Effect of Torsion Consideration in Analysis of Multi Storey frame

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ABSTRACT

At present scenario many buildings are asymmetric in plan and/or in elevation based on the distribution of mass and stiffness along each storey throughout the height of the building. Most recent earthquakes have shown that the irregular distribution of mass, stiffness and strengths may cause serious damage in structural systems.Torsional behavior of asymmetric building is one of the most frequent cause of structural damage and failure during strong ground motions. In this work a study on the influence of the torsion effects on the behavior of structure is done. In building two cases are considered, case one is without considering torsion and case two is considering torsion. The Indian standard code of practice IS-1893 (Part I: 2002) guidelines and methodology are used to analyzed and designed building. Results are compared in terms of % Ast in columns.

Keywords: ***Asymmetric plan, Earthquake, Eccentricity, Torsion.***

I. INTRODUCTION

Most recent earthquakes have shown that the irregular distribution of mass, stiffness and strengths maycause serious damage in structural systems. However an accurate evaluation of the seismic behaviorof irregular buildings is quite difficult and a complicated problem [1].Due to the variety of parameters andthe choice of possible models for torsionally unbalanced systems, there is as yet no common agreementnor any accurate procedure advised by researchers on common practice in order to evaluate the torsionaleffects. Seismic damage surveys and analyses conducted on modes of failure of building structures during past severe earthquakes concluded that most vulnerable building structures are those, which are asymmetric in nature. Asymmetric building structures are almost unavoidable in modern construction due to various types of functional and architectural requirements. Torsion in buildings during earthquake shaking may be caused from a variety of reasons, the most common of which are non-symmetric distributions of mass and stiffness [4,6]. Modern codes deal with torsion by placing restrictions on the design of buildings with irregular layouts and also through the introduction of an accidental eccentricity that must be considered in design. The lateral-torsional coupling due to eccentricity between centre of mass (CM) and centre of rigidity (CR) in asymmetric building

structure generates torsional vibration even under purely translational ground shaking [2,3]. During seismic shaking of the structural systems, inertia force acts through the centre of mass while the resistive force acts through the centre of rigidity as shown in Fig. 1.

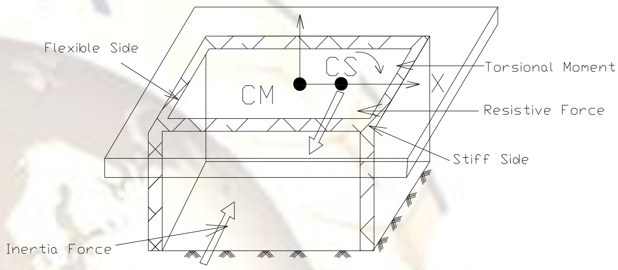


Fig1- Generation of torsional moment in asymmetric structures during seismic excitation.

II. BUILDING DETAILS

Torsional behavior of asymmetric building is one of the most frequent sources of structural damage and failure during strong ground motions. In this work a study on the influence of the torsion effects on the behavior of structure is done. In building two cases are considered,
i) with considering torsion ii) without considering torsion.

The Indian standard code of practice IS-1893 (Part I: 2002) guidelines and methodologyare used to analyzed and designed building. Results with and without torsion is compared in terms of Ast required.Each case includes 9 beams of same orientation from first to last floor.

The structural analysis and design of nine storey reinforced concrete asymmetrical frame building has been done with the help of Staad.pro software. The building is assumed as residential building. Linear static analysis has been done. Regular grid plan of the structure is shown in fig 2. The structure is assumed to be located in seismic zone III on a site with medium soil. Building contains different irregularity like plan irregularity and Re-Entrant corner irregularity [3].

