Comparative Study on Conventional Frame and Combined Model Frame under High Earthquake Zone

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Abstract - In this study, 3D analytical model 12 storey structure generated for basic model frame and combined model frame are evaluated by linear static (Response spectrum) and non-linear (Push over) analysis in high earthquake zone by structural analysis tool ETABS.

From the linear static Response spectrum analysis it can be seen that displacement, storey drift, and time period are more in basic model as compared to combined model. The frequency and storey shear are more in combined model as compared to the basic model.

From above studies it can also be seen that the non-linear static pushover analysis shows formation of hinges at performance point in basic model frame are more that leads to quaking the structure and required retrofitting as compared with combined model frame, the combined model frame behaves much better in high earthquake as compared with basic model frame.

***Key Words*:** Asymmetric building, Response spectrum analysis and Pushover analysis in ETABS.

1. INTRODUCTION

Earthquake disaster always one of the greatest natural calamities thrust upon mankind. Past earthquake has demonstrated that common buildings are highly vulnerable to strong seismic ground motion and typical design methods, lack basic resistance to earthquake forces. Urgent measure of seismic strengthing is required to upgrade seismically to huge stock of such existing building. A number of prescriptive techniques for retrofitting of such buildings are suggested by various interest groups, but a formal quantitative approach in necessary to this effort of retrofitting.

The current study deals with the comparative study on basic model frame and combined model frame of 12 storey building which is situated in high earth quake zone (zone V). The response spectrum analysis and non-linear static push over analysis is carried out. The ETABS software is used to analysis and the results are compared. The comparative study includes the displacement, storey drift, frequency and time period, storey shear, from non linear push over analysis displacement, base shear and performance point. It is found that the basic model frame requires a retrofitting after the analysis (zone 5). The combined model doesn't require a retrofitting.

1.1 OBJECTIVES

The objective of the current study is to compare combined model frame and basic model frame and comparing the behavior of model for analyzed results with the following objectives:

This study is comprised of three phases,

1. Creation of 3D basic frame model and combined frame model (no. of story 12).

2. Analysis basic model frame and combined model frame by linear response spectrum analysis and non-linear static pushover analysis.

3. Study and compare the behavior of combined model frame and basic model frame for analyzed results.

2. BUILDING DESCRIPTION

The asymmetric building plan is taken for the current study; a building is an ordinary moment resisting frame building. A 12 story RC frame building is taken for the analysis. The story height is 3m taken for all floors. The area of the plan is 30m X 24m. The total height of the structure is 36m. The building frame element is modeled in ETABS and it is classified as beam and concrete elements, slab is modeled as thin membrane.

Table-1 Sectional details of basic model

Model type	Story	Column	Beam	Slab
	9 to 12	300X1000	230X600	200
Basic model	5 to 8	300X1000	230X600	200
	B to 4	300X1000	230X600	200

Table -2: Sectional details of combined model

Model type	Story	Column	Beam	Slab
	9 to 12	300X1200	230X600	200
Combined	5 to 8	300X1300	230X600	200
	B to 4	300X1400	230X600	200

Table-3: Seismic loading zone

DETAIL	VALUE
R(response reduction factor)	5
I(Importance factor)	1
Z(Zone-III)	0.32
Sa/G(Soil type II)	Type2

