

Effective of Seismic Load on Behavior of Rectangular Shear Wall in RC Frame structure

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Abstract

The usefulness of shear walls in the structural planning of multistory buildings has long been recognized. When walls are situated in advantageous positions in a building, they can be very efficient in resisting lateral loads originating from wind or earthquakes. Incorporation of shear wall has become inevitable in multi-storey building to resist lateral forces. In present work, twenty storey buildings have been modeled using software ETABS by dynamic analysis. All the analyses has been carried out as per the Indian Standard code books. Based on the literature of previous studies most effective positioning of shear walls has been chosen. This study is done on RC framed multistory building with RC shear walls with fixed support conditions. This paper aims to study the behaviour of reinforced concrete building by conducting dynamic analysis for most suited positions and location of Rectangular shear wall. Estimation of structural response such as; axial force, shear force ,torsion, moment , storey drift is carried out. Dynamic responses under zone V earthquake as per IS 1893 (part 1) : 2002 have been carried out.

Index terms— rectangular shear wall, frame structure, dynamic analysis, seismic load, structural response.

1 Introduction

Author: MAHDI HOSSEINI, P.h.D. scholar student in Structural Engineering, Dept. of Civil Engineering, Jawaharlal Nehru Technological University Hyderabad (JNTUH), Hyderabad, Telangana, India. e-mail: civil.mahdi.hosseini@gmail.com earthquake, distance from the earthquake source(epicenter), local ground conditions that may amplify ground shaking (or dampen it), the weight (or mass) of the structure, and the type of structural system and its ability to with stand abusive cyclic loading. In theory and practice, the lateral force that a building experiences from an earthquake increases in direct proportion with the acceleration of ground motion at the building site and the mass of the building (i.e., a doubling in ground motion acceleration or building mass will double the load).This theory rests on the simplicity and validity of Newton's law of physics: $F = m \times a$, where 'F' represents force, 'm' represents mass or weight, and 'a' represents acceleration.

2 b) Why are Buildings with Shear Walls Preferred in

Seismic Zones? Reinforced concrete (RC) buildings often have vertical plate-like RC walls called Shear Walls in addition to slabs, beams and columns. These walls generally start at foundation level and are continuous throughout the building height. Their thickness can be as low as 150mm, or as high as 400mm in high rise buildings. Shear walls are usually provided along both length and width of buildings. Shear walls are like vertically-oriented wide beams that carry earthquake loads downwards to the foundation.

"We cannot afford to build concrete buildings meant to resist severe earthquakes without shear walls." Mark Fintel, a noted consulting engineer in USA Shear walls in high seismic regions requires special detailing. However, in past earthquakes, even buildings with sufficient amount of walls that were not specially detailed for seismic

performance (but had enough well distributed reinforcement) were saved from collapse. Shear walls are easy to construct, because reinforcement detailing of walls is relatively straightforward and therefore easily implemented at site. Shear walls are efficient; both in terms of construction cost properly designed and detailed buildings with Shear walls have shown very good performance in past earthquakes. The overwhelming success of buildings with shear walls in resisting strong earthquakes is summarized in the quote: And effectiveness in minimizing earthquake damage in structural and non-Structural elements (like glass windows and building contents). The seismic weight of building is the sum of seismic weight of all the floors. The seismic weight of each floor is its full dead load plus appropriate amount of imposed load, the latter being that part of the imposed loads that may reasonably be expected to be attached to the structure at the time of earthquake shaking. It includes the weight of permanent and movable partitions, permanent equipment, a part of the live load, etc. While computing the seismic weight of columns and walls in any storey shall be equally distributed to the floors above and below the storey. Earthquake forces experienced by a building result from ground motions (accelerations) which are also fluctuating or dynamic in nature, in fact they reverse direction some what chaotically. The magnitude of an earthquake force depends on the magnitude of an T f Seismic Load Abstract-The usefulness of shear walls in the structural planning of multistorey buildings has long been recognized. When walls are situated in advantageous positions in a building, they can be very efficient in resisting lateral loads originating from wind or earthquakes. Incorporation of shear wall has become inevitable in multi-storey building to resist lateral forces. In present work, twenty storey buildings have been modeled using software ETABS by dynamic analysis. All the analyses has been carried out as per the Indian Standard code books. Based on the literature of previous studies most effective positioning of shear walls has been chosen. This study is done on RC framed multistorey building with RC shear walls with fixed support conditions. This paper aims to study the behaviour of reinforced concrete building by conducting dynamic analysis for most suited positions and location of Rectangular shear wall. Estimation of structural response such as; axial force, shear force, torsion, moment, storey drift is carried out. Dynamic responses under zone V earthquake as per IS 1893 (part 1): 2002 have been carried out.

