Analysis of Progressive Collpse of RCC Building With Blast Loading And Seismic Loading

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Abstract- *This project work presents the progressive collapse analysis of RCC building for blast and seismic loading. In structure due to the spread of local damage form element to element ultimately whole or proportionately larger structure gets collapsed in progressive collapse. 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 seismic 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),Medium rise (DCR IS 1.6)and high rise building(DCR is1.9) DCR within the acceptance criteria.*

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

I. INTRODUCTION

1.1 GENERAL

Progressive collapse could be a scenario wherever native failure of a primary structural element ends up in the collapse of neighboring members that, in turn, ends up in further collapse. Explosive loading became a major drawback that has got to be addressed very often. Progressive collapse happens once a structure has its loading pattern or boundary conditions modified such structural parts are loaded on far side their capability and fail. The abnormal loads initiate the progressive collapse. Modern building style and construction practices enabled one to create lighter and additional optimize structural systems with significantly lower over design characteristics. Damage to the assets, loss of life and social panic are factors that need to be reduced if the threat of terrorist action cannot be stopped. Planning the structures to be totally blast and seismic resistant is not a sensible and economically possible. But current engineering and field knowledge will enhance the new and existing building to mitigate the results of an explosions and seismic activities. The guideline U.S. General Services Administration (GSA) provides detailed stepwise procedure regarding methodologies to resist the progressive collapse of structure. In this procedure, structure during this procedure, one in all the necessary vertical structural parts within 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. In this research work progressive collapse analysis on low G+4, medium G+17and high riseG+22building is performed and its validation in accordance with GSA 2013.Response of RCC frame structure under blast and seismic loading is analysed and DCR of low rise, medium rise and high rise building for blast and seismic loading according with GSA 2013 is find out.

Staad pro to analyze the different parameters in progressive collapse.

1.2 AIM

To Study progressive collapse analysis Of RCC low, medium and high rise building during progressive collapse with blast and seismic loading using staad pro.

1.3 OBJECTIVES

- To perform progressive collapse analysis on low, medium and high rise building and its validation in accordance with GSA 2013.
- To check Response of RCC frame structure under blast and seismic loading.
- To check c/d ratio of low rise building, high rise building for different earthquake zones in according with GSA 2013.

- To analyse the time of collapse of building.

II. LITERATURE REVIEW

Yara M. Mahmoud, Maha M. Hassan, Sherif A. Mourad, Hesham S. Sayed 'Assessment of progressive collapse of steel structures under seismic loads' 2018[12] Progressive collapse involves a series of failures that lead to partial or total collapse of a structure.. This loss is caused by abnormal loads such as bombings, gas explosion, earthquakes.etc. Progressive collapse due to seismic actions has not received much attention in spite of its importance and repeated occurrences. Author intended to investigate the progressive collapse potential of steel moment resisting and braced frames designed according to Egyptian local standards due to damage caused by seismic actions. One first- storey column is fully removed at arbitrary locations within the building using alternate path method recommended in the UFC guidelines in order to study consequences and check safety of adjacent members. 3-D nonlinear dynamic analyses are employed using SAP2000 is employed in the performed parametric study.

