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COLLAPSE BEHAVIOR OF RCC BUILDING FRAME WITH AND WITHOUT SHEAR WALL

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Abstract: Progressive collapse is generally defined as small or local structural failure results in damage and failure of the adjoining members and in turn, causing total collapse of the building or a disproportionately large part of it. This investigation deals with the effect of progressive collapse behaviour of G+3 RCC building frame with and without shear wall. Progressive collapse of building structures is initiated by loss of one or more vertical load carrying members, usually columns. If the neighbouring elements are not designed to resist the redistributed loads, failure will happen with further load redistribution until equilibrium is reached, resulting in partial or total collapse of the structure. The study includes the investigation of critical columns for a 4 storey RCC building with and without shear wall. The height of building is 3.2m at each floor. The behavioural changes investigated, under critical load path of the building subjected to a sudden collapse of load bearing member. This RCC building is designed as per relevant Indian codes and investigation is carried out considering the load path where maximum behavioural changes occur in terms of displacement, vertical reaction and axial forces after removal of load bearing member due to progressive collapse. The numerical investigation is carried out using commercially available software STAAD Pro. It is observed that ground floor columns are most critical for load transfer and joint displacement when subjected to progressive collapse.

Keywords: Progressive collapse, RCC building, Shear wall, STAAD Pro

1. INTRODUCTION

Prevention or mitigation of progressive collapse appears to be an important issue in the development of several structural design codes. They highlight the necessity of providing

The above graph shows that when the column 51 is removed the node displacement at the top node of removed column 51 is increased by 30 times of the displacement from the initial condition (without column removed condition) in case of frame 1 i.e. without shear wall and 27 times of the displacement from the initial condition (without column removed condition) in case of frame 1 i.e. with shear wall.

Differences in reaction value at adjacent columns before and after column removal scenerio

Removal of column	Adjacent column	Support numbers	Reaction Forces before removal of column of frame 1 i.e. frame without shear wall (KN)	Reaction Forces before removal of column of frame 2 i.e. frame with shear wall (KN)	Reaction Forces before removal of column of frame 1 i.e. frame without shear wall (KN)	Reaction Forces before removal of column of frame 2 i.e. frame with shear wall (KN)	Difference (After-Before)for Frame 1 (KN)	Difference (After-Before)for Frame 2 (KN)
51	52	22	727.16	819.37	1096.78	1165.61	369.62	346.24
51	55	25	775.13	863.05	1007.56	1069.61	232.43	206.56
51	56	26	1108.34	1351.06	1118.28	1828.72	9.94	477.66
52	51	21	487.72	560.46	765.4	822.01	277.68	261.55
52	53	23	832.35	935.11	1152.88	1235.24	320.53	300.13
52	56	26	1108.34	1351.06	1245.85	1793.27	137.51	442.21
53	52	22	727.16	819.37	1186.49	1246.12	459.33	426.75
53	54	24	568.97	657.02	795.66	863.12	226.69	206.1
53	57	27	1256.8	1461.47	1463.13	2014	206.33	552.53
54	53	23	832.35	935.11	1178.26	1255.8	345.91	320.69
54	57	27	1256.8	1461.47	1274.67	2000.13	17.87	538.66
54	58	28	891.62	1006.76	1261.36	1354.95	369.74	348.19
55	51	21	487.72	560.46	734.11	761.86	246.39	201.4
55	52	22	727.16	819.37	735.67	830.72	8.51	11.35
55	56	26	1108.34	1351.06	1469.38	2015.2	361.04	664.14
58	54	24	568.97	657.02	902.48	961.64	333.51	304.62
58	57	27	1256.8	1461.47	1536.43	2066.25	279.63	604.78
58	62	32	894.3	1009.36	1241.22	1327.94	346.92	318.58
59	55	25	775.13	863.05	1024.89	1074.1	249.76	211.05
59	60	30	1110.15	1327.83	1469.54	1946.11	359.39	618.28
59	63	33	773.97	894	1024.83	1103.03	250.86	209.03
62	58	28	891.62	1006.76	1238	1325.9	346.38	319.14
62	61	31	1259.89	1445.21	1537.73	2003.97	277.84	558.76
62	66	36	891.9	1026.51	1239.02	1345.1	347.12	318.59
63	59	29	776.85	865.64	1029.05	1098.13	252.2	232.49
63	64	34	1006.86	1145.56	1367.82	1502.7	360.96	357.14
63	67	37	489.44	567.29	746.56	806.98	257.12	239.69

