DYNAMIC ANALYSIS OF STEEL MOMENT RESISTING FRAME ON SLOPING GROUND WITH BRACINGS AND SHEAR WALL

Sanjay S D[1], Supreeth S[2]

[1] *P.G. Student, Civil Engineering Department, Sri Jagadguru Balagangadharanatha Institute of Technology, Bengaluru - 560060, Karnataka, India*
[2] *Assistant Professor, Civil Engineering Department, Sri Jagadguru Balagangadharanatha Institute of Technology, Bengaluru - 560060, Karnataka, India*

Abstract - *India is one of the developing country, caused scarcity of land because of industrialization and urbanization; therefore there has been considerable increase in construction of multistory buildings in hilly areas.*

The buildings situated on hill slopes in earthquake prone areas are generally irregular, torsionally coupled & hence, susceptible to serve damage when affected by earthquake ground motion. Such buildings have mass & stiffness varying along the vertical & horizontal planes, resulting the center of mass & center of rigidity do not coincide on various floors, hence they demand torsional analysis, in addition to lateral forces under the action of earthquakes. These unsymmetrical buildings require great attention in the analysis & design. Analysis of hill buildings is somewhat different than the buildings on leveled ground, since the column of hill building rests at different levels on the slope. The various floors of such buildings step backs towards hill slope and at the same time buildings may have setbacks also. It is observed that the seismic behaviour of buildings on sloping ground differ from other buildings. Most of the studies agree that the buildings resting on sloping ground has higher displacement and base shear compared to buildings resting on plain ground and the shorter column attracts more forces & undergoes damage, when subjected to earthquak.

In this work, building in the sloping ground need to be make considered in order to make exists as of when all the maximum storey drift occured, computed with all the design eccentric condition in a high rise structures, at another end the structures with transverse to all an axis which will be of more than 1.2 times the average storey drifts at par the two ends of the building. Here our aim is to make understand the importance of codal provision which will be in particularly suggesting the bracing provision for high rise buildings. 6 numbers of different types of twelve storied RC framed and RC framed with shear wall buildings in the sloping grounds are considered. Dynamic analysis has been performed by Response Spectrum Method for all the different seismic zones and for all the soil conditions. Variations of the result of all the structural elements are been studied in a detail manner for all other different parameters.

Key Words: **Sloping Ground, Bracings, Shear Wall, Story Shears, story drifts, Story Displacements.**

1.INTRODUCTION

Seismology is a concept in which the study of all the vibrations of earth will be done, which is mainly caused due to the earthquakes. The structural element resisting all the lateral forces available which will be acting and will be due to the seismic and the wind loading conditions and the shear walls or with the bracings in which it will be provided in order to make resist all the available lateral sway conditions and it will be much more susceptible to the damage that will be causing when it was affected by the ground motions. Shear walls are one in which it will be the most commonly available by the lateral load resisting systems in the tall structure.

Shear wall which is of high in the plane stiffness conditions and the strength considerations which will be used in order to make the simultaneously in order to make resist all the larger horizontal and the dead loads. So that there will be much in order to make study all the shape and the locations of the shear walls and also with the bracings on to the seismic performances of the building which will be located on a sloping grounds.

The design will be of Criteria for the earthquake Resistant Design of the Structures it has to make ensure that the structures which will make possess with at least of all a minimum strengths to make withstand all the minor earthquakes which will be occurring much frequently, without causing any damage resist moderate earthquake.

