Progressive Collapse with Blast And Seismic Loading of RCC Building Using Staad-Pro

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Abstract- *This research work presents the progressive collapse analysis of RCC building for blast and seismic loading. The term progressive collapse defined as the ultimate failure or proportionately large failure of a portion of a structure due to spread of a local failure from element to element throughout the structure. Progressive collapse analysis is performed on low rise for G+4, medium rise for G+17 and high rise for G+22 building and its validation in accordance with General Services Administration 2013 Guidelines, to check Demand Capacity Ratio of a respective structure. The response of RCC framed structure under blast and seismic loading is checked in this work. Regular framed structures of G+4, G+17,G+22 are designed and analyzed using Staad proV8i SS5.Time history analysis method is used for progressive collapse analysis. Columns are removed to initiate the progressive collapse. The Elcentro data is used for sesmic time history analysis and for blast analysis time history load is calculated as per IS 4991.Natural frequency, storey drift ,base shear ,vertical displacement before and after column removal are calculated and Demand Capacity ratio is checked .The obtained DCR values shows that columns are safe for low rise(DCR is 1.5)and high rise building(DCR is1.9) and for medium rise G+17 building (DCR is 2.8)collapsed element has been redesigned and additional reinforcement is required to limit the DCR within the acceptance criteria, in order to save partially stable structure.*

Keywords- Progressive Collapse, Demand capacity ratio, column removal, blast and seismic loading,Staad pro.

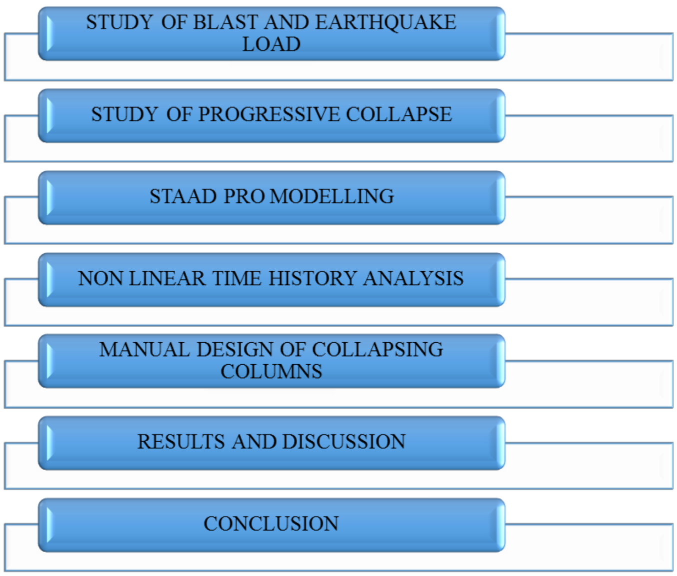
I. INTRODUCTION

Explosive loading incidents have become a serious problem that must be addressed quite frequently. Many buildings that could be loaded by explosive incidents are moment resistant frames either concrete or steel structures, and their behavior under blast loads is of great interest. Besides the immediate and localized blast effects, one must consider the serious consequences associated with progressive collapse that could affect people and property. Progressive collapse occurs when a structure has its loading pattern, or boundary conditions, changed such that structural elements are loaded beyond their capacity and fail in the past, structures designed to withstand normal load conditions were over designed, and have usually been capable of tolerating some abnormal loads. Modern building design and construction practices enabled one to build lighter and more optimized structural systems with considerably lower over design characteristics. Essential techniques for increasing the capacity of a building to provide protection against explosive and seismic effects shall be discussed both with an architectural and structural approach. Damage to the assets, loss of life and social panic are factors that have to be minimized if the threat of terrorist action cannot be stopped. Designing the structures to be fully blast resistant is not a realistic and economical option, however current engineering and architectural knowledge can enhance the new and existing buildings to mitigate the effects of an explosions and seismic activities.

1.1 Definition of progressive collapse

The General Services Administration, USA adopt the basic definition of that "Progressive collapse is a situation where local failure of a primary structural component leads to the collapse of adjoining members which, in turn, leads to additional collapse". The abnormal loads, like explosions, vehicle collisions, human errors, represent the main causes that lead to progressive collapse of buildings. The seismic design and detailing of a structure provides it with certain levels of continuity, ductility and redundancy, depending on the provisions for the seismic zone and for the ductility class. An increasing number of progressive collapse around the world lead more disastrous event leading to loss of life, injuries and large number of death and not dealt with common codal provision to address the progressive collapse in conventional design. Considering this an important issue, United States Department of Defense (DOD) and United States General Services Administration (GSA), and Euro codes published a string of various guidelines and specifications. It is not economical as well to design the structures for accidental events unless they have reasonable chance of occurrence. Considering these aspects, many government authorities and local bodies have worked on developing some design guidelines to prevent progressive collapse. Among these guidelines, U.S. General Services Administration (GSA) and Department of Defense (DoD)guidelines by United Facilities Criteria (UFC) - New York, provide detailed stepwise procedure regarding methodologies to resist the progressive collapse of structure. In this procedure, one of the important vertical structural elements in the load path i.e. column, load bearing wall etc. is removed to simulate the local damage scenario and the remaining structure is checked for available alternate load path to resist the load. The dynamic response of the building misevaluated after calculating the loading phenomena on different surfaces of the building as the record of pressure time history