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When a building is subjected to wind or earthquake load, various types of failure must be prevented:

- ? Slipping off the foundation (sliding) ? Overturning and uplift (anchorage failure)
- ? Shear distortion (drift or racking deflection) ? Collapse (excessive racking deflection)

Most RC buildings with shear walls also have columns; these columns primarily carry gravity loads (i.e., those due to self-weight and contents of building). Shear walls provide large strength and stiffness to buildings in the direction of their orientation, which significantly reduces lateral sway of the building and thereby reduces damage to structure and its contents.

Since shear walls carry large horizontal earthquake forces, the overturning effects on them are large. Thus, design of their foundations requires special Attention. Shear walls should be provided along preferably both length and width. However, if they are provided along only one direction, a proper grid of beams and columns in the vertical plane (called a moment-resistant frame) must be provided along the other direction to resist strong earthquake effects.

4 II.

5 Methodology

Quite a few methods are available for the earthquake analysis of buildings; two of them are presented here:

1. Equivalent Static Lateral Force Method (pseudo static method).
 2. Dynamic Analysis.
 - i. Response spectrum method.
 - ii. Time history method.
- a) Dynamic Analysis Dynamic analysis shall be performed to obtain the design seismic force, and its distribution in different levels along the height of the building, and in the various lateral load resisting element, for the following buildings:

Irregular buildings: All framed buildings higher than 12m in zones IV and V, and those greater than 40m in height in zones II and III.

The analysis of model for dynamic analysis of buildings with unusual configuration should be such that it adequately models the types of irregularities present in the building configuration. Buildings with plan irregularities, as defined in Table ?? of IS code: 1893-2002 cannot be modeled for dynamic analysis.

Dynamic analysis may be performed either by the Time History Method or by the Response Spectrum Method.

6 b) Time History Method

The usage of this method shall be on an appropriate ground motion and shall be performed using accepted principles of dynamics. In this method, the mathematical model of the building is subjected to accelerations from earthquake records that represent the expected earthquake at the base of the structure.

7 c) Response Spectrum Method

The word spectrum in engineering conveys the idea that the response of buildings having a broad range of periods is summarized in a single graph. This method shall be performed using the design spectrum specified in code or by a sitespecific design spectrum for a structure prepared at a project site. The values of damping for building may be taken as 2 and 5 percent of the critical, for the purposes of dynamic of steel and reinforce concrete buildings, respectively. For most buildings, inelastic response can be expected to occur during a major earthquake, implying that an inelastic analysis is more proper for design. However, in spite of the availability of nonlinear inelastic programs, they are not used in typical design practice because: 1. Their proper use requires knowledge of their inner workings and theories. design criteria and 2. Result produced are difficult to interpret and apply to traditional design criteria , and 3. The necessary computations are expensive. Therefore, analysis in practice typically use linear elastic procedures based on the response spectrum method. The response spectrum analysis is the preferred method because it is easier to use. (i) Wind Speed=50m/s (ii) Terrain Category =2 (iii) Structure Class=B (iv) Risk Coefficient(k_1)=1 (v) Topography(k_3)=1 c) Material Properties 3. Floor Finishing =1KN/m² 4. Wind load Seismic Loading (i) Seismic zone factor(Z)=0.36 (ii) Soil Type= Medium(II) (iii) Response Reduction factor(R) =5% (iv) Story Range=Base to 20 (v) Important factor(I)=1

8 Structure

G+19 earthquake resistant structure with Rectangular shear wall.

