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Seismic Analysis of RCC Irregular Buildings with Shear Wall and Steel Bracings

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Abstract
The natural calamity known to mankind from many years which has dangerous impact both on living as well as non-living beings is Earthquake. The migration of people and less available land leads to construction of irregular plan of buildings which has more damages than buildings having regular plan. Bracing systems and shear wall are generally used techniques to overcome the damage caused by earthquake. Bracings improve the displacement capacity of the structure along with the stiffness and strength capacity. While shear wall resists load parallel to the plane of the wall. In this project, we analyzed the seismic performance of a Reinforced Concrete building having re-entrant corner irregularity with steel bracings and shear wall in ETABS Software. The study shows that though X bracing and Inverted V Bracing shows similar results it is recommended to provide X bracing than shear wall and other bracings.
Keywords: Steel Bracings, Shear Wall, Irregular plan, Re-entrant corner Irregularity, Seismic Analysis, ETABS2016, Story Displacement.

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I. INTRODUCTION

Now-a-days construction industry focuses on vertical expansion of structure (high rise building) due to the scarcity of available land as well as urbanization. Urbanization leads to more income opportunity which leads to migration. Now-a-days there is more construction of irregular buildings than regular buildings due to available land, architectural demands, etc. The present scenario consists of T, C, L, O, etc., shapes of building which has irregular configuration in plan. As per IS 1893:2016 (Part I), a building is said to have re-entrant corner in any plan direction, when its structural configuration in plan has a projection of size greater than 15% of its overall plan dimension in that direction. Since there is more damage due to earthquake to buildings having irregularity as compared to regular buildings. Hence there is a need to study seismic performance of irregular buildings.

Shear Wall is one of the most useful technique used to counteract the damage caused by seismic forces. These walls require special consideration for seismic forces as they should be safe under repeated loads. Therefore, it is very important that shear wall constructed to resist earthquakes should be designed for ductility. They should be placed such as to avoid torsional stresses.

The Bracing systems can also be provided in the reinforced concrete structure but its provision in RC structure is complicated. Bracing system is used mainly as they act by reducing the bending moments and shear forces in the columns of the structure and the lateral load on the structure are transferred to the foundation by axial action. Besides, they also improve the stiffness and strength capacity of the structure. In bracing frames, beams and columns are designed only to support vertical load, since the bracing system should carry all lateral loads.

1.1.1 Aim and Objectives

The aim of the present study is to study the seismic response of RCC structure having irregular plans located in seismic zone III with medium soil condition. The objectives to achieve the aim of the project are as follows:

- To compare following parameters for building having L, Plus and T Shaped irregular plan with steel bracing and shear wall:
- Story displacement
- Story drift
- Time period
- Base shear
- To analyse how particular bracing behave differently for each shaped irregular plans out of L, Plus and T in terms of seismic parameters.

- To evaluate which bracing shows better performance for RCC building having L shaped, Plus Shaped and T shaped irregular plans.
- To differentiate seismic performance of building after application of steel bracings and shear wall.

1.1.2 Problem Statement

To perform dynamic analysis for L shaped, T shaped and Plus shaped RCC framed structure with 12 numbers (Foundation + Ground Floor +10 story) of multi-story building for zone III with medium soil condition. There are 6 bays of 4m in X direction whereas 5 bays of 4m in Y direction.

1.1.3 Input Parameters

Table 1: Properties of Structure

Parameters	RCC Frame
Type of Structure	Residential
Type of Frame	SMRF (Bare Frame) SCBF (Braced Frame)
Plan area	24m* 20m
Number of story's	12
Height of Building	34.5 m
Height of each floor	3 m
Depth of foundation	1.5 m

Table 2: Material Properties

Parameters	Material Properties
Grade of Concrete	Beam and Slab (M25) Column and Shear Wall (M30)
Grade of Reinforcing Steel	HYSD 415
Material for bracing	Fe410
Density of Concrete	25
Density of Steel	-

