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Seismic Performance of high-rise Buildings with Different Structural Systems

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ABSTRACT:

In the present world scenario, construction of high rise building is being preferred due to rapid increase in the cost of land, lack of land availability and also to preserve land in rural areas for agricultural use. The design of high rise buildings is primarily governed by wind and seismic loads. The performance of the buildings depends on the structural configuration and the present study aims at comparing the performance of high rise building with different configurations.

In the present study, high rise buildings have been investigated under the effect of seismic loads with different structural, namely, (i) special moment resisting frames (ii) frame-shear wall buildings (iii) outrigger systems (iv) braced model . The building models are assumed to be located in Guwahati, Assam which is one of the most earthquake-prone zones in India

A detailed analysis of the building system is done by modeling the geometry, material section properties and boundary conditions. All the analysis and design work is conducted using ETABS 2016 version. The post analysis consist typical characteristic comparison related to storey displacement, storey drift, Story Shears. Etc

KEYWORDS: High rise building; finite element; frame-shear wall system, out-trigger systems.

I. INTRODUCTION

Over the past years, the procedure for designing high rise buildings has changed. Building high rise buildings is preferred in the current scenario due to a rapid rise in land costs and unavailability of land. The lateral loads govern the design of high rise

Buildings as these loads tend to cause dynamic actions on high rise buildings. Depending on the site parameters and height, the effect of these loads is predominant on high rise buildings. It should be ensured that, even when exposed to lateral loads, the structure must be nonviolent and functional during its anticipated life.

Analysis of high rise buildings is of paramount importance to the engineers. To design a structure, these loads must be resisted by specifying the forces on the structure. The high rise buildings subjected to lateral loads involve excessive degrees of freedom, making it difficult to determine the responses involved in computational work (stress, displacement, drift, etc.). A more detailed analysis is generally sidestepped by making some valid assumptions to make the solution practically feasible. Therefore, there is a definite need to satisfy the trade-off between results accuracy and the cost of calculation to analyze large buildings.

Because of their aesthetic beauty, high rise towers and buildings have captivated humankind since the commencement of civilization. The building practice of high rise buildings was instigated in the 1880s and has grown for commercial and inhabited purposes in large part. The fast-growing commercial activities to be as close to each other and the city center, are primarily responsible for creating high rise commercial buildings, stroking powerful weight on the existing land. The high land costs and the requirement to preserve noteworthy agricultural production contributed to driving inhabited buildings upward.

The viability of high rise buildings is always dependent on the resources available, the level of edifice expertise, and the state of progress of the amenities needed for building use. As an outcome, significant progress has occurred in the history of high rise buildings from time to time. At the same time, the designers must bear in mind the building's security and serviceability criteria. In developing an appropriate lateral force resistance system, it is necessary to plan rigid plane interconnections between the different perpendicular apparatuses to form complex assemblages such as coupling walls and rigid frames thatgenerate a whole structural assembly with lateral rigidity many times greater than the sum of the lateral rigidity of the discrete perpendicular components.

DIFFERENT FORMS OF HIGH RISE BUILDINGS

In the field of high rise buildings, there are several structural forms that have evolved to date. For all these structural forms, the fundamental design philosophy is to put maximum possible load bearing element around the exterior peripheral of buildings to maximize their flexural stiffness. It is possible to take advantage of all structural forms by placing the foremost vertical members and overturning the lateral load tensile pressures with the compressive pressures from self-weight. The different high rise building structural forms whichare presented in this study are namely: (i) special moment resisting frames, (ii) frame-shear wall buildings, (iii) outrigger systems, (iv) braced model (v) outrigger system with belt truss.

II. METHODOLOGY

Draw the various structure of different structure system in e-tab software , assigning the all section and material properties. Analyse the all structures and comparison carried out . The all structures is compare with story displacement, story shear and story drift and overturning moment.

EVALUATION

Five different structural systems, namely, rigid frame system, shear wall system, braced system, outrigger system of the same plan dimension of 36 m by 36 m are analyzed using ‘ETABS 2016’ with finite element modeling technique. The models are G+20storeyed concrete frames with steel bracings and outriggers with a height of 63 m. The buildings are assumed to be located in seismic zone factor V.