9 a) Problems in the Building Due to Earthquake

Main problems that would be arising due to earthquake in the structure are story drift and deflection of the building due to its large height and also torsion and others, so if the structure is proved to be safe in all the above mentioned problems than the structure would be safe in all cases in respect earthquake.

Regular buildings: Those greater than 40m in height in zones IV and V, those greater than 90m in height in zone II and III.

10 Table I:

The materials used in structure and their general properties are

11 d) Load Combinations

Load combination is the foremost important criteria for designing any structure and more important is the distribution of those loads on to various components of the structure like beams, columns, slabs and in our case shears walls and concrete core wall too. There are many kinds of loads existing depending on the location of the where the structure is to be constructed for example in a place where wind is frequent there we have to consider the wind loads and places where rains are heavy rain loads are included and same way all the other loads such as snow loads, earthquake load and etc. are included however DEAD LOADS, LIVE LOADS AND IMPOSEDLOADS are always included. Dead loads are all common depending on the structural components and specific gravity of the structure, to get the self weight of the structural component volume or area of the component is multiplied by the specific gravity of the component. Live loads depend on the purpose we are constructing the building. Imposed loads depend on the seismic loads, dead loads and according to are 1893 part 1 percentage of those values is finally considered.

The following Load Combinations have been considered for the design.

12 1.

(DL+ LL) 2.

(DL $\pm$ EQXTP) 3.

(DL $\pm$ EQYTP) 4.

(DL $\pm$ EQXTN) 5.

(DL $\pm$ EQYTN) 6.

(DL + LL $\pm$ EQXTP) 7.

(DL + LL $\pm$ EQYTP) 8.

(DL + LL $\pm$ EQXTN) 9.

(DL + LL $\pm$ EQYTN) 10.

(DL $\pm$ WLX) 11.

(DL $\pm$ WLY) 12.

(DL + LL $\pm$ WLX) 13.

(DL + LL $\pm$ WLY) 14.

1.5(DL+ LL) 15.

1.

13 DISCUSSION ON RESULTS

The basic intent of design theory for earthquake resistant structures is that buildings should be able to resist minor earthquakes without damage, resist moderate earthquakes without structural damage but with some non-structural damage. To avoid collapse during a major earthquake, Members must be ductile enough to absorb and dissipate energy by post elastic deformation. Redundancy in the structural system permits redistribution of internal forces in the event of the failure of key elements. When the primary element or system yields or fails, the lateral force can be redistributed to a secondary system to prevent progressive failure.

IS 1893 (part-1) Code recommends that detailed dynamic analysis, or pseudo static analysis should be carried out depending on the importance of the problems.

IS 1893 (part-1) Recommends use of model analysis using response spectrum method and equivalent lateral force method for building of height less than 40m in all seismic zones as safe., but practically there may be the building which are more than 40m in height. So there exist so many problems due to the increase in height of the structure.

The following assumptions shall be made in the earthquake resistant design of structures:

Earthquake causes impulsive ground motions, which are complex and irregular in character, changing in period and amplitude each lasting for a small duration. Therefore, resonance of the type as visualized under steady-state sinusoidal excitations will not occur as it would need time to buildup such amplitudes. The structural prototype is prepared and lots of data is been collected from the prototype. All the aspects such as safety of structure in shear, moment and in story drift have been collected. So now to check whether to know whether the structure is safe with established shear walls and all construction of core wall in the center we need to compare the graphical values of structure with the shear wall and a simple rigid frame structure.

14 a) Story Drift

The tallness of a structure is relative and cannot be defined in absolute terms either in relation to height or the number of stories. The council of Tall Buildings and Urban Habitat considers building having 9 or more stories as high-rise structures. But, from a structural engineer's point of view the tall structure or multi-storied building can be defined as one that, by virtue of its height, is affected by lateral forces due to wind or earthquake or both to an extent. Lateral loads can develop high stresses, produce sway movement or cause vibration. Therefore, it is very important for the structure to have sufficient strength against vertical loads together with adequate stiffness to resist lateral forces. So lateral forces due to wind or seismic loading must be considered for tall building design along with gravity forces vertical loads. Tall and slender buildings are strongly wind sensitive and wind forces are applied to the exposed surfaces of the building, whereas seismic forces are inertial (body forces), which result from the distortion of the ground and the inertial resistance of the building. These forces cause horizontal deflection is the predicted movement of a structure under lateral loads and story drift is defined as the difference in lateral deflection between two adjacent stories. Lateral deflection and drift have three effects on a structure; the movement can affect the structural elements (such as beams and columns); the movements can affect non-structural elements (such as the windows and cladding); and the movements can affect adjacent structures. Without proper consideration during the design process, large deflections and drifts can have adverse effects on structural elements, nonstructural elements, and adjacent structures.