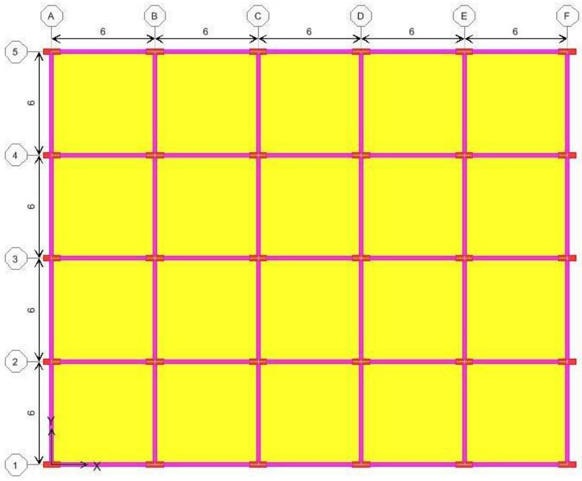

Fig- 1: Plan of the model

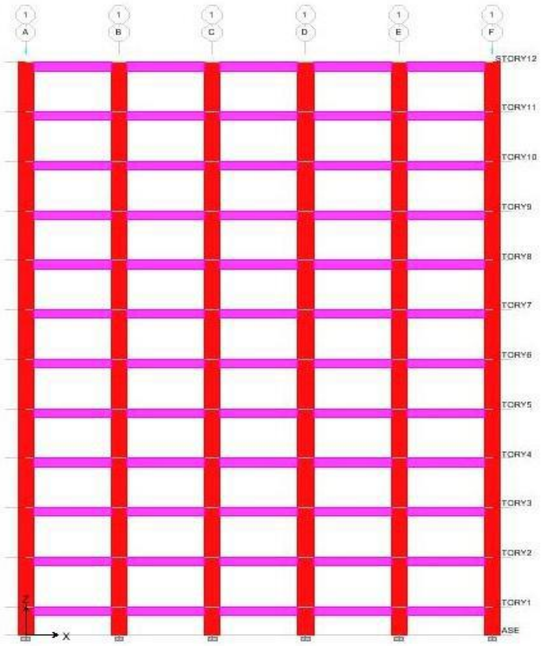

Fig-2: Elevation of Basic model

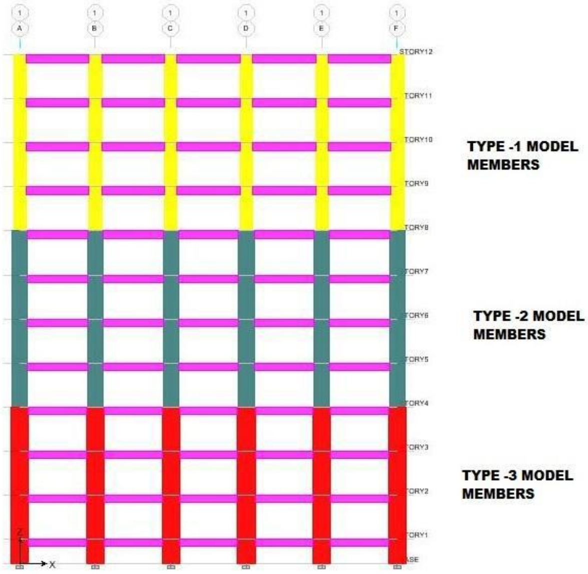

Fig- 3: Eevation of combined model

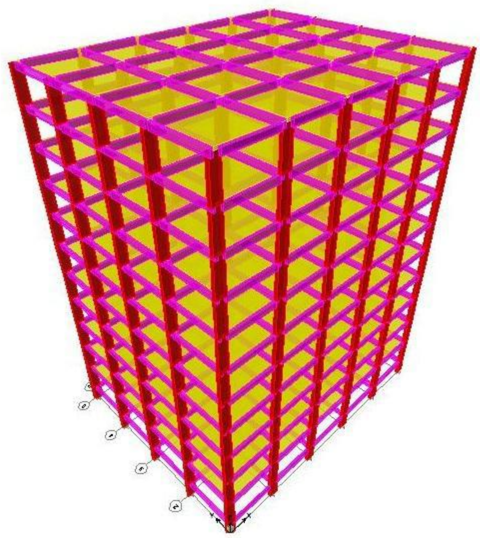

Fig- 4: 3D View of combined model

2.1 METHODOLOGY

The 12-story a conventional RC Frame structure with same size of beams and columns and Combined RC Frame structure is modeled with varied column sizes are modeled in ETABS. Then the frames are analyzed by the linear dynamic analysis (Response spectrum analysis) and non-linear static analysis (Pushover analysis) under earthquake zone V and soil type II.

