Asymmetric Building under Seismic Loading and its structural responce.

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***Abstract*- Structural asymmetry can be a major reason for buildings poor performance under severe seismic loading, asymmetry contributes significantly to the potential for translational-torsional coupling in the structures dynamic behavior which can lead to increased lateral deflections, increased member forces and ultimately the buildings collapse.In this paper the inelastic seismic behavior and design of asymmetric multistoried buildings are studied. The effects of torsion on buildings are analysed.. Study also shows that there is increase in shear, in columns and the columns at outer frame need some special attention.**

***Keywords*–Centre of mass, Centre of stiffness, eccentricity.**

I. INTRODUCTION

The analysis of structure by considering separate sets of mutually orthogonal planer frames and subjected to horizontal components of base motion parallel to their respective planes assumes no interaction between the forces acting on members common to two perpendicular frames and neglects torsional effect. In addition, a two dimensional analysis can allow only for an approximate consideration of the stiffness contribution of elements lying normal to the plane considered. Such an approach is consistent with present design practice and should yield reasonable results for most cases, particularly if a predominantly linear response can be assumed and no appreciable torsional effects are present.

In considering inelastic response however the interaction of forces resulting from components of motion parallel to each of the principle planes in a structure may cause early yielding in some members and modify the response of the structure significantly. The determination of the interaction effects in such a case will require a three dimensional analysis of the response of the entire structure. A study of the earthquake response of a simple, single story, three dimensional frame models showed that the interaction of moments along two mutually perpendicular directions resulted in early yielding in the columns with a consequent reduction in the input energy and the response velocity. The interaction also tended to produce greater permanent lateral displacement.

The study of dynamic torsional effects in buildings, particularly in multi-storey structures where this effect is more pronounced has been possible only with the recent development of programme for the dynamic analysis of three dimensional frame structures. Torsion occurs when the centre of mass does not coincide with the centre of rigidity in a story level. This can be a result of a lack of symmetry in the building plan or random disposition of live loads in an otherwise symmetrical structure. Torsion can also be included in symmetrical structures by the rotational components of ground motions.

Structural symmetry can be a major reason for buildings poor performance under severe seismic loading, asymmetry contributes significantly to the potential for translational-torsional coupling in the structures dynamic behavior which can lead to increased lateral deflections, increased member forces and ultimately the buildings collapse.

Yielding in corner column or end shear wall in buildings due to torsional stresses tends to destroy the symmetry in an originally symmetrical building or increase the eccentricity in an unsymmetrical building, as the centre of resistance moves away from the yielding member. The increase in the eccentricity causes yielding to develop further. This tendency towards magnification of torsional effects by yielding in corner or at end elements suggests that such elements should be designed more conservatively than other member where torsional vibrations can be significant.

Asymmetric Building- Types of Irregularities:These irregularities are categorized in two types:

1. Vertical Irregularity
   a) Stiffness Irregularities – Soft Storey:
   b) Mass Irregularities:
   c) Vertical Geometric Irregularity

2. Horizontal/Plan Irregularity

II. EXPERIMENT AND RESULT

Data:

1) Slab Thickness = 150 mm
2) Wall Thickness = 230 mm
3) Size of Beam = 230 mm x 700 mm
4) Size of Column = 400 mm x 400 mm
5) Live load on floors = 3 kN/m^2
6) Floor Finish = 1.0 kN/m^2
7) Grade of Concrete = 20 N/mm^2
8) Grade of Steel = 415 N/mm^2
9) EI = Constant
10) Zone Factor (Z) = 0.16 (zone III)
11) Importance Factor (I) = 1.0
12) Response Reduction Factor (R) = 5.0
13) Damping = 5%