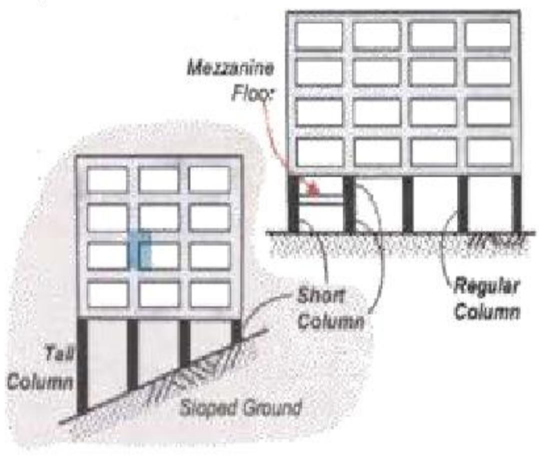

Fig-1: Building in sloping ground

1.1 Objectives Of The Study

Here building in the sloping ground need to be make considered in order to make exists as of when all the maximum storey drift occurred , computed with all the design eccentric condition in a high rise structures, at another end the structures with transverse to all an axis which will be of more than 1.2 times the average storey drifts at par the two ends of the building. Here our aim is to make understand the importance Of type codal provision which will be in particularly suggesting the bracing provision for high rise buildings. 6 numbers of different types of twelve storied RC framed and RC framed with shear wall buildings in the sloping grounds are considered. Dynamic analysis has been performed by Response Spectrum Method for all the different seismic zones and for all the soil conditions. Variations of the result of all the structural elements are been studied in a detail manner for all other different parameters.

1.2 Limitations Of The Study

Our present study which will be mainly focus on the building on the sloping grounds effects of a different high rise structures, and all the structural modeling is carried out with only a shear walls. However in order to compute its real behaviour of the structure, FEM method can be adopted with a frames and different types of the shear walls and the interface elements is recommended.

In Our study was not considered during our analysis of the structures. Bases with a fixed conditions will be made assumed for our analysis process of the columns in our present study, however it is to be noted that the torsional responses will be much increased because of all the foundational movements. This will be a aspect which is not considered and will be not studied.

In our present study, seismic analysis will need to be carried with in its elastic limits. However the behavior of the structure due to the torsional irregular condition structures are too often highly complex in nature in its elastic limit ranges and that need to be further investigated by make it carrying the inelastic type analysis of the structure.

2. MODELING

For design and analysis we are using ETABS version 9.7.4 features a powerful graphical user interface system and design mechanisms.

The most common method of forming a different kind of structure is included in the simplest process. The basic model was first created and then other configurations will be updated to different models. Here we are presenting 5 different patterns.

1. Type A – regular model in sloping ground with bracings.
2. Type B – regular model in sloping ground with shear wall.

2.1 Model Design Of Type A and B

In our model, the structure as ductile shear wall with SMRF. Number of stories as G+30 and each storey height 3.0m. Foundation type as isolated footing and seismic zone Z-3.

2.2 Materials Properties

Grade of concrete M30 and grade of steel Fe500. Slab thickness 200mm , Beam size as ISMB600 , column size as built up section and thickness of shear wall 200mm.
Dead load intensity roof finishes 1.5 KN/m^2 and floor finishes 1.5 KN/m^2