Table X:

When the initial sizes of the frame members have been selected, an approximate check on the horizontal drift of the structures can be made. The drift in the non-slender rigid frame is mainly caused by racking. This racking may be considered as comprising two components: the first is due to rotation of the joints, as allowed by the double bending of the girders, while the second is caused by double bending of the columns. If the rigid frame is slender, a contribution to drift caused by the overall bending of the frame, resulting from axial deformations of the columns, may be significant. If the frame has height width ratio less than 4:1, the contribution of overall bending to the total drift at the top of the structure is usually less than 10% of that due to racking. The following method of calculation for drift allows the separate determination of the components attributable to beam bending, and overall cantilever action. Drift problem as the horizontal displacement of all tall buildings is one of the most serious issues in tall building design, relating to the dynamic characteristics of the building during earthquakes and strong winds. Drift shall be caused by the accumulated deformations of each member, such as a beam, column and shear wall. In this study analysis is done with changing structural parameters to observe the effect on the drift (lateral deflection) of the tall building due to earthquake loading.

15 IS 1893 Part 1 Codal Provoisions for Storey Drift Limitations

The storey drift in any storey due to the minimum specified design lateral force, with partial load factor of 1.0, shall not exceed 0.004 times the storey height For the purposes of displacement requirements only, it is permissible to use seismic force obtained from the computed fundamental period (T) of the building without the lower bound limit on design seismic force Global Journal of Researches in Engineering () Volume XVII Issue III Version I

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Year 2017 E specified in dynamic analysis. The tallness of a structure is relative and cannot be defined in absolute terms either in relation to height or the number of stories.

V.

17 Conclusion

? It is evident from the observing result that the shear wall should be near to center of mass and center of rigidity of structure. ? Shear walls must provide the necessary lateral strength to resist horizontal earthquake forces. ? When shear walls are strong enough, they will transfer these horizontal forces to the next element in the load path below them, such as other shear walls, floors, foundation walls, slabs or footings. ? For the columns located away from the shear wall the Bending Moment is high and shear force is less when compared with the columns connected to the shear wall. ? Shear walls also provide lateral stiffness to prevent the roof or floor above from excessive side-sway. ? When shear walls are stiff enough, they will prevent floor and roof framing members from moving off their supports. Also, buildings that are sufficiently stiff will usually suffer less nonstructural damage. ? The vertical reinforcement that is uniformly distributed in the shear wall shall not be less than the horizontal reinforcement. This provision is particularly for squat walls (i.e. Height-to-width ratio is about 1.0). However, for walls with height-to-width ratio less than 1.0, a major part of the shear force is resisted by the vertical reinforcement. Hence, ? It is evident from the observing result that the shear wall are making value of torsion very low.

? Based on the analysis and discussion, shear wall are very much suitable for resisting earthquake induced lateral forces in multistoried structural systems when compared to multistoried structural systems without shear walls. They can be made to behave in a ductile manner by adopting proper detailing techniques.

? It is evident from the observing result that for combination loads 1.2 (DLLEQX) & 1.2 (DLLEQY) maximum value of moment at story one and minimum value of shear force also at story one. The Moment is maximum when the shear force is minimum or changes sign. ? The story drift for the combination load (DL+LL+EQY) in X & Y direction shown different performance and less value for story drift in all combinations at story 20. The value of story drift is very low because of adding shear walls to the building.

adequate vertical reinforcement should be provided for such walls.