The building nomenclatures for the four different building models are shown in table 1. The buildings name starting with ‘p’ indicates plan, following with a number which indicates the plan number and the last alphabet indicates the building type (R- rigid frame, S- shear wall,B- braced system, O- outrigger system).

Table 1 Building Nomenclature

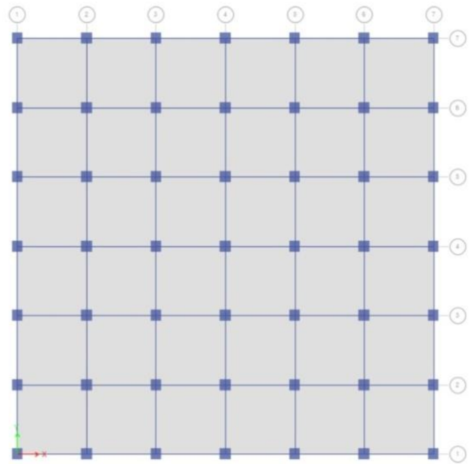
BUILDING TYPE	NAME
Rigid frame system	P-I-R
Shear wall system	P-II-S
Braced frame system	P-III-B
Outrigger system	P-IV-O
Outrigger system with belt truss	P-(v)-OT

Materials and Geometry

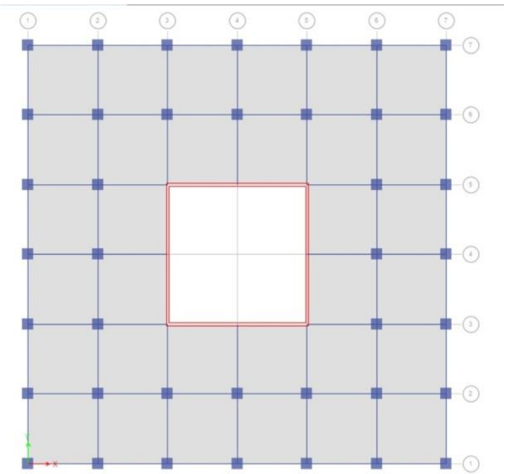
The buildings have concrete frames of rectangular beams and columns, with concrete walls 250 mm thick and 175 mm thick slab. The shear walls are 250 mm, 200 mm and 150 mm thick for

Shear wall model, outrigger model respectively. Steel bracings used as outriggers and bracings are ISWB sections. The materials used are M30 concrete and FE550 grade steel.

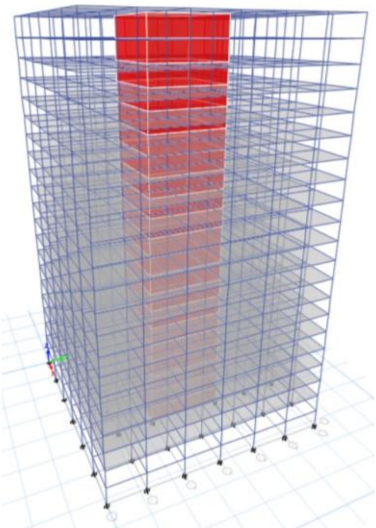
The various plans and elevation of the models investigated in this study are shown in Figure.



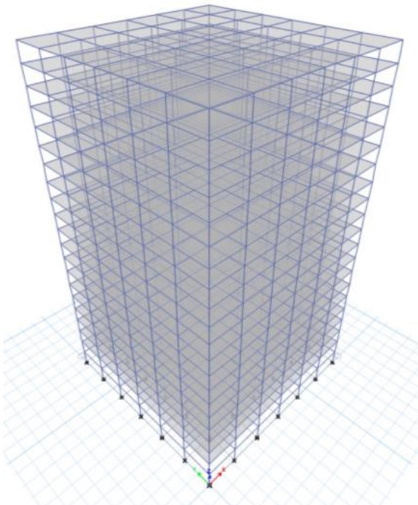
2-D plan - rigid frame system and braced frame system



