Non-linear Static Progressive Collapse Analysis of Asymmetric High Rise R.C.C. Structure

Sushil Darak, H. R. Magar Patil

Abstract: ***The developments in construction make it compulsory for architects to plan the high rise structures in RCC. Unfortunately due to some reasons like gas explosion, terrorist attack, fire etc. high rise structures undergoes some major component failure. As the major component fails, sometimes part of the structure or whole structure tends to collapse. This behavior of the structure is called as progressive collapse. Progressive collapse may be a chain reaction of failures that circulates either throughout or some of the structure lopsided to the first local failure. The progressive collapse of building structure is commenced when one or more vertical load carrying members are removed. One of the important characteristics of progressive collapse is that the final damage is not related to the initial damage. In this project it is proposed to carry out progressive collapse analysis of regular and irregular structures. Structural model of building has been fashioned din ETABS and loads are applied as per GSA guidelines, for evaluation of progressive collapse nonlinear static method of analysis has been used. The analysis is done using ETABS 18 software and using codes of analysis, IS 1893: 2016, IS 456: 2016. Joint displacements, axial force, bending moment are evaluated. In all cases progressive collapse of internal column is more critical as compared to other cases.***

Keywords: ***Progressive Collapse, non linear static analysis, seismic force, Storey Drift, Etabs2018.***

I. INTRODUCTION

Tall buildings are a unique class of structures with their own unique features and demands. you're often occupied by an oversized number of individuals. which will lead to their injury, loss of functionality or collapse quite serious and negative effects for the lives and economies of the regions affected. Each tall building represents a major investment and per se tall building analysis is usually performed using more sophisticated techniques and methodologies. Therefore by understanding modern approaches to seismic analysis of tall buildings is also very valuable to structural engineers and researchers. The American Society of engineering means ASCE, 2005 is that the sole mainstream standard which addresses the problem of progressive collapse in some detail. the rules for progressive collapse resistant design are noticeable in u. s. government documents, General Service Administration (GSA, 2003)[8] and Unified Facility Criteria (UFC, 2009). The GSA guidelines have provided a method to diminish the progressive collapse potential in structures supported Alternate Path Method (APM). It defines scenarios within which one among the building's columns is removed and also the damaged structure is analyzed to check the system responses.

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With the current scenario of accelerating reasons for disaster like situation at industrial or residential workplace. during this project the behavior of a multi-storeyed RCC building frame having different geometrical shapes are analyzed using the software ETABS 2018. The structural parameters of all the buildings are discussed, just like the forces of the story, story drift, base reactions, mode-periods etc. Nonlinear static Push over analysis of the models is dispensed.

A. Objectives Of The Research

1. In the present study, nonlinear static analysis of symmetrical and unsymmetrical ten storeys RC framed building by using software ETABS V 18.1.0
2. To perform pushover analysis for the structure with and without removing the column from the position under consideration as per GSA guidelines.
3. To determine the potential for progressive collapse
4. Seismic analysis of building
6. To give the preventive measures