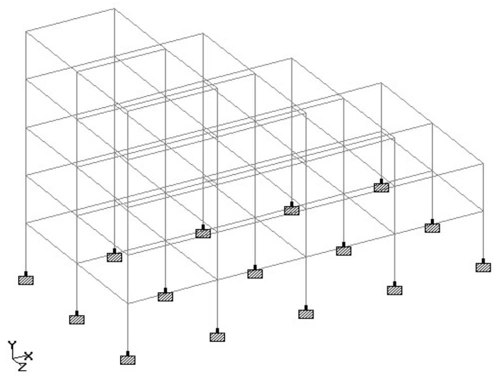

Figure 1-Building with Irregular Frame

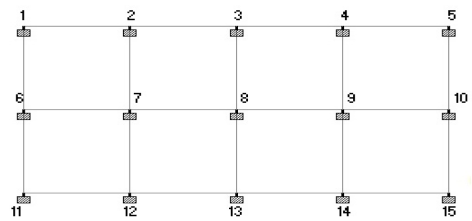

Figure 2-Plan of Building

III.ANALYSIS

Results of Response Spectrum Analysis-

By performing Response Spectrum Analysis the frequency for corresponding time period, mass participation factor and maximum base shear in x and z directions has been calculated. However, three mode

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shapes have tabulated. This maximum base shear has been used for design of structure.

Table 1-Result of Response Spectrum Analysis when Earthquake in X-Direction

Mode	Acceleration (G)	Damping	Frequency (Cycles/sec)	Period (Sec)	Accuracy
1	1.25002	0.05000	1.325	0.7654	3.132E-16
2	2.0000	0.05000	1.672	0.5998	6.500E-15
3	2.150000	0.05000	2.865	0.3670	8.275E-16

Table 2-Mass Participation Factors and Base Shear in X-Direction

Mode	Mass Participation Factors in Percentage						Base Shear in kN		
	X	Y	Z	SUMM X	SUMM Y	SUMM Z	X	Y	Z
1	7.45	0.00	0.00	680.00	0.00	0.00	251.6	0.00	0.00
2	0.00	0.00	0.00	70.300	0.00	0.00	0.00	0.00	0.00
3	1.64	0.00	0.00	73.44	0.00	0.00	3.89	0.00	0.00

TOTAL SRSS SHEAR 334.14 0.00 0.00

TOTAL 10PCT SHEAR 334.14 0.00 0.00

TOTAL ABS SHEAR 435.70 0.00 0.00

1) Design of Members Without Torsional Effect-

Following loads have considered for design of structure

A. Load

1) Dead Load (DL)
2) Live Load (LL)
3) Earthquake Load in X-Direction (ELx)

B. Load Combinations

According to IS1893-2002, following load combinations have considered,

1) 1.5 DL + 1.5 LL
2) 1.2 DL + 1.2 LL +1.2ELx
3) 1.2 DL + 1.2 LL - 1.2ELx

Note: Since frame at (x, z, 0.0) and frame at (x, z, 10.0) are similar to each other so members of frame at (x, z, 0.0) only are considered for design and same design will be provided for the members of frame at (x, z, 10.0). The frames at (x, z, 0.0), (x, y, 5.0), (x, y, 10.0) are as shown in fig. no. 3a, 3b, 3c.

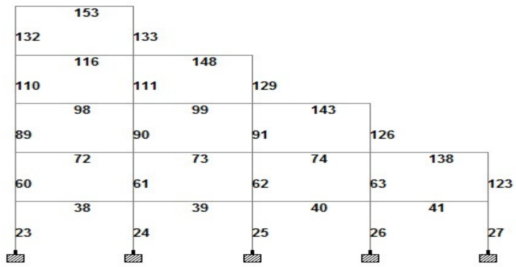

Figure 3a-Frame at (x,z, 0.0)

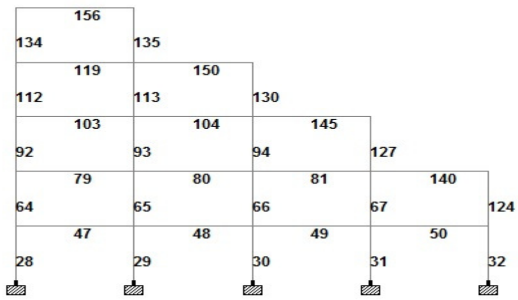

Figure 3b-Frame at (x,z, 5.0)