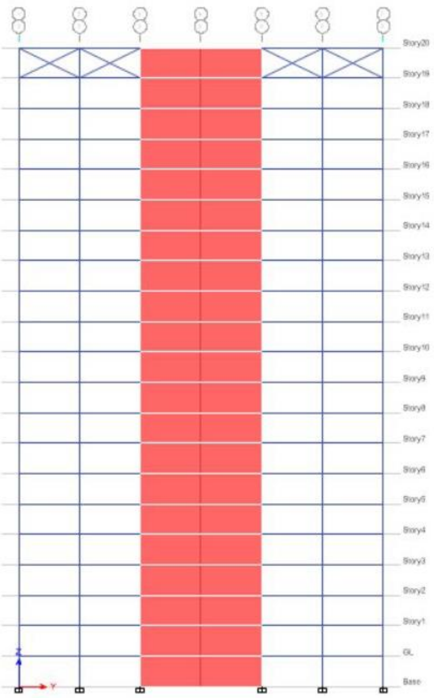
2-D plan - shear wall system, outrigger system and outrigger system with belt truss.



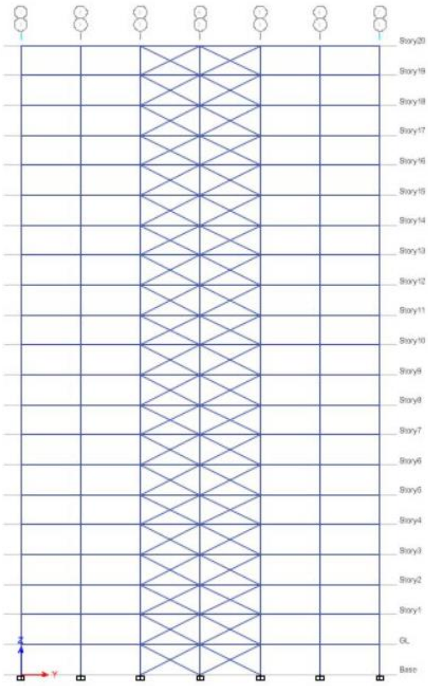
Model from ETABS of shear wall system



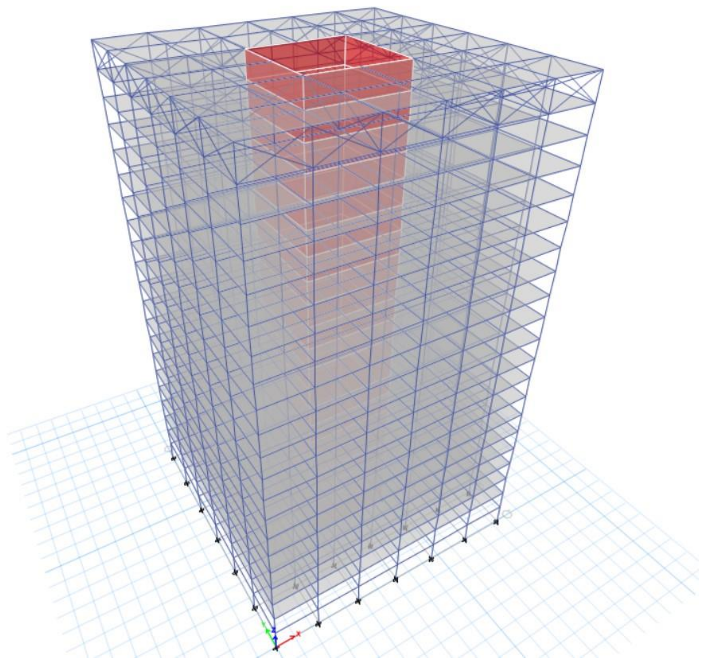
Model from ETABS of Rigid Frame system



Model from ETABS of outtrigger system



Model from ETABS of Brace Frame system



Model from ETABS of outrigger system with belt truss system

Design

A detailed procedure of analysis is performed for four different structural systems of high-rise building. The analysis results (building responses) for different systems are compared to get the performance of various stiffening systems used in the study.

Four 20 strayed building models of different structural systems of high-rise building, namely, rigid frame model, shear wall model, braced frame model, outrigger model are modeled using finite element modeling technique in 'ETABS 2016'. A linear response spectrum analysis is conducted with seismic loading according to IS 1893 (2002).

The members are designed with 3-4% rebar percentage and keeping column/beam capacity ratio equal or more than 1.5. It is checked whether the members are passing the design or not, to fix the member sizes. Further with a target displacement of 0.126 m, the member sizes are optimized. This displacement is taken as H/500 = 0.126 m, the acceptable limit for maximum displacement as per IS 1893 (Part 1): 2002. The various parameters, such as base shear, inter-story drift ratio, roof displacement, etc. are compared for the different structural systems. Meanwhile, the results are compared with the loads calculated manually and it is checked whether the results are within acceptable limit or not. The member sizes optimized for different models.