III. METHODOLOGY

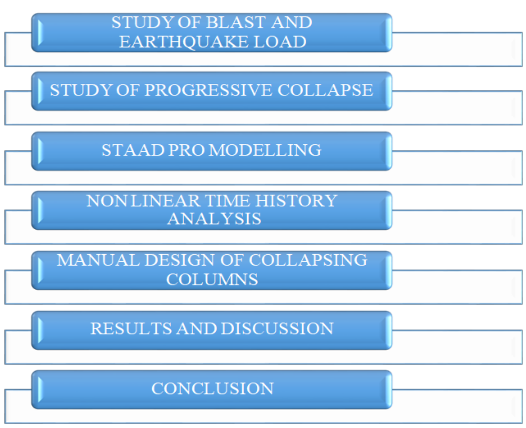

Fig 1: Methodology flowchart

High rise structures are constructed in main areas that may be main targets of terrorist activities. Vehicle omb 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. To analyze high rise steel structure for blast loading, we have to make model of high rise steel structure using Stadd-pro software which can resist all types of loading such as dead load, live load, sesmiclaod, using IS800-2000 and IS1893. The following parameters are to be checked after analysis of blast loading on structure, Demand Capacity Ratio (D.C.R.). Bending moments.(B.M). Shear Force.(S.F). deflection. storydrift. Loading due to blast will not be linear as intensity of loading depends on various criteria so for analysis of structure Non-Linear dynamic analysis is to be done.The blast is applied in X direction. The total column-beam joints are on the front face of building. The forces due to blast loading should be applied to the buildings as triangular loading functions calculated separately for each joint of the front face of the building, taking into account the distance to each joint from the source of explosion. Once the reflected pressure at each beam-column joint is calculated it should be multiplied with Tributary area to get the peak load at that joint. Positive time duration can also be find out, now we can generate the Load-Time history of each joint as input STAAD-Pro. The response of building with and without soft storey in terms of displacement, velocity and acceleration will be obtained.

COMPARATIVE STUDY OF PORTAL FRAME BEFORE AND AFTER COLLAPSE:

Comparative study of portal frame before and after collapse is as follows:

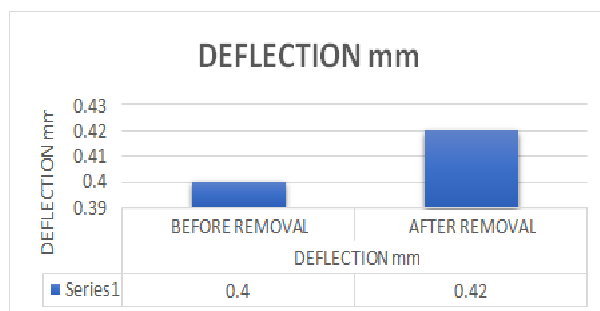

Fig 2: Deflection comparison

From the above graph the deflection of frame before removal of column is up to 0.44 mm and after removal is up to 0.42 mm, deflection after removal greater than before removal.

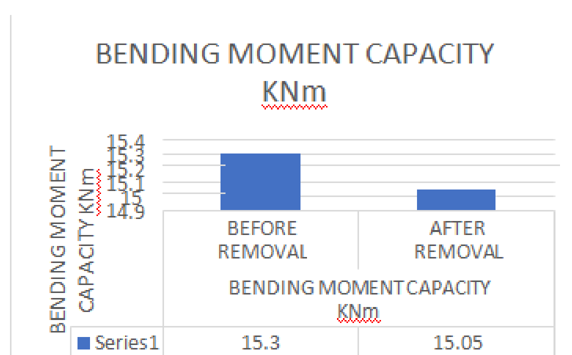

Fig 3: Bending moment comparison

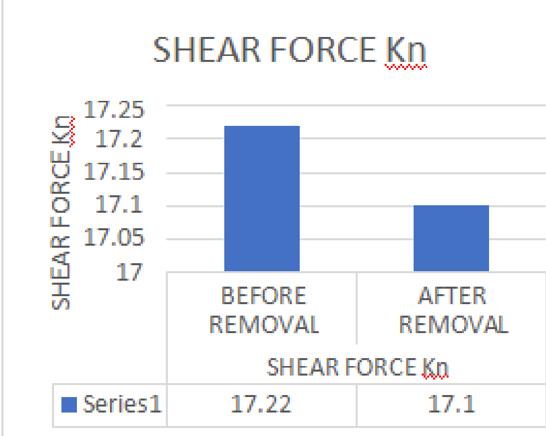

Fig 4: Shear force comparison

IV. MODELING

4.1 MODELLING AND ANALYSIS

A. Modelling of frame

Dynamic analysis using the time history analysis calculates the underground structure responses at discrete time steps using discretized record of synthetic time history as base motion. Time history analysis is the study of the dynamic response of the structure at every addition of time, when its base is exposed to a particular ground motion. The blast wave parameter is calculated by IS 4991and for seismic base shear IS1893-2002 code is used. DCR is the ratio of Member force to the Member strength. Acceptance criteria as per GSA guidelines (1.5 for typical building, 2 for atypical building.)

