Progressive Collapse Analysis Of Building

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ABSTRACT

The term "progressive collapse" defined as the ultimate failure or proportionately large failure of a portion of a structure due to the spread of a local failure from element to element throughout the structure. Following the General Services Administration guidelines (GSA, 2003) three dimensional (3D) models of building were developed to analyze and compare the progressive collapse response by commercially available computer program, STADD PRO. The objective of this work is to study the two different analysis procedures for evaluating their effectiveness in modeling progressive collapse scenarios; linear static and linear dynamic procedures. Analysis is carried out for (G+4) RC earth quake resistant buildings for different analysis procedures to compare DCR values. It was observed that dynamic amplification factor of 2 used in linear static equation is a good estimate for static analysis procedure since linear static and linear dynamic analysis procedure yield approximately the same maximum moment. Static analysis have low DCR value compare dynamic procedure this may be due to dynamic amplification factor of 2 used in linear dynamic analysis. Linear dynamic analysis gives more conservation results than static analysis.

Keywords **–** PROGRESSIVE COLLAPSE, GSA, DCR, DYNAMIC ANALYSIS, LINEAR DYNAMIC ANALYSIS

1.INTRODUCTION

Many practicing engineers and academic researcher have engaged in the prevention of progressive collapse since the progressive collapse of Ronan point apartment building in 1968.The recent progressive collapse of Alfred P.Murrah Federal Building and world Trade center (WTC), researchers are more focused than ever on constructing building safer from progressive collapse. Rapid urbanization and unavailability of space across world is resulting in increasing of construction of multi-storey buildings. Multi-storey buildings are susceptible to damage due to sudden impact, earthquake, explosions, fire, blasts, design or construction error, overload due occupant misuses, vehicular collision etc, unless they are adequately consider in design and analysis. Moreover such building undergoes progressive collapse leading to the failure of whole structure. The term "progressive collapse" has been used to describe the spread of an initial local failure in a manner analogous to a chain reaction that leads to partial or total collapse of a building. The underlying characteristic of Progressive collapse is that the final state of failure is disproportionately greater than the failure that initiated the collapse. Progressive collapse is a complicated dynamic process where collapsing system redistributes the loads in order to prevent the loss of critical structural members, beam, column, and frame connections must be designed in a way to handle the potential redistributes of large loads. The causes of progressive collapse phenomena are human made hazard (blast or explosion, vehicle impact, fire, etc) or natural hazards. From past it shows abnormal loads can cause structural damage that results in loss of support in the structure, such sequential failures can spread from element to element, eventually leading to the entire or disproportionately large part of the structure.

2. MATHEMATICAL MODELING

The correct analysis will depend upon the proper modeling the behavior of materials, elements and connectivity. Therefore, it is important to select an appropriate and simple model to match the purpose of analysis. In progressive collapse assessment mathematical modeling of the structure is based on earthquake loading because it simulates actual behavior of the structure. For the proposed work, three-dimensional model is selected. A three-dimensional model has independent displacements at each node and can simulate any type of behavior. Fig shows three-dimensional model of a frame considered for analysis

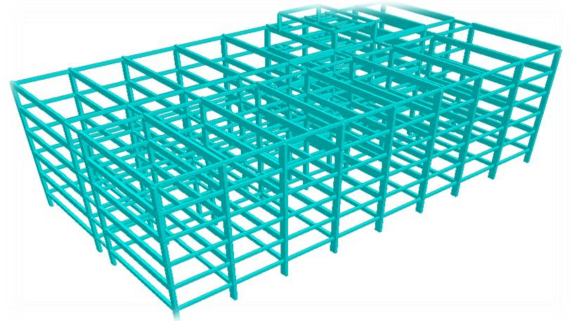

Fig 2.1: Three-Dimensional Model of Frame

2.1. DEMAND CAPACITY RATIO (DCR)

Demand capacity Ratio is defined as the ratio of the force (bending moment, axial force, shear force) in the structural member after the instantaneous removal of a column to the member capacity.

