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Progressive Collapse Analysis of Three Dimensional Two Bay Five Storey Bare and Infilled Frames under Corner and Middle Column Removal

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Abstract: ***Demand Capacity Ratio (DCR) assessment of the structural progressive collapse of two bay five storey bare frame without wall load , bare frame with wall load and Infilled frame with cement mortar (IFCM). IN this paper linear static analysis is carried out under corner and middle column removal base on GSA guidelines. Finite element software was used to design two bay five storey reinforced concrete building frame using Indian Standard (IS code). Finally all the three cases according to the progressive collapse resistant behaviour indicator DCR values to investigate in ability in progressive collapse, this present result shows Infilled frame with cement mortar shows to prevent the progressive collapse of Reinforced concrete building.***

Keywords : ProgressiveCollapse, Two Dimensional, Bare, Infilled Frame, Corner, Middle, Linear Static

I. INTRODUCTION

The spread of an underlying neighbourhood disappointment from component to component, in the long run bringing about the breakdown of a whole structure or an excessively huge piece of it, has been known as' 'dynamic breakdown" [1]. Power is absolutely a property of the structure interestingly with an increasingly broad definition given in Eurocode UNI EN 1991-1-7 [2] Progressive breakdown of a structure takes places when the structure has its stacking example or limit condition changed to such an extent that the basic component is stacked past a definitive limit and fall flat. In this circumstance when any part component bar or segment, the other component looks for elective burden ways to redistribute the heap connected to it. Accordingly, different components may cause fizzle cause disappointment mechanism.

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Progressive breakdown previously pulled in the pulled in the consideration of designers after the auxiliary disappointment of a 22 story precast structure in the Ronan point loft breakdown in London in 1968. The fundamental driver of the Ronan point breakdown was a human mistake (gas blast) at the eighteenth floor causing the floors over the breakdown [3].In ongoing years numerous analysts are focused on the basic dynamic breakdown in any type of catastrophic events (seismic tremor, torrent and tropical storms) human-made calamities like (bomb impact, fire and so forth.) [4-8]. Basic Engineers are customarily centred on improving the auxiliary offices while meeting the code offices. In India, the majority of the structures have been intended to oppose the sidelong loads like breeze and seismic. In spite of the fact that the four investigation techniques introduced in this examination can be utilized freely, they supplement one another, and along these lines it is prescribed that a joined dynamic investigation methodology Marjanishvili 2004 [9] be used. This involves starting with an easier static strategy, trailed by progressively complex investigation techniques as vital until it is resolved that the likelihood of dynamic breakdown is low, or until all accessible building strategies are depletedPowel [10] analyzed both direct static and dynamic investigation and presumed that dynamic examination is more exact than static investigation. Osama A.Mohamed [11] carried out eight storey moment resisting frame under external column removal study. Many researchers are focused on 2D frames [12-17] with nonlinear dynamic analysis in concrete and steel structures.S.Gowtham et al (2017)[18] studied the linear static progressive collapse analysis- bare frame in three dimensional reinforced concrete building frame using SAP2000.

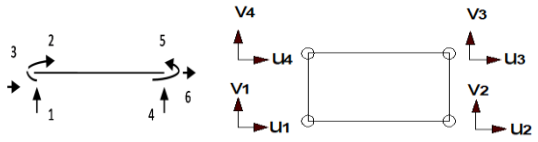
II. OBJECTIVE

The main objective of this paper is comparison study for experimental prototype model for three Dimensional two span five storey reinforced concrete building below three different loading conditions (i) Bare frame with without wall load (ii) Bare frame with wall load and (iii) Infilled frame with Cement mortar (IFCM) under corner and middle column removal condition.

In this present study linear static analysis is carried out using a finite element software SAP2000 [19], displacement. Demand Capacity ratio (DCR).In this present study the maximum internal forces like axial force in columns and bending moment and shear force for beams.

