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Behaviour of Asymmetric Building During Earthquake

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Abstract - *In this paper we study about the seismic analysis of the asymmetrical building, in which building have three different shape such as T, L and plus shape. At every re-entrant corner provided curved beam with slab. The main purpose of providing curve beam in every model to reduce the mainly torsion at corner because storey overturning moment is maximum at the base and if the torsion is also maximum at the base then maximum chances to produce the crack at the re-entrant corner of the building. There are six models in this paper and taking zone five for seismic analysis. All the analysis of the models are done with the help of the ETABS software by using two different IS Code such as IS CODE 1893 part1: 2016 for the earthquake resistant design of the structure and IS CODE 456:2000 for design and analysis of the reinforced concrete structure. The height of the every model is 27m and considering that frame is special moment resisting frame. The main purpose of this paper to study the variation of torsion of frame at corner, storey overturning moment, base shear, etc due to provide the curved beam and without curved beam.*

Key Words: Time History Analysis, ETABS, Asymmetrical Building, L shape, T shape, Plus shape, Seismic Analysis.

1.INTRODUCTION

Earthquake resistant design of reinforced concrete building is continuing area of research because structures have been prone to earthquake since the first structure was built. The utilization of space in urban cities has caused many changes in the structure of building we want more functionality in less space which makes building asymmetric. In the past the Seismic damage surveys analyzed and concluded that asymmetric building more prone to damage during earthquake hence the seismic behavior of an asymmetric structure has become important.

Different type of Irregularity of building presented in figure.

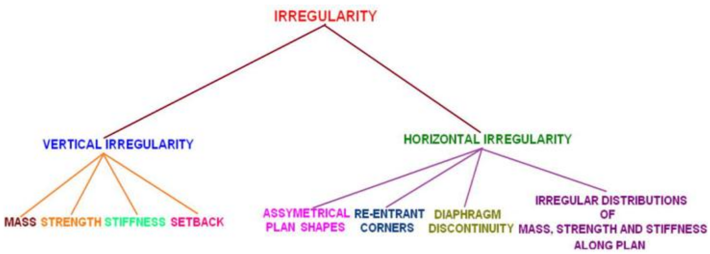

Fig-1: Irregularity

The re-entrant, lack of continuity or " Inside" corner is the common characteristic of building configurations that, in plan, as the shape of an L T.H +.or combination of shapes occurs due to lack of tensile capacity and force concentration. According to IS 1893 (Part 1: 2016. plan configurations of a structure and its lateral resisting system contain re-entrant corner where both projections of the structure beyond the re-entrant corner are greater than 15% of its plan dimension in the given direction re-entrant corners of the buildings are subjected to two types of problems The first is resulting in a local stress concentration at the notch of the re-entrant corner and the second problem is torsion.

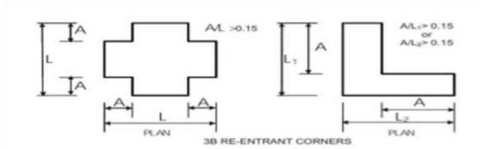

Fig-1.1: Plan Irregularity

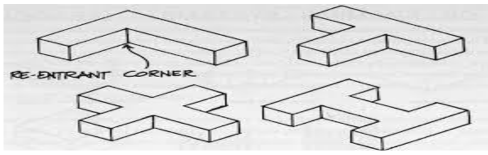

Fig-1.2: Re-entrant Corner

2. Modelling Detailing

In this paper we prepared six model in which model shape is L, T and Plus (+) and providing the curved beam at every re-entrant corner to increase the value storey stiffness, to reduce the mode of time period as well as effect of the torsion at the frame member. Taking bay to bay distance 3m and storey height is also 3m. Details data are provided in the given table:-

Table-2: Section Parameter

S.No	Parameter	Value
1.	Concrete	M25
2.	Rebar	Mild250, HYSD415

3.	Beam	450mmX350mm
4.	Column	500mmX350mm
5.	Slab	160mm
6.	Angle of Curved Beam	3 degree
7.	Height of Building	27m (9 storey)

2.1. Load on Model

According to the IS CODE 1893 part- 2016, for earthquake we consider some data such as importance factor (I) =1.2, Response reduction factor (R)=5, Zone=0.36 and soil type is 2nd.