Table 3: Member Properties

Structural Member		RCC	
		Width (mm)	Depth (mm)
Beam		300	380
Column	Story1 – Story2	500	700
	Story3 – Story12	400	650
Slab		120 mm	
Shear Wall		230 mm	
Steel Bracing		ISA 200*150*15 (Back-to-back)	

Table 4: Loads

Type of Load	Load considered
Floor finish	1.5
Imposed load	3 (All floor) 1.5 (Only roof)
Wall load	6.095(All floor) 3.45 (Story 12)

Table 5: Earthquake load parameter

Seismic Zone	III
Zone Factor	0.16
Importance Factor	1.2
Type of Soil	Medium (II)
Response Reduction Factor	5 (Bare frame structure) 4.5 (Braced frame structure) 4 (Structure with shear Wall)

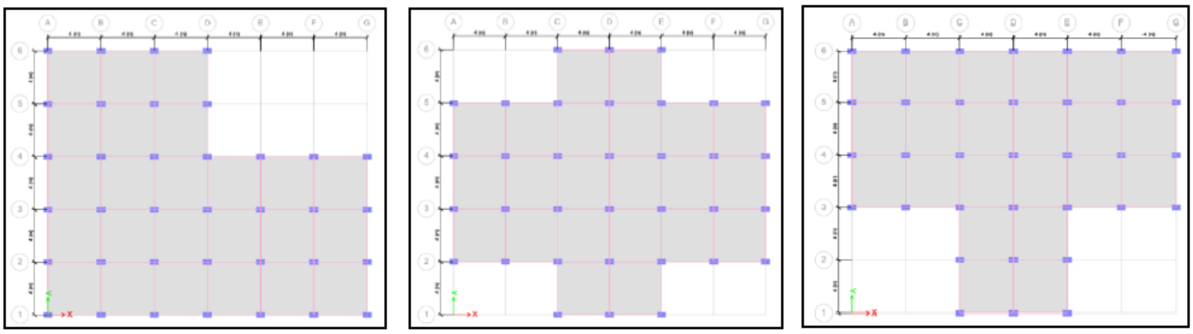

Figure 1: Plan of L, Plus and T Shaped RCC building without bracing and shear wall