DCR limit values depending on the cross sectional dimensions and on the construction materials. In DCR, demand indicates the Bending moment of the member obtained from the static analysis of frame and the capacity indicates the ultimate moment resistance capacity of the member i.e. Plastic Moment. DCRs are not used to determine the acceptability of component behavior, but it is used only to determine the structure's regularity of the building. DCRs for building components are calculated by following Eq.

$$DCR = Mmax / Mp$$

Mmax: Bending Moment of the member obtained from the analysis

Mp: Expected ultimate moment capacity of the member. ($Mp=0.138Fckbd^2$)

The acceptance criteria for DCR are given below

For typical structure (symmetrical structure) = DCR≤ 2.0

For typical structure (unsymmetrical structure) = DCR≤ 1.5

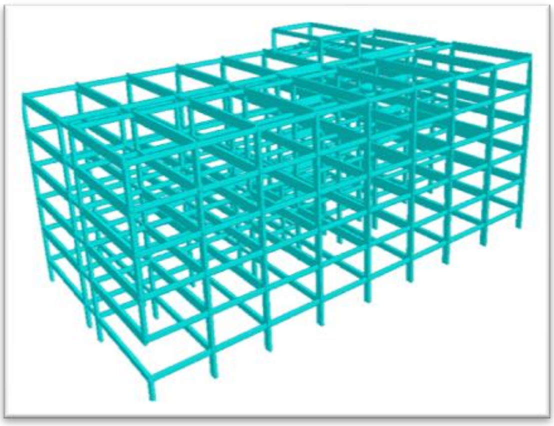

Fig 2.2: Three-Dimensional Model of Case-I

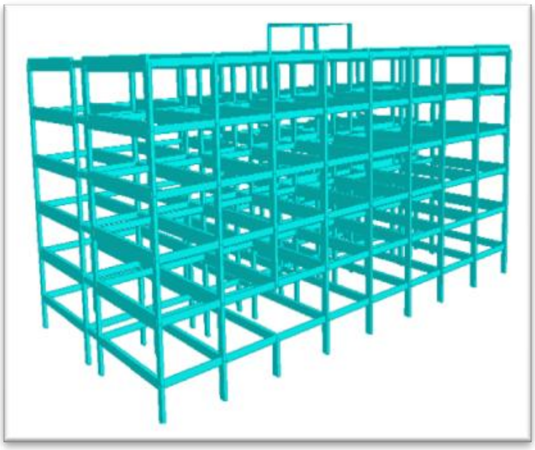

Fig 2.3: Three-Dimensional Model of Case-I

3. PERFORMANCE ANALYSIS

Table 3.1- CASE-I : After removing C1 column most affected column

Column No	Static Case Difference			Seismic Case Difference		
	Fy	Mx	Mz	Fy	Mx	Mz
C1	-	-	-	-	-	-
C2	29	79	93	30	23	72
C3	4	32	94	3	0	79
C4	0	12	100	1	10	85
C10	37	70	0	38	29	78
C11	1	78	87	1	24	42
C12	0	75	35	0	13	57
C13	0	11	74	0	10	90
C19	6	52	51	6	49	56
C20	0	60	25	0	33	78
C21	0	42	64	0	0	42
C22	0	14	82	0	12	49
C28	19	59	68	16	28	55
C29	3	63	93	3	32	44
C30	0	48	79	0	1	66
C31	0	15	67	1	11	36

Table 3.2- CASE-II: After removing C3 column most affected column

Column No	Static Case Difference			Seismic Case Difference		
	Fy	Mx	Mz	Fy	Mx	Mz
C1	6	31	55	4	6	41
C2	30	76	92	30	13	72
C3	-	-	-	-	-	-
C4	26	72	100	27	10	86
C5	3	29	91	2	6	30
C10	0	59	4	0	26	35
C11	1	75	66	1	13	87
C12	26	81	7	28	19	36
C13	1	70	4	1	11	86
C19	0	40	10	0	6	58
C20	0	49	17	0	35	15
C21	3	72	15	3	45	31
C22	0	43	6	0	24	10
C28	1	40	6	2	24	73
C29	3	53	4	3	34	22
C30	10	67	3	11	41	20
C31	2	50	1	2	23	19