Table-2.1: Load on Model

S.No	Load Name	Values
1.	Dead Load	Auto defined
2.	Live load at slab	3KN/m2
3.	Roof load	2KN/m2
4.	Live load at curved slab	1KN/m2
5.	Parapet wall	7.5KN/m
6.	EX	IS 1893 Part 1 2016
7.	EY	IS 1893 Part 1 2016
8.	Wall load	14KN/m

2.2. Modelling

Given below the figure of the given model with plan and 3d view:-

2.2.1. L shape without curved beam at the re-entrant corner (M1)

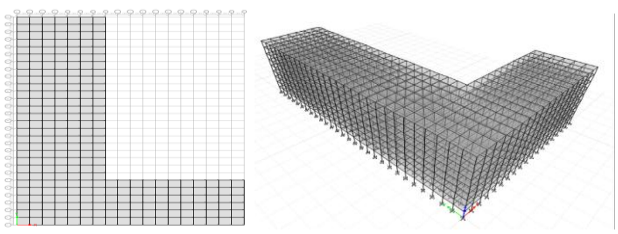

Fig-2.2.1: Plan and 3D View of Model 1

2.2.2. L shape with curved beam at re-entrant corner (M2)

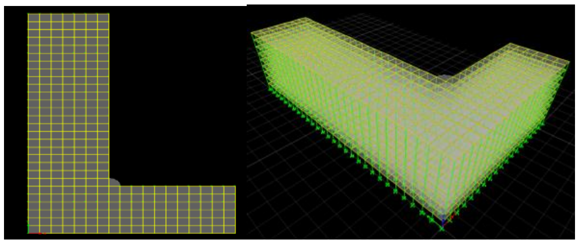

Fig-2.2.2: Plan and 3D view of Model2

2.2.3. T shape without curved beam at re-entrant corner (M3)

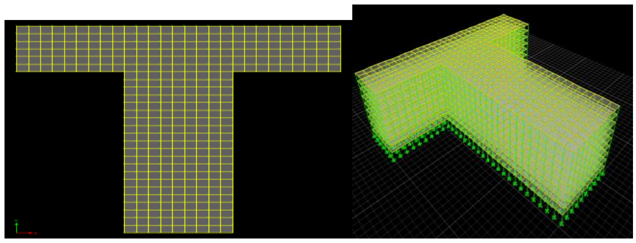

Fig-2.2.3: Plan and 3D view of Model3

2.2.4. T shape with curved beam at re-entrant corner (M4)

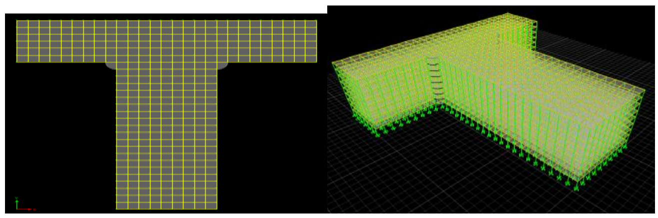

Fig-2.2.4: Plan and 3D view of Model4

2.2.5. Plus (+) shape without curved beam at re-entrant corner (M5)

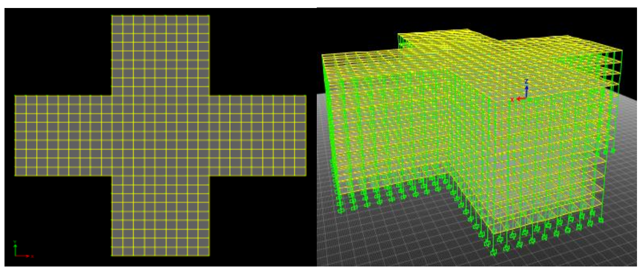

Fig-2.2.5: Plan and 3D view of Model5

2.2.6. Plus (+) shape with curved beam at re-entrant corner (M6)

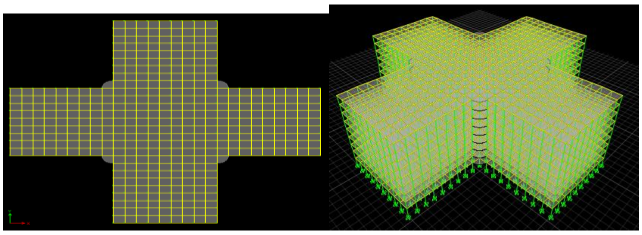

Fig-2.2.6: Plan and 3D view of Model6

3. METHODOLOGY

This chapter is including the method of the analysis of the open ground storey building due to various load type, load combination.