Table 1: Models Specifications of G+4, G+17, G+22storey building.

Specification	G+4	G+17	G+22
Beam Size	230*500mm	230 X 500 mm	230 X 500 mm
Column Size	230*600mm	Column up to fourth floor Size: 230 X450 mm Column up to fourth floor to seventh floor Size: 230 X 420 mm Column up to seventh floor to tenth floor Size: 230 X400 mm Column up eleventh floor to seventeen floors: 230 X 380mm	Column up to fourth floor Size:230 X450 mm Column up to fourth floor to seventh floor Size: 230 X 420 mm Column up to seventh floor to tenth floor Size: 230 X400 mm Column up eleventh floor to twenty second floor: 230 X 380mm
Slab Thickness	150mm	150 m	150mm
Storey height	3m	3m	3m
Grade of concrete	M25	M25	M25
Explosive type	C4 explosive	C4 explosive	C4 explosive

V. RESULTS AND DISCUSSION

Progressive collapse analyses with blast loading results are as follows:

Table 2: Natural Frequency Hz for G+4

NATURAL FREQUENCY for G+4		
Mode	BEFORE REMOVAL	AFTER REMOVAL
1	2.280	2.166
2	2.854	2.711
3	2.860	2.717
4	6.687	6.352
5	6.972	6.623
6	8.582	8.152

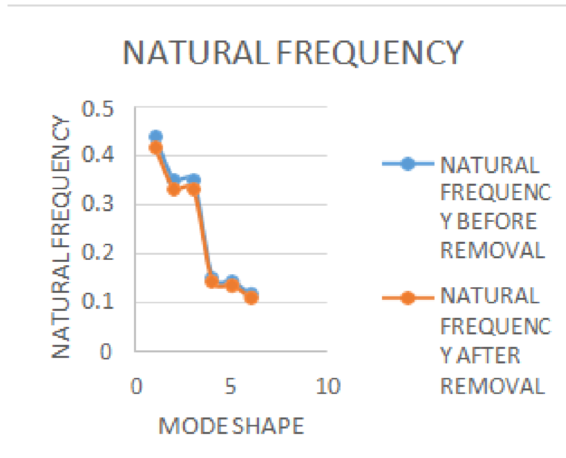

Fig 5: Natural frequency Vs Mode shapes

From the above graph the Natural frequency of frame before removal of column is greater than after removal.

Table 3: Time period

TIME PERIOD		
Mode	BEFORE REMOVAL	AFTER REMOVAL
1	0.439	0.41705
2	0.35	0.3325
3	0.35	0.3325
4	0.15	0.1425
5	0.143	0.13585
6	0.117	0.11115

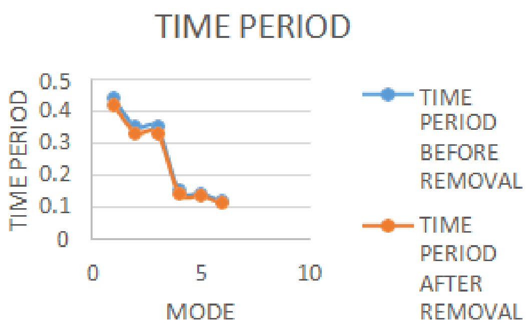

Fig 4: Mode shapes

From the above graph the Time Period of frame before removal of column is greater than after removal.