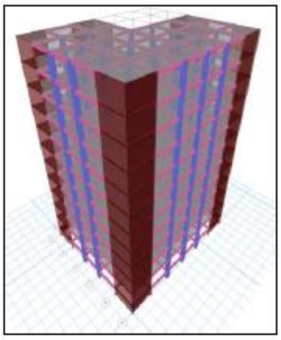

Figure 2: 3D View of L Shaped building with shear wall

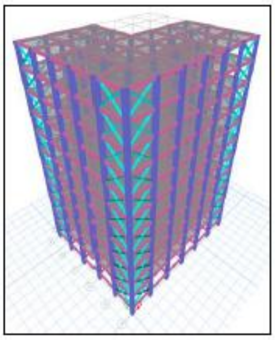

Figure 3: 3D View of L Shaped building with X Bracing

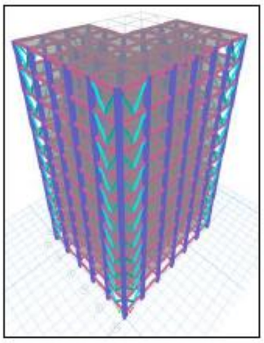

Figure 4: 3D View of L Shaped building with V Bracing

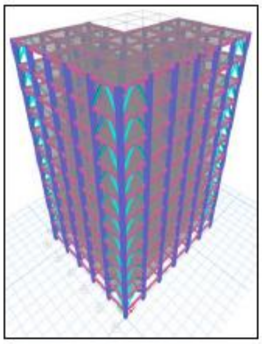

Figure 5: 3D View of L Shaped building with Inverted V Bracing

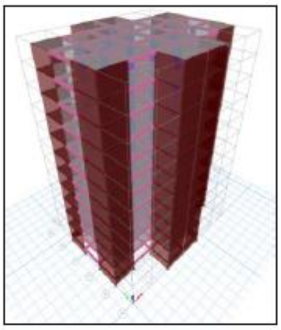

Figure 6: 3D View of Plus Shaped building with shear wall

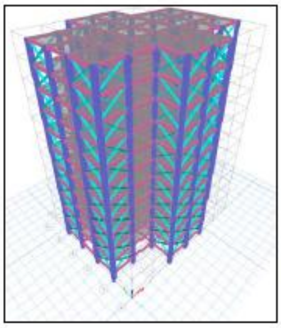

Figure 7: 3D View of Plus Shaped building with X Bracing

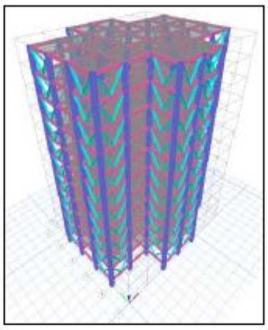

Figure 8: 3D View of Plus Shaped building with V Bracing

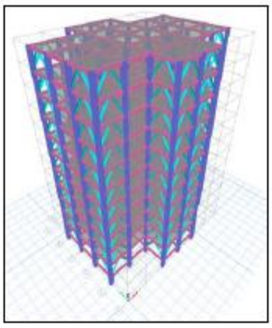

Figure 9: 3D View of Plus Shaped building with Inverted V Bracing

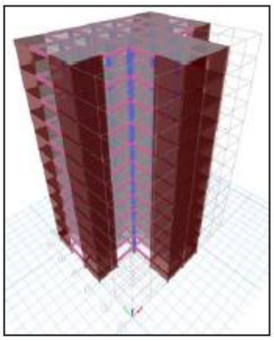

Figure 10: 3D View of T Shaped building with shear wall

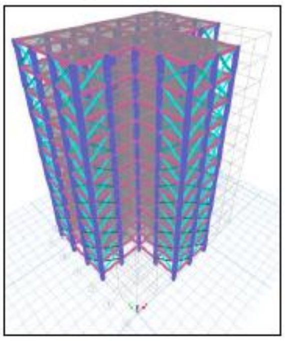

Figure 11: 3D View of T Shaped building with X Bracing

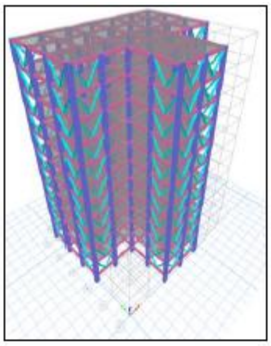

Figure 12: 3D View of T Shaped building with V Bracing

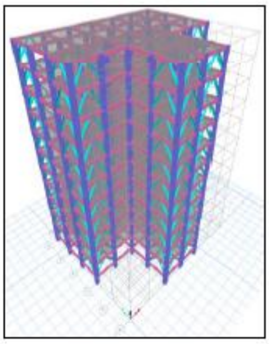

Figure 13: 3D View of T Shaped building with Inverted V Bracing

II. RESULT AND DISCUSSION

The results obtained are as discussed below:

1.3.1 STORY DISPLACEMENT

The displacement of a story with respect to the displacement of the bas is known as story displacement.

Table 6: Story displacement (mm) in X and Y direction

Type of frame Structure	Story Displacement (mm)					
	L Shaped		T Shaped		Plus Shaped	
	X direction	Y direction	X direction	Y direction	X direction	Y direction
Bare frame	95.12	105.04	96.43	99.87	91.28	99.86
Shear wall	34.31	32.36	27.24	21.60	7.62	17.35
X Bracing	33.68	31.60	32.28	25.02	15.43	20.53
V Bracing	38.84	36.63	37.43	29.20	18.97	24.11
Inverted V Bracing	33.46	31.39	32.04	24.74	16.03	20.01

