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ANALYSIS OF NON-ENGINEERED STRUCTURE USING SAP 2000

Lokesh Choudhary[1], Ankit Pachouri[2]

[1,2]*Assistant Professor, Dept. of Civil & Environmental Engineering, The North Cap University, (India)*

ABSTRACT

Non engineered buildings are those buildings which are constructed without the intervention of an engineer. In developing countries like India, 85% of the total houses are non-engineered and prone to failures when subjected to sudden loading from earthquakes. In the present study, a survey of a residential area in Gurgaon city has been carried out and a real life non engineered building has been chosen for carrying out linear static analysis to find out vulnerable locations subjected to high stress concentrations during seismic loading. Plan and elevation of the building has been created to suitable scale and analysis of the same has been carried out using structural modeling tool SAP2000. Deflection profile, Moment diagrams and stress concentration contours have been plotted in the global X and global Y directions and weak and vulnerable locations in a framed non engineered building has been identified.During the analysis of modeled structure, it has been found that the joints, a) at the bottom of the columns b) beam-column junctions and corners of the openings in the infill walls, are the locations of high stress concentration and are prone to failure under seismic loading. It is these locations where cracks originate and starts propagating towards points of low stress concentration. The development of these cracks further leads to collapse of the structure and various strengthening schemes must be adopted to increase the strength of these weak locations.

Keywords: Non-engineered Building, SAP2000

I. INTRODUCTION

Earthquakes have always been a kind of natural disaster which takes a huge toll of human lives and cause a great loss to property all over the world. Unfortunately, the number is even higher in developing nations. All the atrocities and damage is due to the failure and eventual collapse of manmade structures. Generally, buildings are divided in two sub categories, namely engineered buildings and non-engineered buildings. History proves that all the earthquakes that occurred, have significantly affected buildings which have been constructed without the intervention of structural engineers.

In developing countries like India, most places of residences (non-engineered buildings) are traditionally constructed in small towns and villages, either in the conventional architectural style or ordinary houses using materials which are locally available. However, in the last few decades, people are getting attracted towards adoption of masonry construction for houses, because of improved economic conditions and standard of living. This type of construction is highly appreciated and is generally seen as a measure of status in the society. This has led to the construction of houses which look like masonry structures but are not actually the ones because of non-adherence to the requirement of the same. Lack or limitation of resources, be it financial, skill related, or construction material related, has resulted in low quality and workmanship. And the situation is getting worse from year to year. Forget about the high magnitude earthquakes, this type of construction becomes dangerous to human life, even with relatively small ground motion. [1]

Few major causes of failure of Non-engineered Construction are:

(a) Most of these buildings are not built according to standard codal provisions.

(b) Lack of proper engineering and workmanship supervision.

(c) Restricted fund availability.

This category of structures include small houses with less plan area and smaller commercial buildings which are constructed by owners themselves or local masons without giving consideration to architectural or engineering facts. Such buildings/dwellings will no doubt have load bearing masonry walls (confined, unconfined). These members according to engineering principles are not designed to take moments generated due to various kinds of loading. Irrespective of the facts whether the wall is confined or unconfined, it is expected to carry loads arising due to strong ground motion in addition to all the vertical loads. Myriad buildings which do not adhere to the structural requirements of a masonry construction and are constructed with unacceptable workmanship, inappropriate ductile detailing of RCC structures will eventually be subjected to seismic forces and will perform poorly.Again the consequences are in the form of loss in human lives, loss of property etc.

II. VULNERABILITY OF NON-ENGINEERED STRUCTURES

The vulnerability of the non-engineered structures is basically with respect to seismic failure. Several constructional details that contribute significantly towards vulnerability are:

- Lack of proper skills for masonry construction
- Inadequate reinforcement in joints
- Inappropriate execution of the construction work
- Poor splicing, if at all done
- Lack of ductile detailing of reinforcement
- Inappropriate development length of reinforcement and size of structural components.
- Unsuitable alignment

Hence, due to ground motions, small or large in magnitude,myriad non-engineered buildings, houses in developing nations,get collapsed. Such vulnerability of buildings/ structures could not only be considered due to lack of knowledge among masses about right or wrong but could also be because of poverty, uncontrollable population growth, urbanization etc.