III. MODELLING AND DESCRIPTION OF THE STRUCRURE

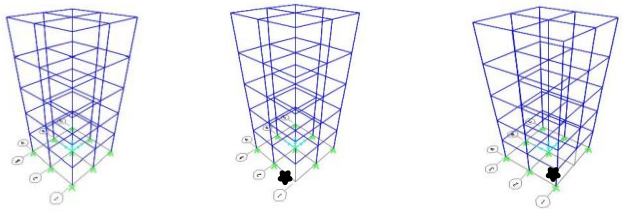
The present study have three dimensional prototype two bay five storey reinforced concrete building frame, bay width are 3m x 3m in both longitudinal and transverse direction of 3m, and storey heights are 3m. Beam sizes are 230mm x 300 mm and column dimensions are 400mm x 230mm. In this present study grade ofconcrete M30 and HYSD bars are used. Brick Masonry 1:6 was used. Under each cases, three different load cases without wall load, with wall load and IFCM. The frame members are modelled the frame members are modelled and as beam elements with three degrees of freedom per node (Figure 1. (a)) and the infill is modelled as four noded plane stress elements (Figure 1 (b)) with two degrees of freedom per node and with homogeneous masonry properties. The interface connecting the frame to infill in the case of the infilled frame is also modelled with four noded plane stress elements (Figure 4.2(b)) with interface characteristics of that of cement mortar. The analysis is carried out with a standard structural software package that is Structural analysis program SAP2000 Ver. 18. Three structural configurations are shown in Figure 2 and Figure 3.The beam and columns are designed based on IS 456:2000 [20].For Column 4 no's of 16mm dia as a main bar and 8mm diameter for ties and Beam 2 no's of 12mm dia Tension bars and 2# 10mm dia for Compression side 2 Legged 8mm diameter stirrups @ 200mm C/C spacing.



a) Beam Element (b) Plane Stress Element

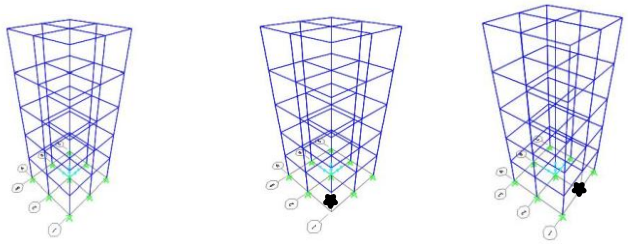
Figure 1 Elements used for Analysis.

Case -I



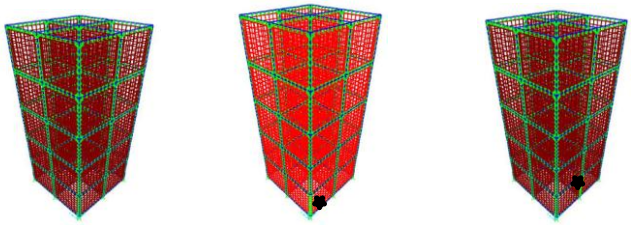
a) Without Column removal b) Corner Column Removal c) Middle Column Removal

Case - II



a) Without Column removal b) Corner Column Removal c) Middle Column Removal

Case – III



a) Without Column removal b) Corner Column Removal c) Middle Column Removal

Figure 2. Three dimensional prototype two bay five storey RC buildings

Linear Analytical Study

DCR calculated by using the below formula As per Cl.: 3.2.11.1.2 of UFC 4-023-03 [21], for deformation controlled action,

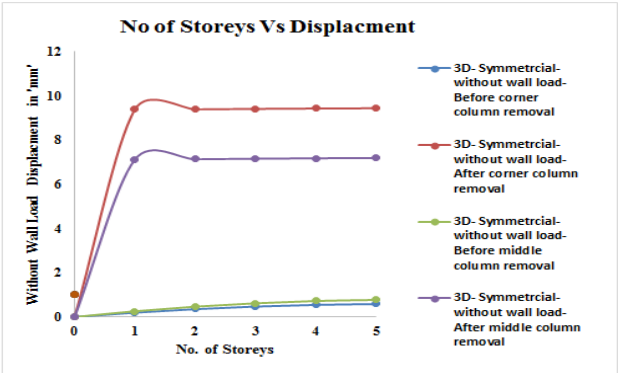
$$DCR = Q_{UD}/Q_{CE} \quad \text{..... (1)}$$

Where QUD = Force (Bending moment, Axial force, Shear force)
QCE = Expected ultimate factored capacity

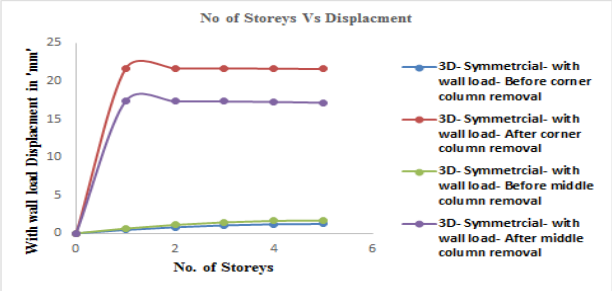
IV. RESULT OF ANALYSIS

The results of the above analysis are presented here for three dimensional two span five storey, for bare frame without wall load, bare frame with wall load and IFCM under each cases both corner and middle column removal was considered. The results of the three dimensional configuration study are presented with respect to (i) Vertical Deflection and (ii) maximum DCR values of internal forces (iii) Principal Stresses