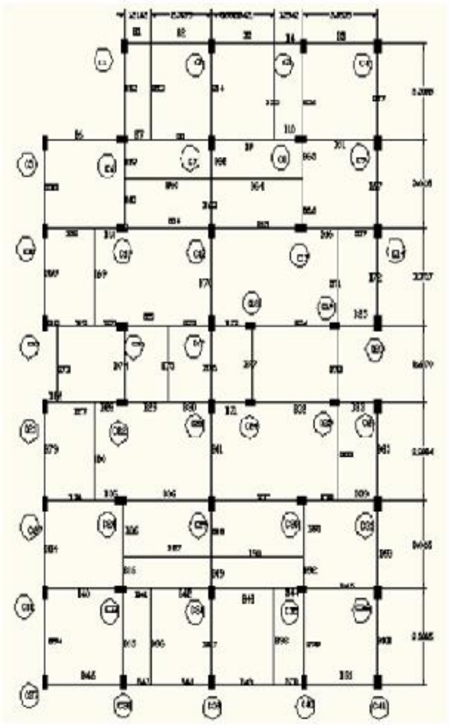


Fig 2- Building plan

Structural data: Table1: Structural data

No of storey	=	9
Ground storey height	=	2m
Intermediate storey height	=	3m
Total no of columns	=	41
Slab thickness	=	140mm
Outer wall	=	230mm
Inner wall	=	150mm
Parapet (1m height)	=	230mm
Beam size	=	B1= 150 x 450 mm
	=	B2= 230 x 300mm
	=	B3= 230 x 450 mm
Column size	=	A1 = 300 x 450 mm
	=	A2= 300 x 600 mm
	=	A3= 300 x 750 mm
Grade of concrete	=	M25
Grade of steel	=	Fe500
Density of concrete	=	25kN/m3
Density of brick	=	20 kN /m3
Live load	=	2 kN /m2
Roof Live load	=	1.5 kN /m2
Floor finish	=	1.5 kN /m2

III. ANALYSIS AND DESIGN

The asymmetric building is analyzed by modeling two models

Case 1: With considering torsion

Case 2: Without considering torsion.

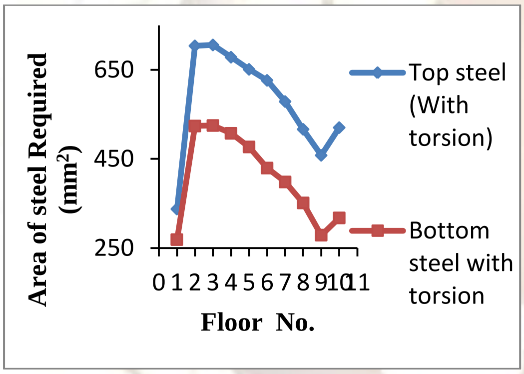
Case 1 building is modeled in Staad.pro software. Supports are assigned as fixed supports neglecting soil structure interaction. Case 1 is design for 13 load combinations. Case 2 building is same as case1, from output data from Staad.pro the design area of steel required is calculated by considering one beam at ground floor up to top floor of same orientation. Considering 4 numbers of cases of beams at critical stage to define the torsion effect. Each case includes 9 beams of same orientation from first to last floor. Taking Floor No. on X-axis and Area of steel (Ast) in

mm^2 on Y-axis in both with considering and without considering torsion effect.

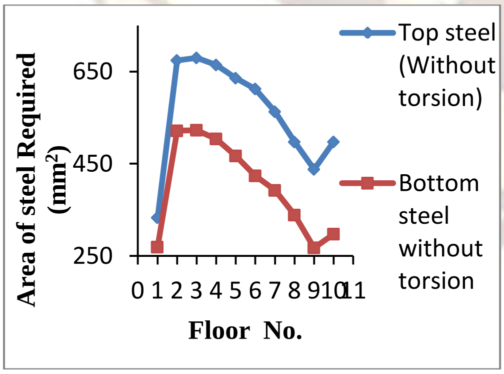
IV. RESULT AND DISCUSSION

Table No. 1.Comparison of area of steel (Ast) in mm^2 for beam - B6

No. Of Floor	Beam No.	Area of Top steel with Torsion mm^2	Area of Bottom steel with Torsion mm^2	Area of Top steel without Torsion mm^2	Area of Bottom steel without Torsion mm^2
Gr. fl.	757	337.55	268.9	333.08	269.41
1	925	703.78	523.93	674.16	521.53
2	1093	705.83	525.06	679.59	522.85
3	1261	678.38	507.54	664.32	503.96
4	1429	651.13	476.92	635.61	467.04
5	1597	626.42	429.58	612.25	423.9
6	1765	578.82	398.35	562.86	392.38
7	1933	516.52	351.29	497.29	338.81
8	2101	458.07	278.95	437.87	267.86
9	2269	520.32	317.69	497.40	297.55



Graph 1.1 Astvs floor No.with torsion.

