EVALUATION OF PROGRESSIVE COLLAPSE OF MULTISTORY MRF BUILDING

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Abstract - *The aim of this study is to investigate whether Moment Resisting Frame steel structures which have been designed based on seismic codes, are able to resist progressive collapse with damaged columns at different locations under seismic loading. The progressive collapse potential has been assessed in connection with 4,7 and 15-story buildings with 4 bays by applying the alternate load path method recommended in GSA guidelines. Member removal in this manner is intended to represent a situation where an extreme event, such as vehicle impact or past earth quake shock or construction error, may cause a critical column, as a result of local or global buckling, to lose a part or whole of its load bearing capacity. In contrast with 3-D models, two-dimensional frames represent very high sensitivity to base shear reduction and element removal. In case of the middle column removal, the structure is more robust than in a corner column removal situation. The influence of story number, redundancy and location of critical eliminated elements has been discussed.*

Key Words: Progressive collapse, GSA, DCR, Storey drift, Base shear.

1.INTRODUCTION

Structural safety has always been a key preoccupation for responsible for the design of civil engineering projects. One of the mechanisms of structural failure which has gained increased attention over the past few decades is referred to as progressive collapse. One or several structural members suddenly fail, whatever the cause (accident, attack or earthquake), and the building then collapses progressively, every load redistribution then causes the failure of other structural elements, until the complete failure of the building or a major part of it. This phenomenon is now gradually taken into account in design standards because of the catastrophic nature of its consequences, rather than for its high probability of occurrence. The attention of the engineers was first drawn to the issue of progressive collapse after the partial collapse of a building called 'Ronan Point', in London, in 1968. Several normalization committees then started to rethink and improve their standards pertaining to progressive collapse design procedures. Nonlinear analysis gives an image of the behavior of the structure in case of strong earthquakes, when it is assumed that the elastic capacity of it will be exceeded. Consequently design engineers have the convenience of noticing the collapse modes, the potential of progressive collapse or to detect possible errors in the design of the structure.

2. PROBLEM STATEMENT

Beam size -0.23*0.45m
Column size-0.23*0.45m
Span of beam-5m
Span of column-5m
Load combination as per GSA

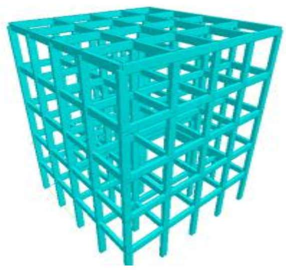

Fig - 2.1 Staad pro Model of the structure

3. METHODOLOGY

The step-by-step procedure for conducting the linear elastic, static analysis for progressive collapse as per GSA is as follows.

Step 1. Remove a vertical support from the location being considered and conduct a linear-static analysis of the structure. Load the model with 2(DL + 0.25LL).

Step 2. Determine members and connections that have DCR values that exceed the acceptance criteria. If the DCR for any member end connection exceeds based upon shear force, the member is to be considered as a failed member. In addition, if the flexural DCR values for both ends of a member or its connections, as well as the span itself, exceed (creating a three hinged failure mechanism), the member should be considered a failed member. Failed members should be removed from the model, and all the dead and live loads which are associated with failed member should be applied on the remaining members.

Step 3. For a member or connection whose QUD/QCE ratio exceeds the applicable flexural DCR values, place a hinge at the member end or connection to release the moment. This hinge has to be located at the center of flexural yielding for the member or connection. Use rigid offsets and/or stub members from the connecting member as needed to model the hinge in the proper location. For yielding at the end of a member the center of flexural yielding should not be taken to be more than ½ the depth of the member from the face of the intersecting member, which is usually a column.

Step 4. At each inserted hinge, apply equal-but-opposite moments to the stub/offset and member end to each side of the hinge. The magnitude of the moments should equal the expected flexural strength of the moment or connection, and the direction of the moments should be consistent with direction of the moments in the analysis performed in Step 1. **Step 5.**Re-run the analysis and repeat Steps 1 through 4. Continue this process until no DCR values exceed the criteria. If moments have been re-distributed throughout the entire building and DCR values are still exceeded in areas outside of the allowable collapse region, the structure will be considered to have a high potential for progressive collapse.