3. RESULT AND DISCUSSTION

3.1 Response Spectrum Analysis

I) Time period

Table- 4: Time period in sec

Storey	TP-BM	TP-CM
1	3.13329	2.97272
2	2.46142	2.27445
3	2.2881	2.09282
4	1.03232	0.98529
5	0.7841	0.70764
6	0.70831	0.62201
7	0.60475	0.57545
8	0.43495	0.39747
9	0.42122	0.37662
10	0.37612	0.31291
11	0.31844	0.2982
12	0.28266	0.23497

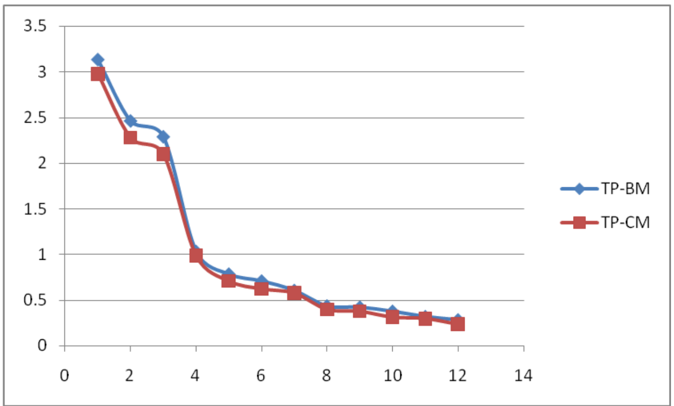

Fig 5 Time Period in modes

II) Frequency

Table 5: Frequency in cycle/sec

Storey	FR-BM	FR-CM
1	0.319154	0.336392
2	0.406269	0.439667
3	0.437043	0.477825
4	0.968696	1.014934
5	1.275356	1.413156
6	1.411813	1.607696
7	1.653587	1.737761
8	2.299141	2.515932
9	2.374079	2.655224
10	2.658719	3.195838
11	3.140289	3.35351
12	3.537844	4.255953

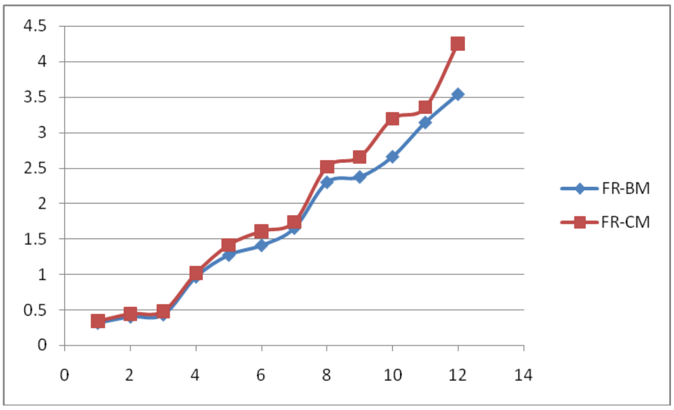

Fig 6: Freequancy WRT to modes

III) Displacement

Table 6: Displacement in x-directin

Storey	UX-BM	UX-CM
STORY12	44.5737	41.5885
STORY11	43.0209	39.6793
STORY10	40.8848	37.2671
STORY9	38.0943	34.2639
STORY8	34.6705	30.6632
STORY7	30.6554	26.5791
STORY6	26.0957	22.0897
STORY5	21.0489	17.2782
STORY4	15.6115	12.3133
STORY3	9.9987	7.5229
STORY2	4.7055	3.345
BASE	0	0

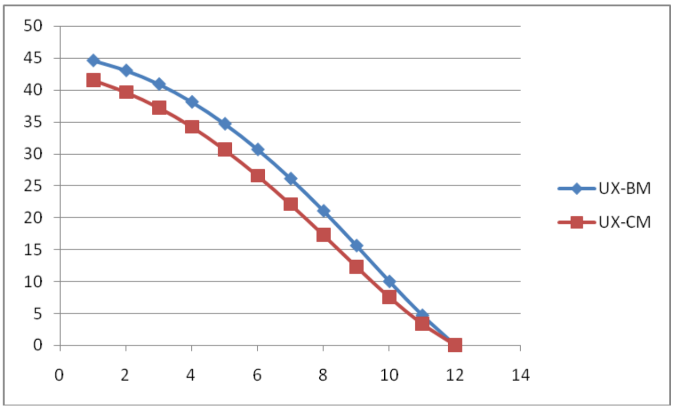

Fig 7 Displacement in X- direction

Table -7: Displacement in Y-direction

Storey	UY-BM	UY-CM
STORY12	59.1764	56.2413
STORY11	57.9218	55.0145
STORY10	55.6453	52.7821
STORY9	52.4082	49.5997
STORY8	48.3077	45.5636
STORY7	43.4173	40.8701
STORY6	37.803	35.479
STORY5	31.5281	29.447
STORY4	24.6369	22.8185
STORY3	17.1559	15.7885
STORY2	9.1764	8.3423
BASE	0	0

