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Evaluation of Shear Wall and Masonry Infill for RC Building Frame

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Abstract— ***The sudden movement of earth causes damage to or collapse of buildings and other manmade structures. Hence seismic analysis is necessary for a structure. In the present study, an attempt is made to study the difference in structural behaviour of 3-dimensional 4*6 bays, 12 storey basic moment resisting RC frame provided with external and internal shear wall and masonry infill as LLRS. The detailed investigations are carried out for zone V of seismic zone of India as per IS 1893 (part-1):2002, considering primary loads and their combinations.6 models are analysed which consists of basic moment resisting frame with square column and frames with external shear wall and internal shear wall at corners and mid frames and frames with masonry infill as LLRS. The results obtained from the Equivalent static lateral load method are thoroughly investigated for maximum values of joint displacements, support reactions, beam force, forces in truss elements. The results indicate better resistance to lateral loads in the presence of masonry infill provided at centre frame of the building.***

Keywords— ***External Shear wall, Internal Shear wall, Masonry infill, LLRS, Staad Pro, ESLM.***

I. INTRODUCTION

A natural hazard like Earthquake causes damage to or collapse of buildings and other man-made structures. Seismic analysis and design is necessary for a structure to withstand minor earthquakes elastically without any structural damage, and major earthquake with acceptable level of damage depending on the importance of the building ensuring safety of people and contents, and thereby a disaster is avoided.

Many existing buildings lack the seismic strength and detailing requirements as per Indian standard codes of practice at present.

An existing structure may need **upgrading** if the structure was initially not designed and constructed to resist an earthquake i.e. designed only for gravity loads but still has not undergone failure. For structures, which have undergone failure due to earthquake, it is essential to **retrofit** for future use. There are several techniques which can be thought off for upgrading or retrofitting, but the one which is suitable structurally and economically for the existing condition of the building, requires a thorough investigation, so research is very much essential in this regard.

II. PRESENT INVESTIGATION

The studies on External Shear walls and Internal Shear walls in comparison with Masonry Infill for 12 storey frames are limited. Most of the studies are confined to 10 storey building, whereas structures have varying no. of stories, and such studies are limited. Thus, the present investigation is concerned with detailed 3D study of results of analysis of a twelve storey moment Resisting Frame having four bays along X and six bays along Z provided with external shear wall at corner, external shear wall at mid frame, internal shear wall at corner, internal shear wall at mid frame and masonry infill as Lateral load resisting systems (LLRS), in comparison with identical Moment Resisting Bare Frame (without any special LLRS feature) subjected to gravity load, seismic load and their combinations. External shear wall Internal shear wall and masonry infill are considered in the present investigation. The study is hoped to be helpful during retrofitting of such structures which are initially designed only for gravity loads and found unsafe for seismic loads and any combination of loads.

III. METHOD OF ANALYSIS

The present study undertaken deals with Linear Static Analysis i.e., Equivalent Static Linear Load Method.

A. Modelling of the structures

For the present 3D study STAAD.Pro software package is used.

IV. DETAILS OF THE PROBLEM CHOSEN

A. Plan and height of the bare frame

The plan (Figure1) consists of four bays of span 5.0m each along X direction, six bays of span 5.0m each along Z direction. The typical Twelve –storey building has each storey height of 3.0m along Y direction.

Beam Cross–Sections Size

Along X and Z directions (for all frames considered): 230mm X 500mm

Plinth Beam Size

P1 along X and Z directions (for all frames considered): 230mm X 300mm

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Column Size Square column (for all frames considered): 750mm X 750mm.

Shear Wall Thickness (for all frames considered): 100mm

Masonry Wall thickness (for all frames considered): 230mm

B.Frames with special features of LLRS:

1. Frames with External Shear Wall at Corners provided at end bays along X and Z directions (ESXZ4C) (Figure 2).
2. Frames with External Shear Wall at Mid Frames provided at mid bays along X and Z directions (ESXZ4M) (Figure 3).
3. Frames with Masonry infill at Corner of the building (idealized as diagonal compressive strut-MDS) (Figure 4).
4. Frames with Internal Shear Wall at Corners provided at end bays along X and Z directions (ISXZ4C) (Figure 5).
5. Frames with Internal Shear Wall at Mid Frames provided at mid bays along X and Z directions (ISXZ4M) (Figure 6).