3.1. Linear Time History Analysis

It calculates the solution to the dynamic equilibrium equation for the structural behavior (displacement, member force etc.) at an arbitrary time using the dynamic properties of the structure and applied loading when a dynamic load is applied. The Modal superposition method and direct method are used for linear time history analysis. The data of the time history is taken from the file of the ETABS

After choosing the file of the time history which name is "ALTADENA-1"then graph will make:-

3.2. Load Combination

According to the IS CODE 1893 part1 2016, we use the mainly 13 load combination which is given below in table:-

Table-3.2: Load Combination

A.1.5(DL+LL)	**B.**1.2(DL+LL+EX)	**C.**1.2(DL+LL-EX)
D.1.2(DL+LL+EY)	**E.**1.2(DL+LL-EY)	**F.**1.5(DL+EX)
G.1.5(DL-EX)	**H.**1.5(DL+EY)	**I.**1.5(DL-EY)
J.0.9DL+1.5EX	**K.**0.9DL-1.5EX	**L.**0.9DL+1.5EY
M.0.9DL-1.5EY		

4. RESULTS.

In the result chapter we study about the result which came out after the analysis of the above six model such as M1, M2, M3, M4, M5 and M6:

4.1. Response spectrum curves

4.1.1. Response spectrum curve for L Shape With and Without Curved Beam (M1, M2)

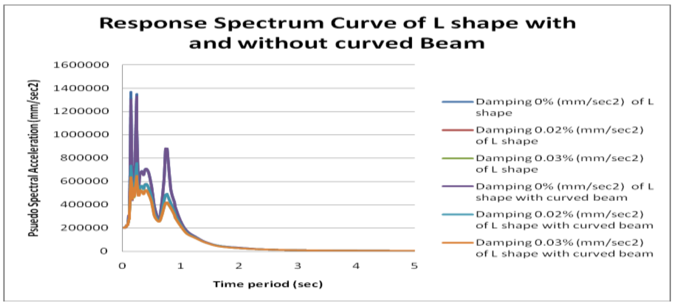

Chart-4.1.1: For Model1 and Model2

4.1.2. Response spectrum curve for T Shape With and Without Curved Beam (M3, M4)

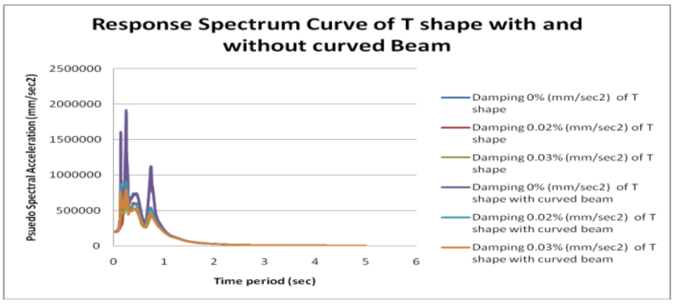

Chart-4.1.2: For Model3 and Model4

4.1.3. Response spectrum curve for Plus (+) Shape With and Without Curved Beam (M5, M6)

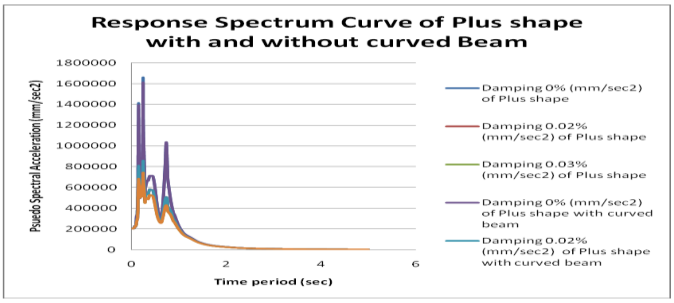

Chart-4.1.3: For Model5 and Model6

4.2. Modal Time Period

According to IS CODE 1893 part1:2016, the modal time period is defined as The modal natural period of mode k is the time period of vibration in mode k. where k= 1,2,....defined mode.

4.2.1.Modal Time Period For L shape with and without Curved Beam (M1, M2)

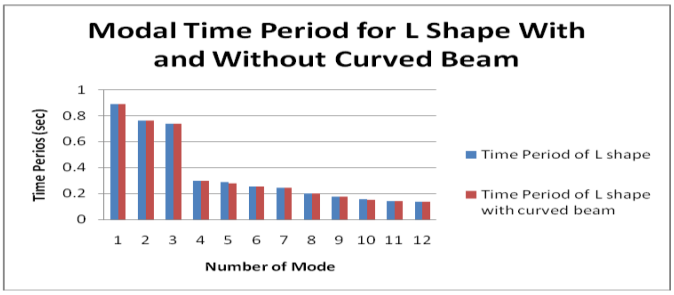

Chart-4.2.1: Time Period for Model1 and Model2

Table-4.2.1: Time Period for Model1 and Model2

Mode	Time Period of L shape	Time Period of L shape with curved beam
1	0.889	0.889
2	0.763	0.763
3	0.738	0.738
4	0.296	0.296
5	0.289	0.278
6	0.254	0.253
7	0.244	0.244
8	0.202	0.198
9	0.176	0.176
10	0.154	0.153
11	0.142	0.142
12	0.136	0.135