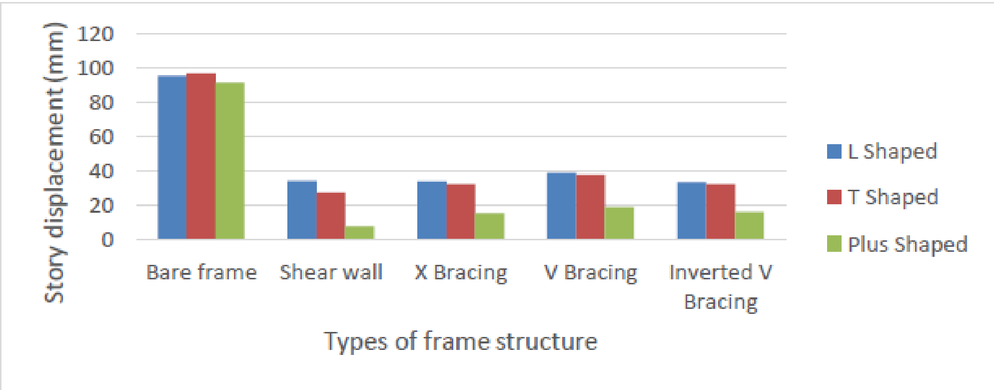

Figure 14: Story displacement in X direction

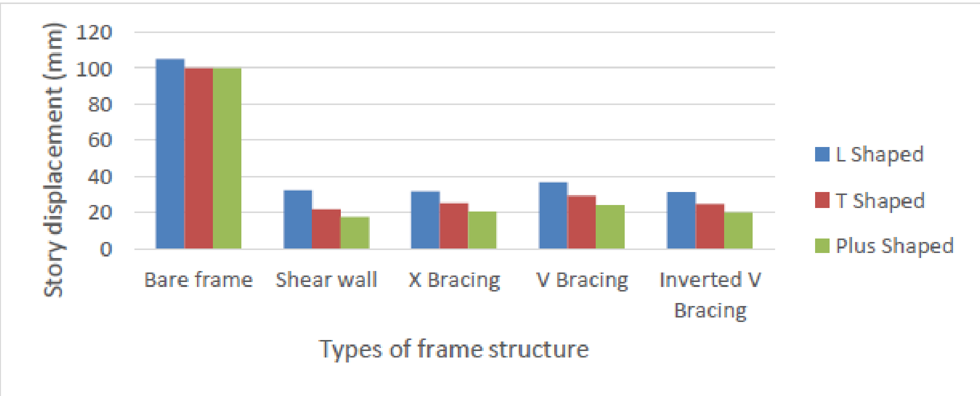

Figure 15: Story displacement in Y direction

- Figure 14 and 15 shows that bare frame structure of L, T and Plus shaped building has maximum story displacement in X and Y direction.
- From table 6 we can say that shear wall reduces maximum story displacement compared to X, V and Inverted V bracing systems for T and Plus shaped building whereas in case of L shaped building there is maximum reduction in story displacement for X bracing system.
- The percentage reduction in story displacement after application of X bracing system for L, T and Plus shaped building is 64.59%, 66.52%, 83.09% in X direction respectively. While in Y direction it is 69.91%, 74.94%, 79.44% respectively.
- V bracing shows the minimum reduction in story displacement for L, T and Plus shaped RCC building.

1.3.2 STORY DRIFT

Story drift of any floor is the displacement of the floor with respect to the displacement just down the floor. Such as story drift of ith floor is the difference of the story displacement of ith and i-1th floor. That's why sometimes is called inter story drift**.**