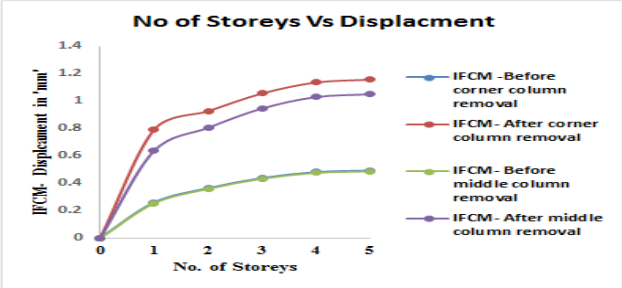
Results of Analysis of Vertical Deflection of Two bay-Five Storey Three Dimensional Building



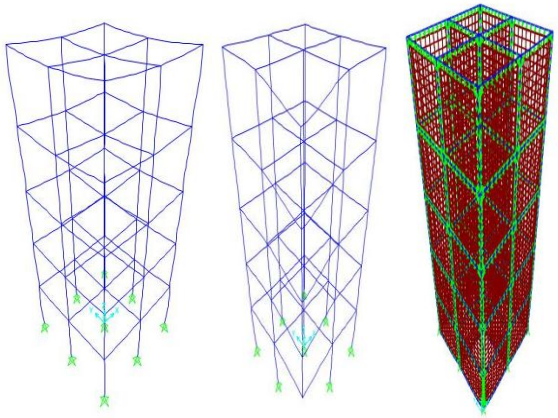
(a) Without wall load



(b) With wall load



(c) IFCM



(d) Maximum Corner Displacement profile of BF with Wall load and without column displacement

Figure 3. Vertical Deflection for Three Dimensional – Two Bay Five Storey RC Building.

From Figure 3 (a), 3(b) & 3 (c) for vertical deflection pattern for bare frame without wall load, Bare frame with wall load. The typical vertical deflection diagram of the bare frame (without wall load), with wall load and IFCM are shown in Figure 3. From this figure 3(b) with wall load case the maximum vertical deflection t is observed 26.6917mm at second storey level under corner column removal which is reduced to 0.7913mm when the frame is infilled frame with cement mortar (IFCM). This means that there is a reduction of 96.35% in vertical deflection of the bare frame with wall load by infilled (IFCM). It shows that the stiffness of the frame also increased.

Results for Internal forces in Three dimensional two bay five storey RC frame:

The internal forces in the frame such as maximum DCR value for Axial force, bending moment, and Shear force are presented.

Maximum Axial DCR force Values.

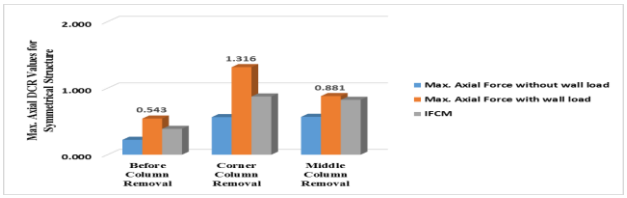


Figure 4(a) Maximum and Minimum Axial force profile of BF without wall load, With Wall load and IFCM

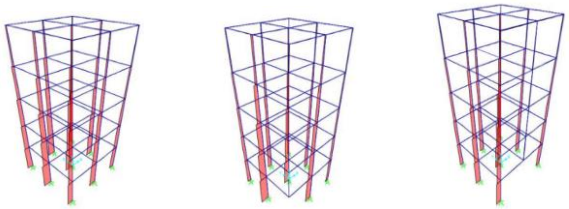


Figure 4(b) Case-I Without wall load- Before Column removal, Corner column and Middle Column removal AFD Diagrams

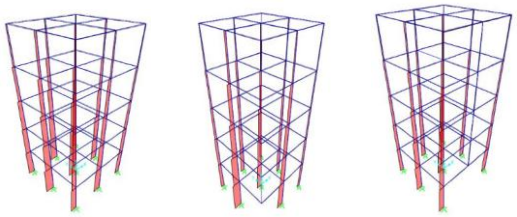


Figure 4(c) Case-II with wall load- Before Column removal, Corner column and Middle Column Removal AFD Diagrams

