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Performance of BRB of RC Frame Structure with Concept of Soil Structure Intersection

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***Abstract*: Earthquakes are one of the most dangerous natural phenomena on the planet. Seismic waves throughout the ground will destroy structures, cost lives, and cost huge sums of money in losses and repairs. When these seismic waves penetrate the soil layer, their properties are greatly affected. The effect of the relation between the superstructure and the primary soil are not taken into account in conventional foundation layout techniques. The majority of the time, work is under the assumption that the basis is fix. For building design for hard soil, it is appropriate to ignore the impact of soil structure interaction. However, avoiding SSI has incredible effect on structural reaction and construction for a building built on either soft or medium soil. When abnormalities are found in a structure, various frameworks are used to reduce seismic reaction. Buckling Restrained Braced (BRB) are one such choice. In this study, a ten-storey vertically symmetric RC building is connected to a two-storey X shape BRB. The building's reaction can be studied in variety of soil conditions, including soft and medium. The impact of soil-structure interaction will be compared with the results obtained when the structure is assumed to be fixed at the base. ETABS Programming can be used to analyses various parameters such as a storey displacement, storey drift, and overturning moment in order to determine seismic execution. The structure's reaction can be determined using various research methods such as the Equivalent Static Force Method (ESFM), Response Spectrum Method (RSM), and Non-linear Time History Method (NLTHM).**

***Keywords*: Soil-Structure interaction, buckling restrained braces (BRB), vertically symmetric**

1. Introduction

- Throughout history, we've built impressive structures and cities only for them to encounter the forces of nature. Earthquakes are one of the Earth's most destructive forces — the seismic waves throughout the ground can destroy buildings, take lives, and costs tremendous amounts of money for loss and repair.
- According to the National Earthquake Information Center, there is an average of 20,000 earthquakes each year —16 of them being major disasters. On September 20, 2017, a magnitude 7.1 rocked Mexico's capital city and killed approximately 230 people.
- To design an earthquake-proof building, engineers need to reinforce the structure and counteract an earthquake's forces.
    - Using Buckling-Restrained Braces (BRB) is a method to counteract earthquake's forces.

2. Objective of Study

There are the many parameters of the study but the following of Parameters are under study: -

- Storey displacement, Base shear, and overturning moment.

There are the Three Analysis Method using to the Study: - Equivalent Static Method, Response Spectrum Method and Time History Method. In the present study purpose using to the Equivalent Static Method

- To study response of building when soil flexibility is considered.
- Obtain optimum location of BRB.

Table 1
Model Details

No BRB		
SF	SM	SS
9SF	9SM	9SS
BRB Frame at Corner		
CF	CM	CS
9CF	9CM	9CS
BRB Frame at Edge		
EF	EM	ES
9EF	9EM	9ES

Table 2
Material & section parameters

Material property	
Concrete grade	M30
Steel grade	Fe415
section property	
Beam dimension	230 x 450 mm
Column dimension	450 x 450 mm
Slab thickness	135 mm

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3. Analysis of Structural Model

In the present study total 18 no. of model was prepared by using ETABS software. There are Three Support Condition are taken: - Fixed, Medium Soil and Soft Soil.

Three Frames Are Considered: - Simple, BRB at Edge, BRB at Corner. Mass irregularity ratio of 3 is considered on 9th floor. Model number and model specification should be same for all three type of Condition model which is given in following table

Table 4
Seismic parameter

Seismic zone	IV
Soil type	Type II (medium soil), III (soft soil)
Importance factor	1
Response reduction factor	5

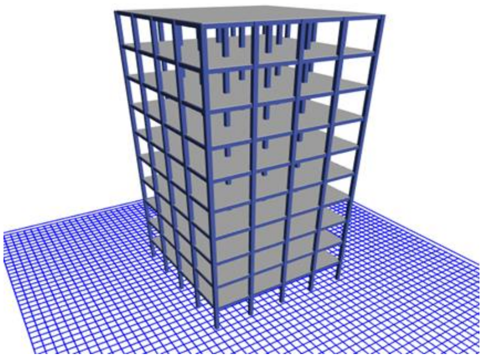

Fig. 1. Simple Building (No BRB)