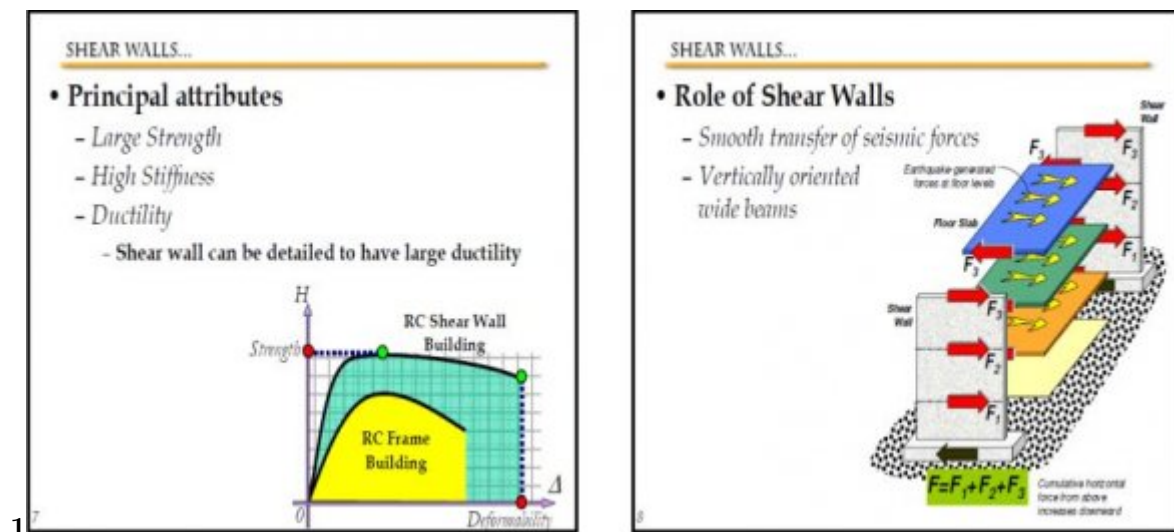


Figure 1: 1 .

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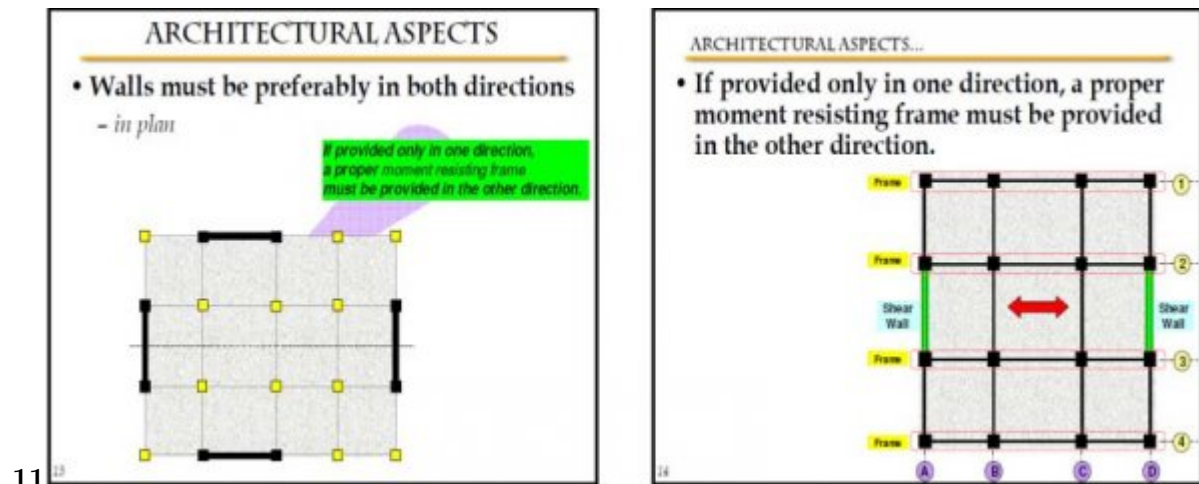


Figure 2: Fig. 1 : 1 :