66	62	32	894.3	1009.36	1242.61	1345.12	348.31	335.76
66	65	35	1154	1303.22	1434.34	1580.51	280.34	277.29
66	70	40	573.3	664.79	914.24	996.16	340.94	331.37
67	63	33	773.97	894	1064.52	1159.69	290.55	265.69
67	64	34	1006.86	1145.56	1012.13	1156.45	5.27	10.89
67	68	38	491.89	573.44	752.03	821.89	260.14	248.45
68	64	34	1006.86	1145.56	1261.59	1385.42	254.73	239.86
68	67	37	489.44	567.29	760.98	820.96	271.54	253.67
68	69	39	580.99	671.97	555.07	655.85	-25.92	-16.12
69	65	35	1154	1303.22	1534.27	1668.34	380.27	365.12
69	68	38	491.89	573.44	450.38	548	-41.51	-25.44
69	70	40	573.3	664.79	808.01	872.67	234.71	207.88
70	65	35	1154	1303.22	1170.9	1321.83	16.9	18.61
70	66	36	891.9	1026.51	1316.88	1430.72	424.98	404.21
70	69	39	580.99	671.97	808.73	881.48	227.74	209.51

Differences in axial force value at adjacent columns before and after column removal scenerio

Removal of column	Adjacent column	Axial forces before removal of column of frame 1 i.e. frame without shear wall (KN)	Axial Forces before removal of column of frame 1 i.e. frame without shear wall (KN)	Axial Forces before removal of column of frame 2 i.e. frame with shear wall (KN)	Axial Forces before removal of column of frame 2 i.e. frame with shear wall (KN)	Difference (After-Before)for Frame 1 (KN)	Difference (After-Before)for Frame 2 (KN)
51	52	708.8	1080.4	689.87	1038.2	371.6	348.33
51	55	755.77	988.19	722.77	929.5	232.42	206.73
51	56	1087.03	1095.8	259.9	360.47	8.77	100.57
52	51	472.13	749.08	469.48	730.28	276.95	260.8
52	53	813.47	1136.27	791.22	1093.9	322.8	302.68
52	56	1087.03	1225.97	259.9	363.16	138.94	103.26
53	52	708.8	1173.57	689.87	1122.61	464.77	432.74
53	54	552.34	778.07	553.11	758.92	225.73	205.81
53	57	1235.5	1443.62	291.42	430.64	208.12	139.22
54	53	813.47	1161.45	791.22	1114.77	347.98	323.55
54	57	1235.5	1251.99	291.42	406.84	16.49	115.42
54	58	871.32	1241.88	853.14	1202.14	370.56	349
55	51	472.13	717.66	469.48	671.35	245.53	201.87
55	52	708.8	716.43	689.87	700.12	7.63	10.25
55	56	1087.03	1451.57	259.9	440.92	364.54	181.02
58	54	552.34	885.45	553.11	858.02	333.11	304.91
58	57	1235.5	1517.75	291.42	452.63	282.25	161.21

58	62	873.27	1222.44	856	1176.76	349.17	320.76
59	55	755.77	1007.03	722.77	935.14	251.26	212.37
59	60	1088.16	1451.17	294.31	480.8	363.01	186.49
59	63	754.96	1007.15	752.43	963.42	252.19	210.99
62	58	871.32	1219.77	853.14	1174.41	348.45	321.27
62	61	1237.88	1518.59	328.91	493.67	280.71	164.76
62	66	871.75	1220.81	872	1193.04	349.06	321.04
63	59	756.88	1010.63	725.66	960.12	253.75	234.46
63	64	985.13	1349.62	965.76	1326	364.49	360.24
63	67	474.46	730.62	474.81	715.99	256.16	241.18
66	62	873.27	1223.81	856	1194.29	350.54	338.29
66	65	1132.51	1415.41	1109.74	1389.33	282.9	279.59
66	70	557.39	897.98	559.71	892.03	340.59	332.32
67	63	754.96	1045.65	752.43	1020.22	290.69	267.79
67	64	985.13	988.97	965.76	974.73	3.84	8.97
67	68	477.04	721.45	480.49	711.89	244.41	231.4
68	64	985.13	1241.96	965.76	1207.35	256.83	241.59
68	67	474.46	729.79	474.81	711.28	255.33	236.47
68	69	564.52	542.87	566.51	552.27	-21.65	-14.24
69	65	1132.51	1516.57	1109.74	1476.76	384.06	367.02
69	68	477.04	442.79	480.49	458.22	-34.25	-22.27
69	70	557.39	777.93	559.71	753.88	220.54	194.17
70	65	1132.51	1147.92	1109.74	1127.1	15.41	17.36
70	66	871.75	1298.02	872	1278.57	426.27	406.57
70	69	564.52	778.59	566.51	762.13	214.07	195.62

