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LEVELWISE BRACED MULTISTOREYED BUILDING FRAMES SUBJECTED TO GRAVITY AND EARTHQUAKE LOADS

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ABSTRACT

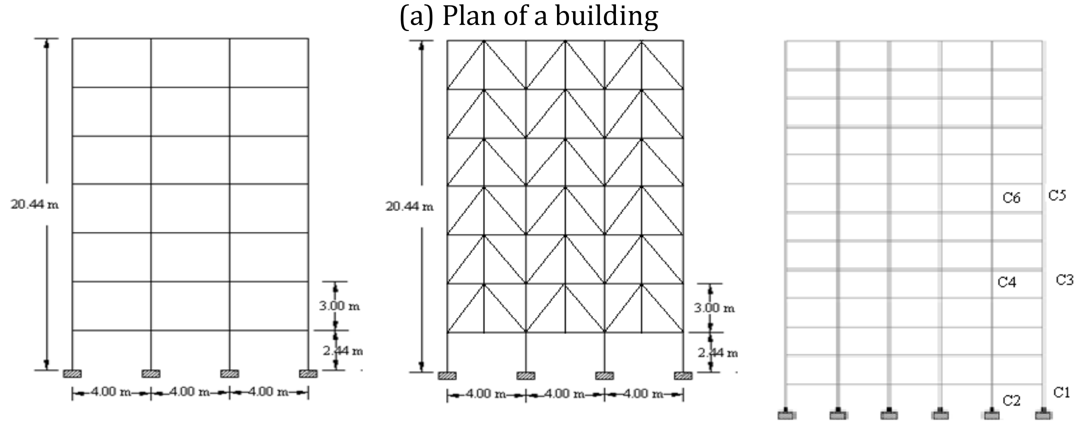
The structure in high seismic areas may be susceptible to the severe damage. Structure has to resist gravity load as well as lateral load which can develop high stresses. Now-a-days, shear wall in R.C.structure and steel bracings in steel structure are most popular system to resist lateral load due to earthquake, wind, blast etc. Wall bracing is a construction technique used to improve the structural performance of a building. Bracing systems include wood or steel or RCC components that help evenly distribute loads and increase the safety of the structure. While traditional framing can support the weight of the roof and floors above, it is not able to resist lateral stresses caused by wind, earthquakes or other forces.

Bracing is efficient because the diagonals work in axial stress and therefore call for minimum member sizes in providing stiffness and strength against horizontal shear. Through the addition of the bracing system, load could be transferred out of the frame and into the braces, by passing the weak columns while increasing strength. In this study R.C.C. building is modeled and analyzed for 3-bay and G+11 structure in three Parts viz.,

(i) Model without RC bracing (bare frame), (ii) Model completely RC braced (fully braced frame), (iii) Model with partially RC level wise braced frames. The computer aided analysis is done by using STAAD-PRO to find out the effective lateral load system during earthquake in high seismic areas. Total 298 possible combinations of level wise bracings are carried out.

Keywords-Bracing, lateral load, strength, stability, Bare frame, fully braced fram etc..

(a) Plan of a building



(a) Bare frame ***(b) Fully zip braced frame*** ***c) specific member considered for analysis***

Figure 2. Configurations used for analysis

Table 1: Models used for this analysis

Sr. No.	Model	Frame Types	Storey Variation	Bay Variation	Beam depth(mm)
1	I	Bare Frame	G+11	4 and 5	350 to 600
2	II	Fully Braced Frame	G+11	4 and 5	350 to 600
3	III	Bay wise Braced Frame	G+11	4 and 5	350

2.4 Load combinations

In the limit state design of reinforced concrete structures, following load combinations shall be accounted as per I.S. 1893 (Part I) – 2002[1], where the terms D.L., I.L., and E.L. stand for the response quantities due to dead load, imposed load and designated earthquake load respectively.