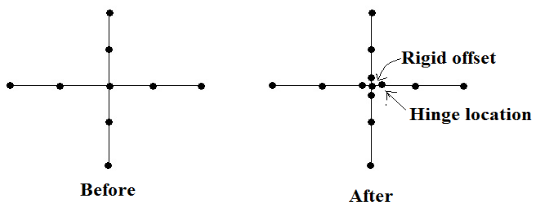

Fig - 3.1 Rigid offset placement

4. RESULT AND DISCUSSION

Comparison of storey drift, base shear and vertical displacement between RCC frame of G+4, G+7 and G+15 building before removal and after removal of column along x-direction

G+4 building

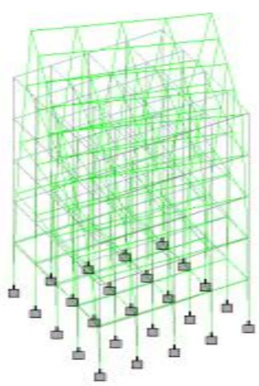

Fig. - 4.1 Displacement in X direction

Storeydrift :-

Table -1

Storey no.	RCC frame	
	Before removal of column	After removal of column
0	0	0
1	1.54	1.694
2	6.16	6.787
3	13.87	15.279
4	24.66	27.17
5	34.35	37.84

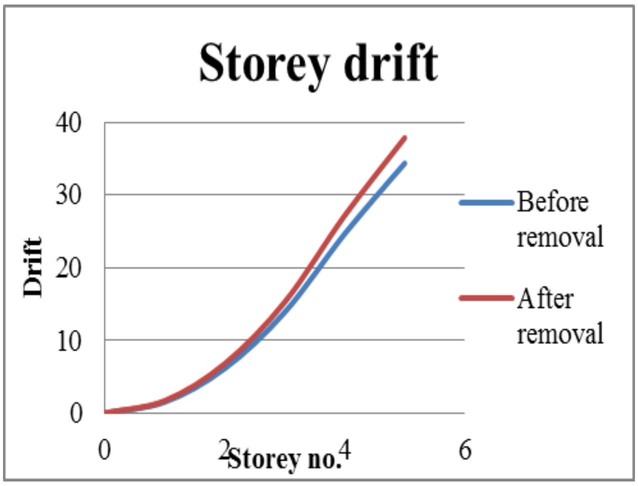

Chart -1: Drift in X direction

Base shear :-

Table -2

Storey no.	RCC frame	
	Before removal of column	After removal of column
0	0	0
1	3.91	4.13
2	15.709	16.522
3	35.346	37.175
4	62.838	66.089
5	87.513	92.04

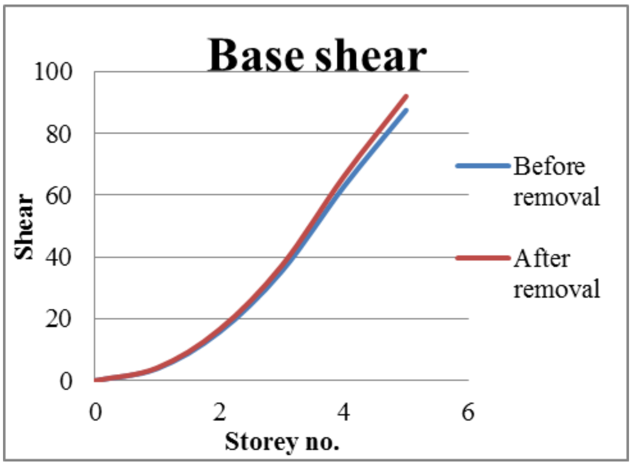

Chart -2: Base shear in X direction

Vertical displacement :-

Table -3

Storey no.	RCC frame	
	Before removal of column	After removal of column
0	0	0
1	0.464	0.585
2	0.836	1.054
3	1.114	1.405
4	1.296	1.636
5	1.383	1.747