II. LITERATURE REVIEW

Progressive collapse study after Ronan point apartment building is on the picture and various researchers are studying the progressive collapse after that incident. The below literature survey includes summary of research papers presented in popular journals on topics similar to current field of study. Fabio Maze, Engineering Structures 80 (2014) 98–108 –Elsevier[1] presented a paper called "Modeling and nonlinear static analysis of reinforced concrete framed buildings irregular in plan."The point of this examination was to survey the seismic defenselessness bearings of fortified cement confined structure with halter kilter plan, in terms of dislodging and quality. The contextual analysis chose for this work is the current town corridor of Spilinga, a modest community close Vibo Valentia (Italy), which was a two-story R.C surrounded structure, with an L-formed unpredictable arrangement. A lumped versatility model (LPM) with a level surface demonstrating (FSM) of the hub load–biaxial twisting second versatile space of R.C cross-segments is executed in a PC code for the nonlinear static investigation of R.C spatial encircled structures. These at last feature that, in the event of in-plan inconsistency, the utilization of limit areas uncovered fundamental to evaluate the bearings of least seismic limit. A research paper presented by Rucha Thombare and Dr. H. R.Magarpatil on the "Non-linear static progressive collapse analysis of the high rise reinforced concrete structure". Progressive collapse study of 12 story RC frame building is proposed in this project by removing separate columns one at a time according to the GSA guidelines. R. Shankar Nair (March 2004) describes in paper previous structural collapse and observation on progressive collapse and description of proportionate and disproportionate collapse[3]. Wibowo, H. .andLau,D.T. (2009) summaries the merits or advantages and limitations of obtainable analysis methods for assessment of progressive collapse of structures and paper concluded that seismic progressive collapse of structures are often analyzed by modifying the present analysis procedures [4]. Authors Yanchao Shi , Zhong-Xian Li , Hong Hao (2010) studied RC structure under case of blast loading susceptible to progressive collapse. a replacement method for progressive collapse analysis of ferroconcrete (RC) frame structures by considering non zero initial conditions and initial damage to adjacent structural members under blast loading is predicted And it's found it gives better prediction [5]. Poonam et al. (2012) says that any storey in building should not be softer than storeys above or below[6]. creators A. Choubey what's more, M.D. Goel (2015) examined RCC building structured in view of Indian standard code of training is thought of what's more, infers that the impact of moving the heap is more on the closest individual from the evacuated part and irrelevant when moved away from evacuated segment [7].

III. METHODOLOGY

Basic plan of buildings for seismic loads is fundamentally concerned with auxiliary security amid major ground movements, but serviceability and the potential for financial misfortune are too of concern. Seismic stacking requires an understanding of the basic execution beneath huge inelastic misshapenness. Behavior beneath this stacking is in a general sense diverse from wind or gravity stacking, requiring much more point by point investigation to guarantee worthy seismic execution past the versatile run. A few auxiliary harm can be anticipated when the building encounters plan ground movements since nearly all building codes permit inelastic vitality dissipation in basic frameworks. In common, for a multi story building it is necessary to require under consideration contributions from more than one mode. Separated from gravity loads, the structure will encounter overwhelming sidelong strengths of considerable greatness amid seismic tremor shaking. It is fundamental to appraise and indicate these horizontal strengths on the structure in arrange to plan the structure to stand up to a seismic tremor. It is inconceivable to precisely decide the earthquake initiated sidelong strengths that are anticipated to act on the structure amid its lifetime. However, considering the noteworthy impacts of seismic tremor due to inevitable disappointment of the structure, it is imperative to estimate these strengths in a levelheaded and practical way.

A. Non Linear Static Pushover Analysis

In this venture the seismic investigation of the structures are carried out by non-linear inactive pushover examination. The pushover investigation of a structure could be an inactive non-linear examination beneath lasting vertical loads and gradually increasing sidelong loads. A plot of add up to base shear versus best relocation in a structure is gotten by this analysis that would show an untimely disappointment or shortcoming. All the pillars and columns which reach abdicate or have experienced pulverizing and indeed break are recognized. A pushover investigation is performed by subjecting a structure to a monotonically expanding design of sidelong loads that appears the inertial strengths which would be experienced by the structure when subjected to ground movement. Beneath incrementally expanding loads many structural components may surrender successively. Hence, at each occasion, the structure encounters a diminish in stiffness. Employing a nonlinear inactive pushover examination, an agent non-linear drive relocation relationship can be gotten.

IV. MODELLING OF STRUCTURE

As the project is based on the asymmetry so different types of structure are considered. To observe the progressive collapse of a building it is necessary to build up 3D model using finite element method. ETABS 18 is used to analyze the models. Here the R.C.C building frames having G+ 10 storey each are selected to model in ETABS as given below.

Type. A: Square in plan.
Type B: Rectangular in plan.
Type C: Irregular plaza.
Type D: Irregular Stepped Building
Type. E: Hexagonal in plan.
Type. F: Octagonal in plan.