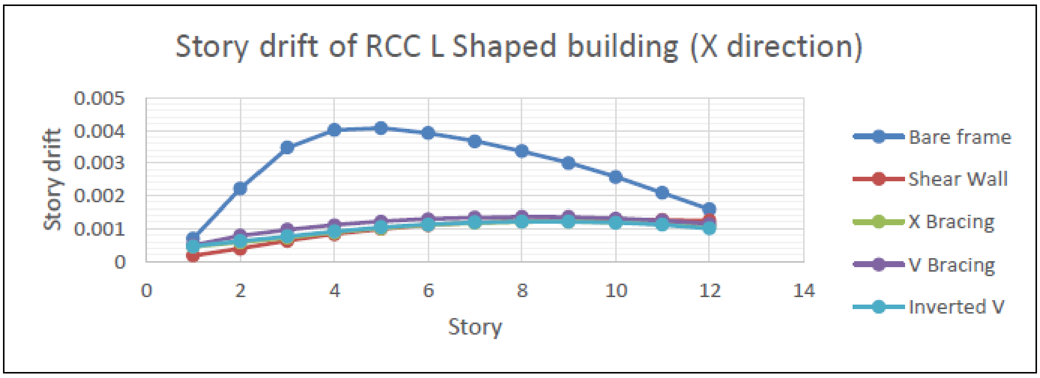

Figure 16: Story drift of L shaped building in X direction

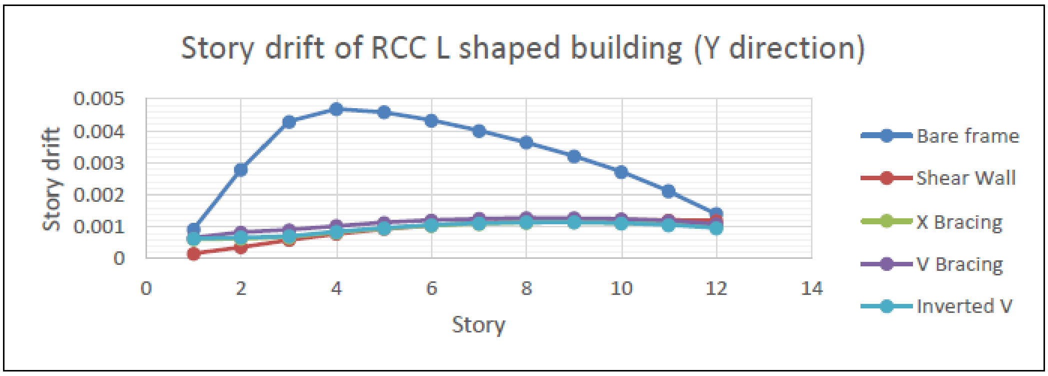

Figure 17: Story drift of L shaped building in Y direction

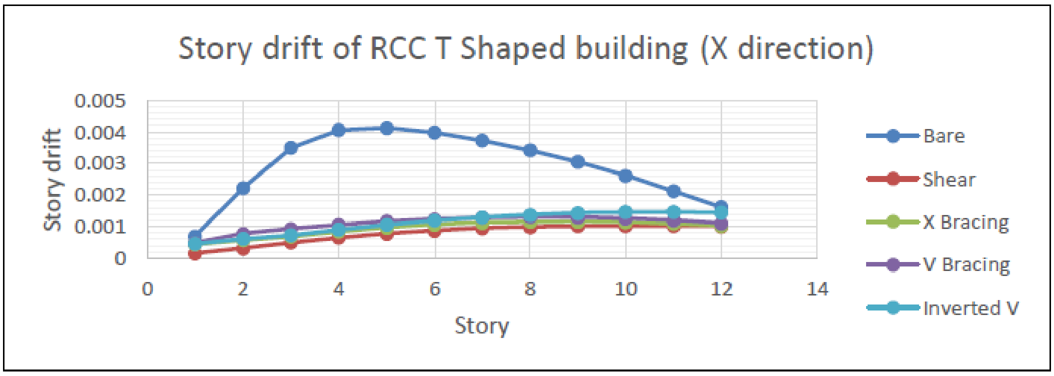

Figure 18: Story drift of T shaped building in X direction

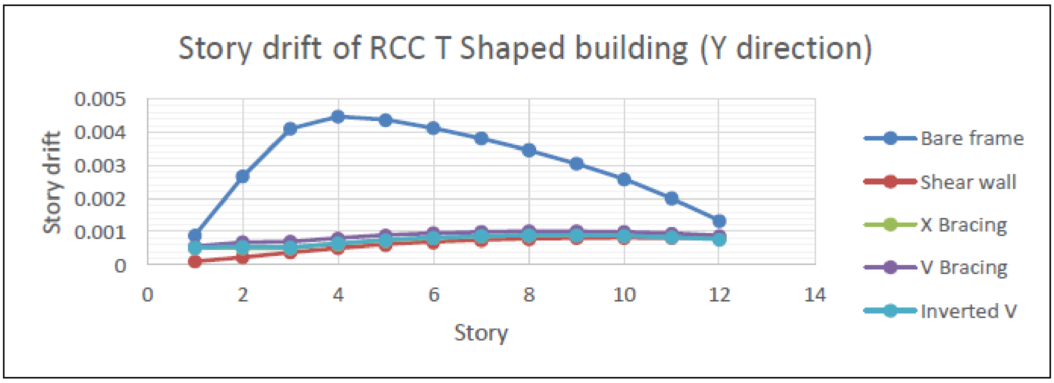

Figure 19: Story drift of T shaped building in Y direction

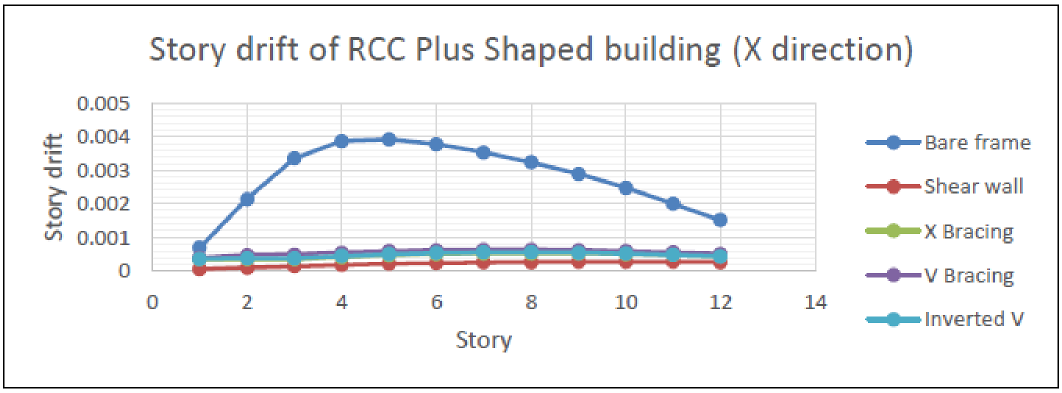

Figure 20: Story drift of Plus shaped building in X direction

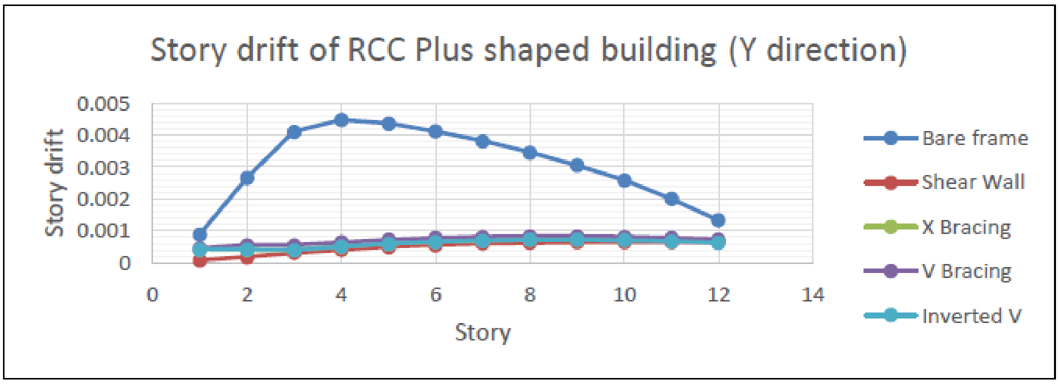

Figure 21: Story drift of Plus shaped building in Y direction

- The above figure shows the story drift of L, T and Plus shaped RCC building in X and Y direction. It is observed that for bare frame structure of L, T and Plus shaped RCC building the maximum story drift value lies in the story level 3rd to 6th story level.
- However, after the application of shear wall and different bracing systems story drift is maximum in the story level 8th to 10th story level for models. This results in greater story drift in that level.
- The shear wall reduces maximum story drift as compared to bracings considered in this study. While X bracing reduces maximum story drift as compared to V and Inverted V bracing systems.
- According to IS 1893:2016 (Part 1), the drift should not exceed 0.004 times the story height. Above figure shows that all the models are within the specified drift limits.

