COMPARATIVE STUDY ON THE EFFECT OF OUTRIGGER SYSTEM WITH BELT TRUSS IN RCC AND STEEL STRUCTURE SUBJECTED TO LATERAL LOADS

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Abstract
High rise structures are developing world wide and introducing new challenges. The stiffness of the building reduces as the structure height increases. The outrigger system with belt truss is a horizontal load resisting system that provides sufficiently great drift control for the tall structure. This system can excessively control drift due to lateral loads; risk of non- structural and structural damages can be reduced. In the present study, 10 models with different location outrigger and belt-truss such as X shape, at every 5,7,10, storeys for different models etc., at different optimum position were modelled and analyzed using SAP2000 software. Since, when the structure is subjected to wind and seismic loads, the bending takes place in the core and rotation of the outrigger arm takes place along with that. Under these situations the columns are subjected to tension and compression. Hence, the study includes the comparison of parameters in RC structure and steel structure such as drift, story shear, and story displacement of models with different location outrigger and belt-truss.

Keywords: - Belt truss, columns, core wall, Outrigger,

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I. INTRODUCTION

A high-rise building is also called multi-story structure that is sufficiently large to demand the use of an elevator or other mechanical device for vertical mobility. A skyscraper is a high-rise structure that is very tall. In the 1880s, the first high- rise structures were built in the US. The combination of steel structural frames and glass external coating made high buildings possible. Such structures have established-rise themselves as common elements of the architectural environment in the majority of nations by the middle of the ^{20th} century.

STRUCTURAL SYSTEM

In the construction of a structure, a structural system is a specific way to assemble and construct the structural components so that they support and transfer maximum load safely to the ground without breaking the permitted stresses in the members and the common form of structural system are.

- Arches
- Barrel vaults
- Cantilevers
- Domes
- Shell and core
- Space frame
- Trussed rafters
- Portal frame

TYPES OF STRUCTURAL SYSTEM

- Braced frame system
- Shear-walled frame system
- Braced-tube system
- Rigid frame system
- Outrigger system

BRACED FRAME SYSTEM

An earthquake and wind resistance structural system is known as a braced frame. Braced frames prevent members from swaying laterally by using shear walls or diagonal steel sections that resemble trusses.

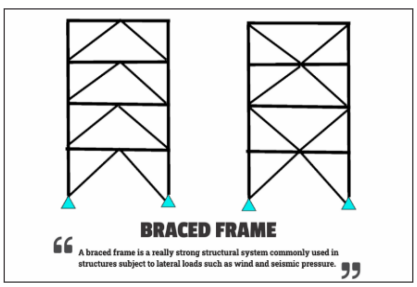


Fig 1.2 Braced frame system

SHEAR-WALLED FRAME SYSTEM

A multistory structural system made up of reinforced concrete frames interacting with reinforced concrete shear walls is known as a reinforced concrete shear wall-frame building structure. Such systems require more complex modelling and analysis than frame systems.

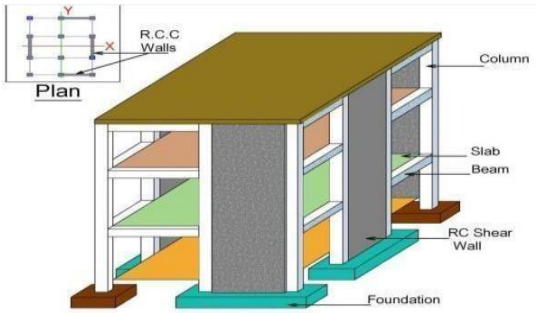


Fig 1.3 Shear walled frame system

RIGID FRAME SYSTEM

Buildings made of steel and reinforced concrete use rigid frame systems, also called moment frame systems. This framework is made up of columns and beams. Rigid frames made of reinforced concrete and steel are applied. While concrete continued to be developed, steel frames dominated early high-rise structures.