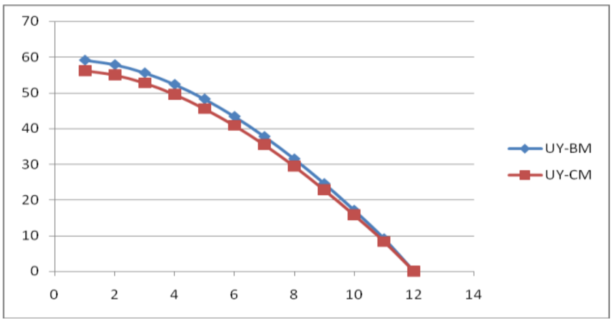

Fig-8 Displacement in Y-direction

IV) Storey Drift Ratio

Table 8: Storey Drift Ratio in X-direction

Storey	Drift X BM	Drift X CM
12	0.000574	0.000685
11	0.000779	0.000857
10	0.000979	0.001029
9	0.001145	0.001176
8	0.001285	0.00128
7	0.001406	0.001362
6	0.001508	0.001421
5	0.001587	0.001439
4	0.001615	0.001375
3	0.001515	0.001195
2	0.001128	0.000807
1	0.000417	0.000279

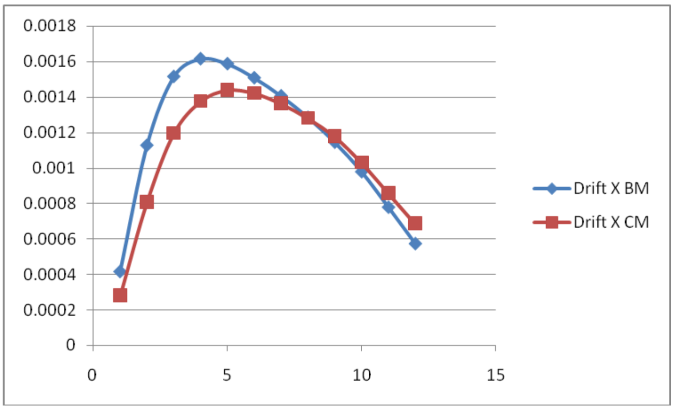

Fig 9 Storey Drift in X-direction

Table 9 Storey drift in Y-direction

Storey	Drift Y BM	Drift Y CM
12	0.00053	0.000527
11	0.000918	0.000904
10	0.001203	0.001187
9	0.001421	0.001399
8	0.001607	0.001542
7	0.00178	0.001708
6	0.001933	0.001857
5	0.002067	0.001985
4	0.002189	0.002054
3	0.002292	0.002139
2	0.002174	0.001978
1	0.000865	0.00079