Table 2 (a) Rigid frame system

Story No.	**Column size (mm x mm)**	**Beam size (mm x mm)**
1-2	1200 x 1200	800 x 400
3-5	1100 x 1100	800 x 400
6-10	1050 x 1050	800 x 400
11-15	1000 x 1000	800 x 400
16-20	950 x 950	800 x 400

Table 2 (b) Shear wall system

Story No.	**Column size (mm x mm)**	**Beam size (mm x mm)**	**Shear wall thickness (mm)**
1-5	1100 x 1100	800 x 400	250
6-10	1000 x 1000	800 x 400	250
11-15	900 x 900	800 x 400	250
16-20	800 x 800	800 x 400	250

Table 2 (c) Braced frame system

Story No.	**Column size (mm x mm)**	**Beam size (mm x mm)**	**Bracing member**
1-2	1200 x 1200	800 x 400	ISWB 550
3-7	1000 x 1000	800 x 400	ISWB 550
8-20	900 x 900	800 x 400	ISWB 550

Table 2 (d) Member sizes for Outrigger system

Story No.	**Column size (mm x mm)**	**Beam size (mm x mm)**	**Shear wall thickness (mm)**	**Outrigger member**
1-5	1100 x 1100	800 x 400	200	ISWB 450
6-10	1000 x 1000	800 x 400	200	ISWB 450
11-15	900 x 900	800 x 400	200	ISWB 450
16-20	800 x 800	800 x 400	200	ISWB 450

Table 2 (e) Member sizes for P-V-OT

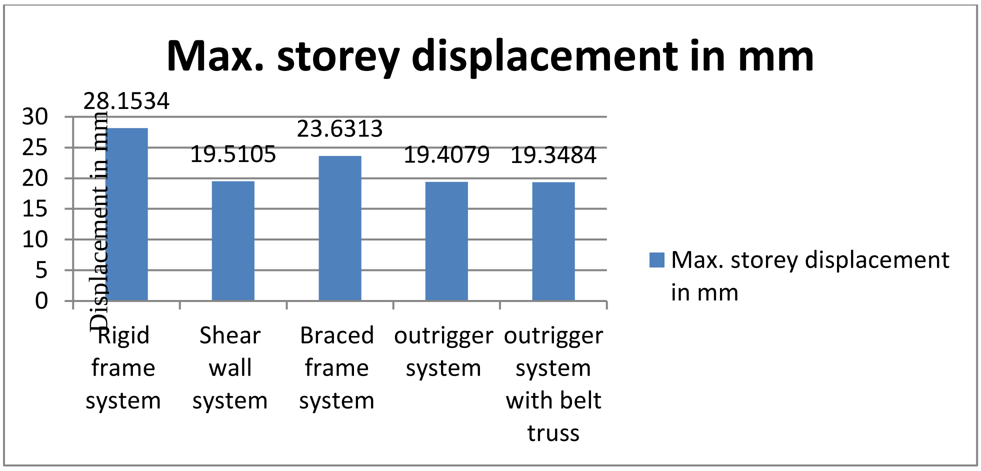
Story No.	**Column size (mm x mm)**	**Beam size (mm x mm)**	**Shear wall thickness (mm)**	**Outrigger member**	**Bracing member**
1-5	1000 x 1100	800 x 400	150	ISWB 450	ISWB 400
6-10	950 x 950	800 x 400	150	ISWB 450	ISWB 400
11-15	900 x 900	800 x 400	150	ISWB 450	ISWB 400
16-20	800 x 800	800 x 400	150	ISWB 450	ISWB 400

PERFORMANCE AND ANALYSIS

Maximum storey displacement:

Story displacement is the lateral displacement of the story relative to the base. The lateral force-resisting system can limit the excessive lateral displacement of the building. The acceptance lateral displacement limit for wind load case could be taken as H/500.

