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Behaviour of Multistorey RCC Structure with Different Type of Bracing System (A Software Approach)

Nauman Mohammed[1], Islam Nazrul[2]

Structure Engineer, Department of Civil Engineering, Faculty of Engineering and Technology, Jamia Millia Islamia, New Delhi, India [1]

Professor, Civil Engineering Department, Islamic University, Medinah Munawwarah, Kingdom of Saudi Arabia[2]

Abstract: Structures in high seismic risk areas may be susceptible to severe damage in a major earthquake. For the variety of structures and possible deficiencies that arise, several retrofitting techniques can be considered. Bracing system is one of the retrofitting techniques and it provides an excellent approach for strengthening and stiffening existing building for lateral forces. Also, another potential advantage of this system is the comparatively small increase in mass associated with the retrofitting scheme since this is a great problem for several retrofitting techniques. Our ability to build seismically safe structures with adequate seismic resistance has increased significantly in the past few decades. Many reinforced concrete frame structures built in seismically active areas are expected to perform inadequately in a seismic event.

Braced frames are known to be efficient structural systems for buildings under high lateral loads such as seismic or wind loadings. The fact that the lateral resistance of frame can be significantly improved by the addition of a bracing system has led to the idea of retrofitting seismically inadequate reinforced concrete frames with steel bracing system. Steel bracing systems have both practical and economical advantages. The potential advantage of bracing system is the comparatively small increase in mass associated with the retrofitting scheme since this is a great problem for several retrofitting techniques. The application of steel bracings is faster to execute. The steel bracings are usually installed between existing vertical members. Furthermore, if it is used in the structure, the minimum disruption of the building is obtained.

Keywords: Retrofitting, Reinforced Cement Concrete, Bracing, Lateral Loads

I. Introduction

During earthquake motions, deformations take place across the elements of the load-bearing system as a result of the response of buildings to the ground motion. As a consequence of these deformations, internal forces develop across the elements of the load-bearing system and displacement behaviour appears across the building. The resultant displacement demand varies depending on the stiffness and mass of the building. In general, buildings with higher stiffness and lower mass have smaller horizontal displacements demands. On the contrary, displacement demands are to increase. On the other hand, each building has a specific displacement capacity. In other words, the amount of horizontal displacement that a building can afford without collapsing is limited. The purpose of strengthening methods is to ensure that the displacement demand of a building is to be kept below its displacement capacity. This can mainly be achieved by reducing expected displacement demand of the structure during the strong motion or improving the displacement capacity of the structure.

II. Related Work

Badoux and Jirsa investigated numerically the behaviour of RC frames retrofitted with external bracing. Researchers stated that the lateral resistance of the existing frame structures is inadequate for two reasons. First, the perimeter frames, which feature weak short columns, are likely to fail in an undesirable mode. Secondly, code provisions may have been upgraded several times since construction, so that current seismic design loads are more than the original values.

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Youssef, Ghaffarzadeh and Nehdi also investigated the use of internal steel bracing for seismic performance of reinforced concrete frames. In their study, the use of concentric internal steel bracing for new construction was investigated experimentally.
Ghobarah and Abou Elfath have investigated analytically the seismic performance of a low-rise non-ductile reinforced concrete building rehabilitated using eccentric steel bracing.

III. OBJECTIVE OF THIS PAPER

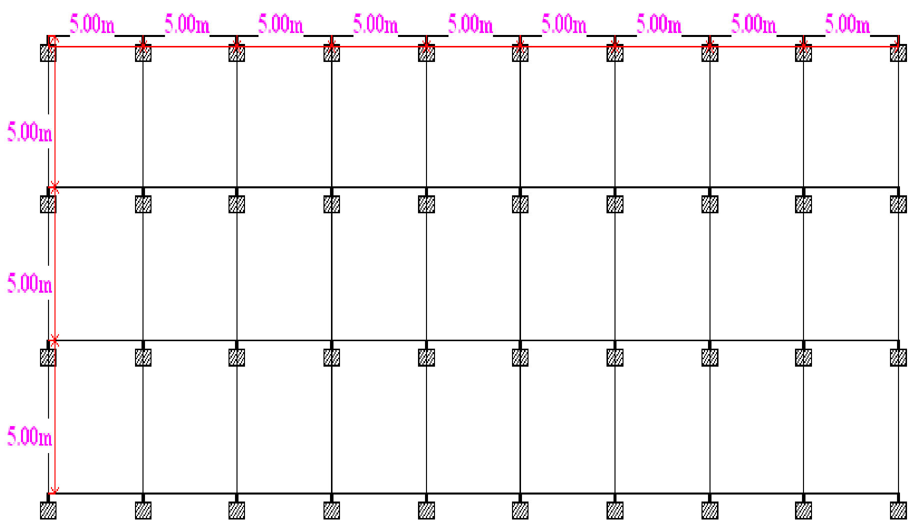
The objective of this paper is to evaluate the response of braced and unbraced structure subjected to seismic loads and to identify the suitable bracing system for resisting the seismic load efficiently.