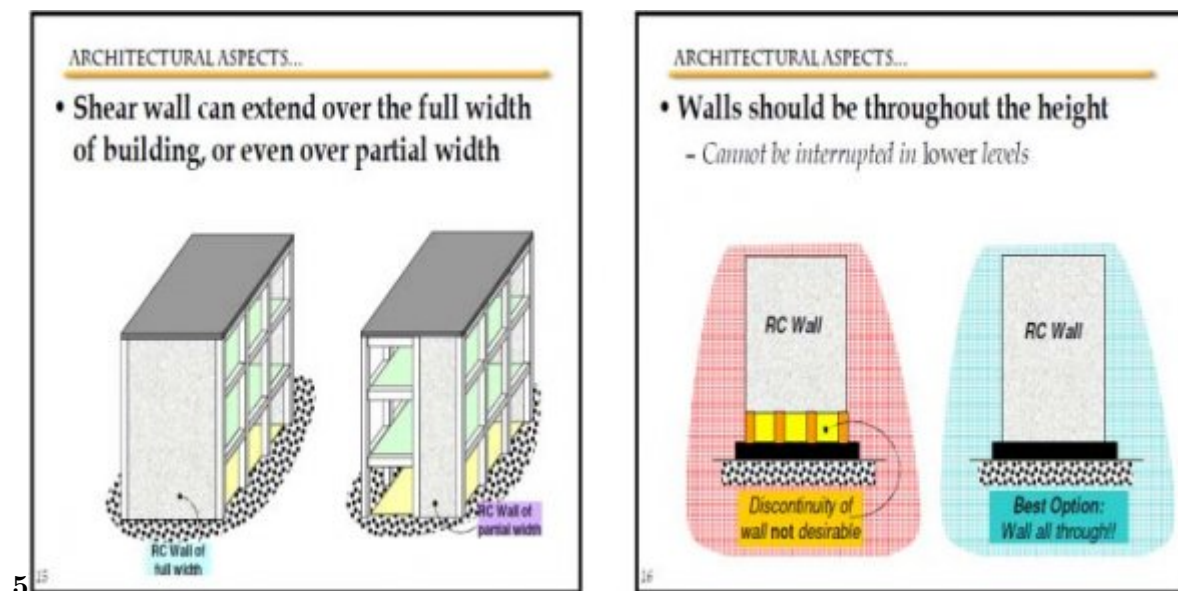


Figure 3: Graph 5 :

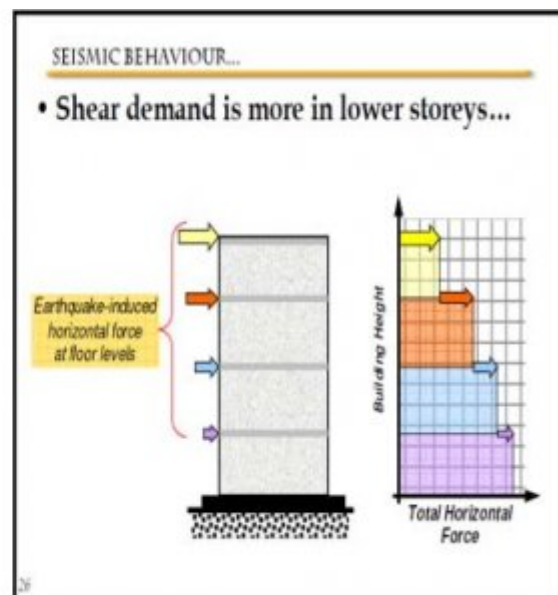
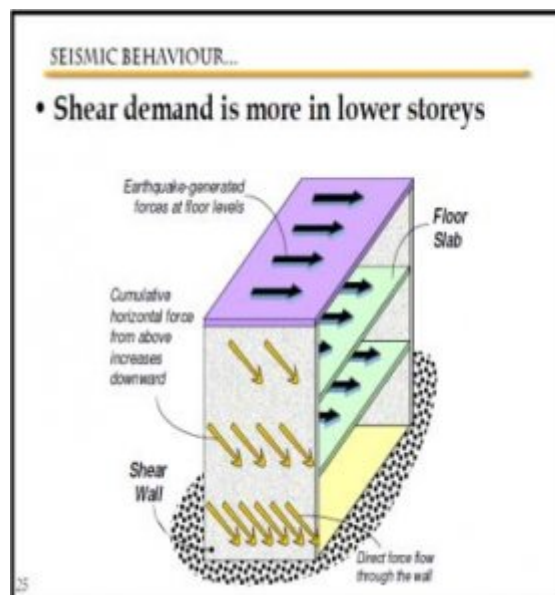