Combinations for limit state of collapse	Combinations for limit state of serviceability
1) 1.5 (DL + LL) 2) 1.2 (DL + LL ± EQ) 3) 1.5 (DL ± EQ) 4) 0.9 DL ± 1.5 EQ	1) (DL + 0.8 LL + 0.8 EQ) 2) (DL + LL) 3) (DL + EQ)

3. RESULTS AND DISCUSSION

3.1 Bare frames and frames with zip type of bracing

Table 2: Variation of axial force- Ra, shear force,-Rs and bending moment- Rm in segment C_1 of *bare frame* having specific no. of bays as depth of beam is changed

No. of bays	Axial force, R_a (G + 11)					
	Beam Depth					
	350	400	450	500	550	600
4	2568.1	2615.0	2659.4	2701.26	2740.5	2773.3
5	2564.1	2609.3	2653.2	2694.7	2732.3	2768.7

No. of bays	Bending moment, R_m (G+11)					
	Beam Depth					
	350	400	450	500	550	600
4	258.990	256.837	254.879	253.509	252.530	251.747
5	265.018	262.457	260.486	258.713	257.531	256.743

No. of bays	Shear force, R_s (G + 11)					
	Beam Depth					
	350	400	450	500	550	600
4	48.780	48.34242	48.02412	47.7456	47.546	47.387
5	49.614	49.133	48.732	48.411	48.171	48.011

Table 3: Variation of axial force, Ra, shear force, Rs and bending moment, Rm in segment C_1 of *fully braced frame* having specific no. of bays as depth of beam is changed

No. of bays	Axial force, R_a (G + 11)					
	Beam Depth					
	350	400	450	500	550	600
4	2606.1	2617.5	2627.7	2637.8	2649.2	2659.4
5	2614.3	2624.4	2635.7	2645.7	2657.0	2668.3

No. of bays	Shear force, R_s (G + 11)					
	Beam Depth					
	350	400	450	500	550	600
4	58.567	57.732	57.215	57.016	56.976	57.135
5	59.432	58.551	58.07	57.829	57.789	57.909

No. of bays	Bending moment, R_m (G+11)					
	Beam Depth					
	350	400	450	500	550	600
4	331.617	320.067	310.083	301.47	294.031	287.179
5	334.77	323.145	313.293	304.426	296.742	289.845

Table 4, 5 and 6 shows variation of axial force- Ra, shear force- Rs and bending moment- Rm respectively in member C_1 in partially braced frames with 4-bay (Mem. C_1, L.C.7) bottom node

Table 4: Variation of Axial force in member C_1 in *partially braced frames*

Ln	Ra for one bay braced at a time	Ln	Ra for two bays braced at a time	Ln	Ra for three bays braced at a time	Ln	Bare Fr.	Fully braced fr.
2.485	0.952	4.796	0.924	7.115	0.915	2.485	1.000	1.122
2.996	0.936	4.890	0.937	7.124	1.171	2.996	1.000	1.122
3.466	0.944	4.949	1.251	7.203	1.182	3.466	1.000	1.122
3.689	1.302	5.438	0.916	7.759	1.106	3.689	1.000	1.122
		5.489	1.189			4.796	1.000	1.122
		5.838	1.168			4.890	1.000	1.122
						4.949	1.000	1.122
						5.438	1.000	1.122
						5.489	1.000	1.122
						5.838	1.000	1.122
						7.115	1.000	1.122
						7.124	1.000	1.122
						7.203	1.000	1.122
						7.759	1.000	1.122