1.3.3 TIME PERIOD

The time required by the structure to complete one cycle of osicllation is known as time period. Time period is generally expressed in seconds.

Table 7: Time period (sec)

Type of frame Structure	Time Period (second)		
	L Shaped	T Shaped	Plus Shaped
Bare frame	2.66	2.65	2.65
Building with shear wall	1.18	1.03	0.91
Building with X Bracing	1.29	1.16	1.04
Building with V Bracing	1.40	1.28	1.14
Building with Inverted V Bracing	1.28	1.15	1.03

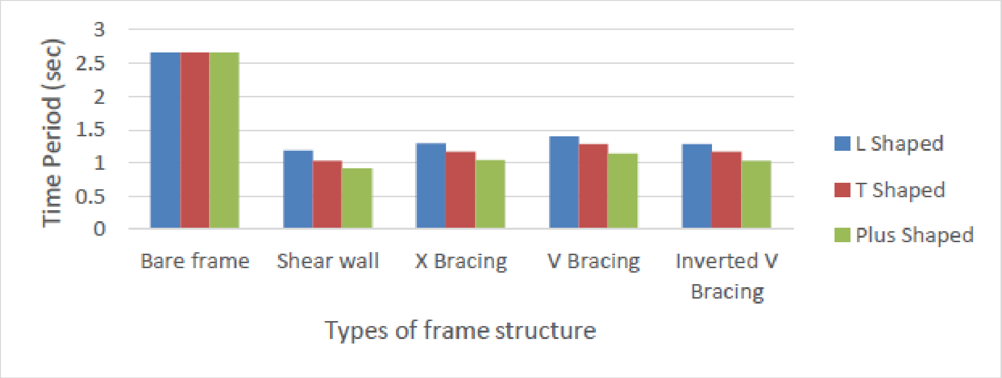

Figure 22: Modal Time Period (sec)

- Figure shows the graph of type of frame structure vs time period for L, T and Plus shaped RCC building structure. From fig. we can see that for L, T and Plus shaped bare frame structure has maximum time period.
- The reduction in time period is maximum for shear wall whereas it is minimum for V bracing system for L, T and Plus Shaped RCC building.
- The percentage reduction in time period after application of shear wall is 55.63%, 61.13% and 65.66% for L, T and Plus shaped RCC building respectively.
- However, the reduction in time period is nearly similar for X bracing system and Inverted V bracing system.
- The time period for X bracing and Inverted V (Chevron) bracing differs by 1% for L, T and Plus shaped building.

1.3.4 BASE SHEAR

The maximum lateral force on the base of the structure due to seismic activity is known as base shear.

Table 8: Base shear in X and Y direction

Type of frame Structure	Base Shear (KN)					
	L Shaped		T Shaped		Plus Shaped	
	X	Y	X	Y	X	Y
Bare frame	2214.31	2019.99	2054.19	1873.64	2054.54	1873.83
Shear wall	2796.48	2550.68	2322.03	2117.93	2343.34	2137.37
X Bracing	2499.35	2279.67	2329.24	2124.51	2344.84	2138.74
V Bracing	2488.49	2269.74	2316.19	2112.60	2327.44	2122.87
Inverted V Bracing	2488.47	2269.72	2316.19	2112.60	2327.44	2122.87