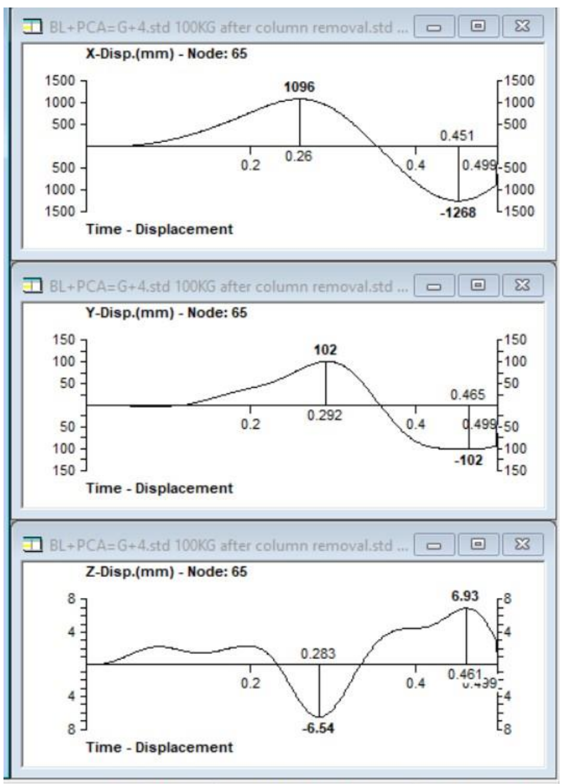

Fig 5: 100Kg TNT before removal time-displacement

From the above graph the 100 Kg TNT after removal time-displacement, on X Direction maximum displacement of 65 node is 1096 mm and Minimum displacement of 65 node on X direction is -1268 mm.same on Y direction maximum displacement of 65 node is 102 mm and Minimum displacement is -102 mm. Other side maximum displacement on Z direction is 6.93 mm and Minimum displacement on Z direction is -6.54 mm.

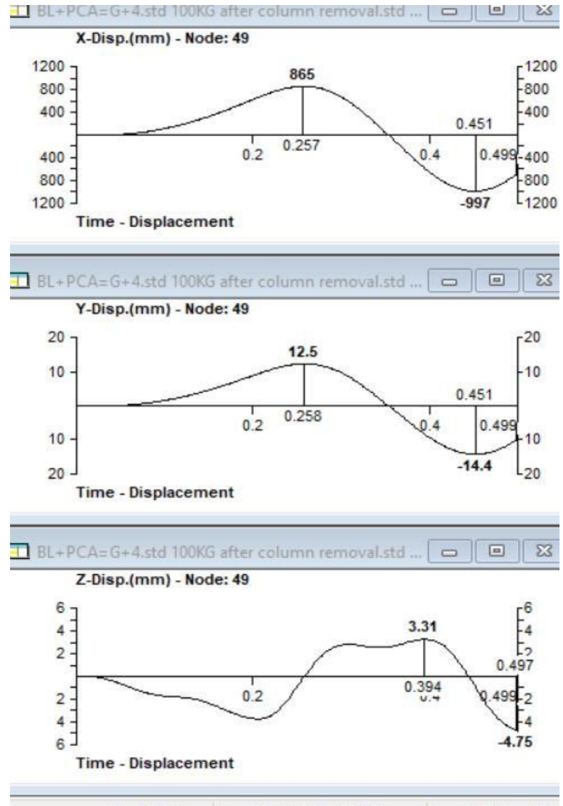

Fig. 6: 100Kg TNT after removal time-displacement

From the above graph the 100 Kg TNT after removal time-displacement, on X Direction maximum displacement of 49 nodes is 865 mm and Minimum displacement of 49 nodes on X direction is -997mm.Same on Y direction maximum displacement of 49 nodes is 12.5 mm and Minimum displacement is -14.4 mm. Other side maximum displacement on Z direction is 3.31 mm and Minimum displacement on Z direction is -4.75 mm.

VI. 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. For G+4 100 kg TNT, due to column removal there is 40.82%, 36.10% & 27.83% increase in displacement, velocity and acceleration respectively.
3. For G+4 200 kg TNT, due to column removal there is 44.96%, 32.87% & 23.03% increase in displacement, velocity and acceleration respectively.
4. For G+4 300 kg TNT, due to column removal there is 44.44%, 31.6% & 21.558% increase in displacement, velocity and acceleration respectively.