IV. MODELLING & ANALYSIS OF BUILDING

The analysis of G+14 floors is carried out using STAAD V8i software for special moment resisting frame situated in zone 4.The RCC G+14 structure is analysed without bracings and with different types of bracings system. Bending moments, shear forces, storey shears, story drifts and axial forces is compared for all type of structural systems i.e. braced and unbraced structural system.

TABLE 1.MODELING DATA FOR BUILDING

Structure	SMRF
No. of stories	G+14
Type of building use	Residential
Young's modulus, E	21.7x106 kN/m^2
Grade of concrete	M25
Density of RCC	25 kN/m^3
Beam Size	0.3x0.5m
Column Size	0.5x0.5m
Dead Load Intensity	5 kN/m^2
Live Load Intensity	3.0 kN/m^2
Seismic Zone, Z	IV
Importance Factor, I	1
Response Reduction Factor, R$_F$	5



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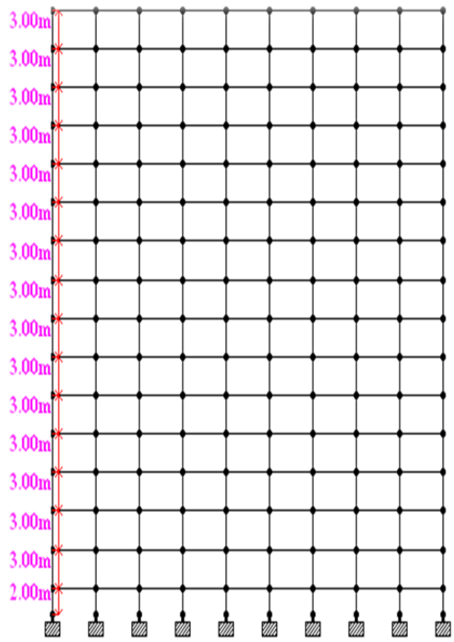

Fig. 2 Elevation of Unbraced Structure

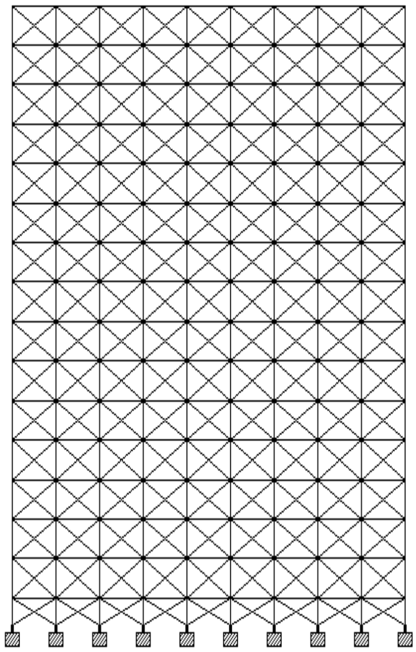

Fig. 3 Elevation of Cross Braced Structure

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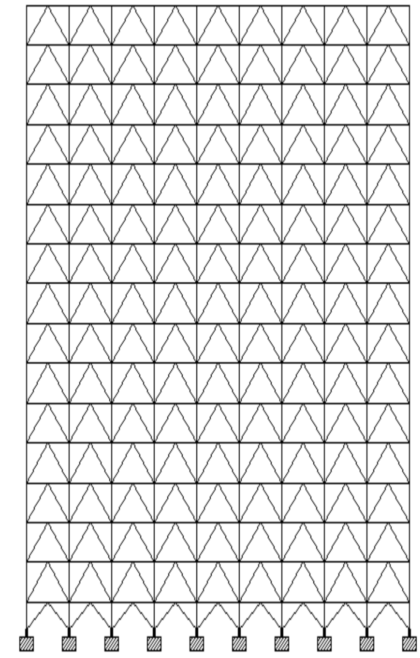