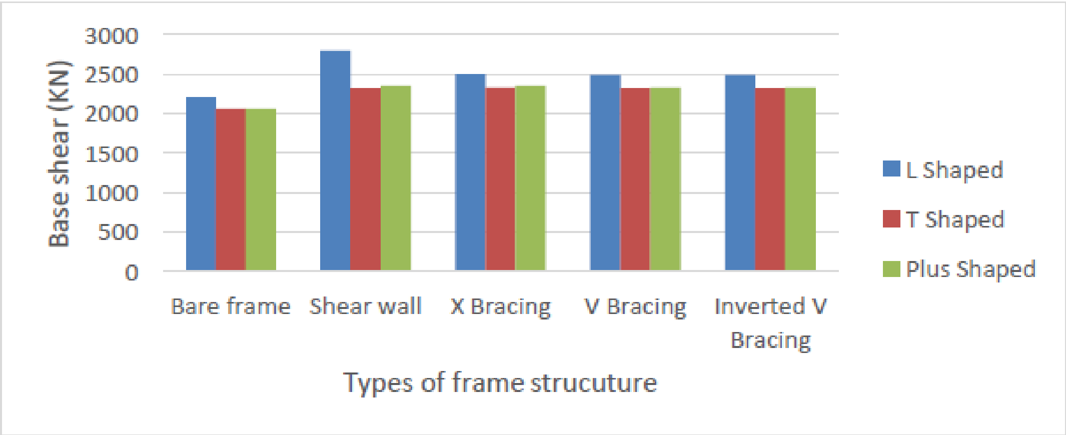

Figure 23: Base shear in X direction

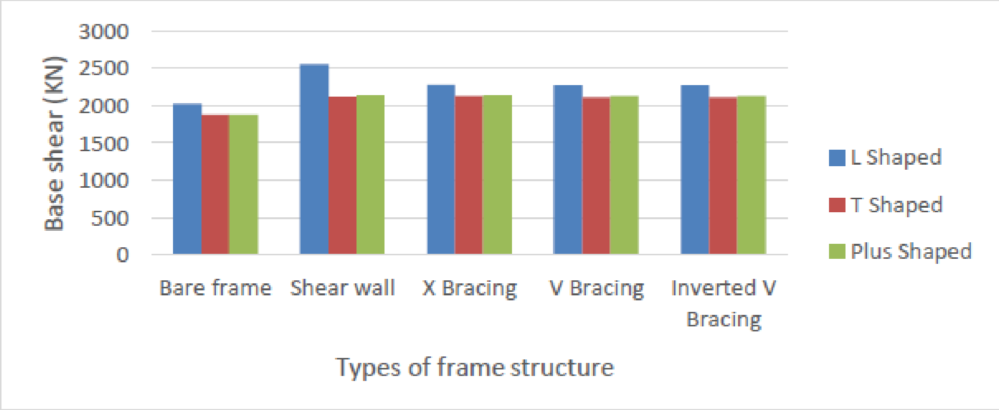

Figure 24: Base shear in Y direction

- The maximum increment in base shear is due to the application of shear wall in both X and Y direction for L shaped building. On the other hand, base shear increment is maximum for X bracing system for T and Plus shaped building.
- However, there is slightly difference between base shear in shear wall and X bracing system for T and Plus shaped building
- The increment in base shear after application of X bracing is 12.87%, 13.38% and 14.12% in both X and Y direction for L, T and Plus shaped building respectively.
- The increment in base shear is similar for V and Inverted V bracing system for L, T and Plus shaped building.

III. CONCLUSION

The seismic analysis of L, T and Plus shaped RCC building provided with shear wall, X, V and Inverted V bracing system is carried out taking into consideration that the buildings are located in zone III. The story drift, story displacement, base shear and time period were obtained. The following conclusions can be stated based on the analysis:

- X bracing system shows better performance compared to V bracing and Inverted V bracing system i.e., Chevron bracing system in both X and Y direction in terms of story displacement.
- The maximum story drift for bare frame structure in both X and Y direction models lies in the story level 3^{rd} to 6^{th} story level.
- However, after applying shear wall and different bracing systems story drift is maximum in the story level 8^{th} to 10^{th} story level for RCC and Steel structure. This results in greater story drift in that level.
- All the models are within the specified drift limits.
- Inverted V bracing shows greater reduction in time period compared to X and V bracing system but maximum reduction in time period is by application of shear wall. However, there is slightly difference in time period between X and Inverted V bracing system.
- The increase in base shear is observed after application of shear wall and bracing systems used under this study.
- The maximum increment in base shear is due to the application of shear wall in both X and Y direction for L shaped building. On the other hand, base shear increment is maximum for X bracing system for T and Plus shaped building.

The application of steel bracing in RCC structure is bit complicated than shear wall. But application of steel bracings will not change existing total weight of building significantly. Hence, they can be used as alternative techniques. It is recommended to provide the X bracing system than V and Inverted V bracing system.

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