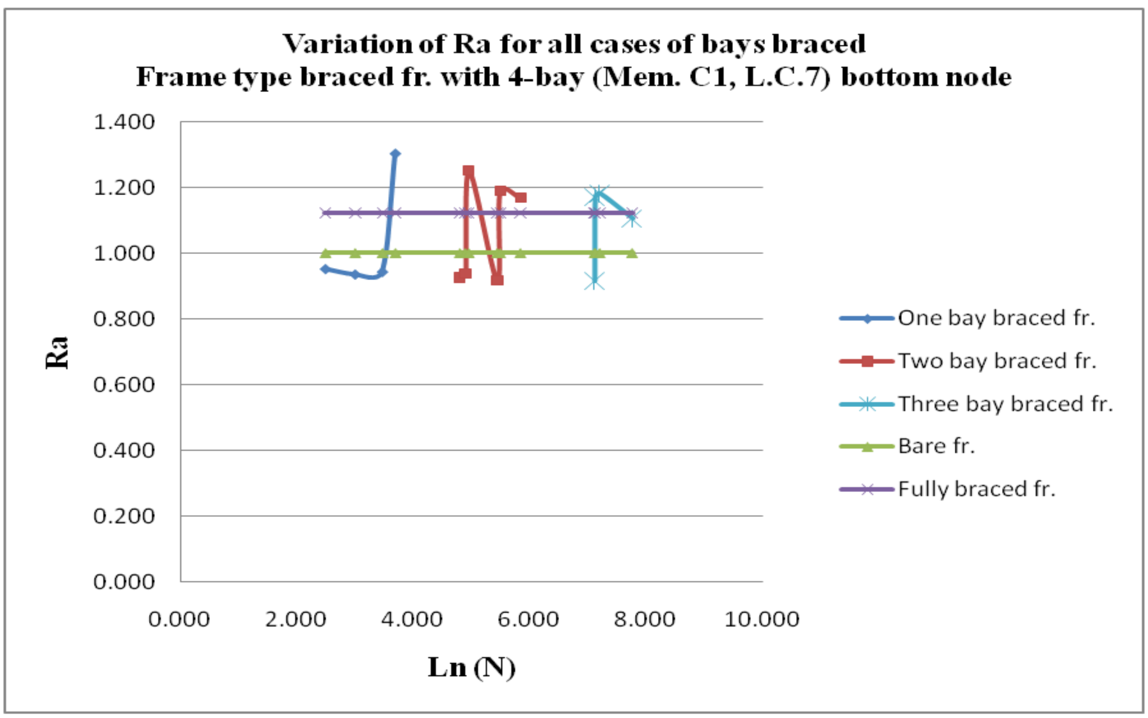


Figure 3. Variation of Ra for all cases of bays braced and Frame type braced fr. with 4-bay (Mem. C_1, L.C.7) bottom node

Table 5: Variation of Shear force in member C_1 in *partially braced frames*

Ln	Rs for one bay braced at a time	Ln	Rs for two bays braced at a time	Ln	Rs for three bays braced at a time	Ln	Bare Fr.	Fully braced fr.
2.485	0.689	4.796	0.733	7.115	1.046	2.485	1.000	1.976
2.996	0.818	4.890	1.006	7.124	1.718	2.996	1.000	1.976
3.466	1.163	4.949	1.793	7.203	2.006	3.466	1.000	1.976
3.689	2.114	5.438	1.111	7.759	2.038	3.689	1.000	1.976
		5.489	1.857			4.796	1.000	1.976
		5.838	2.137			4.890	1.000	1.976
						4.949	1.000	1.976
						5.438	1.000	1.976
						5.489	1.000	1.976
						5.838	1.000	1.976
						7.115	1.000	1.976
						7.124	1.000	1.976
						7.203	1.000	1.976
						7.759	1.000	1.976