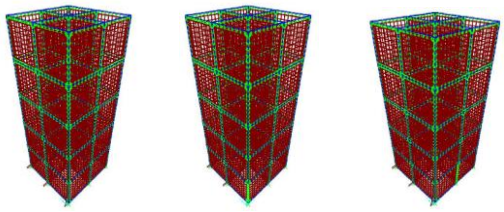
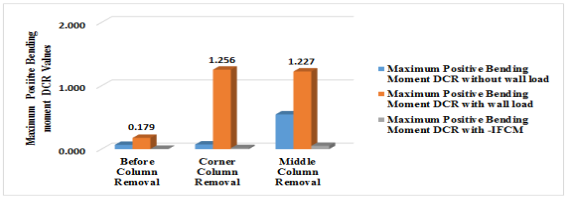


Figure 4(d) Case-III IFCM- before Column removal, Corner column and Middle Column Removal AFD Diagrams

From Figure 4(a) Shows the maximum axial DCR values and Figure 4(b), 4(c) and 4(d) for the axial force diagrams for bare frame without wall load and bare frame with wall load and IFCM.From this figure 4(a) the maximum axial DCR with wall load 1.316 under corner column removal which is reduced to 0.389 when the frame is IFCM. This means that the there is a reduction of 66.7% in axial force for the bare frame and IFCM. The maximum axial DCR was observed next to the column removal case. All the three different load cases,the DCR values are within the permissible limit less than 2 and also the frame shows that the structure is prone against the progressive collapse.

Maximum Span and Support Bending Moment DCR Values:



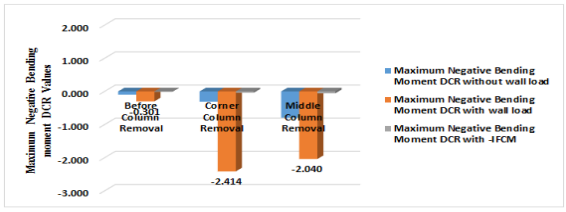


Figure 5(a) Maximum DCR value for Positive and Negative Bending Moment (Span & Support)

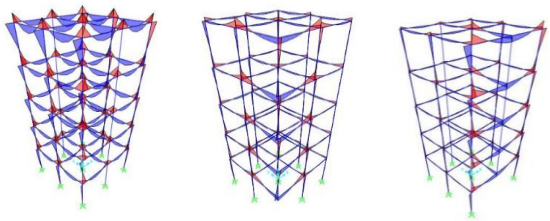


Figure 5(b) Case-I Without wall load- Before Column removal, Corner column and Middle column removal BMD Diagrams

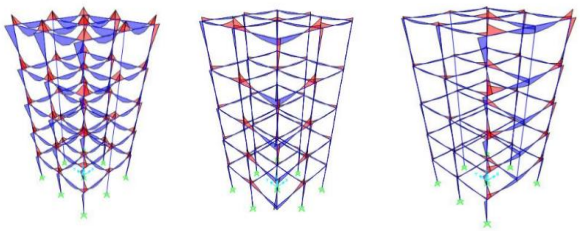


Figure 5(c) Case-II With wall load- Before Column removal, Corner column and Middle column removal BMD Diagrams

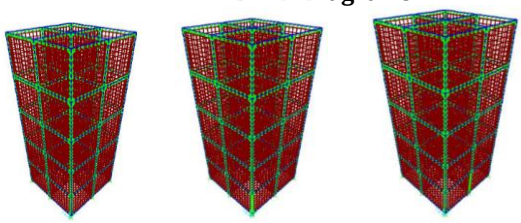
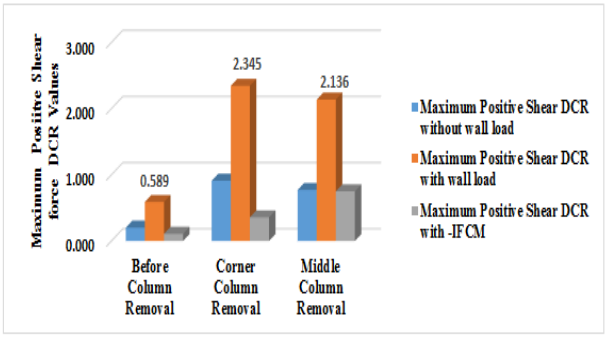


Figure 5(d) Case-III IFCM- before Column removal, Corner column and Middle column removal BMD Diagrams

From figure 5 (a). 5(b)5(c) and 5(d) are shown the positive (Span) and negative (support) bending moments of two bay five storey for bare frame without wall load, bare frame with wall load and IFCM. From figure 5 (a), the maximum positve bending moment (Span moment) is 1.256 under corner column removal when the bare frame with wall load condition (Case-II) and the minimum positve bending moment (Span moment) DCR value is observed 0.005 under the (Case III) before column removal conditoion.When the frame is IFCM, there is a reductino of 99.6% in positve (Span) moment. When compare to the negative (support) moment the maximum DCR was observed -2.414 and 2.040 with bare frame with wall load condition under corner and middle column removal and minimum DCR support value of -0.011 when the frame is IFCM with column removal conditon. This means that there is the reduction of 99.5% and 99.46% in negative (support) moment of the bare frame with IFCM. From all the bending moment DCR graphs it is observed that the beam is bending in nature under corner and middle column removal. When the bare frame with wall load case under corner and middle column removal exceeds the permissible limit more than 2 this may lead to progressive collapse of the structure.