Fig. 4 Elevation of Chevron Braced Structure

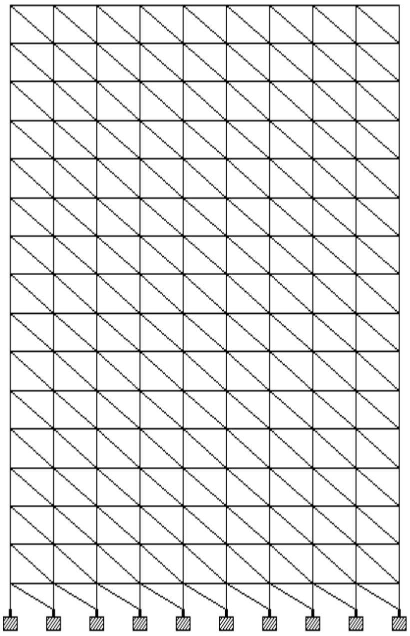

Fig. 5 Elevation of Diagonal Braced Stucture

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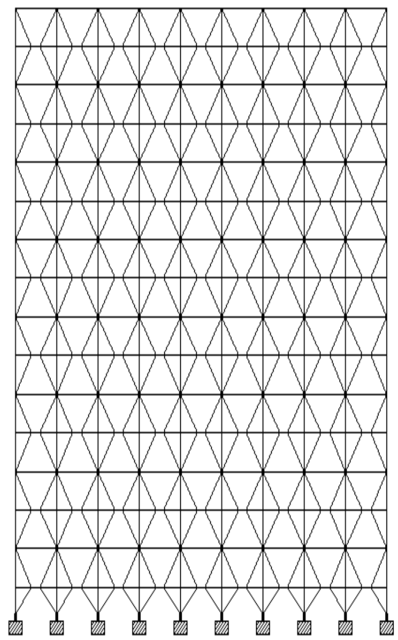

Fig. 6 Elevation of K - Braced Structure

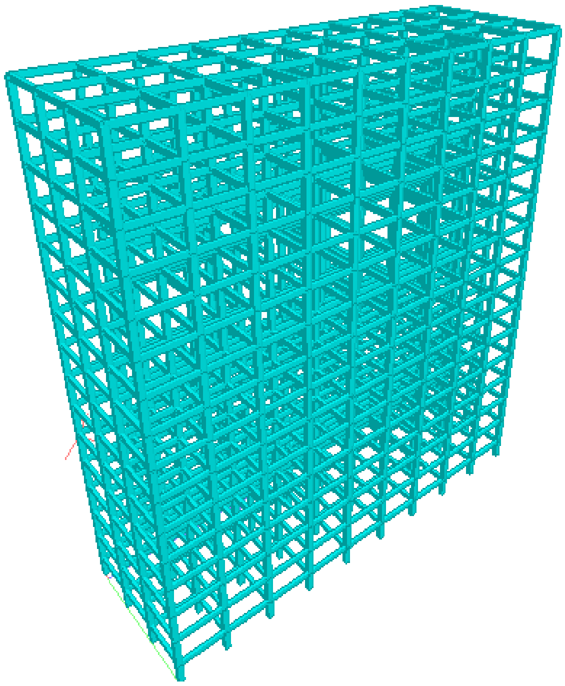

Fig.7 Unbraced Structure

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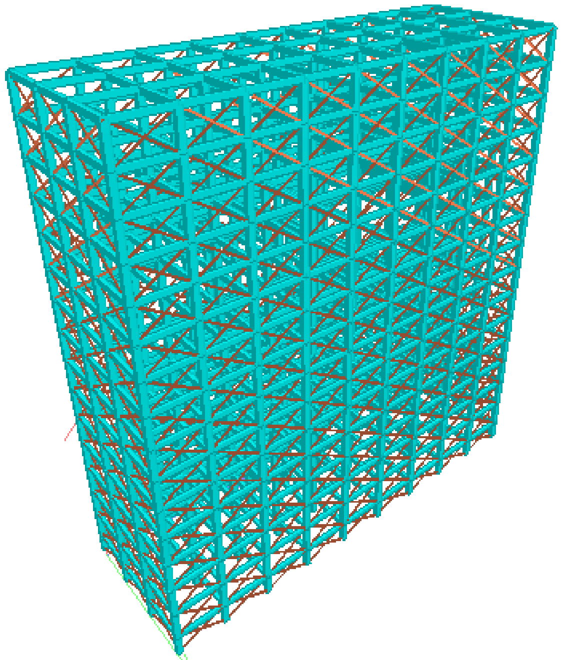