4.2.2.Modal Time Period For T shape with and without Curved Beam (M3, M4)

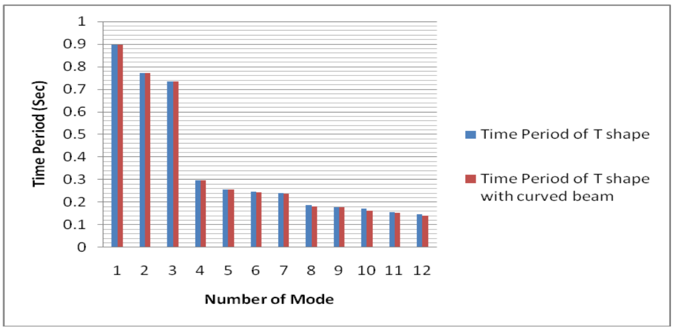

Chart-4.2.2: Time Period for Model3 and Model4

Table-4.2.2: Time Period for Model3 and Model4

Mode	Time Period of T shape	Time Period of T shape with curved beam
1	0.896	0.897
2	0.773	0.773
3	0.734	0.735
4	0.298	0.298
5	0.257	0.257
6	0.248	0.243
7	0.242	0.237
8	0.186	0.181
9	0.177	0.177
10	0.171	0.161
11	0.155	0.154
12	0.148	0.142

4.2.3.Modal Time Period For Plus (+) shape with and without Curved Beam (M5, M6)

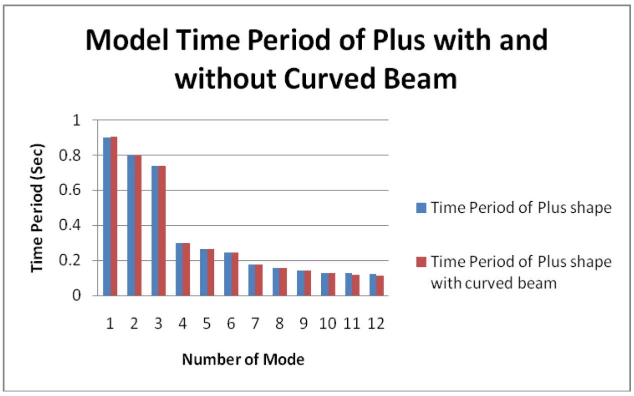

Chart-4.2.3: Time Period for Model5 and Model6

Table-4.2.3: Time Period for Model5 and Model6

Mode	Time Period of Plus shape	Time Period of Plus shape with curved beam
1	0.898	0.9
2	0.794	0.795
3	0.737	0.739
4	0.299	0.299
5	0.263	0.263
6	0.243	0.244
7	0.178	0.178
8	0.156	0.156
9	0.143	0.143
10	0.129	0.127

11	0.127	0.118
12	0.122	0.114

4.3. Storey Drift

According to the IS CODE 1893 part1: 2016, the storey drift is defined as displacement of one level relative to the other level above or below. The storey drift is given below in the table according the seismic load defined in EX.

Table-4.3: Storey Drift

Storey	Load Case	M1 Drift (mm)	M2 Drift (mm)	M3 Drift (mm)	M4 Drift (mm)	M5 Drift (mm)	M6 Drift (mm)
Story 9	EX	1.121	0.626	1.062	1.062	1.035	1.036
Story 8	EX	1.9	1.02	1.848	1.848	1.804	1.806
Story 7	EX	2.54	1.344	2.486	2.487	2.439	2.443
Story 6	EX	3.006	1.579	2.955	2.955	2.907	2.912
Story 5	EX	3.321	1.736	3.274	3.274	3.228	3.233
Story 4	EX	3.508	1.826	3.468	3.469	3.427	3.432
Story 3	EX	3.586	1.858	3.556	3.557	3.522	3.527
Story 2	EX	3.513	1.811	3.498	3.5	3.474	3.479
Story 1	EX	2.5	1.274	2.508	2.509	2.504	2.509

4.4. Storey Stiffness

Storey stiffness is the extent to which an object resists deformation in response to an applied force at the storey. The storey stiffness of the different six model is given below in the table as well as graph due to EX seismic force.