5. For G+4 400 kg TNT, due to column removal there is 44.186%, 31.24% & 21.51% increase in displacement, velocity and acceleration respectively.
6. For G+17 100 kg TNT, due to column removal there is 17.82%, 16.25% & 14.23% increase in displacement, velocity and acceleration respectively.
7. For G+17 200 kg TNT, due to column removal there is 18.92%, 17.1% & 15.5% increase in displacement, velocity and acceleration respectively.
8. For G+17 300 kg TNT, due to column removal there is 19.4%, 18.2% & 21.58% increase in displacement, velocity and acceleration respectively.
9. For G+17 400 kg TNT, due to column removal there is 21.2%, 19.4% & 22.4% increase in displacement, velocity and acceleration respectively.
10. For G+22 100 kg TNT, due to column removal there is 15.20%, 15.30% &13.15% increase in displacement, velocity and acceleration respectively.
11. For G+22 200 kg TNT, due to column removal there is 17.84%, 15.63% & 14.25% increase in displacement, velocity and acceleration respectively.
12. For G+22 300 kg TNT, due to column removal there is 18.54%, 16.59% & 20.35% increase in displacement, velocity and acceleration respectively.
13. For G+22 400 kg TNT, due to column removal there is 20.26%, 17.56% & 21.35% increase in displacement, velocity and acceleration respectively.
14. DCR ratio in all cases is less than by 2 hence sections need not to be redesigned considering blast load and seismic load.
15. While comparing base shear,storey drift and vertical displacement the amplitude due to removal of column incresed by 25-30% for shear,storey drift and vertical displacement because stiffness of structure decresed due to removal of column
16. For low rise building the difference after column removal is more than that of high rise building as high rise building will have more stiffness

REFERENCES

[1] Ahmed Elshaer, Hatem Mostafa, and Hamed Salem ‘Progressive Collapse Assessment of Multistory Reinforced Concrete Structures Subjected To Seismic Actions’2016

[2] A.Choubey‘Analysis of progressive collapse in rc frame structure for different blast loading’ International journal of engineering sciences & research technology(2016)

[3] Chopra A K (2007),’Dynamics of structures—theory and application to earthquake engineering’,3rd edn’

[4] General services administration alternate path analysis & design guidelines for progressive collapse resistance october 24, 2013

[5] IS: 4991-1968,’Criteria for blast resistant design of structures for explosion above ground. Bureau of Indian Standards.’

[6] IS 1893:2002 (Part I),‘Criteria for earthquake resistant design of structures Part1.Bureau of Indian Standards.’

[7] Michael ByfieldWjesundaraMudalige Colin Morison Euan Stoddart ‘A review of progressive collapse research and regulations’2014

[8] Ramon Codina, Daniel Ambrosini, Fernanda de Borbona ‘Alternatives to prevent progressive collapse protecting reinforced concrete columns subjected to near field blast loading’ 2017

[9] Rakshith K G1, Radhakrishna’Collapse resistance of progressive collapse of in RCC structures’(Nov-2013).

[10] Rinsha C1, Biju Mathew2 ‘Progressive collapse analysis of steel frame structures’ Volume: 04 Issue: 05 | May - 2017

[11] RoholaRahnavarda, FaramarzFathiZadehFardb, Ali Hosseinic, Mohamed Suleimand ‘Nonlinear analysis on progressive collapse of tall steel composite Buildings’2018[4]

[12] Yara M. Mahmoud, Maha M. Hassan, Sherif A. Mourad, Hesham S. Sayed ‘Assessment of progressive collapse of steel structures under seismic loads’ 2018

[13] Y.A. Al-Salloum a, H. Abbas a, T.H. Almusallam a, T. Ngo b, P. Mendis b ‘Progressive collapse analysis of a typical RC high-rise tower’ 2018

[14] Yash Jain1, Dr.V.D. Patil2 ‘ Assessment of Progressive Collapse for a Multi-Storey RC Framed Structure using Linear Static Analysis Technique’ Volume 60 Number 3 - June 2018

[15] Z.B.Unde,Dr.S.C.Potnis,’Blast Analysis Of Structures ’ Elesevier(2013)