ISSN No:-2456-2165

Analysis of Reinforced Concrete (Rc) Frames Under Lateral Loads Using Steel Bracings

Puneeth K, Rudresh A N
Asst.Professor, Department of Civil Engineering
ATMECE, Mysore, India

Abstract:- The preliminary prerequisite of a structure is to satisfy serviceability conditions, stiffness and safety. The shape and proportions of the structure effects the distribution of forces. Due to irregularities in the structure it will get deficient stiffness at continuous load path and tension capacity will be re-entrant at corners. Steel bracings are retrofitted to increase the strength of RC frame structure and are good rehabilitation technique. Bracing provide high stiffness due to horizontal shear and is primarily absorbed and resist the lateral forces by developing the internal axial action and relatively small flexural actions. Steel bracings are economical, less self weight, good appearance, less spaced occupied, compared with other retrofitting techniques. Steel bracings are known for its efficient structural system for buildings under high lateral loads. The applications of steel bracings are faster to execute. Seismic study is carried out by considering G+15 unsymmetrical RC structures in zone III with bare frame and compared with X-braced frame, single diagonal braced frame, V-braced frame, K-braced frame bracings and static analysis is carried out using ETABS software. These bracing are used at specific locations and results are obtained for Base Shear, Story Displacement, Story Drift, and Time Periods are compared with bare frame models in seismic zone III.

***Keywords**:- Bare Frame (BF), X – Braced Frame (XBF), Single diagonal Braced Frame (SDBF), V- Braced Frame (VBF), K – Braced Frame (KBF).*

I. INTRODUCTION

Earthquake is a natural disaster which occurs with various magnitude and intensities causing damage to engineering properties and infrastructures which leads to economical loss & loss of life. It is mainly based on focal depth, location, magnitude, origin, and epicentral. Earthquake may be caused by tectonic plate movements. Human activities like coal mining, oil drilling, constructing enormously heavy building, and large amount of water stored in a dam leads to earthquakes. Global warming is also reason for increase in the frequency and intensity of the earthquake. Earthquake damage the buildings fully or partially.

Rehabilitation for damaged buildings has two technique levels: Structural level & member level rehabilitation. In structural level, modification can be done with respect to whole structure, steel bracings is the best example. Seismic performances of Beams, columns, walls are improved in member level. Different rehabilitation techniques to improve the seismic performance of the existing non-ductile RC structure: adding new structural member such as steel bracing or new structural walls, FRP wrapping and steel jackets, use of base isolation or dampers. There are two generally used procedure specifying seismic design of lateral forces (a) Equivalent static analysis, (b) Dynamic analysis, Dynamic analysis has two types (1) Response spectrum, (2) Time history analysis. In Static analysis Base shear is calculated approximately by assuming that structure is rigid, acceleration is same at every point on the structure, also structure and foundation as ideal fixity. It has only one mode of vibration on the structure. An irregular structure leads to erroneous results. Time history method based on suitable ground motion. Response spectrum analysis based on design response spectrum specified in Indian code or on site specific design.

Steel bracings or shear walls are commonly used to increase the seismic performance. Steel bracing system is most commonly used instead of shear elements because it's economical and easiness of construction. Steel bracings are usually used in steel structure. From last two decades the use of steel bracings in RC frames came into practice. Bracings reduced the earthquake induced torsion in the structure. It acts has a truss that provides lateral stiffness to buildings. Steel bracing system contributes less mass, when compare to other retrofitting techniques. Seismic forces are proportional to the weight of the building. Structures designed with bracings can improve the energy absorption and resists the forces generated by ground waves. It provides good ductile property with respect to earthquake loads. This system reduces lateral displacement considerably and also decreases the lateral drift, they decreases shear forces and bending moments in columns.

Nitin Bhojkar and Mahesh Bagade [2015] Use of steel bracings in high raised building to resist against lateral loads. G+9 stories R C building situated in zone III. Main parameters taken into consideration are base shear axial force, story drift, lateral displacement. From the verdict bracing system is the better retrofitting technique. No major change in the total weight of the structure after the addition of bracings. About 65% of lateral displacement is minimized. Increase in stiffness of the structure.