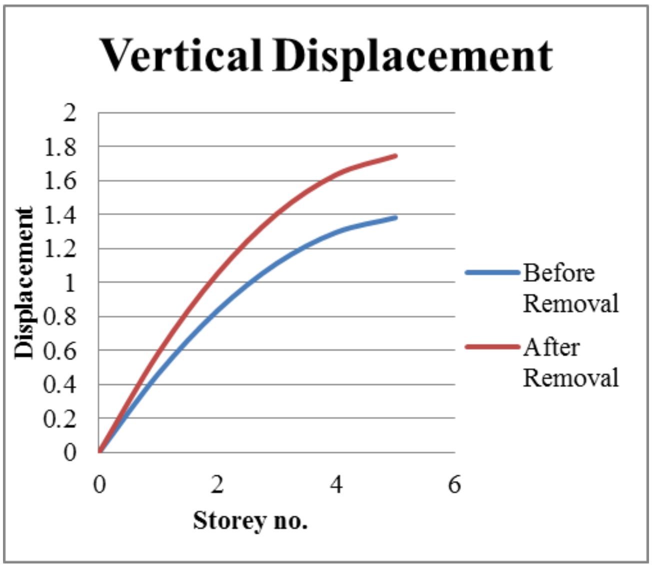

Chart -3: Displacement in X direction

G+7 building

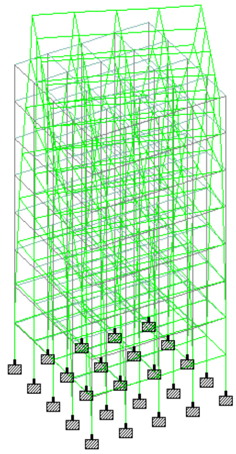

Fig. - 4.2 Displacement in X direction

Storeydrift :-

Table -4

Storey no.	RCC frame	
	Before removal of column	After removal of column
0	0	0
1	0.656	0.722
2	2.61	2.88
3	5.89	6.49
4	10.47	11.528
5	16.37	18.018
6	23.57	25.96
7	32.08	35.33
8	37.35	41.129

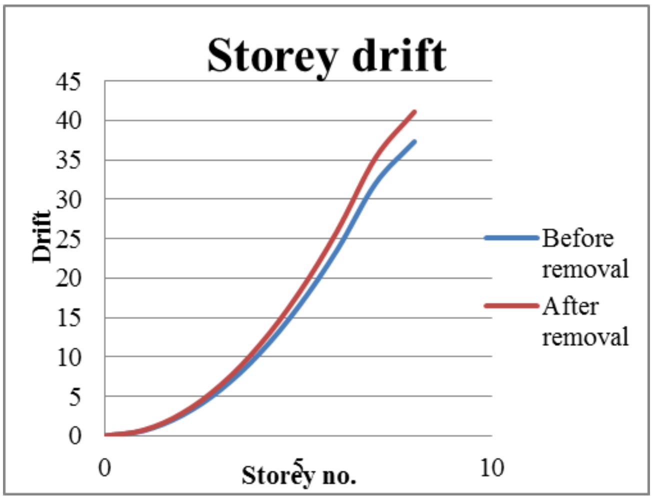

Chart -4: Drift in X direction

Base shear :-

Table – 5

Storey no.	RCC frame	
	Before removal of column	After removal of column
0	0	0
1	1.661	1.753
2	6.673	7.014
3	15.015	15.782
4	26.693	28.057
5	41.708	43.83
6	60.059	63.129
7	81.747	85.925
8	95.167	100.031