Fig. 1 Earthquake Struck Non-Engineered Building [5]

III. LINEAR STATIC ANALYSIS OF A G+2 NON-ENGINEERED BUILDING

In the present study a survey was conducted in the residential area of PalamVihar, Sector 23, 23-A, 22 and building plans of myriad houses were studied.It was found that most of the houses are rectangular in dimensions and are generally built without the consent of engineers/experts or according to the guidelines given by codal provisions for structural safety and reliability. So the model considered for study represents the real life scenario of type of non-engineered construction going on in surrounding areas.

IV.MODELLING

A 3-storey (G+2) unreinforced brick masonry building is considered in the present study, where the load carrying structural system of the building consists of masonry walls, reinforced concrete beams and columns. The building consists of 2 rooms of size *8m x 5m* at the back end and 1 room of size *8m x 4m*in the front,3 attached toilets & bathrooms connected with each room, a kitchen and a hall cum dining. The total height of the building has been taken as*10.5 m* where each storey is considered *3.5 m* high. Thethickness of the wall is taken as *20 cm*. The elevation and plan of the building are as shown in Figure 2 & 3.

In the 3-D model of a building where walls, floors and roof have been simulated as thin shell elements and beams and columns have been simulated as beam elements. The properties of the elements are assigned either as of concrete or brick masonry depending upon the components in the structure.The properties of the material used for the construction purpose is of great importance. The shell wall element is assumed to be brick masonry, the shell floor and roof element and beam element is assumed to be made up of concrete. The properties of these above mentioned materials which are used are poisson's ratio, modulus of elasticity, its unit weight. In this study, compressive prism strength of masonry is considered as *5 MPa*, and tensile strength of the masonry is considered as 10% of the compressive strength, i.e., *0.5 MPa*. Moreover, the limiting tension value at which the unreinforced masonry elements of the structure start cracking is assumed to be *0.2 MPa*. [3]

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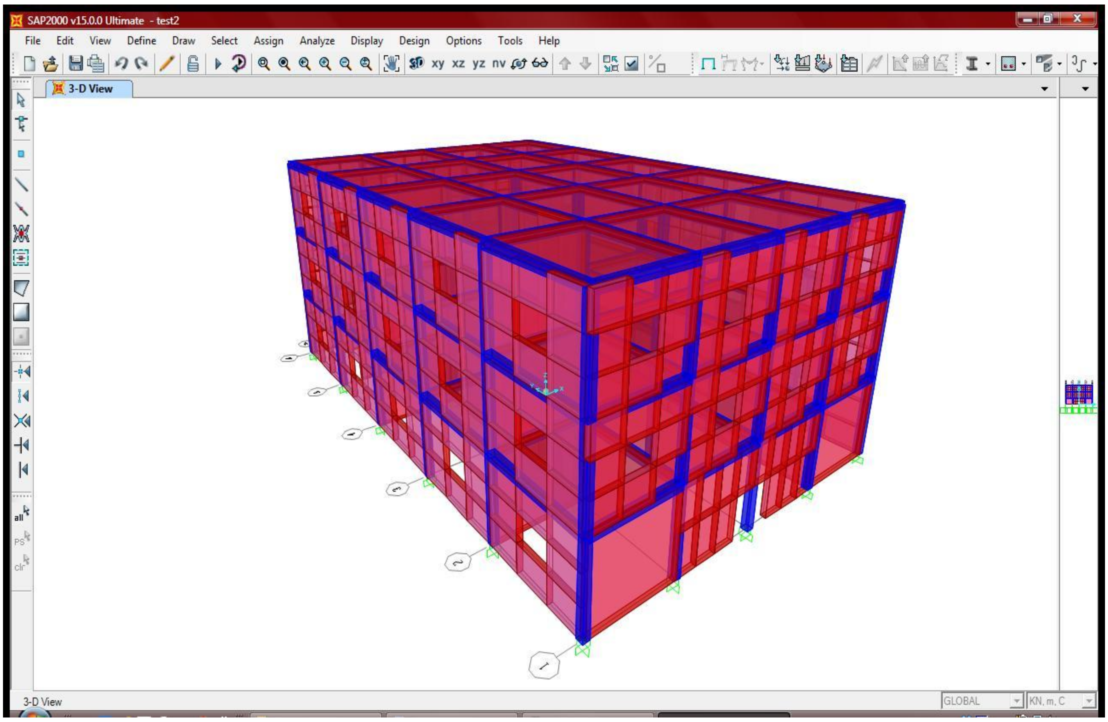