C.Seismic zone

Zone V of Seismic zones of India, as per IS: 1893 (part-1) - 2002 code for which zone factor (Z) is 0.36.

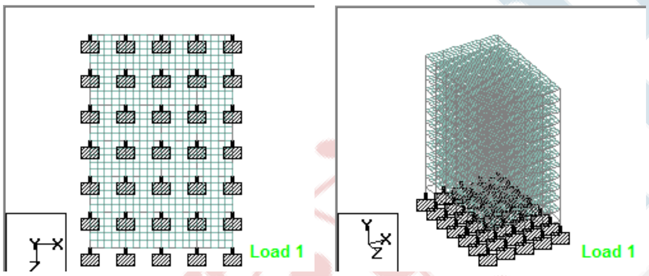

Figure 1. Typical Plan and 3D view of Bare Frame

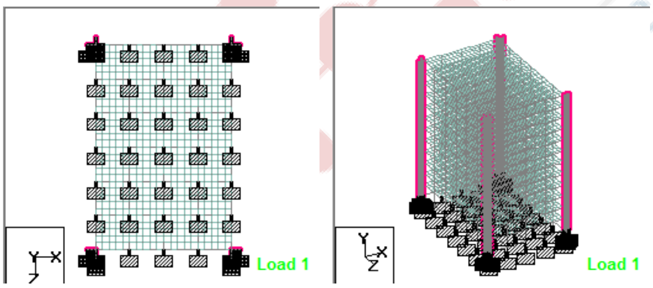

Figure 2. Typical Plan and 3D view of External Shear Wall at Corners (ESXZ4C)

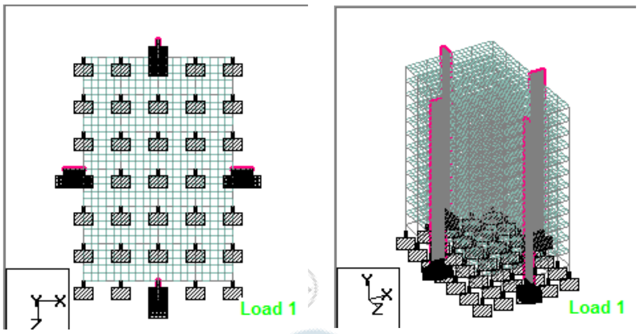

Figure 3. Typical Plan and 3D view of External Shear Wall at Mid Frame (ESXZ4M)

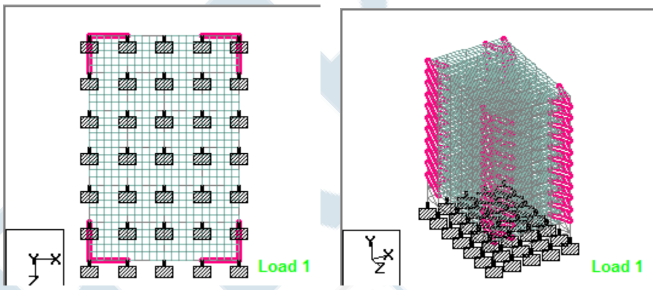

Figure 4. Typical Plan and 3D view of Masonry Diagonal Strut (MDS)

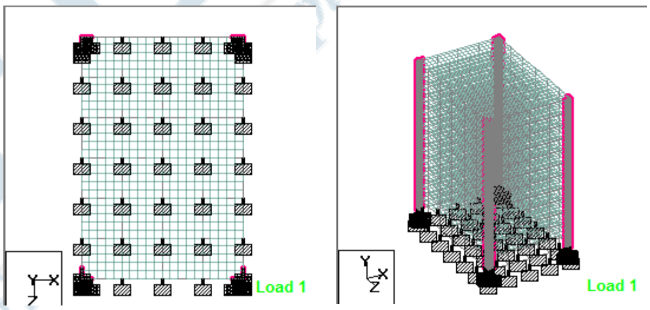

Figure 5. Typical Plan and 3D view of Internal Shear Wall at Corners (ISXZ4C)