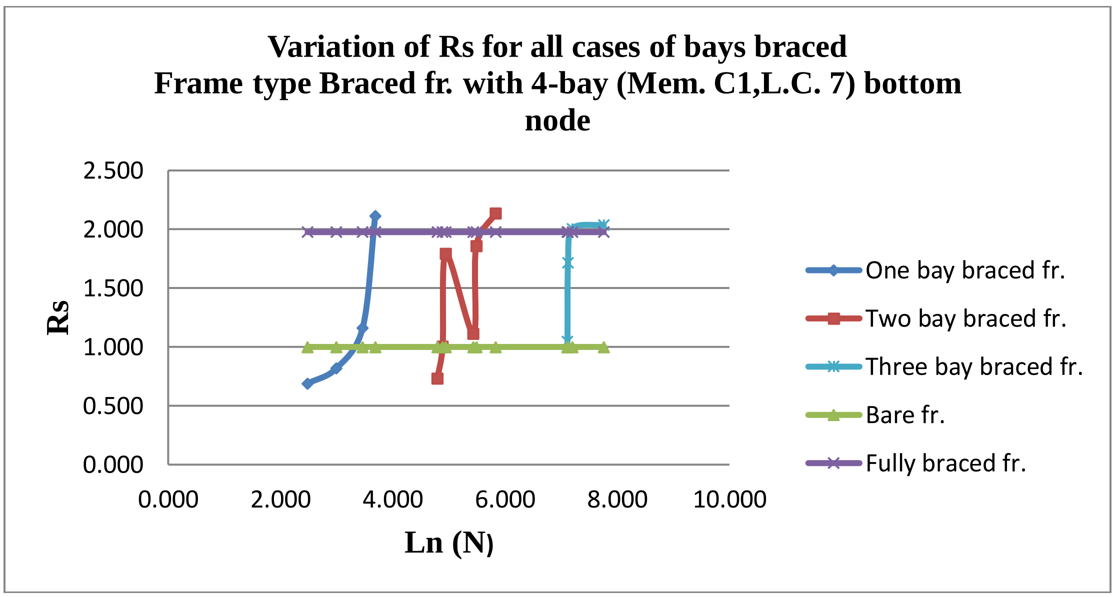


Figure 4. Variation of Rs for all cases of bays braced and Frame type braced fr. with 4-bay (Mem. C1, L.C.7) bottom node

Table 6: Variation of Bending moment in member C_1 in partially braced frames

Ln	Rm for one bay braced at a time	Ln	Rm for two bays braced at a time	Ln	Rm for three bays braced at a time	Ln	Bare Fr.	Fully braced fr.
2.485	0.479	4.796	0.354	7.115	0.368	2.485	1.000	0.514
2.996	0.471	4.890	0.427	7.124	0.498	2.996	1.000	0.514
3.466	0.541	4.949	0.565	7.203	0.547	3.466	1.000	0.514
3.689	0.705	5.438	0.411	7.759	0.535	3.689	1.000	0.514
		5.489	0.558			4.796	1.000	0.514
		5.838	0.593			4.890	1.000	0.514
						4.949	1.000	0.514

5.438	1.000	0.514
5.489	1.000	0.514
5.838	1.000	0.514
7.115	1.000	0.514
7.124	1.000	0.514
7.203	1.000	0.514
7.759	1.000	0.514