Vishwanath K G, Prakash K B, and Anath Desai [2010] Analytical research work on use of concentric steel bracing in existing R C building to resist the seismic loads. The R C building of four stories is conceded for analysis. The peripheral columns are offered with steel bracings. The building is located in zone IV and analysis is carried out in STAAD.PRO software. The number of stories is increased to 8, 12, and 16. After the evaluation of results it is found that X-type bracing s are minimize the lateral displacement, story drift and bending moments.

The objective of the present work is to findout the performance of G+15 storied building under lateral loads and RC buildings with steel bracing such as X, V, diagonal, K in static condition for seismic zone III and soil type 2 using ETABS software. The parameters such as storey drift, displacement, base shear, and time period are compared with the different bracing systems with above parameters and selecting the best among the different steel braces.

II. METHODOLOGY

T-shaped R C building of G+15 stories is considered for modeling with bare frame and different types of bracings (X, V, single diagonal, K). Designed as per Indian standard codes, and linear static analysis is carried out for all models. The performance of RC structure with bracings and without bracings for storey displacements, drifts, base shear & modal time period are compared with the performance of bare frame.

III. MODELLING

Various parameters such as load intensities, material properties, dimension of the structural member and the seismic data considered in the modelling of different types of buildings considered for analysis are mentioned below.

Storey height (including base)	3.5 m
Number of story's	G+15
Type of structure	RCC
Width of bay in X-direction	5m
Width of bay in Y-direction	5m
Bare frame Support condition	Fixed
Braced frame support condition	Pinned
Thickness of slab	175 mm
Wall thickness	230 mm
Cross section property of steel bracing	ISMB 200

Table 1:- Geometrical details of T-shaped building

Numbers of storie s	Beam size in m m	Column size in m m
Ground to 5	300×450	600X600
6 to 10	300X450	450X450
11 to 16	300X450	375X375

Table 2:- Beam and Column cross section details

Grade of concrete	M35
Grade of steel	Fe500
Density of concrete	25 KN/m³.
Poisons ratio of concrete	0.2

Table 3:- Material properties of T-shaped building

Dead load	
Self weight multiplier	1
Wall load	14.03 KN/m²
Parapet wall load	4.6 KN/m²
Floor finish	1.5 KN/m²
Live load	
Floor load	2.5 KN/m²

Table 4:- Load cases

Earthquake code	IS 1893:2002
Seismic zones	III
Importance factor	1
Response reduction	5
Soil type	Medium
Live load reduction	25%