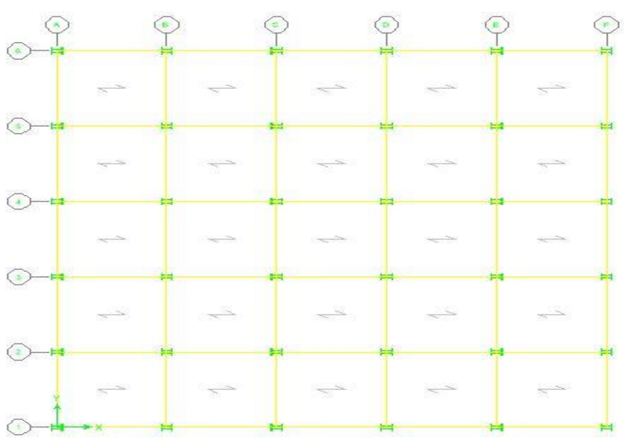

Fig-2: First Storey Plan of Type –A

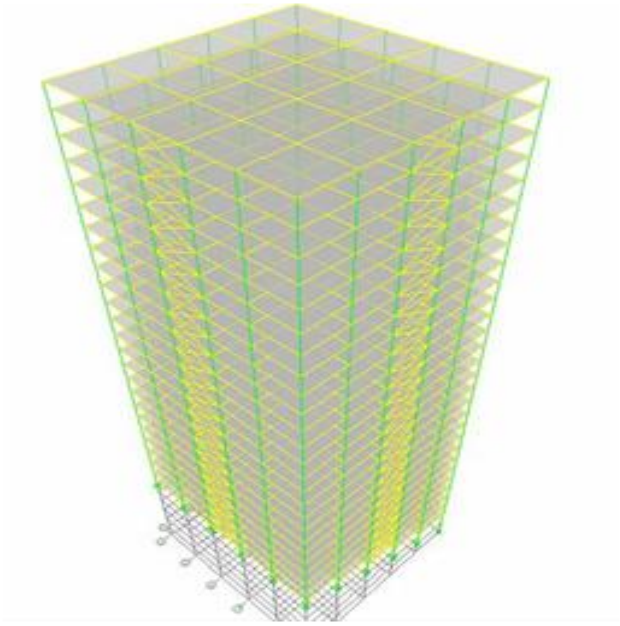

Fig-3: ETABS model of type – A, 30 storied building

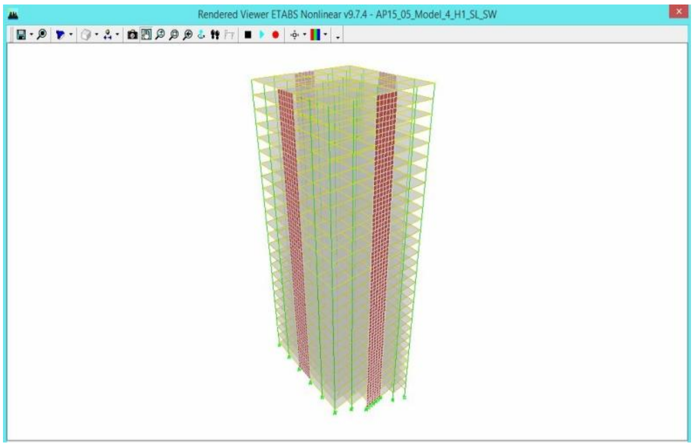

Fig-4: ETABS model screen shot of Type – B, 30 storied building

3. ANALYSIS RESULTS AND DISCUSSIONS

3.1 Model Analysis part of type A and type B

Modal analysis is carried out to understand the dynamic behaviour of structures under different modes. Time period in seconds and frequency for all steel moment resisting frames are considered for the study are presented modes of vibrations. From the analysis results it can be observed that, steel frame on sloping ground will have longer time period compared to all other steel frames on sloping ground. And also it can be observed that, due to sloping ground effect time period has reduced 4.18 seconds to 3.46 seconds which is about 17% reduction. But with the incorporation of the bracings and shear walls still time period has reduced to 3.03 and 2.95 seconds respectively. And frequency is found to be highest for steel moment resisting frame with shear wall and it found to be 0.34 Hz.

Table 1: Mode vs. Time Period

	Time Period (Seconds)	
Mode No.	Sl. Gr.- Bracings	Sl. Gr.- SW
1	3.03	2.95
2	2.76	2.74
3	2.13	2.09
4	0.94	0.87
5	0.85	0.81
6	0.67	0.61
7	0.51	0.44
8	0.46	0.41
9	0.37	0.31
10	0.35	0.26
11	0.31	0.25
12	0.27	0.2

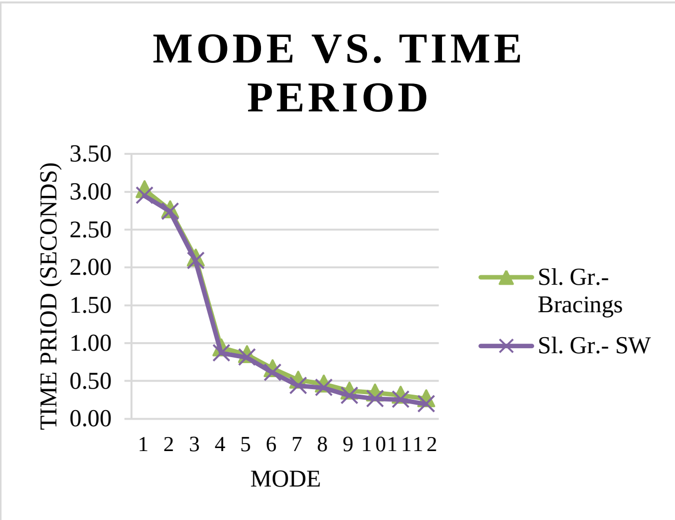

Chart -1: Mode V/s Mode (time) period for different models

Table -2: Mode vs. Frequency

	Frequency (Hz)	
Mode No.	Sl. Gr.- Bracings	Sl. Gr.- SW
1	0.33	0.34
2	0.36	0.37
3	0.47	0.48
4	1.06	1.15
5	1.18	1.24
6	1.5	1.64