4.4.1. Storey Stiffness for L Shape with and without Curved Beam (M1, M2)

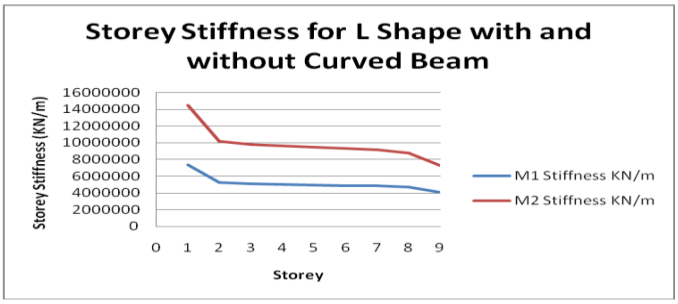

Chart-4.4.1: Storey Stiffness for Model1 and Model2

Table-4.4.1: Storey Stiffness for Model1 and Model2

Storey	M1 Stiffness KN/m	M2 Stiffness KN/m
Storey1	7387812	14503560
Storey2	5237678	10167428
Storey3	5054783	9764710
Storey4	4992407	9598788
Storey5	4944448	9465040
Storey6	4893519	9321292
Storey7	4823065	9122713
Storey8	4686131	8737117
Storey9	4045507	7249212

4.4.2. Storey Stiffness for T Shape with and without Curved Beam (M3, M4)

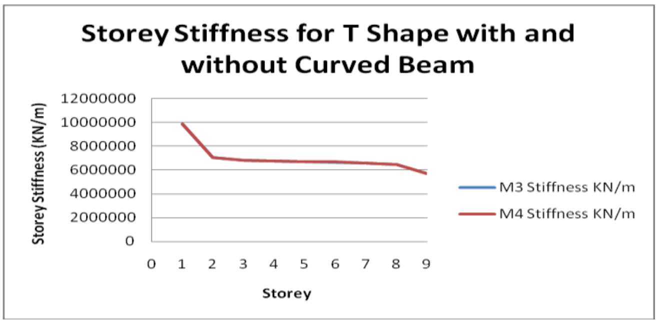

Chart-4.4.2: Storey Stiffness for Model3 and Model4

Table-4.4.2: Storey Stiffness for Model3 and Model4

Storey	M3 Stiffness KN/m	M4 Stiffness KN/m
Storey1	9844362	9850545
Storey2	7032066	7036880
Storey3	6815117	6820202
Storey4	6751210	6756734
Storey5	6705509	6711519
Storey6	6657227	6663749
Storey7	6588891	6595929
Storey8	6442350	6450807
Storey9	5711040	5718540

4.4.3. Storey Stiffness for Plus (+) Shape with and without Curved Beam (M5, M6)

Chart-4.4.3: Storey Stiffness for Model5 and Model6

Table-4.4.3: Storey Stiffness for Model5 and Model6

Storey	M5 Stiffness KN/m	M6 Stiffness KN/m
Storey1	11261734	11263575
Storey2	8088173	8093043
Storey3	7859293	7864200
Storey4	7803631	7809202
Storey5	7766467	7772187
Storey6	7727548	7733545
Storey7	7671351	7678645
Storey8	7541007	7552135
Storey9	6696459	6712607

5. Conclusions

After analysis the above six model which have L, T and Plus (+) shape with and without curve beam and above curved beam provided slab which carry the live load 1KN/m2. We find that due to applied curved beam at the re-entrant corner which reduce the cracking condition at the re-entrant corner as well as in the building, which is given below:-

A. As we know that storey-overturning moment increase from top storey to bottom storey and value of torsion also increasing. Before applied curved beam we found the torsion value in the beam at 1st storey near the re-entrant corner is about 0.8598 KN-m but apply curved beam at re-entrant corner then value of the torsion is about 0.3914KN-m which decrease about 51% at that beam and due to provide curved beam at re-entrant corner the value of the storey overturning moment is also decrease about 1%.

B. Due to providing the curved beam at the re-entrant corner, the value of base shear is increase about 0.1% which is very low. From this data we can say that to avoid the effect of the re-entrant corner in the building we can provide the curved beam at the re-entrant corner.

C. After study the modal time period in the above model with and without curved beam at the re-entrant corner, then find that model time period is almost same at the higher mode but at the lower model time period is decrease about 0.5 % by providing the curved beam at the re-entrant corner.

D. From the above analysis result we found that the value of the storey stiffness is increasing by providing the curved beam at the re-entrant corner, which helps to resist the deformation at the storey of the building. By proving the curved beam at the re-entrant the value of the storey stiffness is increase about 0.6% as compared to without the curved beam at the re-entrant corner.

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