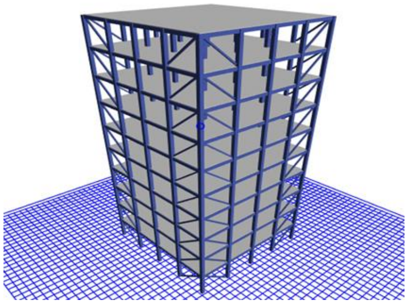

Fig. 2. Location of BRB at Corner

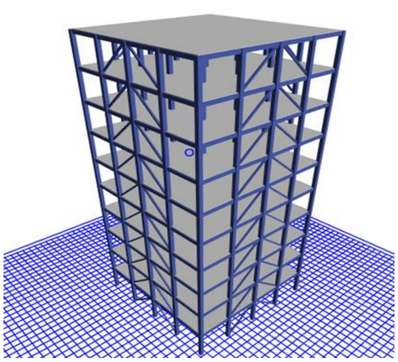

Fig. 3. Location of BRB at Edge

1) Modeling and Analysis of Structure

G+9 storey building with square floor plan of R.C.C frame designed by ETAB software. To prepared different model in ETAB, following data should be considered. And this primarily data should be same for all the models.

4. Results

1) Equivalent Static Analysis Method: Displacement Without BRB

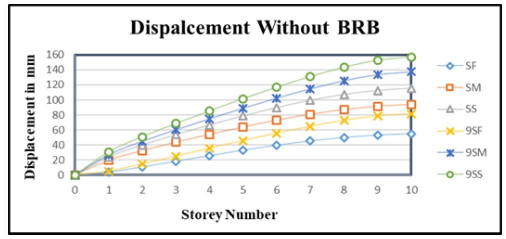

Fig. 4. Displacement without BRB

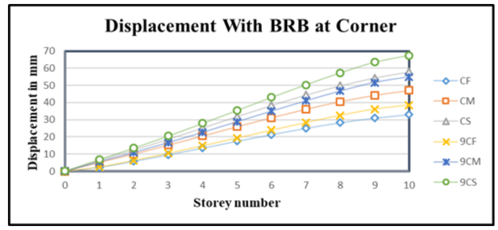

Fig. 5. Displacement with BRB at Corner

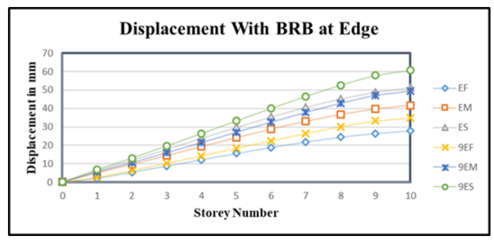

Fig. 6. Displacement with BRB at Edge

According to the findings, the most storey displacement was found for mass eccentric building with soft soil at the surface, and the least for normal buildings with BRBs at the edge and a fixed foundation. BRB decreased displacement by 35% to 65% since its introduction. When compared to BRB in the corner position, BRB at the edges was 6% to 7% more effective. For buildings with medium soil and soft soil at the foundation, there is only minor displacement.