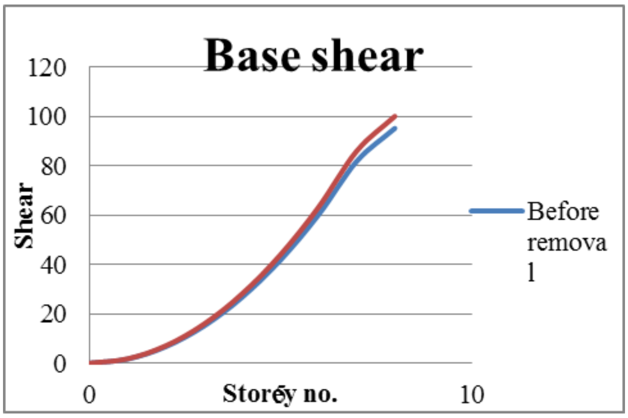

Chart -5: Base shear in X direction

Vertical displacement :-

Table – 6

Storey no.	RCC frame	
	Before removal of column	After removal of column
0	0	0
1	0.8	0.97
2	1.3	1.83
3	1.8	2.57
4	2.2	3.19
5	2.56	3.68
6	2.89	4.05
7	3.18	4.3
8	3.35	4.41

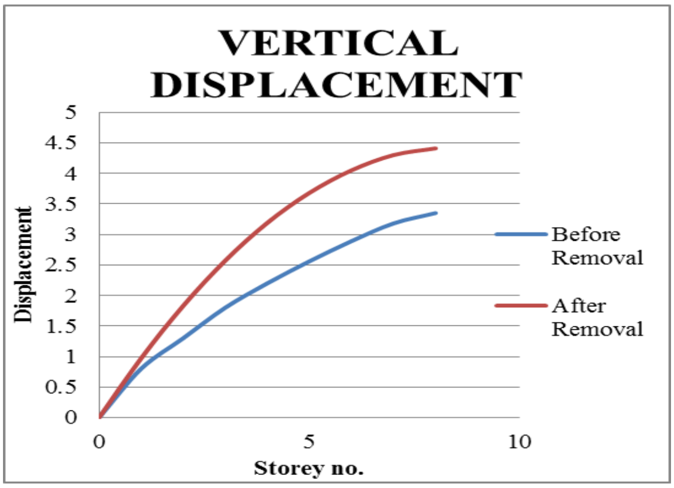

Chart -6: Displacement in X direction

G+15 building

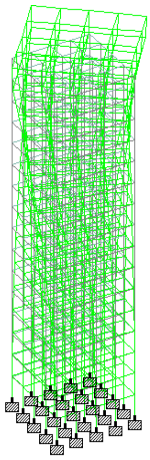

Fig. - 4.3 Displacement in X direction

Storey drift :-

Table – 7

Storey no.	RCC frame	
	Before removal of column	After removal of column
0	0	0
1	0.176	0.193
2	0.703	0.773
3	1.58	1.738
4	2.81	3.091
5	4.39	4.829
6	6.33	6.963
7	8.62	9.471
8	11.26	12.375
9	14.25	15.664
10	17.59	19.338

11	21.29	23.408
12	25.33	27.852
13	29.73	32.692
14	34.48	37.917
15	39.59	43.527
16	42.15	46.132