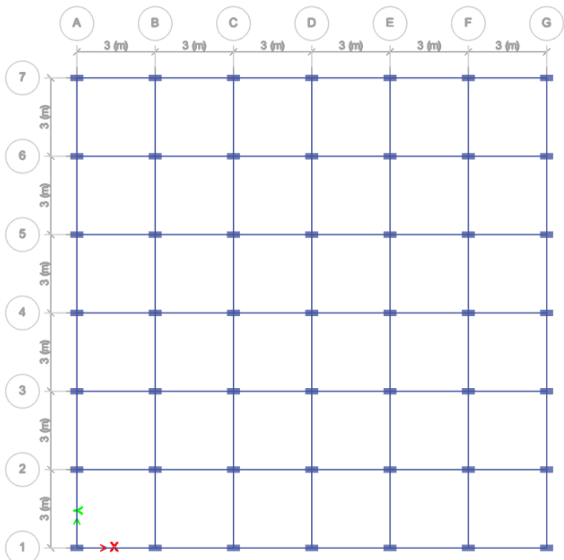

Figure 1 Plan view of square structure

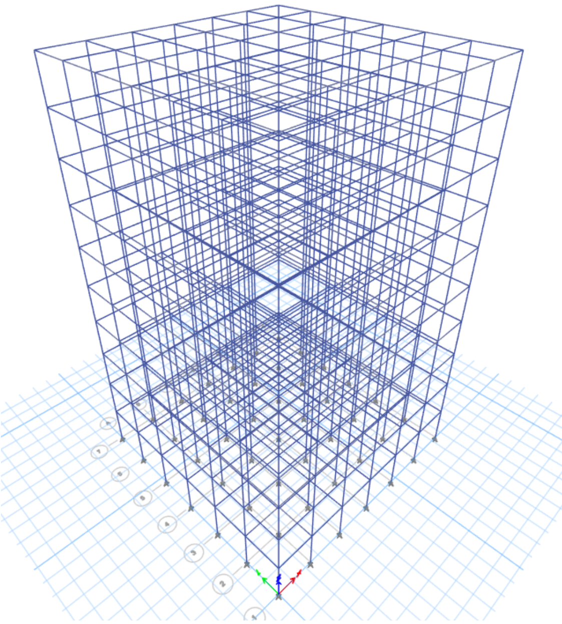

Figure 2 Isometric view of square structure

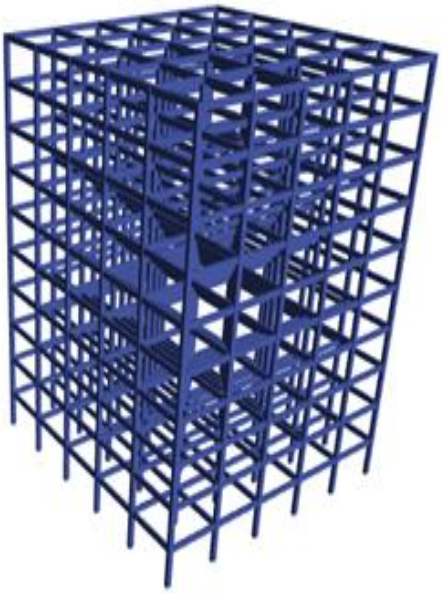

Figure 3 Rectangular plan view

Figure 4 Rectangular isometric view

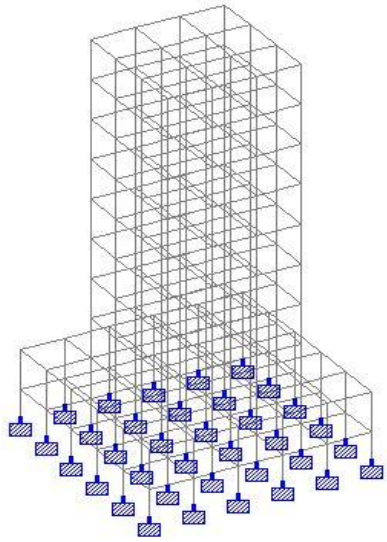

Figure 5 Isometric view of irregular plaza building

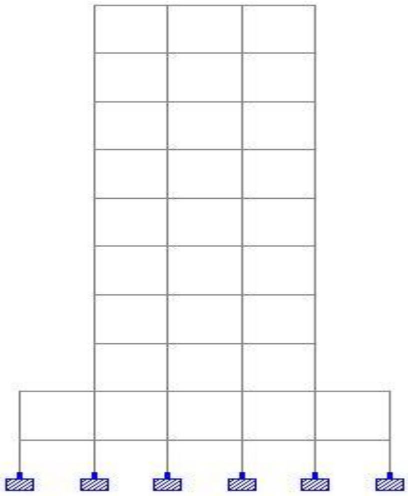

Figure 6 Front view of irregular plaza

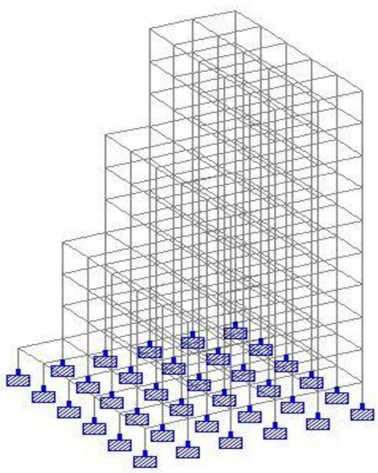

Figure 7 Isometric views of irregular stepped building figure

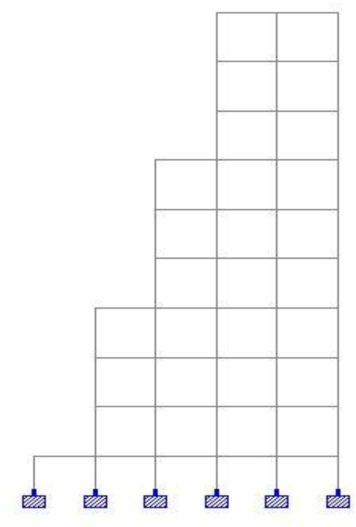

Figure 8 Front view of irregular stepped building