Table 5:- Earthquake parameters

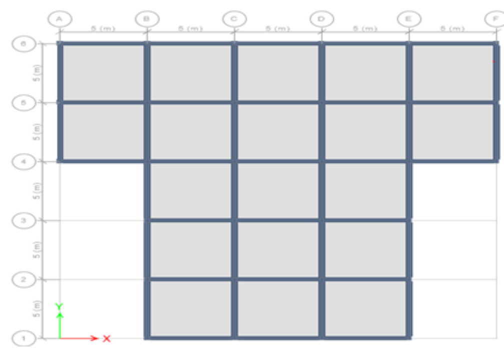

Fig 1:- Plan of framed building

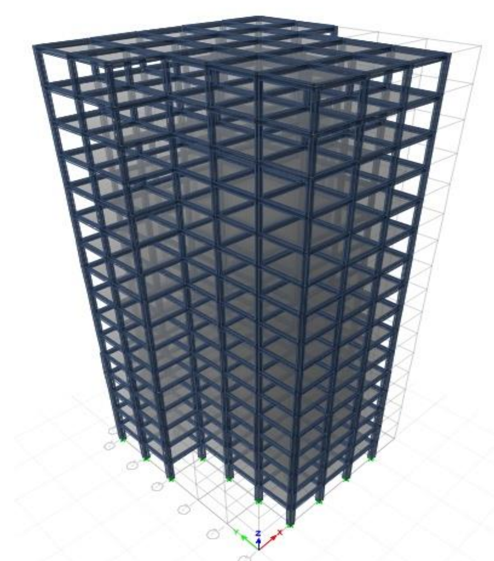

Fig 2:- 3-D view of structure

ISSN No:-2456-2165

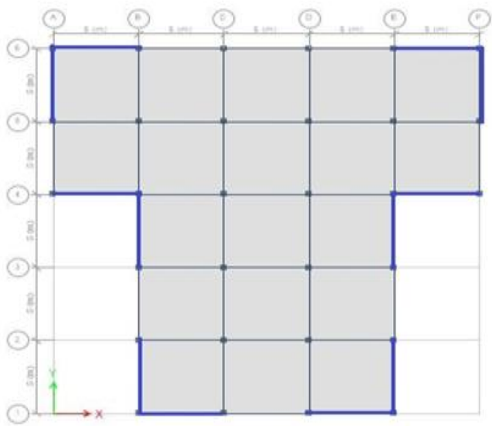

Fig 3:- Top view of braced models (darken part shows location bracings are placed)

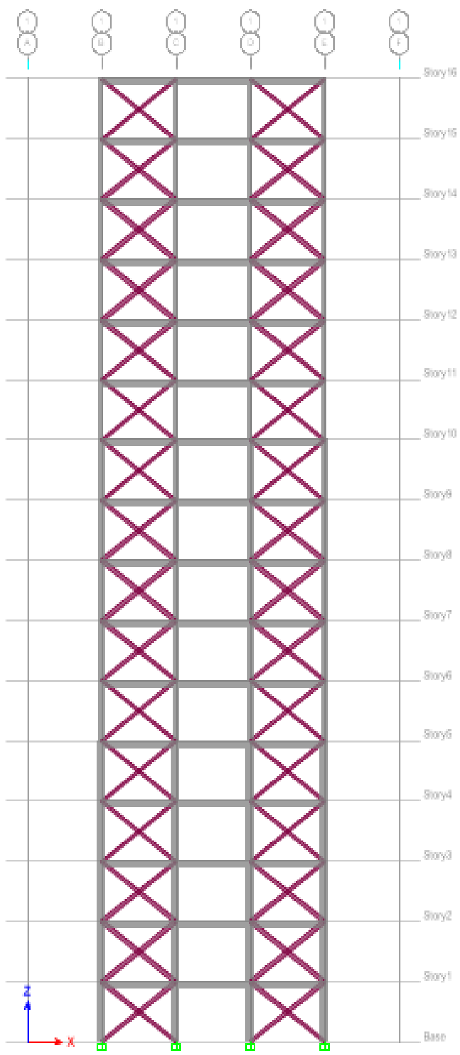

Fig 4:- Elevation view of X-Bracing

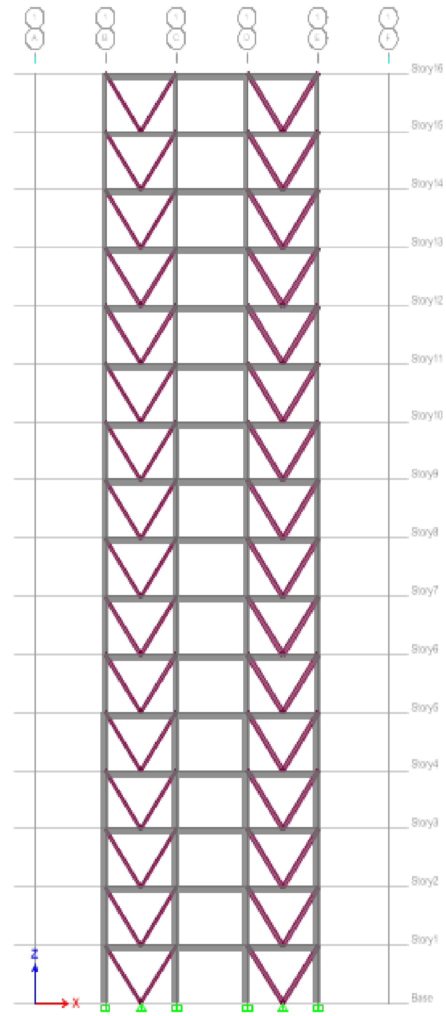

Fig 5:- Elevation view of V-Bracing

IV. RESULTS AND DISCUSSIONS

Comparison of various parameters such as time period, displacement, storey shear, storey drift ratio of different types of reinforced concrete (RC) buildings with respect to existence and non existence of bracings has been characterized in the below tables.