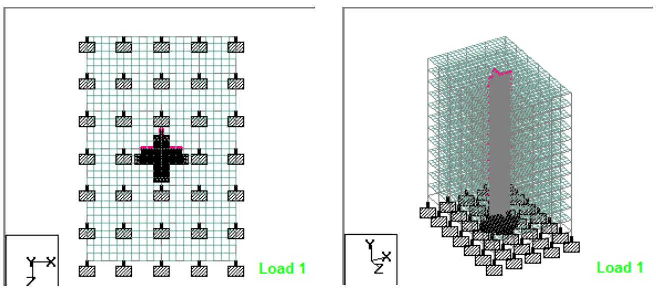

Figure 6. Typical Plan and 3D view of Internal Shear Wall at Mid frame (ISXZ4M)

D.Types of primary loads and load combinations

The structural systems are subjected to three types of Primary Load Cases as per IS: 875-1987 code, they are

1. Dead Load case (Gravity load), "DL"
2. Live Load case (Gravity load), "LL"
3. Seismic Load in X-direction (Lateral), "ELx"
4. Seismic Load in Z-direction (Lateral), "ELz"

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In addition, the structural systems are subjected to 13 different Load Combinations, they are:

5. 1.5(DL+LL) 9.1.2(DL+LL-EL_Z) 13. 1.5(DL-EL_Z) 17. (0.9DL-1.5EL_Z)
6. 1.2(DL+LL+EL_X) 10. 1.5(DL+EL_X) 14. (0.9DL+1.5EL_X)
7. 1.2(DL+LL+EL_X) 11. 1.5(DL-EL_X) 15. (0.9DL-1.5EL_X)
8. 1.2(DL+LL+EL_Z) 12. 1.5(DL+EL_Z) 16. (0.9DL+1.5EL_Z)

The dead load consists of self-weight of structural elements and masonry wall load of thickness 230mm.The live load considered is as adopted for medium office, hospital or hostel building i.e., 4kN/m^2 as per IS code IS:875-1987. Equivalent Static Linear Method is adopted for the calculation of the lateral load at each floor level as per IS: 1893 (part-1)-2002 code. The lateral loads applied are given in Table 1.

E. Physical properties considered for present study.

Density of brick wall = 18.85 kN/m^3
Poisson's Ratio of concrete = 0.17
Density of R.C.C = 25 kN/m^3
E of concrete = 2.17185x 10^7 kN/m^2

V. RESULTS AND DISCUSSIONS

The results obtained by "Equivalent Static Lateral Force Method" of analysis, are presented in Table 2, along with the corresponding load cases. The table indicates the results of frames with all types of LLRS considered (i.e. ESXZ4C, ESXZ4M, ISXZ4C, ISXZ4M and MDS)

and for the moment resisting Bare frame (BF). The discussion focus on the comparison between frames with LLRS considered and the basic Bare frame with respect to the maximum joint displacements (X, Y and Z directions), Maximum support reaction, Maximum member end forces (axial force, shear force, bending and torsion moment) and forces in truss element.

A. Maximum Joint Displacements

For all structural systems considered, the maximum joint displacement is observed at the top storey level, the bare frame (without any LLRS) undergoes the maximum joint displacement namely Max X and Max Z.

a. Effect of load and load combinations.