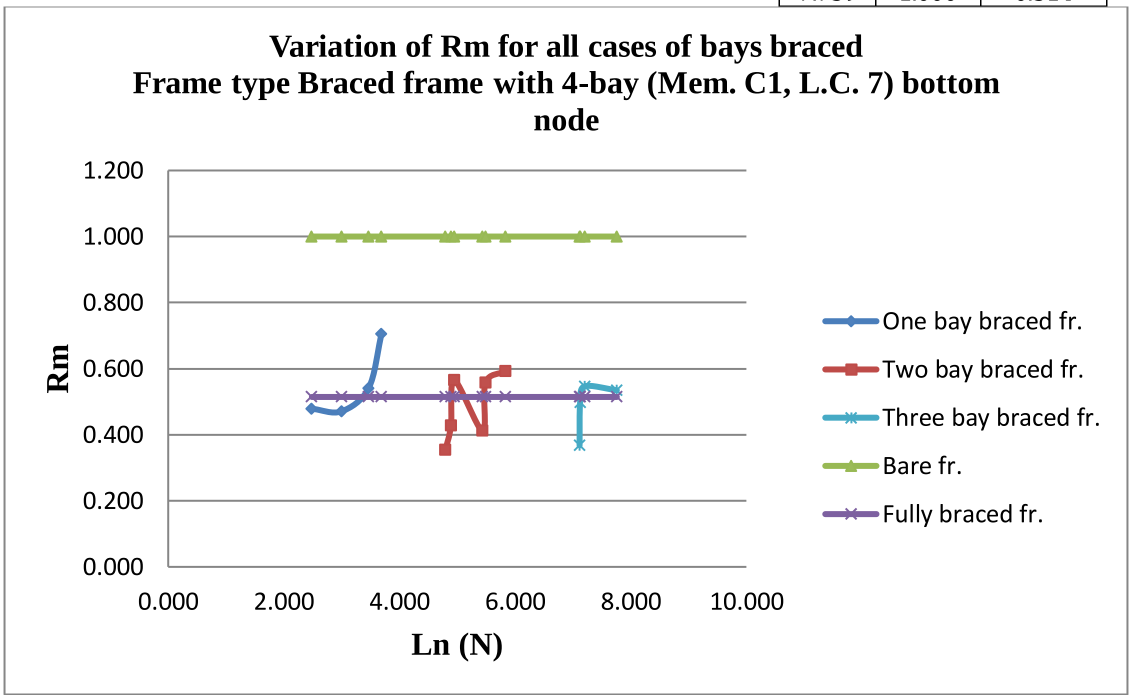


Figure 5. Variation of Rm for all cases of bays braced and Frame type braced fr. with 4-bay (Mem. C1, L.C.7) bottom node

Table 7, 8 and 9 shows variation of axial force, Ra, shear force, Rs and bending moment, Rm respectively in member C_1 in partially braced frames with 5-bay (Mem. C1, L.C.7) bottom node

Table 7: Variation of Axial force in member C_1 in partially braced frames

Ln	Ra for one bay braced at a time	Ln	Ra for two bays braced at a time	Ln	Ra for three bays braced at a time	Ln	Ra for four bays braced at a time
2.565	0.957	4.812	0.928	7.118	0.916	9.421	0.910
3.045	0.942	4.875	0.934	7.124	0.926	9.422	1.144
3.526	0.941	4.970	0.944	7.131	1.201	9.429	1.187
3.738	0.952	5.024	1.290	7.203	0.923	9.507	1.155
3.912	1.358	5.451	0.918	7.209	1.212	10.063	1.103
		5.485	0.931	7.282	1.223		
		5.537	1.233	7.758	0.909		
		5.838	0.922	7.763	1.148		
		5.861	1.226	7.804	1.175		
		6.116	1.217	8.146	1.138		

For each abscissa that is for logarithm of reference number pertaining to above cases For bare frame, R_a = 1, For fully braced frame, R_a = 1.122

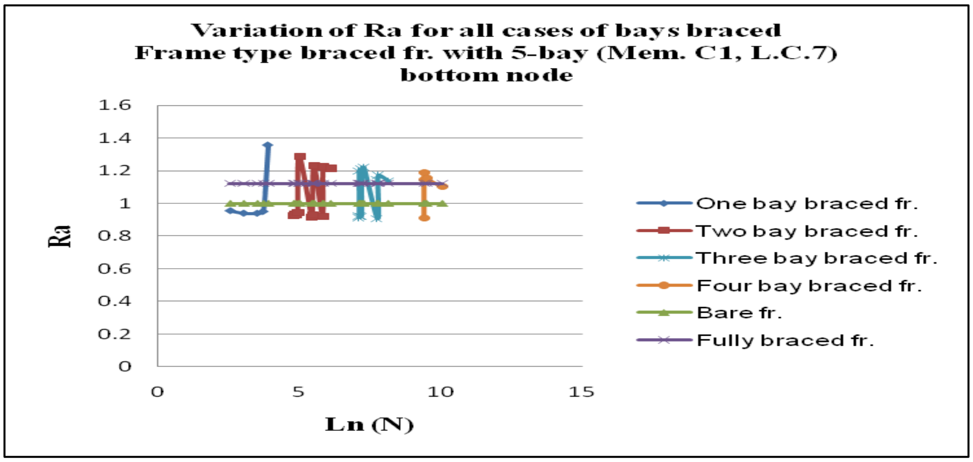


Figure 6. Variation of Ra for all cases of bays braced and Frame type braced fr. with 5-bay (Mem. C1, L.C.7) bottom node