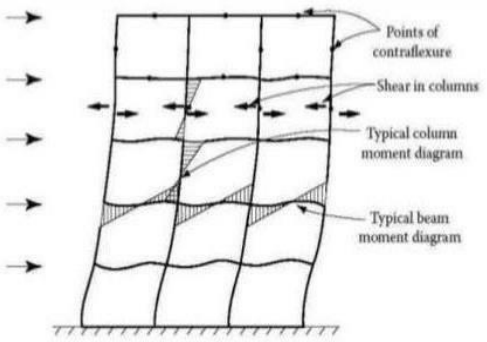


Fig 1.4 Rigid frame system

II. OBJECTIVES OF THE STUDY

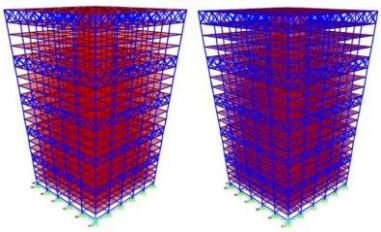
The main objectives to study the behavior of seismic performance of comparison of RC building and steel building using outrigger and belt-truss system to resist the lateral load by using the SAP 2000 software.

1) Comparison with RC buildings and steel buildings is necessary to comprehend the behaviors of outrigger and belt- truss systems.
2) Analysis is carried out using the dynamic method, Time history method using the code book IS 1893-2016 and also applying the Time history and analysis by using SAP 2000 for high seismic zone.

IV. DESCRIPTION OF THE MODELS

SL	DESCRIPTION	RCC	STEEL
1	Columns	750x750mm	600x600 mm
2	Beams	600x600mm	ISMB600450
3	Slab Thickness	125 mm	125 mm
4	Span length	6 m	6 m
5	Floor height	3.2 m	3.2 m
6	Height structure	G+20	G+20
7	Live load	3.0 kN/m	3.0 kN/m
8	Grade concrete	M-25	M-25
9	Grade of steel	Fe 500	Fe 500
10	Size of outrigger	ISLB 600	ISLB 600
11	Soil type	M soil II)	Msoil II)
12	Damping ratio	0.05	0.05
13	Reduction factor	5	5
14	Importantfactor(I)	1.5	1.5
15	Seismic factor	0.16	0.16
16	Seismic Zone	III	III

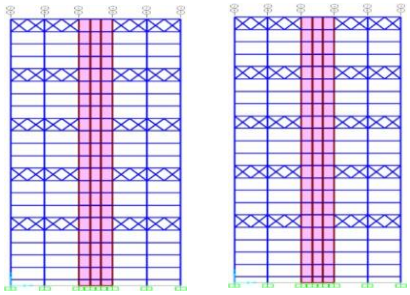
A. MODELS CONSIDERED FOR ANALYSIS



A **B**

A) Structural model of RC with Outrigger and belt truss system
B) Structural model of steel with Outrigger and belt truss system

B. ELEVATION VIEW OF MODELS

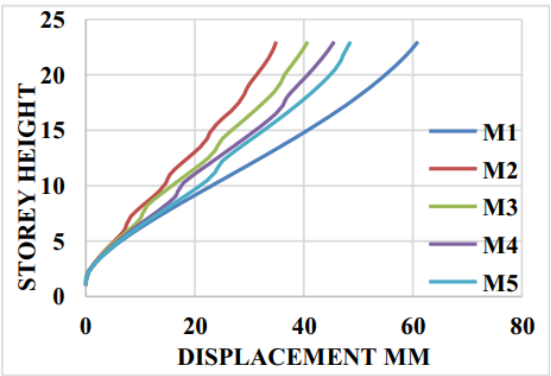


A **B**

V. RESULTS AND DISCUSSION: -

DISPLACEMENT OF RC STRUCTURE: -

Displacement values for all RC frame structures are given below, where M1 indicates the Conventional structure, M2 outrigger and belt truss at every 4th storey of the structure, similarly M3 indicates the outrigger and the belt trusses at every 5th storey, M4 indicates the Outrigger and the belt trusses at every 7th storey and M5 indicates the Outrigger and belt trusses at every 10th storey of the building as given below in graph.



