig 7**:** Storey Displacement of RC Diagrid and CFST diagrid structures in Medium soil

Storey displacement of all the models are within the safe permissible limit as per IS 1893-2002.Storey displacement increases with respect to increase in height of the building. The storey displacement is maximum at the top floor in all the building models. The maximum relative storey displacement is decreased for CFST diagrid than RC diagrid.

For Medium soil, maximum decrement with respect to RC diagrid models of ZONE 5, ZONE4, ZONE3, and ZONE2 is 12.9%. Displacement of RC diagrid models are more in all zones compared to CFST diagrid models. It can be seen that in the obtained results of 4 zones, increase of storey displacement is more in zone5 compared to other zones, but the percentage increasing the storey displacement is similar in all zones.

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C. Storey Drift

Storey drift increases with respect to increase in height of the building up to 16th storey and gradually decreases till the top floor. The storey drift is maximum at the 16th floor in all the building models. The maximum relative storey drift is decreased for CFST diagrid than RC diagrid. For Medium soil, maximum decrement with respect to RC diagrid models of ZONE 5, ZONE4, ZONE3, and ZONE2 is 13.49%. Drift of RC diagrid models are more in all zones compared to CFST diagrid models. It can be seen that in the obtained results of 4 zones, increase of storey drift is more in zone5 compared to other zones, but the percentage increasing the storey drift is similar in all zones.

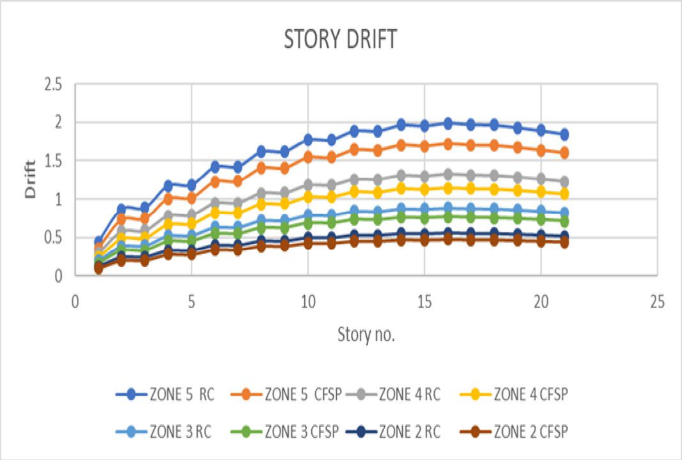

Fig 8**:** Storey Drift of RC Diagrid and CFST diagrid structures in Medium soil

D. Storey Acceleration

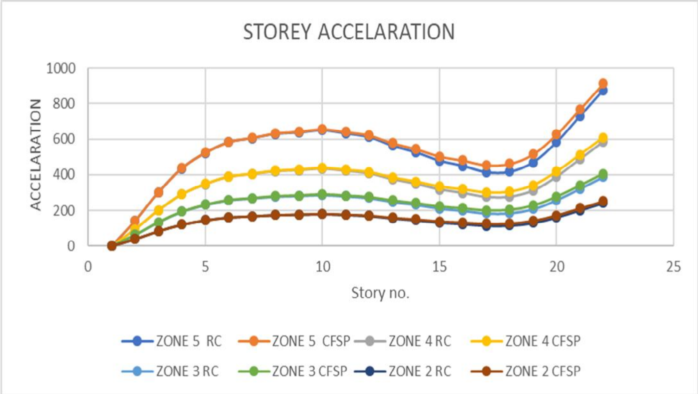

Fig 9**:** Storey acceleration of RC Diagrid and CFST diagrid structures in Medium soil

Storey acceleration increases with respect to increase in height of the building. Storey acceleration is maximum at the top floor in all the building models. The maximum relative storey acceleration is decreased for RC diagrid than CFST diagrid. For Medium soil, maximum decrement with respect to CFSTdiagrid models of ZONE 5, ZONE4, ZONE3, and ZONE2 is 4.06%. Acceleration of CFST diagrid models are more in all zones compared to RC diagrid models. It can be seen that in the obtained results of 4 zones, increase of storey acceleration is more in zone5 compared to other zones, but the percentage increasing the storey acceleration is similar in all zones.

E. Storey Shear

Storey shear increases with respect to decrease in height of the building. Storey shear is maximum at the first floor in all the building models. The maximum relative storey shear is decreased for RC diagrid than CFST diagrid. For Medium soil, maximum decrement with respect to CFST diagrid models of ZONE 5, ZONE4, ZONE3, ZONE2 is 3.7%.Storey shear of CFST diagrid models are more in all zones compared to RC diagrid models.it can be seen that in the obtained results of 4 zones, storey shear is more in zone5 compared to other zones, but the percentage increasing the storey shear is similar in all zones.