II. METHODOLOGY



High rise structures are constructed in main areas that may be main targets of terrorist activities. Vehicle bomb or any man made blast are main weapons of terrorist to attack on highly crowded area. Due to such conditions nowadays there is heavy demand of blast resisting high rise structural design. Not only terrorist activities but also due some of accidental blast, structure can fail. For example Ronan Point building in which gas explosion took place on 18th floor which caused partially collapse of structure

2.1 Modeling of frame

The space frame building is modeled in STAAD-Pro. The beams and columns are modeled as beam elements and the slab is modeled as a plate element

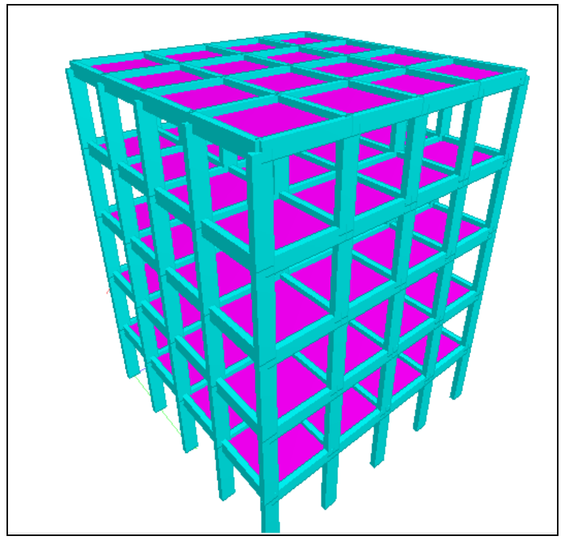


Fig.1 G+4 storey building

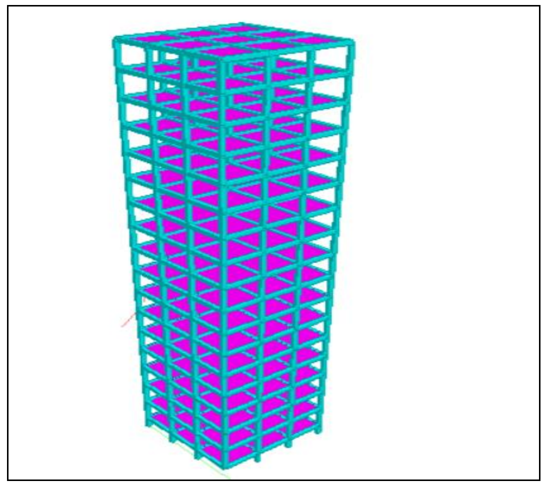


Fig. 2 G+ 17storey building

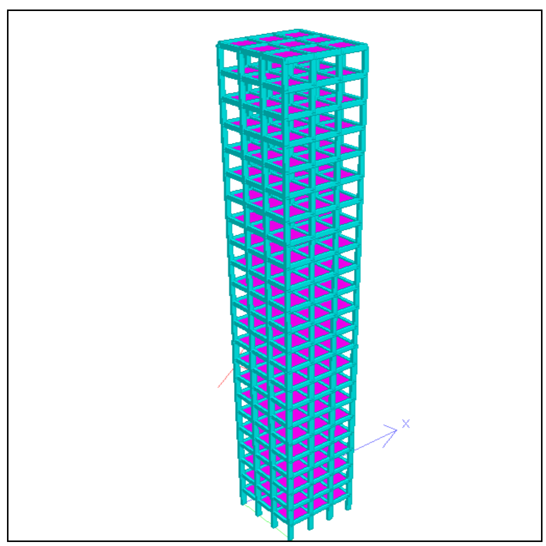
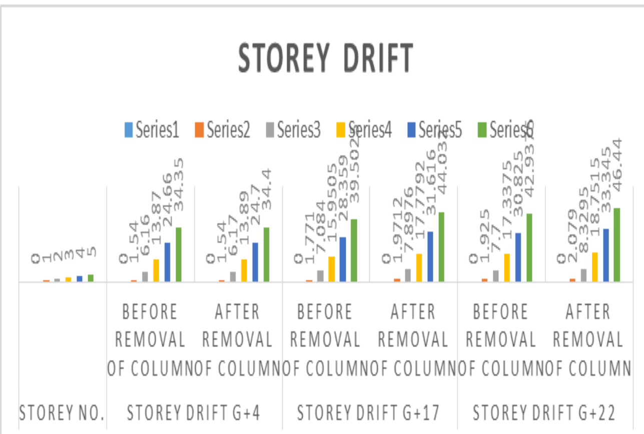