7	1.95	2.3
8	2.17	2.44
9	2.71	3.28
10	2.9	3.8
11	3.21	3.94
12	3.76	5.12

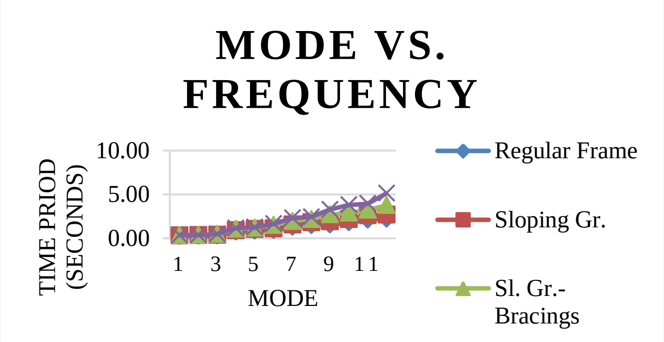

Chart -2: Mode V/s Frequency for different models

3.2 Story Shears

The maximum base shear developed at the ground level of the steel structure. It can be seen that due to sloping ground effect, base shear has reduce about 9%. And due to incorporation of bracings slight increase in the base shear about 0.53%, but due to RC shear wall, base shear has increase about 5%.

Table -3: Maximum Base Shear

Maximum Base Shear (kN)	
Sl. Gr.- Bracings	**Sl. Gr.- SW**
1711	1794

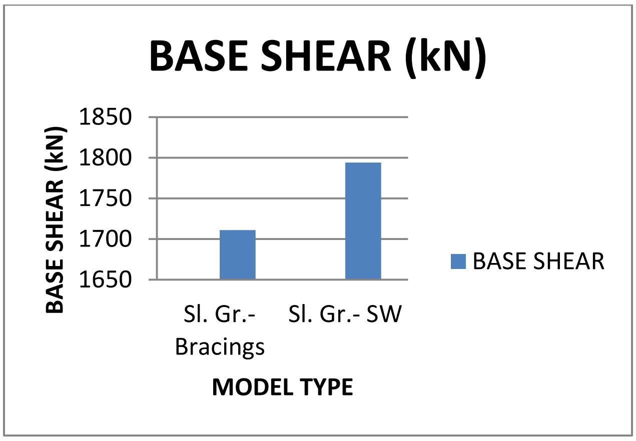

Chart -3:Maximum Base shear

3.3 Story displacements

Story displacements are presented in below tables for X and Y direction. Due to sloping ground effect, reduction in the displacements of 33% is found and 43% with the utilization of bracings and shear wall on sloping grounds due to earthquake loads along X direction. A negative sway is observed at the bottom story of the steel structure since moment resisting frame is resting on sloping ground.

In the regular frame along Y direction, the displacements has increased from 59.1 mm to 73.9 mm due to the orientation of the built up columns. In Y direction also displacements are reduced to 51.6 mm i.e., about 30% due the effect of sloping ground. Additional 19% reduction in the displacements is found due to addition of bracings and shear walls along the peripheral of the steel moment resisting frame.

Table -4: Story vs. Story Displacements – X direction

	Story Displacements - X Direction	
Story	Sl. Gr.- Bracings	Sl. Gr.- SW
Story30	34.00	34.00
Story29	33.30	33.20
Story28	32.50	32.30
Story27	31.60	31.30
Story26	30.60	30.30
Story25	29.50	29.20
Story24	28.30	28.00
Story23	27.00	26.70
Story22	25.70	25.40
Story21	24.30	23.90
Story20	22.80	22.40
Story19	21.20	20.80
Story18	19.60	19.20
Story17	18.00	17.50
Story16	16.30	15.80
Story15	14.70	14.10
Story14	13.00	12.40
Story13	11.20	10.70
Story12	9.50	8.90
Story11	7.90	7.30
Story10	6.20	5.70
Story9	4.60	4.20
Story8	3.10	2.80

Story7	1.60	1.60
Story6	0.60	0.70
Story5	0.10	0.20
Story4	-0.10	0.02
Story3	-0.05	-0.01
Story2	-0.03	-0.02
Story1	-0.02	-0.01