For structural systems considered, load combinations for which Max X and Max Z occur are load cases 10 or 11 i.e 1.5 (DL ± Elx) and 12 or 13 i.e. 1.5 (DL ± Elz).

b. Effect of LLRS

The value of Max X reduces by 5% in ESXZ4C, 13% in ESXZ4M, 12% in ISXZ4C, 31% in ISXZ4M and 56% with addition of masonry infill when compared with bare frame. The addition of masonry infill as LLRS reduces the Max Z by 55%. The value of Max Z reduces by 5%,12%,12%,30% in ESXZ4C, ESXZ4M, ISXZ4C and ISXZ4M respectively when compared with bare frame.

Table I: Lateral Load at each storey calculated by Equivalent Static Lateral Force method for zone V in kN

BARE FRAME/ ESXZ4C/ESXZ4M				MDS				ISXZ4C/ ISXZ4M			
X axis end Frame	X axis mid frame	Z axis end Frame	Z axis mid Frame	X axis end	Mid frame	Z axis end	Z axis mid	X axis end Frame	X axis mid frame	Z axis end Frame	Z axis mid Frame
1.02	1.56	1.54	2.29	1.04	1.60	1.52	2.33	1.01	1.54	1.48	2.26
4.10	6.26	6.15	9.17	4.18	6.41	6.07	9.32	4.03	6.12	5.93	9.03
9.22	14.08	13.83	20.62	9.39	14.42	13.66	20.97	9.07	13.78	13.33	20.32
16.40	25.03	24.58	36.67	16.70	25.64	24.28	37.27	16.13	24.49	23.71	36.12
25.62	39.11	38.41	57.29	26.09	40.06	37.94	58.24	25.2	38.27	37.04	56.44
36.89	56.32	55.32	82.50	37.58	57.69	54.63	83.87	36.28	55.10	53.34	81.28
50.21	76.66	75.29	112.29	51.15	78.52	74.36	114.15	49.38	75.00	72.6	110.63
65.59	100.13	98.34	146.66	66.80	102.56	97.12	149.10	64.5	97.96	94.82	144.50
83.01	126.72	124.46	185.62	84.55	129.80	122.92	188.70	81.64	123.98	120.01	182.88
102.48	156.45	153.65	229.16	104.38	160.25	151.75	232.96	100.79	153.06	148.16	225.78
124.00	189.30	185.92	277.29	126.30	193.90	183.62	281.88	121.95	185.21	179.27	273.19
111.56	172.72	166.37	253.20	112.96	175.53	164.97	256.01	110.31	170.22	162.32	250.70

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B. Maximum Support reactions

a. *Effect of load and load combinations*

For structural systems considered, the maximum support reaction Fx and F_y occurs when seismic load combination 10 or 11 i.e 1.5 (DL ± Elx) is applied.

b. *Effect of LLRS*

The maximum support reactions Fx and Fz decreases by 58% in case of External Shear wall, 24% in case of Internal Shear wall and increases by 74% in case of MDS respectively.

Table II: Magnitude of the parameters considered and corresponding Load case

Parameter	Notations	Bare frame		ESXZ4C		ESXZ4M		MDS		ISXZ4C		ISXZ4M	
		Magnitude	L/C	Magnitude	L/C	Magnitude	L/C	Magnitude	L/C	Magnitude	L/C	Magnitude	L/C
Joint. displacement	Max Abl	454.14	10	429.23	10	396.13	10	199.99	14	398.18	10	312.86	10
	Max X	454.14	10	429.22	10	395.66	11	199.59	14	398.09	10	312.16	10
	Max Z	440.52	13	416.59	13	384.62	12	196.76	16	387.11	12	305.64	13
Support reactions	Max Fx	277.40	14	916.52	10	696.24	11	862.34	10	1321.38	11	894.61	11
	Max Fy	7584.77	5	7584.8	5	10444	10	10449	10	7549.29	5	8454.02	11
	Max Fz	276.02	12	902.77	13	687.10	12	840.64	12	1311.70	13	900.74	13
	Max Mx	1759.75	12	1216.0	13	981.67	17	1684.30	12	1140.08	12	790.18	12
	Max Mz	1788.70	15	1271.3	10	1010.1	11	1683.32	10	1191.91	11	819.27	10
Beam Forces	Axial Force	193.11	13	607.14	12	599.70	12	946.62	10	920.56	13	575.52	13
	Shear Y	222.37	10	214.87	11	206.49	11	136.40	10	856.51	10	1197.86	10
	Max Mx	89.80	10	86.38	11	78.98	11	42.46	14	92.47	10	100.41	11
	Max Mz	307.88	11	295.45	10	290.74	10	165.72	10	312.88	10	436.10	10
Truss Forces	Axial force	-	-	-	-	-	-	1688.01	10	-	-	-	-
	Axial stress	-	-	-	-	-	-	7.41	10	-	-	-	-