Table 8: Variation of Shear force in member C_1 in partially braced frames

Ln	Rs for one bay braced at a time	Ln	Rs for two bays braced at a time	Ln	Rs for three bays braced at a time	Ln	Rs for four bays braced at a time
2.565	0.673	4.812	0.630	7.118	0.734	9.421	1.070
3.045	0.729	4.875	0.744	7.124	0.974	9.422	1.720
3.526	0.872	4.970	1.040	7.131	1.705	9.429	2.013
3.738	1.242	5.024	1.877	7.203	1.102	9.507	2.105
3.912	2.262	5.451	0.791	7.209	1.818	10.063	2.078
		5.485	1.071	7.282	2.120		
		5.537	1.887	7.758	1.121		
		5.838	1.195	7.763	1.810		
		5.861	1.991	7.804	2.114		
		6.116	2.301	8.146	2.185		

For each abscissa that is for logarithm of reference number pertaining to above cases For bare frame, R_s = 1,For fully braced frame, R_s = 1.976

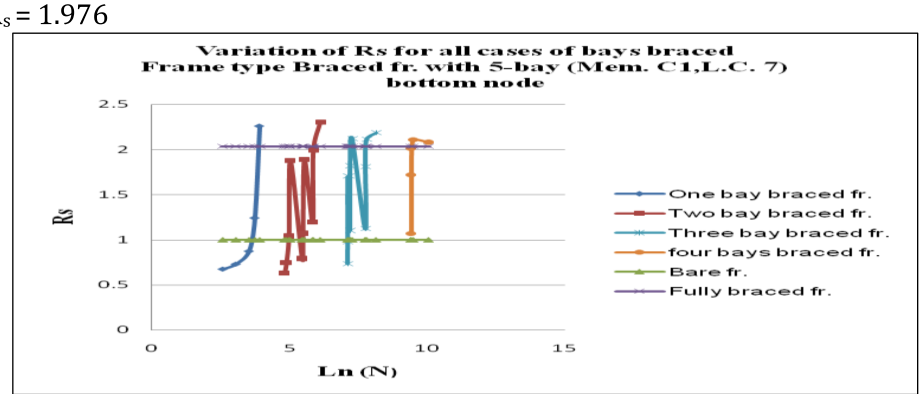


Figure 7. Variation of Rs for all cases of bays braced and Frame type braced fr. with 4-bay (Mem. C1, L.C.7) bottom node

Table 9: Variation of Bending moment in member C_1 in partially braced frames

Ln	Rm for one bay braced at a time	Ln	Rm for two bays braced at a time	Ln	Rm for three bays braced at a time	Ln	Rm for four bays braced at a time
2.565	0.507	4.812	0.356	7.118	0.323	9.421	0.367
3.045	0.486	4.875	0.403	7.124	0.387	9.422	0.492
3.526	0.520	4.970	0.465	7.131	0.520	9.429	0.553
3.738	0.598	5.024	0.616	7.203	0.412	9.507	0.566
3.912	0.782	5.451	0.372	7.209	0.553	10.063	0.548
		5.485	0.453	7.282	0.599		
		5.537	0.599	7.758	0.394		
		5.838	0.459	7.763	0.527		
		5.861	0.621	7.804	0.587		
		6.116	0.662	8.146	0.592		

For each abscissa that is for logarithm of reference number pertaining to above cases For bare frame, R_m = 1,For fully braced frame, R_m = 0.514