Table -5:. Story vs. Displacements – Y direction

	Story Displacements - Y Direction	
Story	Sl. Gr.- Bracings	Sl. Gr.- SW
Story30	41.80	41.10
Story29	41.00	40.10
Story28	40.10	39.10
Story27	39.00	38.00
Story26	37.90	36.80
Story25	36.60	35.50
Story24	35.20	34.10
Story23	33.70	32.60
Story22	32.10	31.00
Story21	30.40	29.30
Story20	28.70	27.50
Story19	26.80	25.70
Story18	24.90	23.80
Story17	23.00	21.80
Story16	21.00	19.80
Story15	19.00	17.80
Story14	16.90	15.70
Story13	14.90	13.70
Story12	12.90	11.70
Story11	10.80	9.70
Story10	8.80	7.80
Story9	6.90	6.00
Story8	5.00	4.30
Story7	3.30	2.90
Story6	1.80	1.70
Story5	0.90	0.90
Story4	0.40	0.40
Story3	0.10	0.10
Story2	0.00	-0.03
Story1	-0.03	-0.03

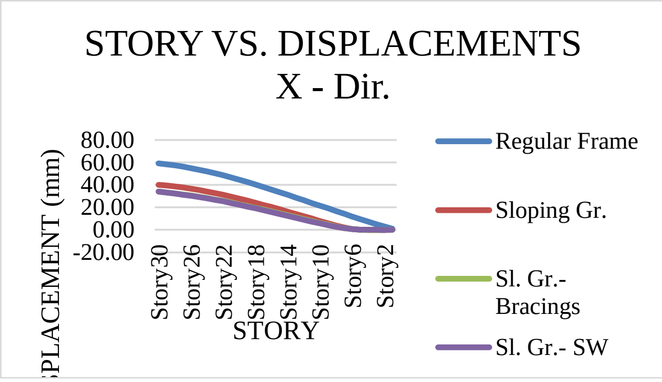

Chart -4: Story vs. Displacements – X direction

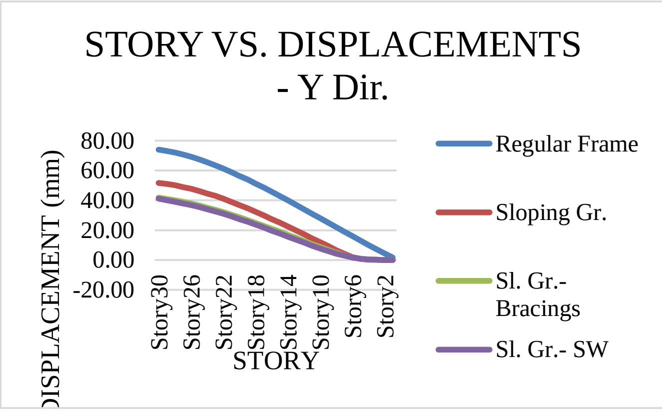

Chart -5: Story vs. Displacements – Y direction

3.4 Story drifts

It is observed that, due to the sloping ground effect, there will be no drifts up-to story 4 and also story drifts are found to be less than that of regular frame of about 35% less in case of steel moment resisting frame resting on sloping ground provided with bracings. Increase in story drifts with height is observed in all the case of models but it is less than about 22% compared to regular frame resting on level ground.

Table -6: Story vs. Story Drifts – X direction

	Story Drifts X - Direction	
Story	Sl. Gr.- Bracings	Sl. Gr.- SW
Story30	0.00024	0.00028
Story29	0.00027	0.00030
Story28	0.00030	0.00032
Story27	0.00033	0.00034
Story26	0.00037	0.00037
Story25	0.00040	0.00040
Story24	0.00042	0.00043
Story23	0.00045	0.00045

Story22	0.00047	0.00048
Story21	0.00050	0.00050
Story20	0.00052	0.00052
Story19	0.00053	0.00054
Story18	0.00055	0.00056
Story17	0.00056	0.00057
Story16	0.00056	0.00058
Story15	0.00057	0.00058
Story14	0.00057	0.00058
Story13	0.00057	0.00057
Story12	0.00056	0.00056
Story11	0.00055	0.00053
Story10	0.00054	0.00050
Story9	0.00052	0.00046
Story8	0.00049	0.00042
Story7	0.00045	0.00042
Story6	0.00016	0.00017
Story5	0.00005	0.00007
Story4	0.00001	0.00001
Story3	0.00001	0.00000
Story2	0.00001	0.00000
Story1	0.00001	0.00000