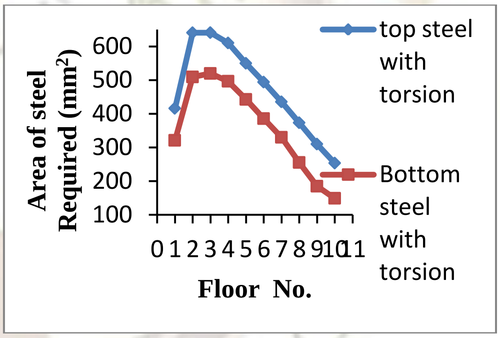


Graph 1.2 Astvs floor No. without torsion.

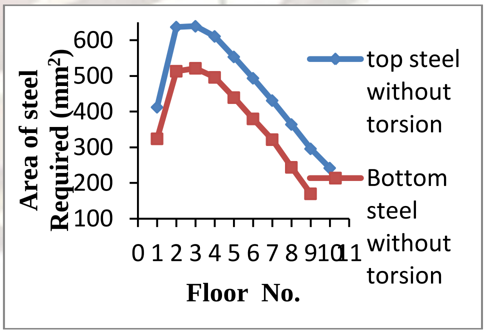
Beam B6 is an exterior beam with span 3.6m. From the above graphs it can be concluded that area of steel decreases from ground floor to top floor. The trend of this curve declining towards end because the torsional moment deceases from ground floor to top floor. Top steel with torsion & without torsion isvaries by 2% to 5%. Bottom steel with torsion & without torsion is varies by 3% to 6%. Here the variation of torsion moment is not significant becausestiffness of beam is less. Stiffness is varying according to span of beam. Displacement increases due to seismic force increases towards top floor.

Table No. 2 Comparison of area of steel (Ast) in mm^2 for beam-B40.

No. Of Floor	Beam No.	Area of Top steel with Torsion mm^2	Area of Bottom steel with Torsion mm^2	Area of Top steel without Torsion mm^2	Area of Bottom steel without Torsion mm^2
Gr.fl.	759	415.74	320.95	412.17	323.76
1	927	640.28	509.03	636.83	513.16
2	1095	640.52	519.44	639.07	521.43
3	1263	609.86	496.27	610.67	495.96
4	1431	549.53	442.35	553.25	439.21
5	1599	493.72	385.38	493.4	379.56
6	1767	435.21	329.92	430.89	321.42
7	1935	373.1	255.23	363.9	243.76
8	2103	309.81	184.77	295.62	169.67
9	2271	253.35	148.95	241.71	140.71



Graph 2.1 Astvs floor No. with torsion.



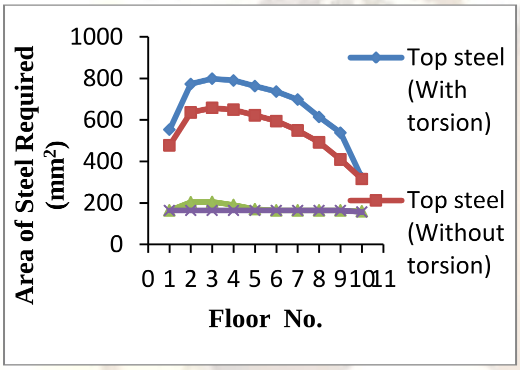
Graph 2.2 Astvs floor No. without torsion.

Beam B40 is an interior beam with span 3.5m. Above graphs shows that area of steel for decreases towards top floor. This trend shows that torsion moment & stresses decrease towards top floor. Top steel with torsion & without torsion is varies by 2% to 4%. Bottom steel with torsion & without torsion is varies by 2% to 8%. The seismic load is varying according to floor that is increases towards top floor. Displacement increases due to seismic force increases towards top floor.