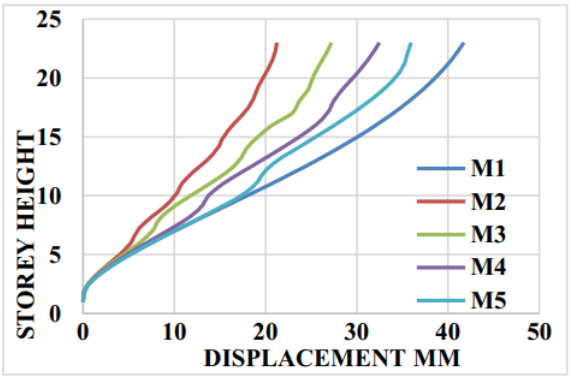
Graph 4.5: Displacement vs storey

Graph 4.5 shows the displacement vs storey graph of Model 1, Model 2, Model 3, Model 4, Model 5.

Graph 4.5 represents the comparison of all the RC Framed models with & without Outrigger and belt truss system & with different locations Outrigger and belt truss system of the structure models so that the comparison can be done easily. From the graph, it is obvious that model present in zone III i.e., model 1 is exhibiting highest displacement and model 2 and model 3 is having the lesser displacement compared to other models. However, the displacement are reducing by introducing Outrigger and belt truss system in the model. this is significant reduction and the models with Outrigger and belt truss system can be adopted in seismic zone III so that the chances of failure of the building can be reduced.

Displacement of Steel Structure: -

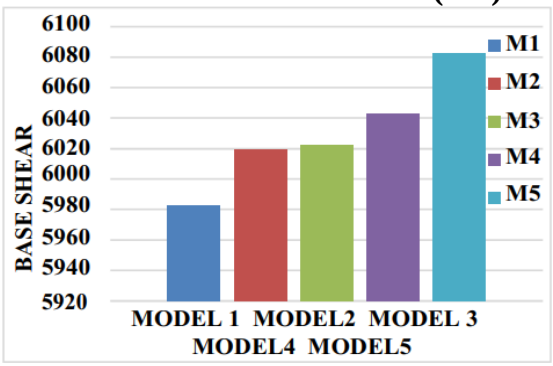
Displacement values for all Steel frame structures are given below, where M1 indicates the Conventional structure, M2 outrigger and belt truss at every 4th storey of the structure, similarly M3 indicates the outrigger and the belt trusses at every 5th storey, M4 indicates the Outrigger and the belt trusses at every 7th storey and M5 indicates the Outrigger and belttrusses at every 10th storey of the building as given below in table.



Graph 4.6: Displacement vs storey

Graph 4.11 shows the displacement vs storey graph of Model 1, Model 2, Model 3, Model 4, Model 5. Graph 4.11 represents the comparison of all the Steel Framed models with & without Outrigger and belt truss system & with different locations Outrigger and belt truss system of the structure models so that the comparison can be done easily. From the graph, it is obvious that model present in zone III i.e., model 1 is exhibiting highest displacement and model 2 and model 3 is having the lesser displacement compared to other models. However, the displacement is reducing by introducing Outrigger and belt truss system in the model. this is significant reduction and the models with Outrigger and belt truss system can be adopted in seismic zone III so that the chances of failure of the building can be reduced.

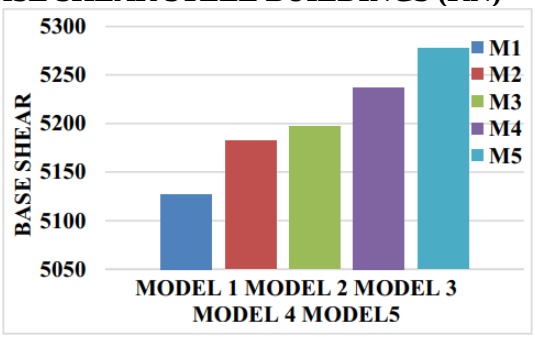
BASE SHEAR RC BUILDINGS (KN).