Table -7: Story vs. Drifts – Y direction

	Story Drifts Y - Direction	
Story	Sl. Gr.- Bracings	Sl. Gr.- SW
Story30	0.00027	0.00033
Story29	0.00031	0.00035
Story28	0.00035	0.00038
Story27	0.00039	0.0004
Story26	0.00043	0.00043
Story25	0.00046	0.00047
Story24	0.0005	0.0005
Story23	0.00053	0.00053
Story22	0.00056	0.00056
Story21	0.00059	0.00059
Story20	0.00061	0.00061
Story19	0.00063	0.00064
Story18	0.00065	0.00065
Story17	0.00066	0.00067
Story16	0.00067	0.00068
Story15	0.00068	0.00068
Story14	0.00068	0.00068
Story13	0.00068	0.00068
Story12	0.00068	0.00066
Story11	0.00066	0.00064
Story10	0.00065	0.0006
Story9	0.00062	0.00055
Story8	0.00059	0.00048
Story7	0.0005	0.00039
Story6	0.00031	0.00028
Story5	0.00017	0.00018
Story4	0.00009	0.0001
Story3	0.00004	0.00004
Story2	0.00002	0.00000
Story1	0.00002	0.00002

Story drifts are found higher along Y direction as compared to X direction. Along Y direction story drifts are found to be in the range of 0.00002 to 0.00009 unlike in X direction. At level 9, story drift is found to be 0.00055 for steel frame with shear wall resting on sloping grounds which is less than about 45% compared to steel moment resisting frame resting on level ground, and 37.5% and 12% less than that of steel moment resisting frame resting on sloping ground without and with steel bracings respectively.

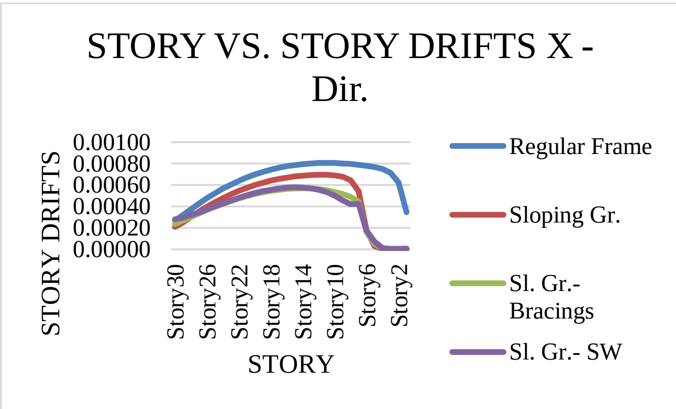

Chart -6: Story vs. Drifts – X direction

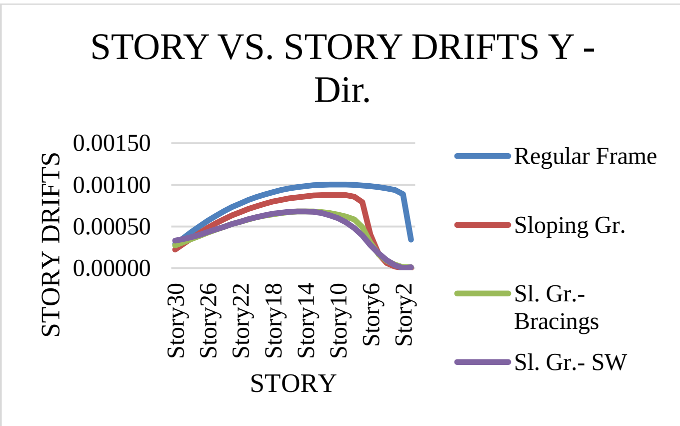

Chart -7: Story vs. Drifts– Y direction

4. CONCLUSIONS

- From the modal analysis we can conclude that due to the introduction of shear walls in steel moment resisting frame resting on sloping ground, time period will reduce hence building frequency will increase, this is due to increase in stiffness of building due to shear walls.

- Buildings resting on sloping ground will have less story shears compared to regular buildings resting on level ground, due to loss in seismic weight from the curtailment of columns and elimination of floor levels.

- Story displacements are found to almost same along X and Y direction for bracings and shear walls steel moment resisting frame, but resistance is more for lateral loads for buildings resisting on sloping ground.

- Shear walls have more efficient in reducing the story drifts compare to all other structural systems.

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