Models	Base Shear in X-direction KN	Base Shear in Y-direction KN
Bare Frame	1718.09	1718.09
X- Braced Frame	1726.10	1726.10
Single Diagonal Braced Frame	1722.10	1722.10
V- Braced Frame	1723.74	1723.74
K- Braced Frame	1724.80	1724.80

Table 6:- Maximum Base Shear in X and Y direction for Linear static Analysis (ZONE III)

ISSN No:-2456-2165

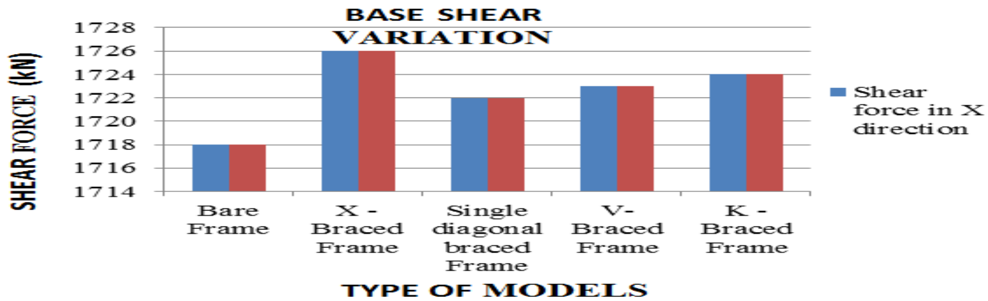

Fig 6:- Graphical representation of Maximum Base Shear in X and Y direction for Linear static Analysis (ZONE III)

Story displacement in mm										
Story Level	BF		XBF		SDBF		VBF		KBF	
	X direc^n	Y direc^n	X direc^n	Y direc^n	X direc^n	Y direc^n	X direc^n	Y direc^n	X direc^n	Y direc^n
16	93.7	93.6	46	41.6	53.3	49.7	50.8	46.5	56.6	53.1
15	91.8	91.8	43.6	39.6	51.1	47.8	48.4	44.5	54.5	51.3
14	88.5	88.4	40.8	37.3	48.3	45.4	45.6	42.1	51.7	48.9
13	83.8	83.7	37.8	34.7	45.1	42.6	42.4	39.3	48.4	46
12	77.8	77.8	34.5	31.9	41.5	39.4	38.9	36.3	44.7	42.6
11	70.9	70.8	31	28.8	37.7	35.9	35.1	32.9	40.6	38.9
10	63	63	27.4	25.6	33.5	32	31.2	29.4	36.2	34.8
9	56.3	56.3	24	22.5	29.6	28.4	27.5	26	32.1	31
8	49.2	49.2	20.5	19.4	25.6	24.7	23.7	22.5	27.9	27
7	41.8	41.8	17.1	16.2	21.6	20.9	19.9	19	23.6	22.9
6	34.2	34.2	13.8	13.2	17.7	17.2	16.2	15.5	19.3	18.8
5	26.4	26.4	10.7	10.3	13.8	13.5	12.6	12.2	15.1	14.8
4	20.1	20	8	7.7	10.5	10.3	9.6	9.2	11.5	11.3
3	13.8	13.8	5.5	5.3	7.3	7.1	6.6	6.4	8	7.8
2	7.8	7.8	3.2	3.1	4.2	4.2	3.9	3.8	4.6	4.6
1	2.6	2.6	1.2	1.1	1.5	1.5	1.4	1.4	1.7	1.6

Table 4.2: Storey displacement in X and Y direction for Linear static Analysis (ZONE III)