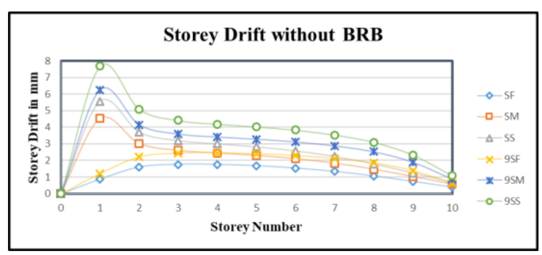

Fig. 7. Storey Drift without BRB

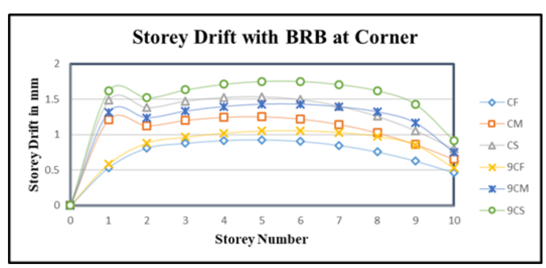

Fig. 8. Storey Drift with BRB at Corner

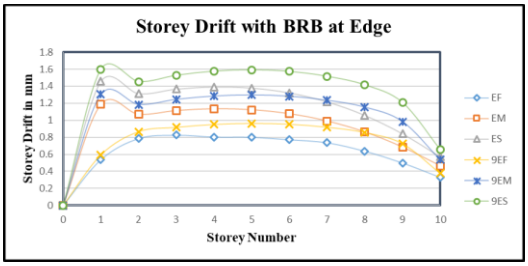

Fig. 9. Storey Drift with BRB at Edge

If the storey drift increase, so does the damage to the walls and column. Drift was greatly diminished when BRB was used. The middle storeys showed the greatest storey drift. As the base condition went from fixed to medium to soft soil, storey drift increased by 30-64%. As mass eccentricity was added, it increased by 30-34%. In addition, BRB at the edge was around 7% more effective than BRB at the corner.

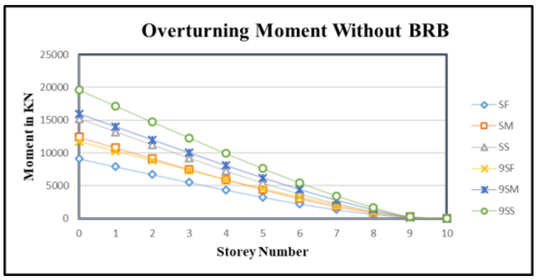

Fig. 10. Overturning Moment without BRB

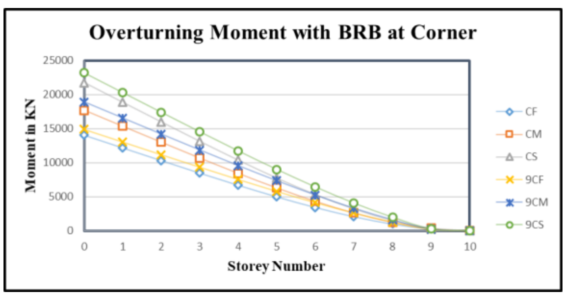

Fig. 11. Overturning Moment with BRB at Corner

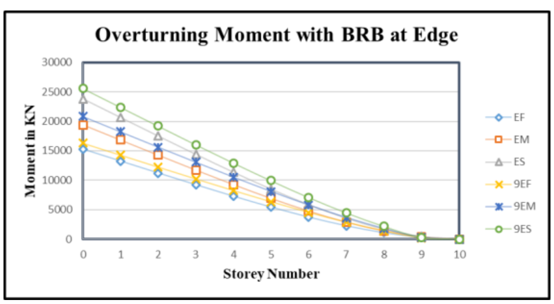

Fig. 12. Overturning Moment with BRB at Edge

The maximum for a mass eccentric building with soft soil at the base and BRB at the ground, an overturning moment was found. As the support state changed from fixed support to medium soil to soft soil, the overturning moment improved.

Table 5
Displacement without BRB

SF	SM	SS	9SF	9SM	9SS
0	0.008	0.01	0	0.012	0.013
3.777	19.46	23.89	5.204	26.89	30.53
10.64	32.43	39.82	14.66	44.73	50.87
18.19	43.62	53.57	25.10	60.19	68.52
25.72	54.12	66.46	35.63	74.88	85.30
32.90	64	78.588	45.92	89.01	101.44
39.49	73.02	89.674	55.73	102.42	116.79
45.23	80.88	99.316	64.80	114.82	130.98
49.82	87.17	107.04	72.73	125.67	143.42
53.00	91.54	112.41	78.68	133.82	152.76
54.77	94	115.42	81.41	137.60	157.11