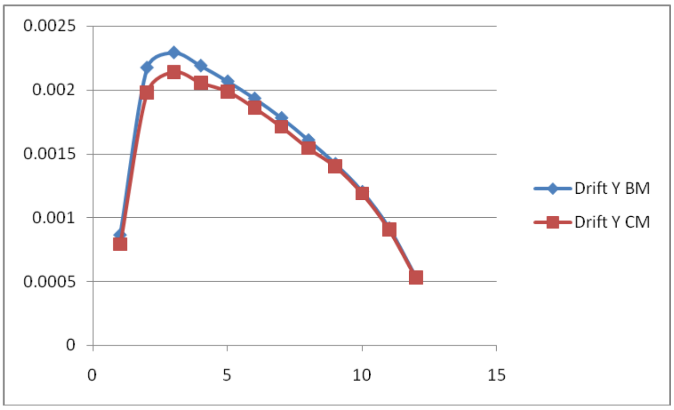

Fig 10 Storey Drift in Y-direction

V) Storey Shear

Table 10: Storey Shear in X-direction

Storey	VX-BM	VX-CM
STORY12	545.5	658.03
STORY11	1055.31	1234.92
STORY10	1389.62	1584.28
STORY9	1608.62	1798.16
STORY8	1787.85	1967.4
STORY7	1954.9	2123.22
STORY6	2104.83	2277.9
STORY5	2255.65	2464.42
STORY4	2434.75	2691.1
STORY3	2616.8	2900.56
STORY2	2732.55	3020.87
STORY1	2738.89	3027.4

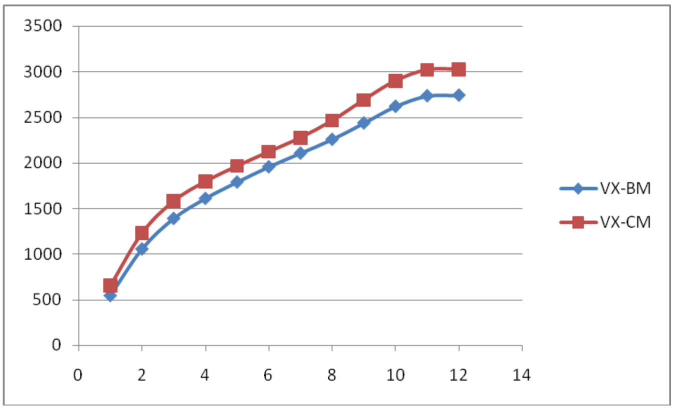

Fig 11 Storey shear in X-direction

Table 11 Storey Shear inY-direction

Storey	VY-BM	VY-CM
STORY12	398.43	433.43
STORY11	753.06	806.94
STORY10	978.8	1049.68
STORY9	1151.23	1227.78
STORY8	1301.41	1387.92
STORY7	1445.28	1540.32
STORY6	1573.13	1678.51
STORY5	1686.74	1796.15
STORY4	1791.93	1910.09
STORY3	1904.53	2033.21
STORY2	2016.97	2153.99
STORY1	2024.44	2162.72