C. Maximum Forces in Beams

Generally the maximum beam forces F_x, F_y, M_x, M_z occur in seismic load combinations.

The greatest value of the maximum Bending moment M_z and Torsion moment M_x in beams of all systems considered occur in Bare frame.

Comparing the frames with LLRS with bare frame, the maximum axial force F_x increases. The maximum shear force F_y decreases in case of MDS and increases in case of External Shear wall and Internal shear wall.

Maximum moment M_x and M_z decreases in both the case of LLRS considered.

D. Forces in Truss elements

The maximum Axial force and Axial stress in strut for frames with Masonry infill occur when load case 10 i.e. 1.5(DL + ELx) is applied.

VI. CONCLUSIONS

It is necessary to consider gravity and seismic loads as well as all the load combinations during analysis of structure.

Provision of ESXZ4C, ESXZ4M, ISXZ4C, ISXZ4M and MDS effectively reduce large displacements found in bare frame as well as other parameters considered.

Internal shear wall are more effective than External shear wall as LLRS.

The best performing LLRS among the LLRS considered is Masonry Diagonal Strut (MDS).

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REFERENCES

[1] Ashraf M., Siddiqui Z.A. and Javed M.A, 2008, Configuration of multistorey building subjected to lateral forces, Asian Journal of Civil Engineering (Building and Housing), Vol. 9, No 5, 2008.

[2] Luis Decanini, FabrizioMollaioli, Andrea Mura, Rodolfo Saragoni,2004, Seismic performance of masonry infilled r/c frames. 13th World Conference on Earthquake Engineering, Vancouver, B.C., Canada, August 1-6, 2004, Paper no. 165.

[3] P.G. Asteris, M ASCE, 2003, Lateral stiffness of brick masonry infilled plane frames, Journal of structural engineering ASCE/ August 2003.

[4] Savitha B.A, Venkatesh S.V, Dr. Sharada Bai H, 2007, Performance of frames with shear walls for seismic loads in low and medium rise buildings, National conference on earthquake engineering, NCEE 2007, 18th and 19th December 2007.

[5] S.V Venkatesh, Dr. H. Sharada Bai and C. Navanitha 2009, Performance of RC frame with and without shear wall subjected to Earthquake load, Proceedings of Civil Engineering Conference –innovation without limits (CEC-09), 18th - 19th September 2009.

[6] S.V Venkatesh, Dr. H. Sharada Bai and Divya S.P 2013, Behavior of shear wall as lateral load resisting systems for 3-Dimensional building frame subjected to seismic load,3rd International Engineering Symposium-IES 2013.

[7] IS: 456-2000 - Code of Practice for Plain and Reinforced

Concrete, Bureau of Indian Standards, New Delhi.

[8] IS: 1893 (Part – 1) – 2002 - Code of Practice for Criteria for Earthquake Resistant Design of Structures, Part 1: General Provisions and Buildings, Bureau of Indian Standards, New Delhi.

[9] IS: 875 – 1987 - Code of Practice for Design Loads (other than Earthquake) for Buildings and Structures, Part 1: Dead Loads, Part 2: Imposed Loads, Part 5: Special Loads and Load Combinations, Bureau of Indian Standards, New Delhi.

[10] NEHRP guidelines for the seismic rehabilitation of building, FEMA 273 / October 1997.