Fig.8 Structure with Cross Bracings

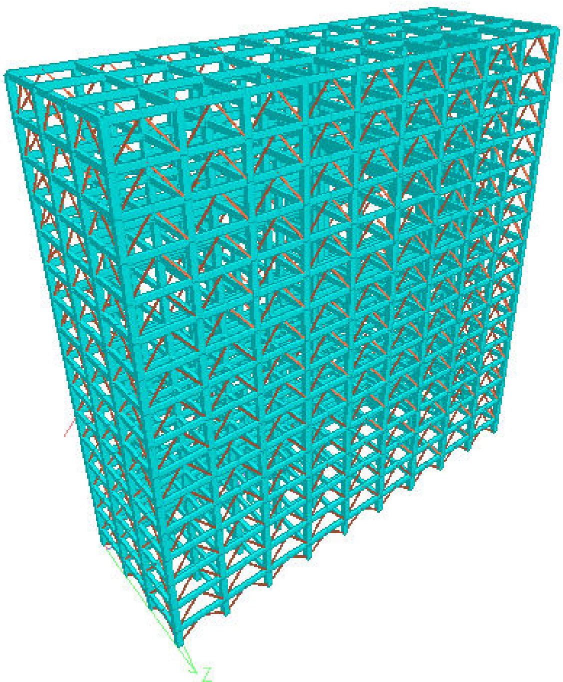

Fig.9 Structure with Chevron Bracings

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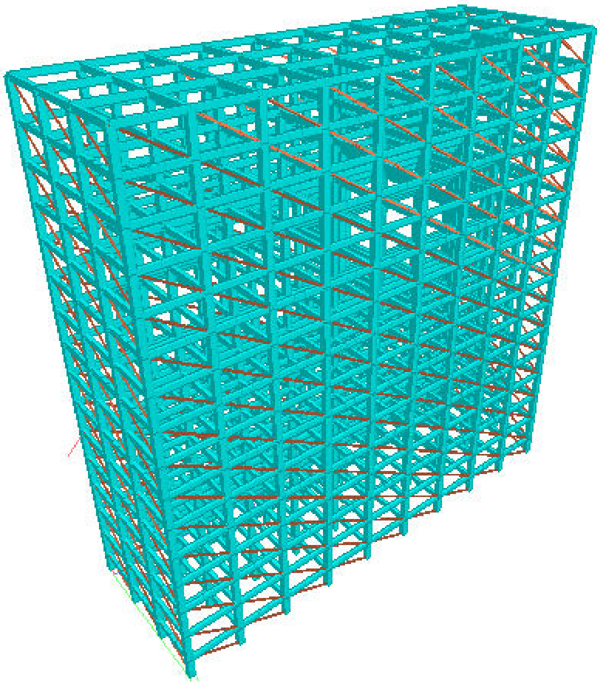

Fig.10 Structure with Diagonal Bracings

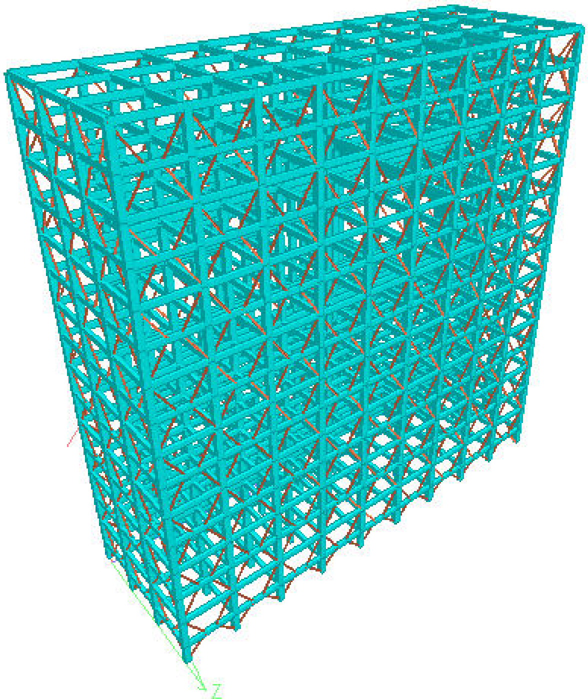

Fig.11 Structure with K- Bracings

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V. RESULTS

TABLE 2. MAXIMUM LATERAL DISPLACEMENT (MM) IN X DIRECTION

Level	Structure Type				
	Unbraced	Cross Braced	Chevron Braced	K- Braced	Diagonal Braced
15	34.769	20.73	21.239	24.712	24.818
14	34.127	20.247	20.784	23.621	23.75
13	33.083	19.515	20.078	23.386	23.49
12	31.655	18.561	19.142	21.827	21.948
11	29.89	17.424	18.012	21.006	21.108
10	27.84	16.141	16.724	19.143	19.257
9	25.553	14.743	15.308	17.872	17.97
8	23.072	13.258	13.791	15.844	15.951
7	20.436	11.71	12.199	14.253	14.346
6	17.683	10.119	10.553	12.159	12.259
5	14.843	8.502	8.872	10.36	10.447
4	11.945	6.873	7.172	8.272	8.366
3	9.012	5.244	5.466	6.352	6.432
2	6.076	3.623	3.767	4.324	4.414
1	3.204	2.03	2.093	2.366	2.435
Ground	0.714	0.556	0.545	0.625	0.657
Base	0	0	0	0	0

TABLE 3. MAXIMUM LATERAL DISPLACEMENT (MM) IN Z DIRECTION

Level	Structure Type				
	Unbraced	Cross Braced	Chevron Braced	K- Braced	Diagonal Braced
15	39.503	32.498	32.489	34.624	34.761
14	38.533	31.56	31.587	33.157	33.3
13	37.153	30.286	30.347	32.404	32.523
12	35.375	28.693	28.785	30.282	30.402
11	33.248	26.831	26.948	28.847	28.945
10	30.828	24.751	24.886	26.259	26.358
9	28.167	22.5	22.647	24.314	24.392
8	25.313	20.121	20.272	21.465	21.543
7	22.312	17.653	17.8	19.171	19.231
6	19.203	15.128	15.266	16.223	16.285
5	16.023	12.578	12.7	13.721	13.766
4	12.806	10.027	10.13	10.802	10.851
3	9.582	7.5	7.579	8.205	8.239
2	6.39	5.022	5.074	5.422	5.463
1	3.318	2.649	2.673	2.881	2.906
Ground	0.727	0.619	0.615	0.66	0.673
Base	0	0	0	0	0