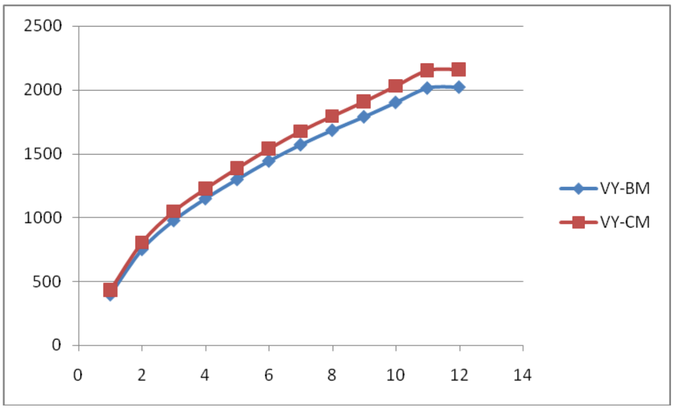

Fig 12 Storey Shear in Y-direction

3.2 Pushover Analysis

I) Pushover curves

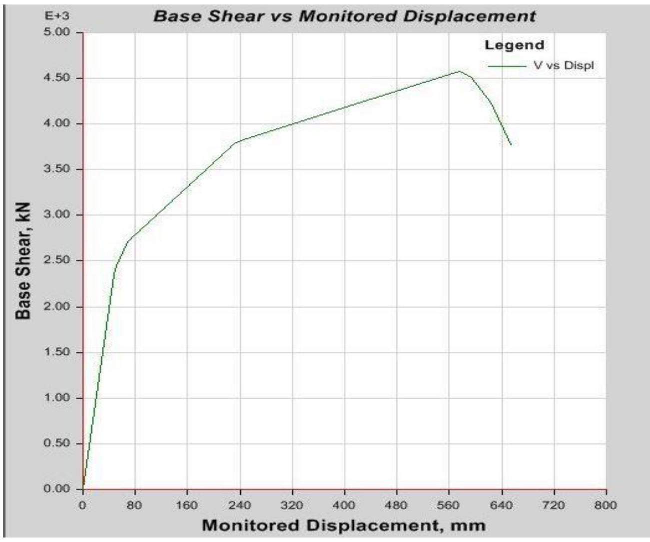

Fig 13 Base shear vs displacement in Basic model*

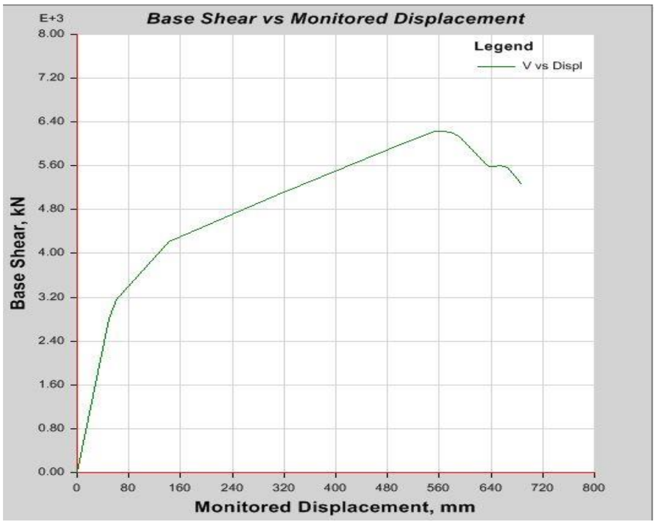

Fig 14 Base shear vs displacement in Combined model

II) Performance point

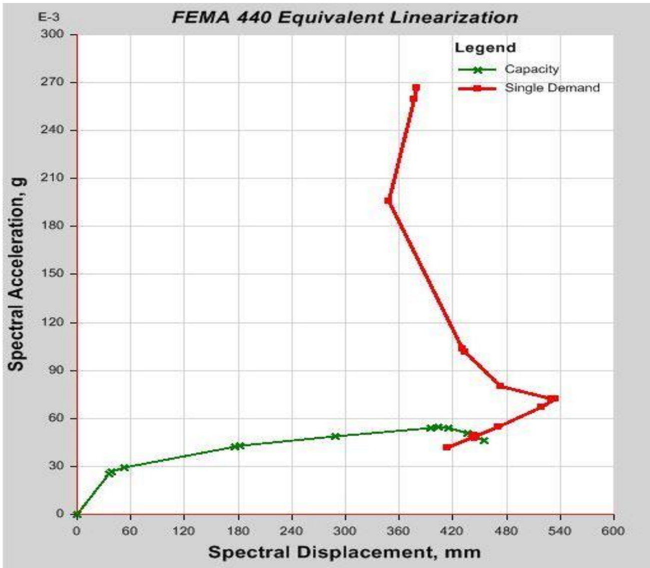

Fig 15 Performance of Basic model

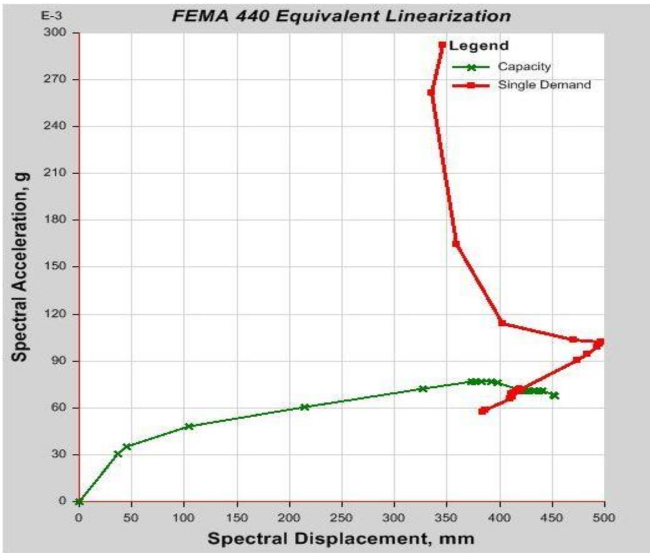

Fig 16 Performance point at Combined model

Table 12 Parameters of Performance point

Model	Spectral Acceleration	Spectral Displacement	Base shear	Displacement
Basic	0.048	444	4043	637
Combined	0.071	418.7	5673	629