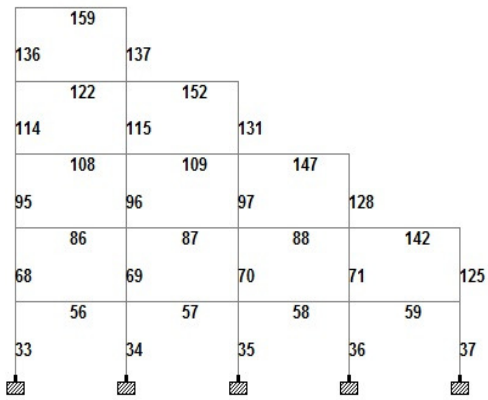

Figure 3c-Frame at (x,z, 10.0)

2) DESIGN OF MEMBERS CONSIDERING TORSION-

Following loads have considered in design of structure

1) Dead Load (DL)
2) Live Load (LL)
3) Earthquake Load in X-Direction (ELx)
4) Shear due to torsion when earthquake in X- dir. (Fx)

C. Load Combinations

According to IS1893-2002, following load combinations are considered,

1) 1.2 DL + 1.2 LL +1.2ELx + 1.2Fx
2) 1.2 DL + 1.2 LL - 1.2ELx – 1.2Fx

D. Comparative Study of Column Design

The shears due to torsion have calculated with the help of Time-History Analysis as well as Response Spectrum Analysis, and the results have tabulated in Table 4 for earthquake in X-direction.

Table 3-Shear due to Torsion when Earthquake in X-Direction

Column line	First Storey	Second Storey	Third Storey	Forth Storey	Fifth Storey
1	7.10	6.88	1.89	1.10	0.57
2	0	0	0	0	0
3	7.10	6.88	1.89	1.10	0.57

Comparative study of Column design-

Table 4-Comperative Results of Column Design

Column no.	Design of column without Torsion			Design of column with Torsion		
	A_{st} (mm^2)	Main Rein.	Lateral Ties	A_{st} (mm^2)	Main Rein.	Lateral Ties
24	1429	12-12Φ	8Φ@190 c/c	1429	12-12Φ	8Φ@190 c/c
123	1200	4-20Φ	8Φ@300	1507	8-16Φc/c	8Φ@255 c/c
129	1689	8-16Φ	8Φ@255 c/c	1797	16-12Φ	8Φ@190 c/c
131	1689	8-16Φ	8Φ@255 c/c	1820	16-12Φ	8Φ@190 c/c
135	499	8-12Φ	8Φ@190 c/c	1399	12-12Φ	8Φ@190 c/c

IV.CONCLUSION

1) Extra reinforcement is required to the column where there is sudden change of massfrom the comparative study of column design.

2) From results it appears that the columns at plinth level are not affected much due to torsion than the columns above the plinth.

3) The columns which are at external frame, where there is sudden change of floor area needs to be taken care in design with some modifications.

REFERENCE

[1] Young-Soo and Bryan Stafford Smith " Assessment of Translational-Torsional coupling in Asymmetric Uniform Wall-frame Structures". Journal Of Structural Engineering (1995),vol-121 ,No-10, pp.1488-1496.

[2] Arnaldo T. Derecho, Mark Fintel, and S.K.Ghosh, "Earthquake Resistant Structure", Handbook of Concrete Engineering.

[3] IS 1893 (Part 1):2000 Criteria for Earthquake Resistant Design of Structures.

[4] Kenji FUJII, Yoshiaki NAKANO and Yasushi SANADA " A Simplified Non-Linear Analysis Procedure for Single Story Asymmetrical Building", Journal Of Japan Association For Earthquake Engineering, (2004), vol-4, No-2, pp.1-20.

[5] R. Tabatabaei and H. Saffari ,"Evaluation of the Torsional Response of Multi story Buildings using Equivalent Static Eccentricity ", Journal Of Structural Engineering ,ASCE, vol-137 , (2011).pp.862-868

[6] S. N. Tande, J. S. Dali and S. C. Potnis ,"Seismic Behavior of Torsion Susceptible Irregular Building Frames",ICESE2012.