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TABLE 4. MAXIMUM AXIAL FORCE (KN) IN COLUMNS FOR DEAD AND LIVE LOAD

Level	**Structure Type**				
	Unbraced	**Cross Braced**	**Chevron Braced**	**K- Braced**	**Diagonal Braced**
Base to Ground	3835.653	3780.03	3771.393	3766.493	3784.458
Ground to 1st	3586.31	3533.598	3524.994	3520.175	3538.032
1st to 2nd	3333.943	3284.542	3276.06	3271.318	3288.946
2nd to 3rd	3084.579	3038.525	3030.245	3025.683	3042.842
3rd to 4th	2837.964	2795.298	2787.296	2781.947	2799.475
4th to 5th	2593.836	2554.596	2546.944	2542.891	2558.585
5th to 6th	2351.94	2316.165	2308.93	2305.186	2319.923
6th to 7th	2112.039	2079.76	2073.008	2069.64	2083.249
7th to 8th	1873.903	1845.153	1838.946	1835.949	1848.336
8th to 9th	1637.316	1612.122	1606.52	1603.942	1614.966
9th to 10th	1402.07	1380.455	1375.516	1373.338	1382.932
10th to 11th	1167.964	1149.947	1145.728	1143.98	1152.035
11th to 12th	934.807	920.403	916.96	915.606	922.081
12th to 13th	702.415	691.632	689.02	688.075	692.885
13th to 14th	470.631	463.471	461.744	461.156	464.288
14th to 15th	239.589	236.05	235.271	235.043	236.411

TABLE 5. MAXIMUM AXIAL FORCE (KN) IN COLUMNS FOR SEISMIC LOAD IN X-DIRECTION

Level	**Structure Type**				
	Unbraced	**Cross Braced**	**Chevron Braced**	**K- Braced**	**Diagonal Braced**
Base to Ground	245.812	442.261	427.296	359.38	383.361
Ground to 1st	230.48	397.099	373.081	360.55	358.611
1st to 2nd	208.474	344.074	322.843	272.256	320.792
2nd to 3rd	185.774	295.283	276.485	278.432	282.02
3rd to 4th	163.401	250.88	233.297	199.282	244.459
4th to 5th	141.598	208.106	193.078	204.839	208.597
5th to 6th	120.506	169.139	155.732	134.409	174.597
6th to 7th	100.281	133.149	121.299	139.288	142.621
7th to 8th	81.113	107.834	97.842	87.329	112.834
8th to 9th	63.229	88.483	79.59	82.676	85.519
9th to 10th	46.896	70.074	62.288	54.719	64.034
10th to 11th	32.424	52.918	46.237	44.637	48.211
11th to 12th	20.163	37.342	31.754	27.092	34.13
12th to 13th	10.507	23.69	19.179	20.25	25.19
13th to 14th	5.546	12.35	6.261	7.038	15.728
14th to 15th	2.521	4.154	3.496	7.244	6.725

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TABLE 6. MAXIMUM AXIAL FORCE (KN) IN COLUMNS FOR SEISMIC LOAD IN Z-DIRECTION

Floor Level	**Structure Type**				
	Unbraced	**Cross Braced**	**Chevron Braced**	**K- Braced**	**Diagonal Braced**
Base to Ground	282.91	522.36	506.647	426.486	457.229
Ground to 1st	266.901	474.401	448.283	427.679	430.942
1st to 2nd	243.388	416.297	392.543	330.284	386.518
2nd to 3rd	218.59	361.211	339.841	337.211	341.58
3rd to 4th	193.814	309.216	289.957	246.522	298.089
4th to 5th	169.423	260.294	242.984	252.936	25.326
5th to 6th	145.611	214.512	199.041	170.77	216.508
6th to 7th	122.576	172.031	158.334	176.485	18.886
7th to 8th	100.547	133.112	121.164	105.47	143.768
8th to 9th	79.793	102.345	94.193	109.759	111.513
9th to 10th	60.627	81.154	73.974	66.907	82.542
10th to 11th	43.401	61.523	55.299	55.562	58.845
11th to 12th	28.512	43.785	38.499	34.294	42.223
12th to 13th	16.396	28.277	23.911	25.446	27.79
13th to 14th	7.5	15.363	11.904	10.279	15.948
14th to 15th	2.834	5.672	3.323	6.585	8.043