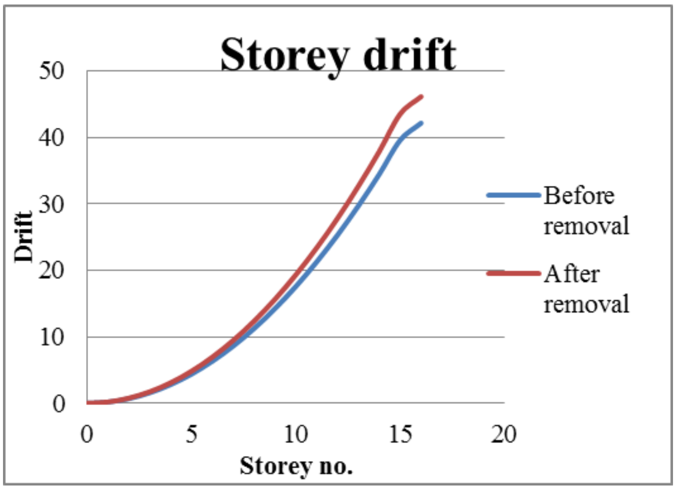

Chart -7: Drift in X direction

Base shear :-

Table – 8

Storey no.	RCC frame	
	Before removal of column	After removal of column
0	0	0
1	0.448	0.468
2	1.793	1.88
3	4.035	4.233
4	7.173	7.527
5	11.207	11.76
6	16.138	16.935
7	21.966	23.051
8	28.69	30.108
9	36.311	38.105
10	44.828	47.044
11	54.242	56.923
12	64.553	67.743
13	75.76	79.504
14	87.864	92.206
15	100.864	105.849
16	106.288	111.343

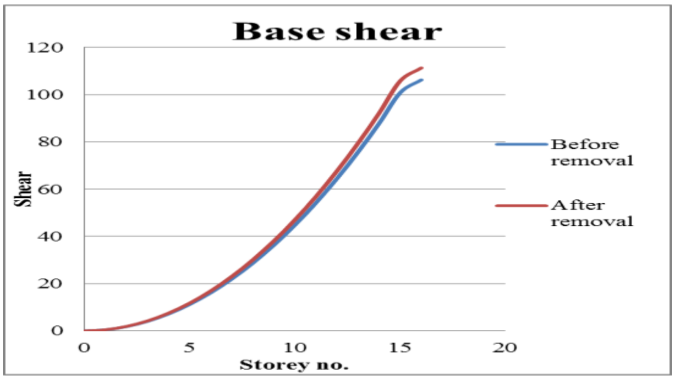

Chart -8: Base shear in X direction

Vertical displacement :-

Table – 9

Storey no.	RCC frame	
	Before removal of column	After removal of column
0	0	0
1	2.056	2.28
2	3.995	4.43
3	5.81	6.446
4	7.51	8.33
5	9.08	10.07
6	10.52	11.68
7	11.84	13.14
8	13.03	14.46
9	14.08	15.63
10	15.01	16.66
11	15.8	17.54
12	16.46	18.28
13	16.98	18.86
14	17.38	19.29
15	17.64	19.59
16	17.76	19.72

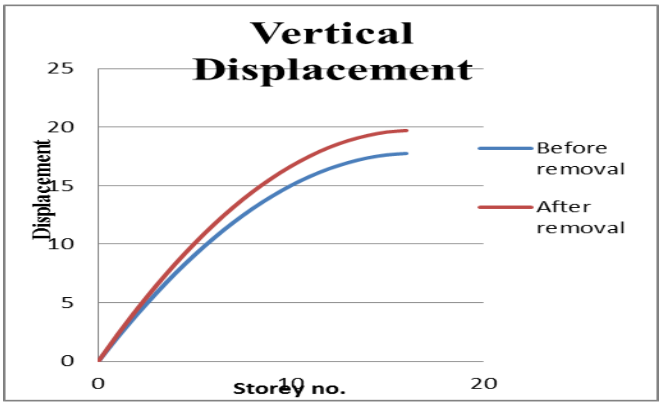

Chart -9: Displacement in X direction

3. CONCLUSIONS

[1] For G+4 building storey drift after removal of column is having 8 to 10 % greater than before removal of column.

[2] For G+4 building base shear after removal of column is having 5 to 6 % greater than before removal of column.

[3] For G+4 building vertical displacement after removal of column is increased by 26%.

[4] For G+7 building storey drift after removal of column is having 8 to 10 % greater than before removal of column.

[5] For G+7 building base shear after removal of column is having 5 to 6 % greater than before removal of column.

[6] For G+7 building vertical displacement after removal of column is increased by 31%.

[7] For G+15 building storey drift after removal of column is having 8 to 10 % greater than before removal of column.

[8] For G+15 building base shear after removal of column is having 5 to 6 % greater than before removal of column.

For G+15 building vertical displacement after removal of column is increased by 37%.

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