Shear Force (Positive & Negative Shear)



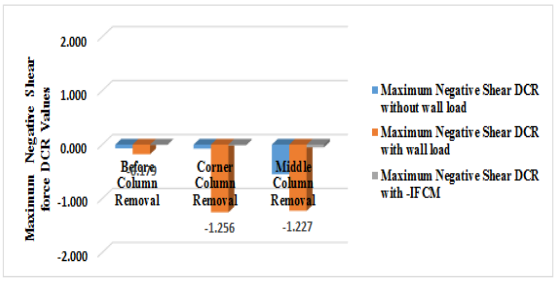


Figure 6(a) Maximum DCR value for Positive and Negative Shear force

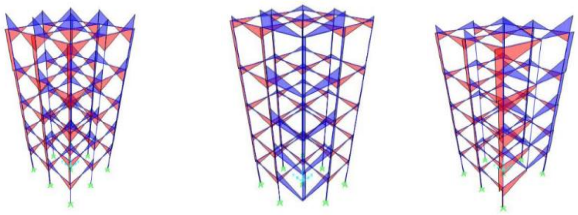


Figure 6(b) Case-I Without wall load- Before Column removal, Corner column and Middle column removal SFD Diagrams

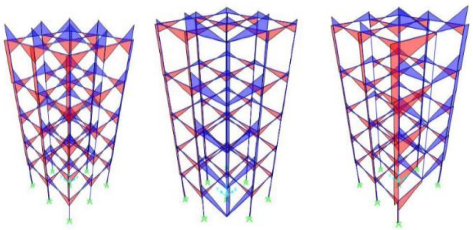


Figure 6(c) Case-II With wall load- Before Column removal, Corner column and Middle column removal SFD Diagrams

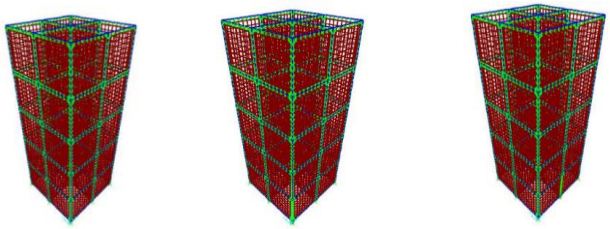


Figure 6(d) Case-III IFCM- before Column removal, Corner column and Middle column removal SFD Diagram

From Figure 6 (a), 6(b),6 (c), 6(d) are various positive and negative shear force diagram. From Shear force DCR the maximum positive shear force DCR was observed 2.345 & 2.136 for corner and middle column removal under bare frame with wall load condition and the minimum positive DCR was observed 0.108 under IFCM condition which means that there is a reduction of 95.4% and 94.9% in positive shear force with IFCM exceeds the permissible limit of 2.0 and the beam under cantilever action when compare to the negative shear force DCR the maximum value is observed 1.256 under corner column removal with Bare frame with wall load condition. All the negative shear force DCR are within the permissible limits.

Conclusion and Recommendations

Based on the analytical results, we draw the following conclusion are obtained Three dimensional two bay five storey RC structure, progressive collapse linear static analysis is carried out displacement and DCR results are compared. The maximum vertical deflection was observed in bare frame with wall load condition at corner column removal and the minimum deflection was observed in IFCM case. When the frame is infilled with cement mortar. This means that there is a reduction of 96.35% in vertical deflection of the bare frame with wall load by IFCM. In DCR columns and Beams are carried out. In axial force DCR all the column was observed within the permissible limit, In Bending moment DCR, Span moments are shown under permissible limit and support moment values are exceeds the permissible limit under corner and middle column removal and its shows the catenary action of the beam and in case of the IFCM beam results shows reduction in bending moment. The positive and negative shear force are carried out. The maximum positive shear force DCR was observed both corner and middle column exceeds the permissible limit and the IFCM shows reduction in shear force of 95.5% and 94.9%.The negative shear force DCR are under the permissible limit. Finally the IFCM would be more conservative.

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