TABLE 7. MAXIMUM SHEAR FORCE (KN) IN COLUMNS FOR DEAD AND LIVE LOAD

Floor Level	**Structure Type**				
	Unbraced	**Cross Braced**	**Chevron Braced**	**K- Braced**	**Diagonal Braced**
Base to Ground	20.84	21.268	20.778	20.798	23.902
Ground to 1st	21.285	21.299	21.257	21.402	24.12
1st to 2nd	23.499	23.675	23.67	23.741	26.036
2nd to 3rd	25.865	26.204	26.262	26.406	28.352
3rd to 4th	27.956	28.44	28.553	28.642	30.38
4th to 5th	29.829	30.445	30.61	30.757	32.176
5th to 6th	31.503	32.237	32.453	32.546	33.758
6th to 7th	32.99	33.83	34.094	34.228	35.139
7th to 8th	34.3	35.233	35.544	35.628	36.331
8th to 9th	35.442	36.456	36.811	36.92	37.342
9th to 10th	36.421	37.503	37.902	37.965	38.181
10th to 11th	37.241	38.38	38.819	38.892	38.85
11th to 12th	37.892	39.076	39.555	39.584	39.34
12th to 13th	38.619	39.839	40.357	40.384	39.9
13th to 14th	39.018	40.291	40.844	40.854	40.15
14th to 15th	48.743	50.094	50.747	50.79	49.673

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TABLE 8. MAXIMUM SHEAR FORCE (KN) IN COLUMNS FOR SEISMIC LOAD IN X-DIRECTION

Floor Level	**Structure Type**				
	Unbraced	**Cross Braced**	**Chevron Braced**	**K- Braced**	**Diagonal Braced**
Base to Ground	36.764	48.631	40.136	35.396	54.84
Ground to 1st	37.245	22.558	23.625	26.755	27.189
1st to 2nd	37.882	23.675	23.827	27.019	27.33
2nd to 3rd	38.015	22.693	23.916	27.074	27.295
3rd to 4th	37.872	22.793	24.014	27.053	27.235
4th to 5th	37.483	22.897	24.085	26.987	32.176
5th to 6th	36.797	22.919	24.047	26.737	26.869
6th to 7th	35.758	22.788	23.833	26.326	26.413
7th to 8th	34.313	22.44	23.38	25.581	25.69
8th to 9th	32.408	21.813	22.625	24.588	24.642
9th to 10th	29.987	20.837	21.506	23.106	23.205
10th to 11th	26.995	19.435	19.942	21.286	21.311
11th to 12th	23.371	17.505	17.838	18.781	18.875
12th to 13th	19.043	14.904	15.057	15.786	15.783
13th to 14th	14.023	11.544	11.511	11.882	11.983
14th to 15th	8.485	7.425	7.234	7.557	7.516

TABLE 9. MAXIMUM SHEAR FORCE (KN) IN COLUMNS FOR SEISMIC LOAD IN Z-DIRECTION

Floor Level	**Structure Type**				
	Unbraced	**Cross Braced**	**Chevron Braced**	**K- Braced**	**Diagonal Braced**
Base to Ground	37.344	47.029	39.809	34.729	49.638
Ground to 1st	38.996	34.989	35.455	36.27	36.257
1st to 2nd	40.957	36.847	37.326	38.145	38.142
2nd to 3rd	41.044	37.112	37.573	38.352	38.339
3rd to 4th	40.867	37.204	37.638	38.317	38.33
4th to 5th	40.377	37.062	37.458	38.084	38.058
5th to 6th	39.563	36.652	37.002	37.47	37.5
6th to 7th	38.37	35.901	36.196	36.64	36.589
7th to 8th	36.736	34.73	34.963	35.202	35.253
8th to 9th	34.6	33.06	33.224	33.507	33.421
9th to 10th	31.902	30.808	30.897	30.939	31.017
10th to 11th	28.579	27.889	27.9	28.097	27.968
11th to 12th	24.567	24.217	24.145	24.081	24.193
12th to 13th	19.836	19.735	19.574	19.826	19.648
13th to 14th	14.154	14.191	13.954	13.929	14.092
14th to 15th	8.781	8.814	8.475	9	8.757

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TABLE 10. MAXIMUM BENDING MOMENT (KN-M) IN COLUMNS FOR DEAD AND LIVE LOAD

Floor Level	**Structure Type**				
	Unbraced	**Cross Braced**	**Chevron Braced**	**K- Braced**	**Diagonal Braced**
Base to Ground	28.513	28.363	28.398	28.466	28.61
Ground to 1st	32.741	32.715	32.823	32.865	31.74
1st to 2nd	36.479	36.606	36.805	36.993	35.305
2nd to 3rd	40.042	40.314	40.601	40.753	38.839
3rd to 4th	43.24	43.65	44.019	44.244	42.052
4th to 5th	46.12	46.661	47.108	47.338	45.003
5th to 6th	48.696	49.359	49.88	50.16	47.722
6th to 7th	50.984	51.759	52.35	52.621	50.155
7th to 8th	52.997	53.873	54.532	54.835	52.315
8th to 9th	54.748	55.712	56.437	56.717	54.209
9th to 10th	56.246	57.285	58.073	58.369	55.846
10th to 11th	57.502	58.602	59.452	59.712	57.256
11th to 12th	58.548	59.697	60.609	60.87	58.457
12th to 13th	59.296	60.466	61.43	61.643	59.348
13th to 14th	59.719	60.923	61.938	62.13	60.14
14th to 15th	97.627	99.433	101.168	101.365	98.231