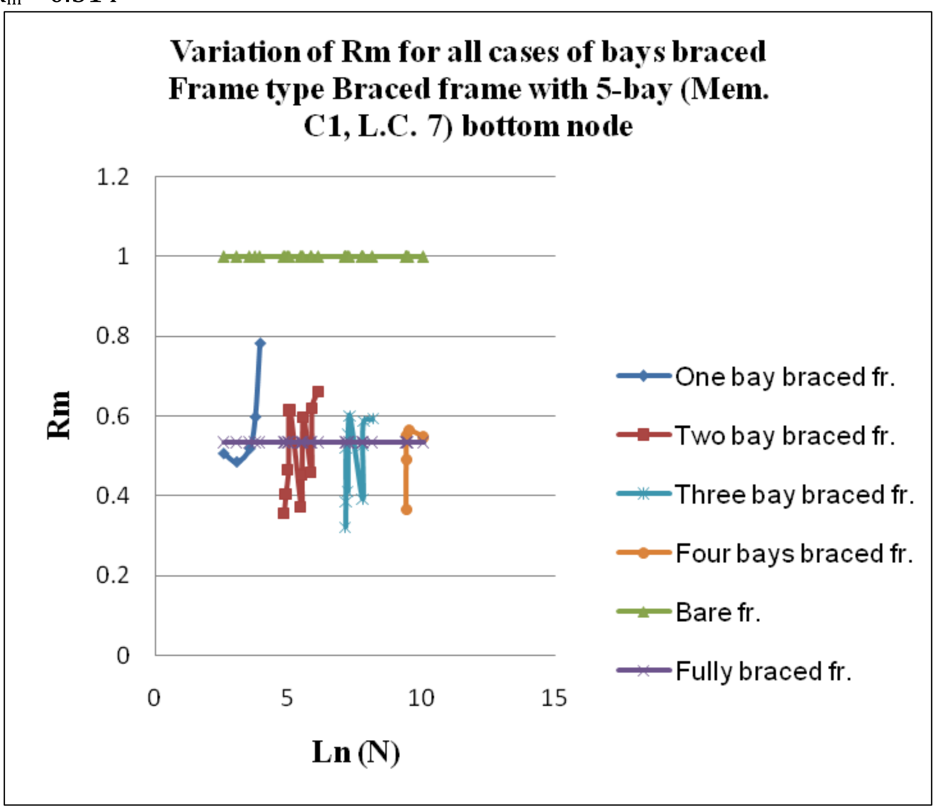


Figure 8. Variation of Rm for all cases of bays braced and Frame type braced fr. with 4-bay (Mem. C1, L.C.7) bottom node

4. CONCLUSIONS

4.1 About Bare Frame

i. For a bare frame irrespective of number of bays C_1 is found to attract about 6.5 to 8% additional axial force as the beam depth increases from 350 mm to 600 mm.

ii. Shear force marginally reduces as the beam depth increases. Percent reduction in the shear for

600mm beam depth was found to be 2.9 for 4 bay and 3.3 for 5 bay frame.

iii. The bending moment is found to reduce about 28% to 15% for 4 and 5 bay structures respectively for beam depth 600mm

4.2 About Fully Braced Frame

i. When compared with bare frames, it is found that axial force attracted by column segment at all levels remains almost same, shear force increases and bending moment reduces substantially.

ii. All frames exhibit a continuous rise in the axial force as the depth of beam increases.

iii. Shear force reduces as the depth of beam increases. This reduction was found to be 2.5 to 2.6% for 600mm beam depth for 4 bay and 5 bay structures respectively.

iv. Braces are subject prominently to axial compression and carry negligibly small shear and bending moment

Following table reveals the reduction in moment in worst loaded column segment C_1 in fully braced frames in comparison with bare frame.

No of Bays	**% Reduction in moment for worst (G+11)**
4	83.02
5	83.97

4.3 About Partially Braced Frames

A) Bay Wise Bracing

Percent saving in material cost and corresponding optimally located bracing pattern for 12 storeyed structure is found as given below.

No. of	**No. of bays**	**Optimum bracing**	**%**
4	Two	2(central)	11.00
5	Three	3(central)	15.07

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