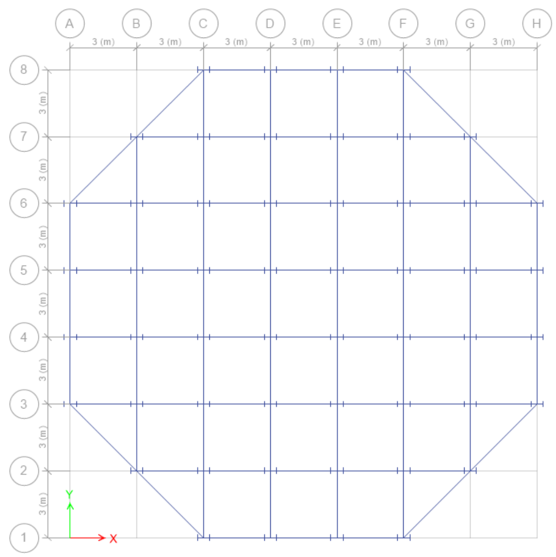

Figure11 Plan of octagonal structure

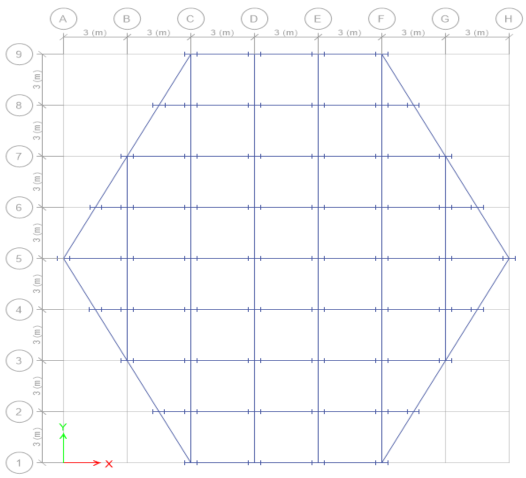

Figure 9 Plan view of hexagonal structure

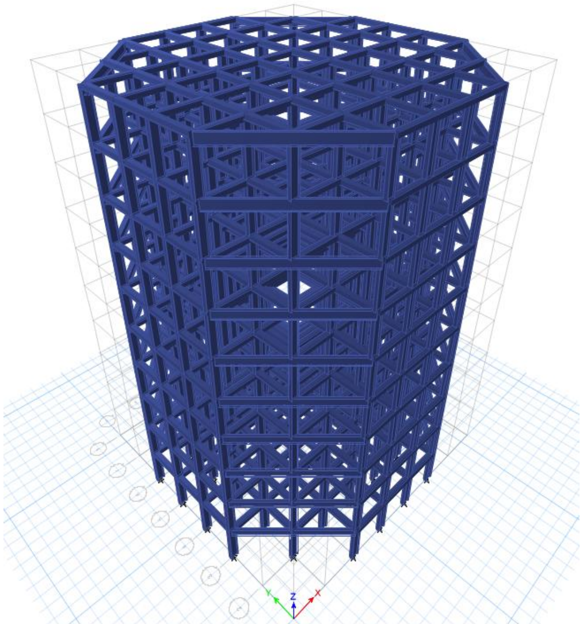

Figure 12 Isometric view of octagonal structure

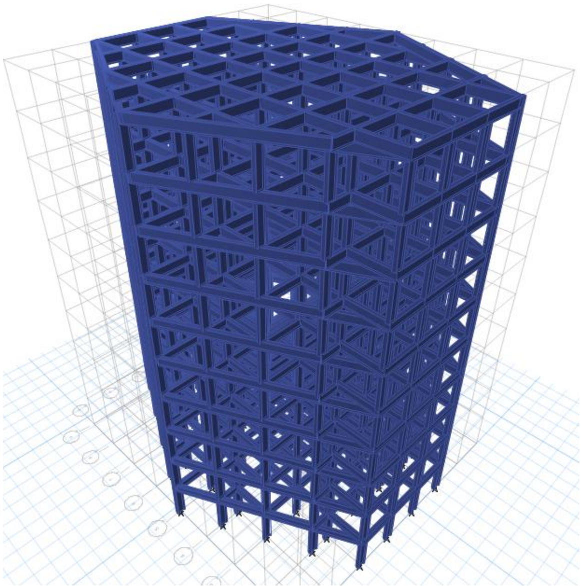

Figure 10 Isometric view of hexagonal structure

A. Material Properties And Geometrical Properties

For the modeling following material properties are considered:

Unit weight of RCC : 30 kN/m3

Unit weight of Masonry : 20 kN/m3

Rebar material : Fe 500

Young’s modulus of concrete : 2x104 N/mm2

Poisson’s ratio : 0.17

Structure type : RCC

Depth of foundation : 2.0 m (below ground level)

Floor to floor height : 3.0 m

Height of base : 3.0 m

Number of storeyes : G + 9

Thickness of slab : 150 mm

Spacing in between column : 3 m in both direction

Dead load : according to IS code 875 (part 1) 2016[9] Self weight of structure

Live load : 3 KN/m + 0.75 (earthquake calculation)
Floor finish : 1 KN/m3
Wall load : 17 KN/m^3
Wall laod on roof : 8.5
The earthquake loads are derived for following seismic parameters as per IS : 1893 (2016)
a. Earth Quake Zone : V
b. Response reduction Factor : 5
c. Importance Factor : 1.5
d. Damping : 5%
e. Soil Type : Medium soil (assumed)