TABLE 11. MAXIMUM BENDING MOMENT (KN-M) IN COLUMNS FOR SEISMIC LOAD IN X-DIRECTION

Floor Level	**Structure Type**				
	Unbraced	**Cross Braced**	**Chevron Braced**	**K- Braced**	**Diagonal Braced**
Base to Ground	63.126	68.364	59.3	60.304	79.711
Ground to 1st	63.697	38.282	40.177	45.499	46.213
1st to 2nd	58.305	34.743	36.598	41.583	41.912
2nd to 3rd	57.235	34.221	36.074	40.69	41.063
3rd to 4th	53.966	34.279	36.098	40.651	40.894
4th to 5th	56.612	34.385	36.133	40.683	40.816
5th to 6th	55.82	34.425	36.172	40.273	40.566
6th to 7th	54.534	34.362	36	39.994	40.051
7th to 8th	52.676	34.019	35.513	38.931	39.18
8th to 9th	50.167	33.303	34.621	37.851	37.862
9th to 10th	46.923	32.117	33.23	35.789	36.009
10th to 11th	42.863	30.354	31.235	33.546	33.523
11th to 12th	37.896	27.877	28.505	30.093	30.289
12th to 13th	31.882	24.469	24.827	26.171	26.121
13th to 14th	24.771	19.964	20.021	20.706	20.897
14th to 15th	16.694	14.334	14.058	14.684	14.628

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TABLE 12. MAXIMUM BENDING MOMENT (KN-M) IN COLUMNS FOR SEISMIC LOAD IN Z-DIRECTION

Floor Level	Structure Type				
	Unbraced	Cross Braced	Chevron Braced	K- Braced	Diagonal Braced
Base to Ground	64.811	67.858	59.998	60.255	74.301
Ground to 1st	67.359	60.486	61.275	62.655	62.657
1st to 2nd	63.846	57.545	58.27	59.506	59.522
2nd to 3rd	62.309	56.497	57.171	58.292	58.297
3rd to 4th	61.556	56.242	56.864	57.823	57.857
4th to 5th	60.62	55.773	56.332	57.196	57.176
5th to 6th	59.704	55.063	55.628	56.401	56.439
6th to 7th	58.248	54.246	54.735	55.48	55.389
7th to 8th	56.172	52.853	53.253	53.675	53.75
8th to 9th	53.384	50.765	51.066	51.556	51.415
9th to 10th	49.79	47.859	48.052	48.153	48.273
10th to 11th	45.299	44.01	44.086	44.412	44.21
11th to 12th	39.803	39.075	39.028	38.922	39.099
12th to 13th	33.253	32.966	32.791	33.14	32.865
13th to 14th	25.003	25	24.692	24.583	24.849
14th to 15th	17.269	17.312	16.751	17.531	17.205

VI. DISCUSSION ON RESULTS

Table 2 & Table 3 show the maximum lateral displacement for seismic load in X & Z direction respectively at different storey levels. The lateral displacements of the structure for various bracings system are compared. The maximum lateral displacement at terrace level in X direction is 34.769mm, 20.73mm, 21.239mm, 24.712mm and 24.818mm for unbraced, cross braced, chevron braced, K-braced & diagonal braced structural systems. Whereas the lateral displacement at the same storey level in Z direction for the above said structural systems are 39.503mm, 32.498mm, 32.489mm, 34.624mm & 34.761 mm respectively. It is noted that the lateral displacement is drastically reduced after the application of bracings system. Maximum reduction in the lateral displacement is observed after the application of cross bracings.

Table 4, Table 5 & Table 6 show the maximum axial force in columns for dead & live load, seismic load in X-direction and seismic load in Z direction respectively. The axial forces of the structure for various types of bracings systems are compared. For dead & live load case, it is observed that the axial force in the structure has been reduced after the application of the bracing system but the axial force values in the columns for the seismic loads are increased. The axial force for seismic load in X direction for unbraced structure at the base level is 245.812 kN which has been increased considerably to 442.261 kN, 427.296 kN, 359.38 kN and 383.361 kN for cross braced, chevron braced, K-braced & diagonal braced structure respectively. The maximum increment in axial force is observed in cross braced structure.