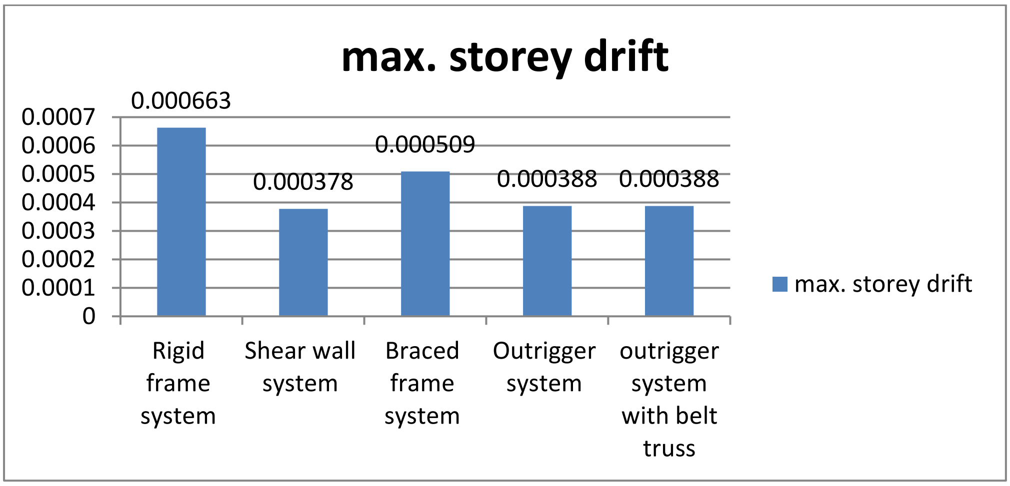
The graphs of lateral displacement are plotted in X and Y direction of model P-I-R, P-II-S, P-III-B, P-IV-O and P-V-OT



Max. Storey drift:

Storey drift is the lateral displacement of a floor relative to the floor below, and the storey drift ratio is the storey drift divided by the storey height.

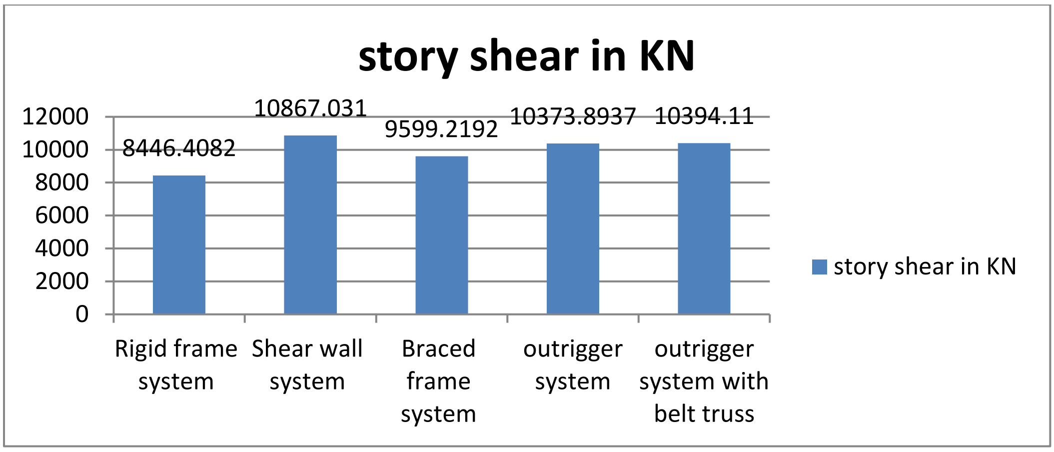
The graphs of max. Storey drift between model P-I-R, P-II-S, P-III-B, P-IV-O and P-V-OT



Storey shear:

It is the lateral force acting on a storey due to the forces such as seismic and wind force. Buildings having lesser stiffness attract lesser storey shear and vice versa.