B. Typical Loading Diagrams:

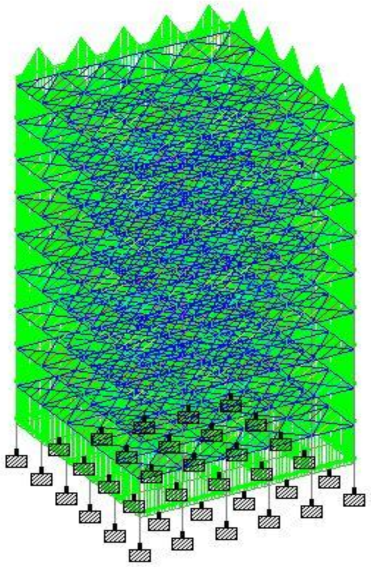

Figure 13 Dead load diagram

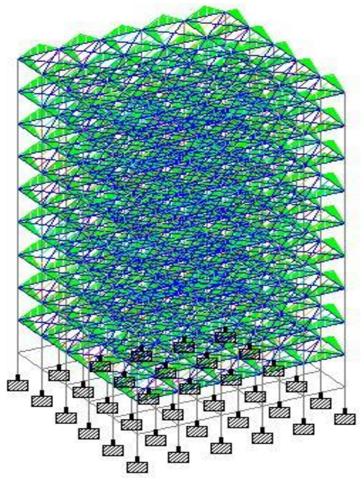

Figure 14 Live load diagram

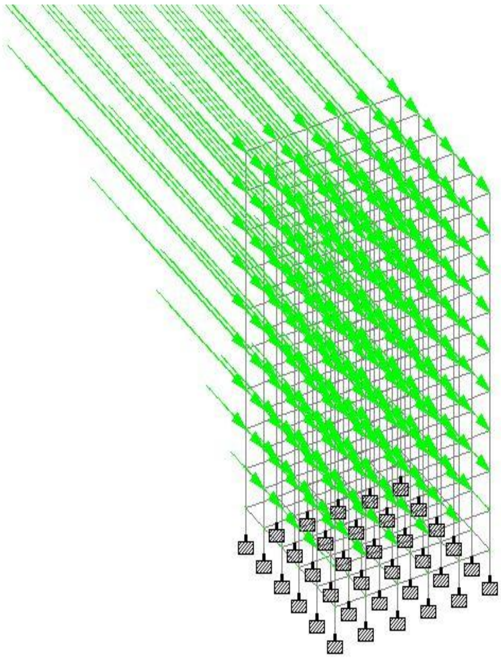

Figure 15 Seismic load in Z direction

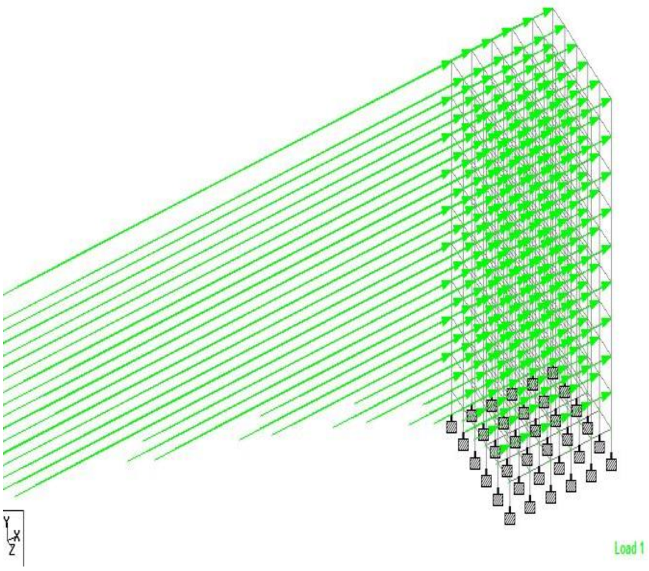

Figure 16 Seismic load in X diection

C. Progressive Collapse Analysis:

In this progressive collapse analysis we are considering three different cases of column removal. All these are from first floor . This procedure is done for all different structures.
Case 1: analyses for sudden loss of corner column.
Case 2: analyses for sudden loss of middle column.
Case 3: analysis for sudden loss of centre column.