Table 7, Table 8 & Table 9 show the shear forces at different stories for all the structural systems i.e. unbraced, cross braced, chevron braced, K-braced & diagonal braced structural systems for dead & live load, seismic load in X direction and seismic load in Z direction respectively. It can be seen that the shear force for column for dead & live load for unbraced and different types of braced structural systems is almost the same, but there is a considerable change in the shear forces for seismic load in both the directions for unbraced and different types of braced structural systems. It is observed that maximum shear force for the unbraced structure for seismic load at base level in X direction is 36.764 kN and it has been increased to 48.631 kN, 40.136 kN, 35.396 kN and 54.84 kN for cross braced, chevron braced, K-braced & diagonal braced structure respectively. It has been reduced to 8.485 kN for unbraced and 7.425 kN, 7.234 kN, 7.557 kN and 7.516 kN cross braced, chevron braced, K-braced & diagonal braced structure respectively at terrace level.

Table 10, Table 11 & Table 12 show the maximum values of bending moments at different stories for all the structural systems i.e. unbraced, cross braced, chevron braced, K-braced & diagonal braced structural systems for dead & live

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load, seismic load in X and Z direction respectively. It can be seen that the bending moments for columns for dead & live load for unbraced and different types of bracing system is almost the same. It can be seen that the maximum bending moments for unbraced, cross braced, chevron braced, K-braced, and diagonal braced structure at base level is 63.126 kN-m, 68.364 kN-m, 59.3 kN-m, 60.304 kN-m and 79.711 kN-m respectively. It has been reduced to 16.694 kN-m, 14.334 kN-m, 14.058 kN-m, 14.684 kN-m and 14.628 kN-m for unbraced, cross braced, chevron braced, K-braced, and diagonal braced structure at terrace level respectively.

VII. CONCLUSION

After the analysis of the structure with different types of structural systems, it has been concluded that the displacement of the structure decreases after the application of bracing system. The maximum reduction in the lateral displacement occurs after the application of cross bracing system. Bracing system reduces bending moments and shear forces in the columns. The lateral load is transferred to the foundation through axial action. The performance of cross bracing system is better than the other specified bracing systems. Steel bracings can be used to retrofit the existing structure. Total weight of the existing structure will not change significantly after the application of the bracings.

REFERENCES

[1] Marc Badoux and James O. Jirsa, "Steel bracing of RC frames for seismic retrofitting", Journal of Structural Engineering, Vol. 116, No. 1, January, 1990.
[2] Mahtab M. and M. Zahedi,"Seismic Retrofit of steel frames using steel plate shear walls". Asian Journal of Applied Sciences. 1(4), pp 316-326, 2008.
[3] Bush T. D., Jones E. A. and Jirsa J. O.,"Behavior of RC frame strengthened using structural steel bracing", Journal of Structural Engineering, Vol. 117, No.4, April, 1991.
[4] Manish S. Takey and S.S.Vidhale,"Seismic response of steel building with linear bracing system (A software approach)", International Journal of Electronics, Communication and Soft Computing Science and Engineering, 2(1), pp 17-25, 2012.
[5] Desai J. P., Jain A. K. and Arya A. S., "Seismic response of R. C. braced frames", Computers and Structures Volume 29 No.4, pp 557-568, 1988.
[6] IS 1893(part 1) – 2002, "Criteria for earthquake resistant design of structures, part 1-general provisions and buildings", fifth revision, Bureau of Indian Standards, New Delhi, India.
[7] Viswanath K.G, Prakash K.B and Desai Anant, "Seismic Analysis of Steel Braced Reinforced Concrete Frames", International Journal of civil and structural engineering volume 1, no 1,pp 114-122, , 2010.
[8] Youssef M. A., Ghaffarzadeh H. and Nehdi M. "Seismic performance of RC frames with concentric internal steel bracing", Eng. Struct., 29, 1561-1568, 2007.
[9] Ghobarah A. and Abou Elfath H. "Rehabilitation of a reinforced concrete frame using eccentric steel bracing", Eng. Struct., 23, 745-755, 2001.

BIOGRAPHY

Mohammed Nauman received his B.Tech. degree in Civil Engineering from Jamia Millia Islamia, New Delhi, India, in 2008 and the M.Tech. degree in Earthquake Engineering from Jamia Millia Islamia, New Delhi, India, in 2013. Currently, he is a practicing structural engineer. His areas of designing are design of multistory RCC and steel structures. His main area of interest is the retrofitting of the existing RCC and steel structures.

Nazrul Islam received her B.Sc degree in Civil Engineering from Aligarh Muslim University, Aligarh, Uttar Pradesh, India, in 1984, the M.E.degree from University of Roorkee, Roorkee, Uttar Pradesh, India in 2004 and Ph.D. degree from Indian Institute of Technology, New Delhi, India in the year 1998. At present he is a Professor in Civil Engineering Department, Islamic University, Madinah Munawwarah, Kingdom of Saudi Arabia. His teaching and research areas include design of offshore structures and structural dynamics.