Figure 4:

17 CONCLUSION

III

[Note: force, Shear Force, Torsion and Moment for column C8, For combination load 1.2(DL+LL+EQX) Graph 2: Axial force, Shear Force, Torsion and Moment for column C8]

Figure 6: Table III :

17 CONCLUSION

IV

Story	Column	Load	Loc	AXIAL FORCE	SHEAR FORCE	TORSION	MOMENT	-6483.38	70.63	-0.701
STORYC8	1.2DL-	1.25								
STORYC8	LLEQX	1.25								
STORYC8	1.2DL-	1.25								
Story	Col-	LLEQX	Loc							
STORYC14	1.2DL-	1.25								
STORYC14	LLEQX	1.25								
STORYC14	Load	1.25								
STORYC14	1.2DL-	1.25								
STORYC14	LLEQX	1.25								
C14	1.2DL-									
	LLEQX									
	1.2DL-									
	LLEQX									
	1.2DL-									
	LLEQX									
	1.2DL-									
	LLEQX									
STORYC8	1.2DLLEQX	1.25		-5386.9	-	83.06	-	5.194		
STORYC14	1.2DL-	1.25		4932.95		131.05	0.904	0.644		
	LLEQX					-				
						0.893				
STORYC8	1.2DLLEQX	1.25		-5045.42	-	82.04	-0.9	5.693		
STORYC14	1.2DL-	1.25		4579.98		135.11	-	0.16		
	LLEQX					0.882				
STORYC8	1.2DLLEQX	1.25		-4712.14	-	79.47	-	6.085		
STORYC14	1.2DL-	1.25		4232.4		137.42	0.893	-		
	LLEQX					-		0.311		
						0.867				
STORYC8	1.2DLLEQX	1.25		-4385.38	-	75.81	-	6.378		
STORYC14	1.2DL-	1.25		3889.84		138.19	0.882	-		
	LLEQX					-		0.769		
						0.847				
STORYC8	1.2DLLEQX	1.25		-4063.7		71.36	-	6.577		
STORYC8	1.2DL-	1.25		-3745.86		66.25	0.867	6.686		
STORYC8	LLEQX	1.25		-3430.85		60.54	-	6.711		
STORYC8	1.2DL-	1.25		-3117.82		54.24	0.847	6.656		
STORYC8	LLEQX	1.25		-2806.06		47.31	-	6.525		
STORYC8	1.2DL-	1.25		-2495.05		39.72	0.822	6.322		
STORYC8	LLEQX	1.25		-2184.39		31.43	-	6.052		
STORYC8	1.2DL-	1.25		-1873.8		22.44	0.791	5.718		
STORYC8	LLEQX	1.25		-1563.2		12.76	-	5.326		
STORYC8	1.2DL-	1.25		-1252.59		2.5	0.752	4.88		
STORYC8	LLEQX	1.25		-942.27		-	-	4.393		
STORYC14	1.2DL-	1.25		-3551.85		8.14	0.707	-		
STORYC14	LLEQX	1.25		-3217.98		137.55	-	1.214		
STORYC14	1.2DL-	1.25		-2887.78		135.59	0.653	-		
STORYC14	LLEQX	1.25		-2560.83		132.36	-	1.647		
STORYC14	1.2DL-	1.25		-2236.72		127.9	0.591	-		
STORYC14	LLEQX	1.25		-1915.07		122.26	-	2.069		
STORYC14	1.2DL-	1.25		-1595.53		115.51	0.519	-		
STORYC14	LLEQX	1.25		-1277.79		107.77	-	2.484		
STORYC14	1.2DL-	1.25		-961.52		99.22	0.438	-		
STORYC14	LLEQX	1.25		-646.26		90.17	-	2.894		
	1.2DL-					80.65	0.346			

VII

[Note: force, Shear Force, Torsion and Moment for column C8, For combination load1.2 (DL+LL+EQY) Graph 6: Axial force, Shear Force, Torsion and Moment for column C8]

Figure 8: Table VII :

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