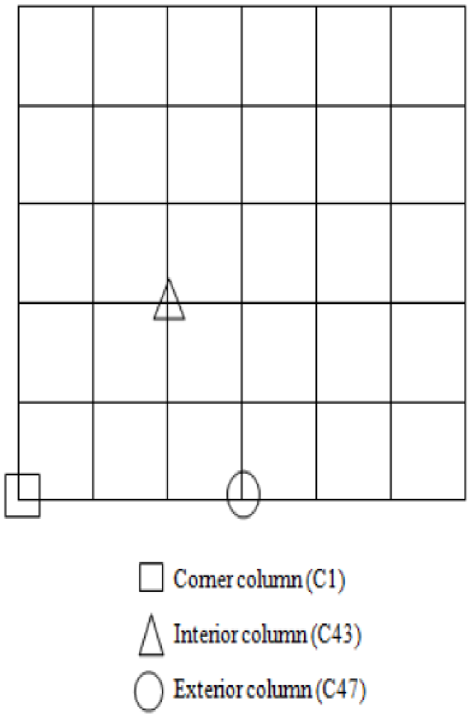

Figure 17 Detail description of model

V. RESULT AND DISSCUSSION:

All the types of structure are analyzed using the software ETABS 2018. The obtained results of each building are tabulated and explained as follows:

A. Base Reactions:

Following are the results obtained for the base reaction in terms of sheer force and bending moment. The obtained results are shown in tabulated form. From the results it seems that the shear force is minimum in case of square and rectangular and also the shear force is maximum in case of irregular plaza and octagon structure.

Table I Comparison Of Base Reactions

ITEM	SQUARE	RECTANGULAR	IRREGULAR PLAZA	IRREGULAR STEPPED	HEXAGON	OCTAGON
MAXIMUM SHEAR FORCE	225.268	220.645	260.531	232.282	262.713	258.279
MAXIMUM BENDING MOMENT	164.848	318.539	386.548	339.66	242.79	220.147

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B. Axial Forces And Storey Drift:

Considering the maximum forces in all the models the axial force exerted in octagonal model is less than the others. It is 7% excess in square, 6% excess in rectangular,1.5% in stepped, 0.5 % in plaza and 0.35% excess in hexagon as compared to octagon.

Storey drift is maximum for square model and minimum for hexagon.

C. Maximum Displacements:

Table II Maximum Displacement

ITEM	SQUARE	RECTANGULAR	IRREGULAR PLAZA	IRREGULAR STEPPED	HEXAGON	OCTAGON
MAXIMUM DISPLACEMENT	80.44	89.339	110.88	105.43	109.55	106.99

VI. SUMMURY AND CONCLUSION:

In this study we analyze a g+9 structure for seismic analysis and also a non- linear progressive collapse analysis.

A. In case of base shear square model performs well. Shear force is minimum in octagonal model and bending moment is minimum in hexagonal model.
B. On the basis of storey drift hexagonal model is best and the square model is poor.
C. On the basis of storey forces square model performs well and octagon poor.
D. Considering the maximum shear force is observed in irregular plaza building and minimum in regular building.
E. In all cases joint displacement is maximum for the removal of interior column.
F. In case of BM values, beams are largely increasing at interior column as compared to other two locations . This because of beams get affected more.
G. Axial forces increased near to the internal column removed.

On the premise of the show consider it is incapable to state that any one of the three models analyzed here is predominant to others. Each demonstrate posses its claim merits and demerits. This ponder uncovers the impact of shape of the structures in resisting the different exasperating strengths against their solidness. There's assist scope for inquire about with respect to the most reasonable shape of the structure which can stand up to seismic and other strengths successfully. When interior column is failed or removed due to any reasons then building undergoes major collapse than corner or any exterior column.

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