Fig 3 G+22 storey building

III. RESULTS AND DISCUSSION

3.1 Summary of results for Storey Drift of G+4,G+17,G+22building models

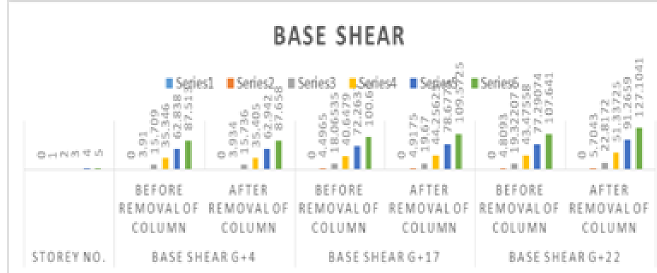
Storey no.	Storey Drift G+4		Storey Drift G+17		Storey Drift G+22	
	Before removal of column	After removal of column	Before removal of column	After removal of column	Before removal of column	After removal of column
0	0	0	0	0	0	0
1	1.54	1.54	1.771	1.9712	1.925	2.079
2	6.16	6.17	7.084	7.8976	7.7	8.3295
3	13.87	13.89	15.9505	17.7792	17.3375	18.7515
4	24.66	24.7	28.359	31.616	30.825	33.345
5	34.35	34.4	39.5025	44.032	42.9375	46.44



In above graph storey drift is compared for building models. It is observed that as number of storey increases storey drift also get increases.

3.2 Summary of results for Base shear of G+4,G+17,G+22 storey building models

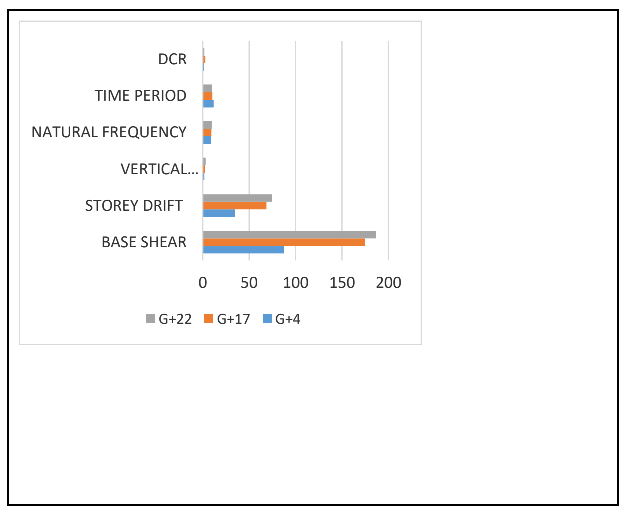
Storey no.	Base Shear G+4		Base Shear G+17		Base Shear G+22	
	Before removal of column	After removal of column	Before removal of column	After removal of column	Before removal of column	After removal of column
0	0	0	0	0	0	0
1	3.91	3.934	4.4965	4.9175	4.8093	5.7043
2	15.709	15.736	18.06535	19.67	19.32207	22.8172
3	35.346	35.405	40.6479	44.25625	43.47558	51.33725
4	62.838	62.942	72.2637	78.6775	77.29074	91.2659
5	87.513	87.658	100.64	109.5725	107.641	127.1041



In above graph base shear is compared for building models. It is observed that as number of storey increases base shear also get increased. Base shear after removal of column is greater than base shear before removal of column.

3.3 Summary of maximum values of different parameters of G+4,G+17,G+22 storey building models with blast loading

Model	G+4	G+17	G+22
Base shear	87.513	174.753	186.91
Storey drift	34.35	68.58	74.55
Vertical displacement	1.747	2.5	3.1
Natural frequency	8.582	9.44	9.86
Time period	11.7	10.5	10.1
DCR	1.5	1.6	1.9



Step by step procedure of column removal is done and DCR is checked for low, medium and high rise building. DCR value, story drift, Base Shear, Time period, natural frequency is compared for G+4, G+17, G+22 for earthquake analysis and blast load analysis.

IV. CONCLUSION

From non-linear dynamic analysis of building subjected to blast load before column removal and after column following conclusions are drawn.

1. Column removals have significant effect on blast performance of buildings.
2. Step by step procedure of column removal is done and DCR is checked for low, medium and high rise building. DCR value, story drift, Base Shear, Time period, natural frequency is compared for G+4, G+17, G+22 for earthquake analysis and blast load analysis
3. For seismic analysis the column from extreme left i.e. plinth level first column is removed and it's observed that low rise and high rise is safe. However, for blast load analysis the columns for maximum load is removed and it's observed that low rise and high rise building is safe same as in seismic loading

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