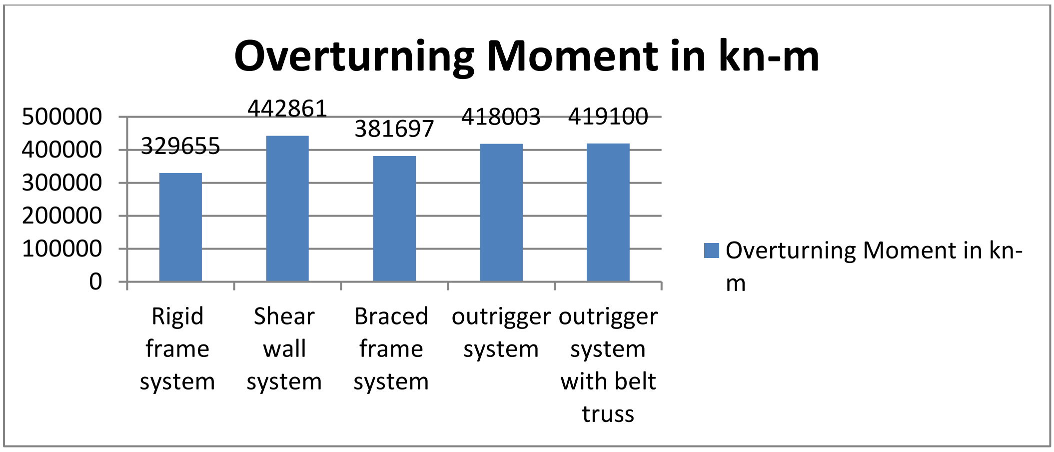
The graphs of storey shear of model P-I-R, P-II-S, P-III-B, P-IV-O and P-V-OT



Overturning Moment:

The "overturning moment" at any horizontal plane is the moment on the structure as a whole resulting from the dynamic earthquake forces above the plane, giving due regard to signs of the modal forces.

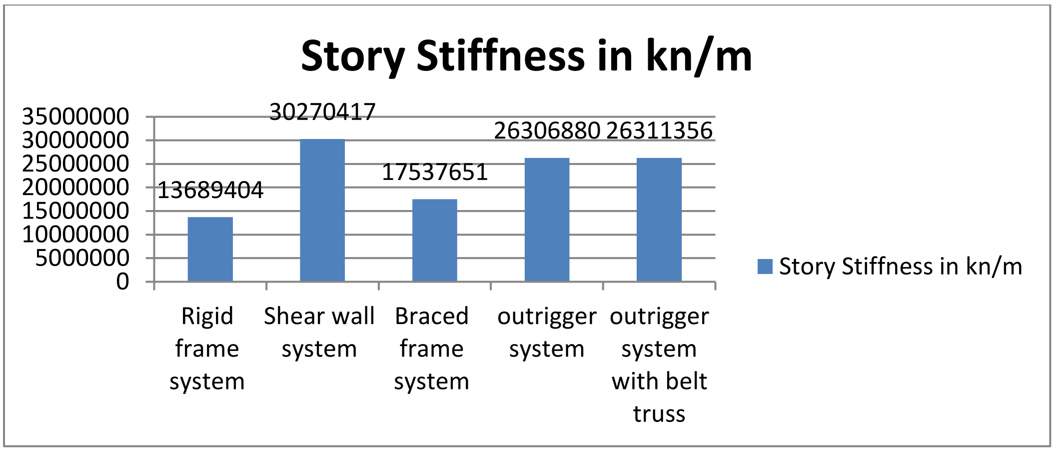
The graphs of Overturning Moment of model P-I-R, P-II-S, P-III-B, P-IV-O and P-V-OT



Story Stiffness:

storey stiffness is estimated as the lateral force producing unit translational lateral deformation in that storey, with the bottom of the storey restrained from moving laterally, i.e., only translational motion of the bottom of the storey is restrained while it is free to rotate.

The graphs of Story Stiffness of model P-I-R, P-II-S, P-III-B, P-IV-O and P-V-OT



IV. CONCLUSION

After analyzing and comparing we have observed that:¬

- Storey displacements are more reduces in case of outrigger system and shear wall system and outrigger with belt truss as compare to braced frame system and rigid frame system.
- Storey drift reduces at each floor in shear wall system and outrigger system and outrigger with belt truss. Finally, it is concluded that the result are highly effective in 20 Storey buildings in zone-5 respectively when shear wall , outriggers and outrigger with belt truss are used.
- From the Base shear point of view, it is analyzed that base shear reduction is more in rigid frame system and Braced frame system as compare to Shear wall system , and outrigger system and outrigger with belt truss system.
- From overturning moment point of view share wall system, outrigger system and outrigger with belt truss system show batter results as compare to braced and rigid frame system.
- Hence it is finally concluded from all the above results that, shear wall system and outrigger system in building structure is more resilient in the event of the earthquake.

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