Increase in joint displacement in vertical direction value at adjacent columns before and after column removal scenerio

Removal of column	Adjacent column	joint displacement at the top of column before removal of column of frame 1 i.e. frame without shear wall (KN)	joint displacement at the top of column before removal of column of frame 2 i.e. frame with shear wall (KN)	joint displacement at the top of column before removal of column of frame 1 i.e. frame without shear wall (KN)	joint displacement at the top of column before removal of column of frame 2 i.e. frame with shear wall (KN)	Increase in joint displacement (After/Before)for Frame 1 (KN)	Increase in joint displacement (After/Before)for Frame 2 (KN)
51	41	-0.1049	-0.1093	-3.1351	-2.9794	30	27
52	42	-0.1577	-0.1609	-2.2732	-2.1787	14	14
53	43	-0.181	-0.1844	-3.3011	-3.1459	18	17
54	44	-0.1228	-0.1288	-5.2467	-5.0805	43	39
55	45	-0.1682	-0.1689	-3.2787	-2.9231	19	17

58	48	-0.194	-0.1988	-4.6557	-4.4036	24	22
59	49	-0.1685	-0.1696	-3.2641	-2.9318	19	17
62	52	-0.1945	-0.1995	-4.6448	-4.4104	24	22
63	53	-0.168	-0.1756	-3.2863	-3.2266	20	18
66	56	-0.1941	-0.2031	-4.6669	-4.6322	24	23
67	57	-0.1054	-0.1106	-3.7703	-3.605	36	33
68	58	-0.1059	-0.1119	-3.9386	-3.6864	37	33
69	59	-0.1255	-0.1319	-6.0852	-5.68	48	43
70	60	-0.1239	-0.1303	-5.9187	-5.7284	48	44

6. CONCLUSION

In this work, the main objective was to investigate the behaviour of the four storey asymmetric RCC building with and without shear wall due to progressive collapse. Studies are carried out to investigate the behaviour of progressive collapse for axial forces in columns, support reactions and node displacement subjected to sudden loss of a vertical support member. Ground floor columns are removed one by one, and the study of progressive collapse initiation on a typical reinforced concrete frame is done with the help of a STAAD Pro. This simple analysis can be used to quickly analyse the structures for different failure conditions and then optimize it for various threat scenarios. Based on this investigation following conclusions are drawn:

1. It is found that larger redistribution of axial forces is more in adjacent columns of removed column than the columns located far from the removed column. Removal of column number 53,66,58 exhibit most critical condition in case of axial force redistribution shows that columns of mid part of frame is critical than other column of building.
2. Percentage increase in axial forces is more in frames of without shear wall than the frames with shear wall.
3. Redistribution of axial force is also depending on the distance and symmetry of the structure. If the adjacent columns with same property and specification are located at same distance from the removed column than the percentage increase in axial load is also same.
4. It is found larger redistribution of support reaction is more in adjacent support of the support of removed column than the supports located far from the support of removed column. Removal of column number 53,52,58 exhibit most critical condition in case

of support reaction redistribution shows that columns of mid part of frame is critical than other column of building.

5. Percentage of increase in support reaction is more in frames of without shear wall than the frames with shear wall.
6. From the joint displacement scenario the displacement of the top nodes of the removed column increases tremendously and it is more for the frame of without shear wall than the for the frame of with shear wall.

It can be concluded that from node displacement criteria maximum change occurs in node number 53, 54 and 44 in both the frame cases i.e. frame without shear wall and with shear wall due to removal of column 54, 63 and 64. Hence from the node displacement criteria critical columns are 54, 63 and 64.

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