III) Hinge Status

Table 14 Hinges status at basic model

Step	A-B	B-C	C-D	D-E	>E	A-IO	IO-LS	LS-CP	>CP	Total hinges
0	1896	0	0	0	0	1896	0	0	0	1896
1	1836	60	0	0	0	1896	0	0	0	1896
2	1716	180	0	0	0	1896	0	0	0	1896
3	1556	340	0	0	0	1896	0	0	0	1896
4	1316	580	0	0	0	1596	300	0	0	1896
5	1296	600	0	0	0	1596	300	0	0	1896
6	1296	600	0	0	0	1346	550	0	0	1896
7	1296	600	0	0	0	1346	550	0	0	1896
8	1296	520	80	0	0	1346	550	0	0	1896
9	1296	460	140	0	0	1346	450	100	0	1896
10	1296	360	240	0	0	1346	350	200	0	1896
11	1296	320	280	0	0	1346	300	250	0	1896

Table 14 Hinges status at combined model

Step	A-B	B-C	C-D	D-E	>E	A-IO	IO-LS	LS-CP	>CP	Total hinges
0	1896	0	0	0	0	1896	0	0	0	1896
1	1836	60	0	0	0	1896	0	0	0	1896
2	1616	280	0	0	0	1896	0	0	0	1896
3	1366	530	0	0	0	1896	0	0	0	1896
4	1346	550	0	0	0	1571	325	0	0	1896
5	1296	600	0	0	0	1396	500	0	0	1896
6	1296	530	70	0	0	1371	500	25	0	1896
7	1296	525	75	0	0	1371	455	70	0	1896
8	1296	505	95	0	0	1371	450	75	0	1896
9	1296	475	125	0	0	1371	425	100	0	1896
10	1296	430	170	0	0	1371	400	125	0	1896
11	1296	425	150	25	0	1371	350	175	0	1896
12	1296	425	115	60	0	1371	350	175	0	1896
13	1296	425	100	75	0	1371	350	175	0	1896
14	1296	425	90	85	0	1371	350	175	0	1896
15	1296	425	80	95	0	1371	350	175	0	1896
16	1296	390	95	115	0	1371	350	175	0	1896
17	1296	350	125	125	0	1371	310	215	0	1896
18	1296	300	175	125	0	1371	275	250	0	1896
19	1296	300	175	80	45	1371	225	300	0	1896

4. CONCLUSIONS

In the present work a 12 storied structure is analysed in ETABS and designed as per IS 456 & IS1893.

- The combined model shows significant reduction in time period about 14% as compared to the basic model. Due to the reduction in the time period the mass and flexibility of combined model is more as compared to the basic model.
- The combine model shows significant reduction in displacement along X-direction is about 29% & displacement along y-direction about 10% as compared to basic model. Due to reduction of displacement in combined model it gives regard strength and stability to the structure.
- By using the combined model structure helps in reducing the storey drift ratio about 33% and 9% along Y-direction. Due to the significant reduction in the storey drift ratio the probability collapse of the structure reduced.
- Combined model frame shows good performance under non-linear static pushover analysis as compared to the basic model frame
- Plastic hinges are more in case of basic model frame as compared to the combined model frame. Most of are in the range of LS-CP hence the structural element which is lies in that range point increases the vulnerability of the structure and such element requires retrofitting.
- As compared to the basic model combined shows significant reduction in the displacement and spectral displacement is about 1.27% and 6.07% at performance point.
- Combined model frame shows significant increases in base shear is about 40.03% as compare to the basic model frame at performance point.
- Combined model frame shows significant increases in Spectral acceleration is about 47.03% as compare to the basic model frame at performance point.

From above Conclusions, it can be concluded that by the use of combined model frame in structures the seismic response of building can be reduced under high Earthquake. Hence retrofitting work ca be avoided.

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