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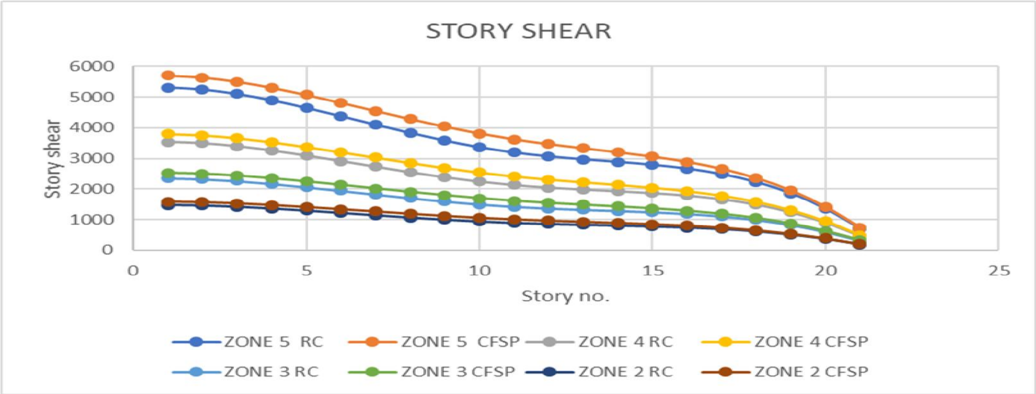

Fig 10: Storey Shear of RC Diagrid and CFST diagrid structures in Medium soil

F. Storey Stiffness

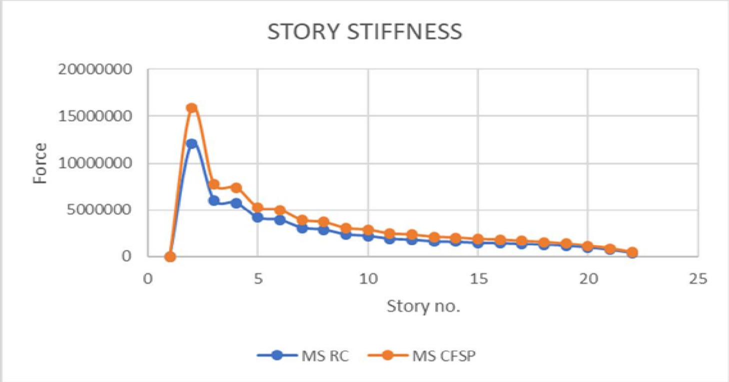

Fig 11: Storey Stiffness of RC Diagrid and CFST diagrid structures in Medium soil

Storey stiffness is maximum at the second floor and decreases gradually till top storey. Storey stiffness is minimum at top storey in all the building models. The maximum storey stiffness is decreased for RC diagrid than CFST diagrid. For Medium soil, maximum decrement with respect to CFST diagrid models for all type of zones is 16.4%.Storey stiffness of CFST diagrid models are more in all zones compared to RC diagrid models.

G. Overturning Moments

Overturning moments decrease with respect to increase in height of the building. Overturning moments are maximum at base in all the building models. The maximum overturning moments is decreased for RC diagrid than CFST diagrid. For Medium soil, maximum decrement with respect to CFST diagrid models of ZONE 5, ZONE4, ZONE3, and ZONE2 is 12.02%.Overturning moments of CFST diagrid models are more in all zones compared to RC diagrid models. It can be seen that in the obtained results of 4 zones, overturning moments is more in zone5 compared to other zones, but the percentage increasing the overturning moments is similar in all zones.

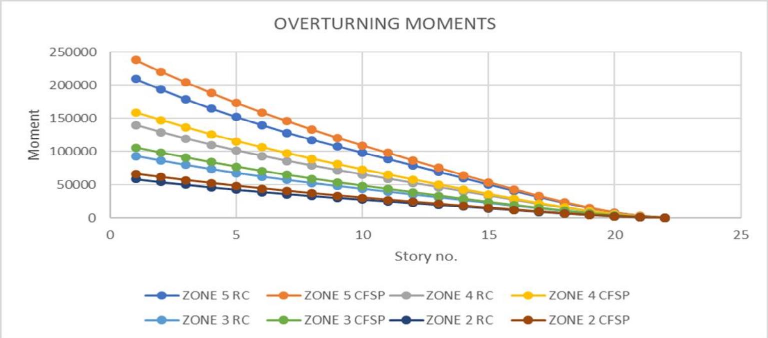

Fig 5.17**:** Overturning Moments of RC Diagrid and CFST diagrid structures in Medium soil

V. CONCLUSIONS AND SCOPE FOR FUTURE WORK

In the present work, RC and CFSP diagrid building are analysed by response spectrum method using ETABS software. The G+20 storey symmetrical square models are compared with parameter such as time period, Storey displacement, storey drift, storey acceleration storey shear, storey stiffness and overturning moments. On the basis of the analysis the following conclusion are drawn

A. The time period is reduced by 13.09% with the use of CFST composite diagrid than RC diagrid. Hence the multi-storey building with RC diagrid has less stiffness due to increase in the time period.
B. Storey displacement and storey drift of all the models are within the safe permissible limit as per IS 1893-2002.
C. Storey displacement is 12.9% less in CFST diagrid building as compared to RC diagrid building. Hence CFST diagrids structure is more efficient in reducing lateral displacements.
D. Maximum relative storey drift is decreased for CFST diagrid than RC diagrid by 13.49% in medium soil.
E. Since time period of CFST diagrid is lesser then RC diagrid, maximum relative storey acceleration is decreased for RC diagrid than CFST diagrid by is 4.06% in medium soil.
F. Storey shear increases with respect to decrease in height of the building. Storey shear is maximum at the first floor in all the building models. Maximum relative storey shear is decreased for RC diagrid than CFST diagrid by 3.7% in medium soil.
G. RC diagrids are more flexible then CFST diagrids. Maximum storey stiffness is decreased for RC diagrid than CFST diagrid by 16.4% in medium soil.
H. Maximum overturning moments is decreased for RC diagrid than CFST diagrid by 12.02 % in medium soil.

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