Table 6
Displacement with BRB at Corner

CF	CM	CS	9CF	9CM	9CS
0	0	0.069	0	0.062	0.076
2.302	5.205	6.391	2.514	5.671	6.964
5.785	10.05	12.344	6.312	10.996	13.503
9.555	15.21	18.684	10.45	16.718	20.529
13.49	20.56	25.256	14.84	22.721	27.9
17.48	25.95	31.867	19.37	28.867	35.447
21.37	31.19	38.308	23.92	35.012	42.993
25.02	36.12	44.355	28.34	41.003	50.349
28.27	40.53	49.775	32.54	46.686	57.328
30.97	44.24	54.325	36.22	51.7	63.484
32.96	47.04	57.762	38.5	54.916	67.434

Table 7
Displacement with BRB at Edge

EF	EM	ES	9EF	9EM	9ES
0	0.062	0.076	0	0.068	0.084
2.179	5.099	6.261	2.55	5.602	6.879
5.379	9.694	11.904	6.268	10.694	13.132
8.741	14.47	17.777	10.205	16.042	19.698
12.17	19.34	23.758	14.288	21.559	26.473
15.59	24.17	29.683	18.426	27.134	33.319
18.86	28.80	35.365	22.521	32.642	40.082
21.86	33.05	40.595	26.464	37.946	46.596
24.45	36.76	45.14	30.14	42.902	52.681
26.48	39.70	48.753	33.253	47.134	57.878
27.82	41.70	51.206	34.87	49.436	60.705

Table 8
Storey Drift without BRB

SF	SM	SS	9SF	9SM	9SS
0.000	0.002	0	0	0	0
0.878	4.524	5.556	1.21	6.253	7.678
1.598	3.016	3.703	2.2	4.149	5.095
1.755	2.604	3.197	2.428	3.596	4.415
1.750	2.442	2.998	2.45	3.415	4.193
1.671	2.296	2.819	2.393	3.285	4.034
1.533	2.100	2.578	2.281	3.121	3.832
1.334	1.826	2.242	2.109	2.883	3.54
1.067	1.463	1.796	1.845	2.524	3.099
0.740	1.018	1.25	1.382	1.894	2.326
0.411	0.570	0.7	0.635	0.879	1.079

Table 9
Storey Drift with BRB at CornerTable title

CF	CM	CS	9CF	9CM	9CS
0	0	0	0	0	0
0.535	1.21	1.486	0.585	1.319	1.619
0.81	1.127	1.384	0.883	1.238	1.521
0.877	1.201	1.475	0.964	1.331	1.634
0.917	1.245	1.528	1.021	1.396	1.714
0.927	1.252	1.537	1.052	1.429	1.755
0.905	1.22	1.498	1.056	1.429	1.755
0.848	1.145	1.406	1.031	1.393	1.711
0.756	1.026	1.26	0.976	1.322	1.623
0.627	0.862	1.058	0.855	1.166	1.432
0.463	0.651	0.799	0.53	0.748	0.919

Table 10
Storey Drift with BRB at Edge

EF	EM	ES	9EF	9EM	9ES
0	0	0	0	0	0
0.538	1.185	1.456	0.593	1.303	1.599
0.786	1.069	1.312	0.865	1.184	1.454
0.826	1.112	1.366	0.916	1.244	1.527
0.804	1.133	1.391	0.95	1.283	1.576
0.801	1.122	1.378	0.962	1.296	1.592
0.772	1.076	1.321	0.952	1.281	1.573
0.737	0.99	1.216	0.917	1.234	1.515
0.637	0.861	1.057	0.855	1.153	1.415
0.499	0.684	0.84	0.724	0.984	1.208
0.329	0.465	0.57	0.376	0.535	0.657