Graph 4.17 All Models Base shear

- From the above table, it clearly shows that maximum Base shaer for Model M2 Outrigger and belt truss system at every 4th storey 6082.95 KN and for Model M3 Outrigger and belt truss system at every 6th storey 6043.09 KN.
- By considering different Models M1 Model M2 Outrigger and belt truss system at every 4th storey is getting Maximum base shear and Model M1 Conventional system is getting the minimum base shear which contains maximum zone factor 0.16 (zone 3).

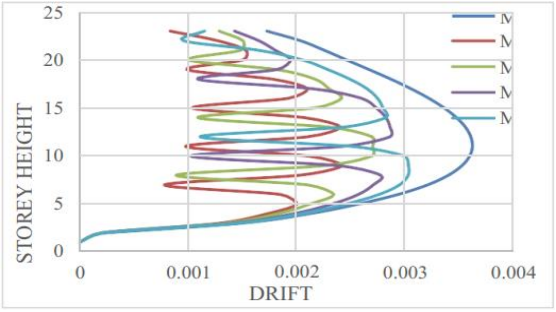
BASE SHEAR STEEL BUILDINGS (KN)



Graph 4.18 All Models Base shear

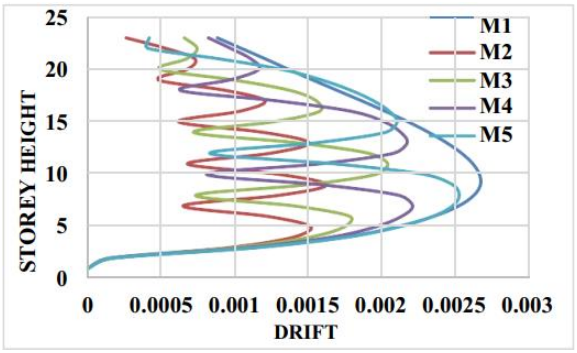
- From the above table, it clearly shows that maximum Base shaer for Model M2 Outrigger and belt truss system at every 4th storey 5277.5 KN and for Model M3 Outrigger and belt truss system at every 6th storey 5237.36 KN.
- By considering different Model M1 Model M2 Outrigger and belt truss system at every 4th storey is getting Maximum base shear and Model M1 Conventional system is getting the minimum base shear which contains maximum zone factor 0.16 (zone 3).

STOREY DRIFT



Graph 4.35: All Model Drift vs storey height

From the graph, it is obvious that model present in zone III i.e., Model-2 and Model-3 is exhibiting minimum drift and is having the lesser strory drifts compared to other models.



Graph 4.36: All Model Drift vs storey height

From the graph, it is obvious that model present in zone III i.e., Model-2 and Model-5 is exhibiting minimum drift and is having the lesser strory drifts compared to other models.

CONCLUSION

- In this study, outriggers and belt truss system which have been designed to reduce the lateral displacements caused by wind and earthquake loads were used to reduce Displacements.
- The study shows that the deflection is minimum in case of steel structure system when compared to RC structures.
- The provision of the outrigger and the belt truss is so mandatory that to attain the deflection limits, this system provides the reverse curvature and constantly reduces the deflection at the top of the structure.
- The optimum design results showed that increasing the number of outrigger installations reduces the total volume of the outriggers to satisfy the allowable drift at the top of the building.
- The provision of core wall at the center with outriggers in the building decreases the forces in the core.
- The steel outriggers are found to be least effective compared to concrete outriggers, although steel outriggers can be employed as the light weight compared to concrete.
- Steel a outrigger can be used as an alternative to the other strengthening technique available as the total weight of the building remains almost same.
- Overall, it is observed that the Outrigger and belt truss system are more effective than the conventional structure.

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