Story Drift Ratio										
Story	BFZ3		XBF		SDBF		VBF		KBF	
	X direc^n	Y direc^n	X direc^n	Y direc^n	X direc^n	Y direc^n	X direc^n	Y direc^n	X direc^n	Y direc^n
16	0.000548	0.000526	0.000756	0.000559	0.000695	0.000529	0.000755	0.000565	0.000665	0.000512
15	0.000974	0.000945	0.000857	0.000657	0.000851	0.00068	0.000881	0.000686	0.000844	0.000685
14	0.001385	0.001348	0.00094	0.000741	0.000981	0.000809	0.000984	0.000789	0.000996	0.000835
13	0.00174	0.001697	0.00101	0.000814	0.001092	0.000922	0.001073	0.000879	0.001124	0.000964
12	0.002042	0.001993	0.001061	0.000872	0.00118	0.001014	0.001141	0.000951	0.001228	0.001071
11	0.002284	0.002232	0.0011	0.000921	0.001255	0.001098	0.001198	0.001016	0.001318	0.001166
10	0.001972	0.001915	0.001049	0.000887	0.001175	0.001038	0.001131	0.00097	0.001226	0.001095
9	0.002085	0.002026	0.001055	0.000904	0.001208	0.00108	0.001151	0.001	0.001268	0.001144
8	0.002178	0.002118	0.001033	0.000895	0.001208	0.001091	0.001141	0.001001	0.001276	0.001162
7	0.002244	0.002183	0.000989	0.000868	0.001187	0.001084	0.00111	0.000985	0.001263	0.001161
6	0.002272	0.002213	0.000936	0.000833	0.00116	0.001073	0.001071	0.000963	0.001244	0.001157
5	0.001875	0.001817	0.000804	0.000724	0.00099	0.000924	0.000913	0.000831	0.001062	0.000997
4	0.001849	0.001795	0.00076	0.000692	0.000963	0.000907	0.000878	0.000807	0.00104	0.000984
3	0.001764	0.001716	0.000688	0.000634	0.000906	0.000863	0.000817	0.000759	0.000984	0.000939
2	0.001507	0.001473	0.000593	0.000555	0.000801	0.000773	0.00072	0.000678	0.000866	0.000835
1	0.000757	0.000744	0.000344	0.000328	0.000453	0.000443	0.000417	0.000398	0.000481	0.000468

Table 4.3: Storey drift in X and Y direction for Linear static Analysis (ZONE III)

Time Period in Seconds					
Modes	BF	XBF	SDBF	VBF	KBF
1	3.583	2.39	2.628	2.541	2.725
2	3.579	2.294	2.555	2.45	2.659
3	3.167	1.668	1.962	1.847	2.082
4	1.265	0.763	0.874	0.822	0.916
5	1.264	0.742	0.856	0.802	0.899
6	1.128	0.545	0.662	0.609	0.707
7	0.734	0.401	0.478	0.44	0.507
8	0.733	0.397	0.474	0.436	0.503
9	0.659	0.293	0.37	0.333	0.4
10	0.515	0.269	0.328	0.298	0.349
11	0.515	0.267	0.326	0.296	0.347
12	0.463	0.22	0.257	0.229	0.277

Table 4.4: Time Period in Seconds for Linear static Analysis (ZONE III)

V. CONCLUSION

In the current study T-shaped G+15 stories building is considered and made an effort to evaluate the seismic performance of bare frame and different types of braces are used under zone III by considering medium soil condition. Linear static analysis (LSA) is carried out, and compared the results. Major conclusions are as follows:

➢ Base shear

- Base shear of the structure directly depends on the self-weight of the building.
- Braced frame structure has baser shear value compared to bare frames.
- Base shear of braced frames increase because of bracings are added extra self-weight to the bare frame structure.
- Over all X-braced frame has more base shear value compared to bare frame and other types of bracings.
- K-braced frame is an alternative for X-braced frame with slightly less base shear value.

➢ Story Displacement

- The top story of the T-shaped building has maximum displacement for all types of structures.
- X-braced frame performed better in reducing story displacement compared to all other models.
- K-braced frame has almost similar displacement values compared to X-braced frames, seems to be a better alternative.

➢ Story Drift

- The story drift ratio is maximum at middle level of the story and decrease towards the roof level.
- Story drift is more in bare frame due to be short of stiffness in the frame compared to brace frame.

➢ Time Period

- The braced frame structure reduces time period and increases stiffness of the braced frame compared to bare frame.
- A braced frame model has less time period values compared to bare frames.
- X-braced frame has less time period compared to other models.
- On the basis of time period building is flexible (T > 1 sec).

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