Table 11
Overturning Moment without BRB

SF	SM	SS	9SF	9SM	9SS
9125	12410	15238	11744	15972	19613
7914	10763	13217	10278	13979	17165
6707	9122	11201	8816.4	11990	14723
5514	7500	9209.8	7365.7	10017	12300
4354	5922	7272.6	5941.5	8080.5	9922.4
3252	4423	5431.9	4564.6	6207.8	7622.8
2240	3047	3742.1	3261.3	4435.3	5446.3
1359	1848	2269.5	2064.1	2807.2	3447.1
654.3	889.8	1092.6	1011.5	1375.6	1689.2
180.8	245.9	301.9	147.5	200.6	246.4
0	0	0	0	0	0

Table 12
Overturning Moment with BRB at Corner

CF	CM	CS	9CF	9CM	9CS
14032	17697	21732	14889	18890	23195
12171	15349	18848	13031	16532	20301
10314	13009	15974	11177	14180	17412
8481	10696	13134	9338.3	11847	14547
6697	8446	10371	7532.6	9556.2	11734
5002	6308	7746.5	5786.8	7341.4	9014.8
3446	4346	5336.6	4134.5	5245.2	6440.7
2089	2635	3236.6	2616.7	3319.7	4076.4
1006	1268	1558.2	1282.3	1626.7	1997.5
278.0	350.6	430.6	187.1	237.4	291.5
0	0	0	0	0	0

Table 13
Overturning Moment with BRB at Edge

EF	EM	ES	9EF	9EM	9ES
15262	19397	23818	16293	20822	25568
13237	16823	20658	14260	18223	22377
11218	14258	17508	12231	15630	19193
9223	11723	14395	10218	13058	16035
7283	9257	11367	8242.7	10533	12934
5440	6914	8490.2	6332.3	8092.3	9936.9
3747	4763	5849.0	4524.2	5781.7	7099.5
2273	2888	3547.3	2863.4	3659.3	4493.4
1094	1390	1707.8	1403.1	1793.1	2201.8
302.4	384.3	471.9	204.7	261.6	321.3
0	0	0	0	0	0

Table 14
Base Reaction

SF	SM	SS	9SF	9SM	9SS
422.4	586.7	727.1	511.1	712.5	880.2
CF	CM	CS	9CF	9CM	9CS
649.4	837.8	1031.5	648.1	835.1	1027
EF	EM	ES	9EF	9EM	9ES
706.3	913.4	1125.3	709.2	924.5	1137.6

5. Base Reaction

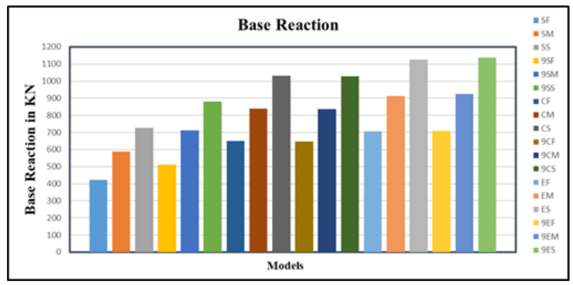

Fig. 13. Base Reaction

A mass eccentric building with a soft soil foundation and a BRB at the edge attracted the greatest base reaction. The addition of mass eccentricity, on the other hand, had no significant impact on the response.

6. Conclusion

The important conclusions which can be derived from this research work are as follow: -

- Optimum response is achieved by using a fixed base with no mass eccentricity and adding BRB at the edge point.
- When BRB is used, displacement is reduced by 40-75 percent.
- In the case of a building with spring dashpots, there is small displacement at the base line. When soft or medium soil is present in the earth, treating the foundation as fixed can be unnecessary technique when examine a building. When hard soil is available, however, it can be overlooked.
- If BRB is used, drift is reduced by 51-61 percent. As result, there could be less damage to the walls.
- A mass eccentric configuration with soft soil at the bottom and BRB at the edge attracts the most lateral force.
- Where a mass eccentric structure has soft soil at the

foundation and a BRB at the tip, the overturning moment is greatest because the lateral load is greatest.

- According to the findings, BRB monitors quake reaction more effectively at the edge that at the corner.

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