Table No. 3.Comparison of area of steel (Ast) in

No. Of Floor	Beam No.	Area of Top steel with Torsion mm^2	Area of Bottom steel with Torsion mm^2	Area of Top steel without Torsion mm^2	Area of Bottom steel without Torsion mm^2
Gr.fl	755	553.37	164.22	477.75	163.83
1	923	772.96	203.36	635.85	163.83
2	1091	798.9	205.01	658.34	163.83
3	1259	789.96	190.64	649.4	163.83
4	1427	763	170.2	622.41	163.83
5	1595	736.8	164.22	594.25	163.83
6	1763	698.3	164.22	549.07	163.83
7	1931	614.16	164.22	492.15	163.83
8	2099	538.36	164.22	409.02	163.83
9	2267	320.06	159.82	315.36	156.60

mm^2 for beam B7.

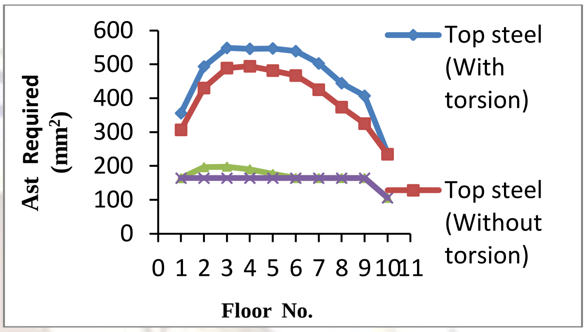


Graph 3.1: Astvs floor No. for top & bottom steel with & without torsion

Beam B-7 is an interior beam with span 1.2m. Here the span of beam is less. Due to this stiffness is more. Hence more moment will be attracted. Above graph shows that top steel with torsion & without torsion is varies by 15% to 25 %. Bottom steel with torsion & without torsion is varies by 2% to 20%. Here torsion moment is more significant. The load from secondary beam comes on it. The effect of seismic force is observed at end of beam but there is no effect on mid span moment & hence on mid span steel.

Table No.4 Comparison of area of steel (Ast) in mm^2 for beam B60.

No. Of Floor	Beam No.	Area of Top steel with Torsion mm^2	Area of Bottom steel with Torsion mm^2	Area of Top steel without Torsion mm^2	Area of Bottom steel without Torsion mm^2
Gr.fl	795	355.72	163.83	306.52	163.83
1	963	493.67	196.23	429.98	163.83
2	1131	548.31	197.89	488.97	163.83
3	1299	545.77	190.08	494.29	163.83
4	1437	904.61	226.99	764.92	163.83
5	1635	538.99	164.22	466.9	163.83
6	1803	502.6	164.22	425.14	163.83
7	1971	444.41	164.22	373.61	163.83
8	2139	407.04	164.22	324.91	163.83
9	2298	236.97	105.57	234.61	105.57



Graph 4.1: Astvs floor No. for top & bottom steel with & without torsion

Beam B-60 is an interior beam with span 1.7m. It can be concluded from above graph that top steel with torsion & without torsion is varies by 10% to 20 %. Bottom steel with torsion & without torsion is varies by 15% to 30%. Here torsion moment is more significant. The load from secondary beam comes on it. The effect of seismic force is observed at end of beam. There is no effect on mid span moment & hence on midspan steel.

V. CONCLUSION

Thus, it can be said that the torsion effect must be taken into account in design practice for asymmetrichigh-rise structures to understand the actual safety margins.

After analyzing the building following concluding points are drawn,

i) In the asymmetric building case 2, that is without considering torsion, it was observed that the area of steel in the beams at critical stage are much smaller than those obtained in the case 1, that is with considering torsion. The bottom bars should be more critical, because they seem to be subjected to more tension than the top bars therefore torsional behavior of asymmetric building is one of the most frequent source of structural damage and failure during strong ground motions.

ii) The variation of Ast is much higher for small span beams.

Most of the designer adopts approximate methods for the torsional analysis of building. However this may be an inaccurate assessment. Several studies of structural damage during the past earthquake reveal that torsion is the most critical factor leading to major damage or complete collapse of building. It is, therefore, necessary that irregular buildings should be analyzed for torsion.

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