Table 3.3: Result of column wise DCR of Linear Static analysis and linear dynamic analysis

Col No	STATIC DCR		SEISMIC DCR	
	Case -I	Case –II	Case -I	Case -II
C1	X	0.41	X	0.92
C2	0.54	0.47	1.41	1.24
C3	0.36	X	1.35	X
C4	0.14	0.45	1.25	1.54
C5	0.17	0.24	1.17	1.24
C6	0.35	0.36	1.57	1.62
C7	0.36	0.35	1.75	1.80

C8	0.11	0.11	1.78	1.69
C9	0.35	0.31	1.18	1.13
C10	0.76	0.093	1.38	0.73
C11	0.52	0.46	1.30	1.15
C12	0.070	0.77	1.11	1.58
C13	0.14	0.44	1.16	1.44
C14	0.16	0.22	1.06	1.12
C15	0.061	0.096	1.29	1.32
C16	0.078	0.048	1.44	1.49
C17	0.13	0.13	1.57	1.49
C18	0.15	0.19	1.09	1.100
C19	0.41	0.33	0.48	0.90
C20	0.29	0.22	0.67	0.65
C21	0.26	0.53	1.29	0.70
C22	0.099	0.20	1.12	0.97
C23	0.50	0.57	1.62	1.69
C24	0.35	0.37	1.70	1.75
C25	0.47	0.46	1.98	1.98
C26	0.13	0.19	1.20	1.21
C27	0.27	0.23	1.18	1.13
C28	0.75	0.18	1.38	0.76
C29	0.31	0.25	0.74	0.72
C30	0.12	0.75	0.90	0.53
C31	0.094	0.22	1.21	1.05
C32	0.37	0.29	1.42	1.39
C33	0.24	0.23	1.53	1.56
C34	0.42	0.42	1.89	1.95
C35	0.135	0.168	1.27	1.31
C36	0.24	0.28	1.103	1.11

A. Comparison of Linear Static DCR And Linear Dynamic DCR

Case I

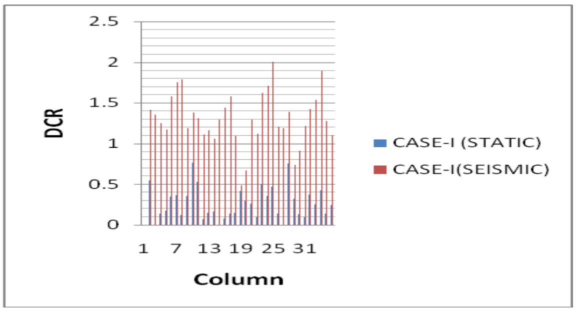

Fig 3.1: Column wise DCR of case-I

Case II

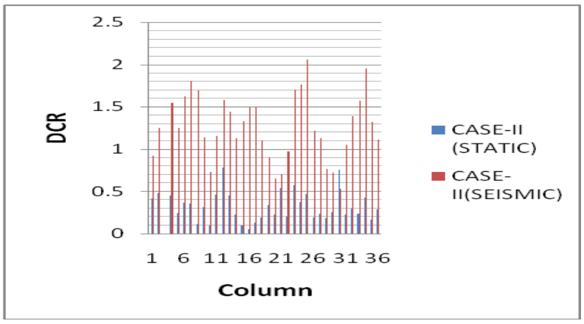

Figure 3.2: Column wise DCR of case-II

4. CONCLUSION

Dynamic analysis procedures for progressve collapse determinations, if modeled using initial conditions methodology, are simple to performe by practicing engineers through computer programs.

The dynamic amplification factor of 2 used in equation is a good estimate for static analysis procedres . Since linear static and linear dynamic analysis procedures yield approximately the same maximum deflection.

Case II of LDA i.e.RC Frame with removal of column has highest DCR value in comparison with LDAcase and other LSA case.Results indicated that DCRof column is 1.98 which is less than 2 i.e. GSA criteria.Hence the frame is less vulnerable to progressive collapse.

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