Fig. 2 3-D view of the Model Showing Elevation

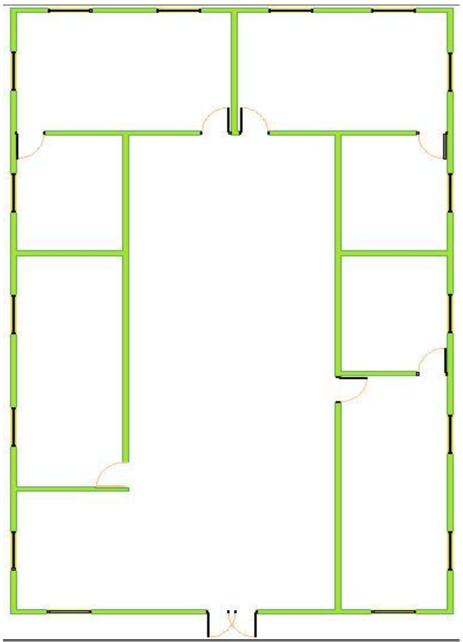


Fig.3 Floor Plan of the Building

Table 1 Material Properties Used in the Model

Material	Unit Weight, γ (KN/m^3)	Modulus of Elasticity, E (MPa)	Poison's Ratio, μ
Concrete (M20)	25	22360	0.30
Brick Masonry	20	1500	0.15

V. LINEAR STATIC ANALYSIS

Static analyses have been carried out on the 3D model of the building using the structural analysis computer software SAP2000. The floors, roofs and walls are considered as shell elements & a variety of subsequent relative base shear loadings are applied to have a complete idea of stress distribution in the building considered. 3D model consists of 1140 joints, 207 shell elements and 237 beam elements. The hypothesis of linear elastic behaviour has been adopted and is modelled as an isotropic continuum.

Following Three load cases have been considered in the analysis:

- Dead load case,
- Lateral load applied in Global X direction (along the length of the building)
- Lateral load applied in Global Y direction (along the width of the building)

The lateral load is calculated as per IS 1893 (Part-I):2002. The seismic zone is kept as zone IV, the importance factor as 1.0, considering it to be a residential building and the response reduction factor to be of 3.0 for under-reinforced construction.

Table 2 Calculation of Lateral Load Distribution at Different Levels

Level	W_i (KN)	h_i (m)	$\frac{W_i h_i^2}{1000}$	$\frac{W_i h_i^2}{\sum W_i h_i^2}$	Lateral load in X & Y directions (kN)
3 (roof)	5562.4	10.5	613.25	0.5343	1229.53
2 (floor)	8724.8	7.0	427.51	0.3725	857.19
1 (floor)	8724.8	3.5	106.88	0.093	215.16
$\sum$				1.0000	2301.2

Where, W = Seismic weight at each storey level

h = height of the storey level

The lateral load calculated, is applied as point loads distributed across the joints on the first and second floor and roof level. This is done by directly applying the loads at joint junctions. To reduce the local effect on the elements the loading pattern can be changed as desired.

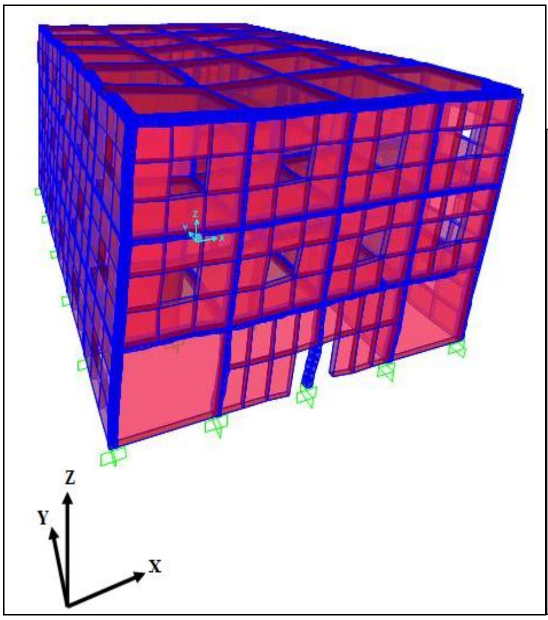
Table 3 Joint Loads to be Applied at Respective Levels

Level	Load in X-direction (KN)	Load in Y-direction (KN)
3	204.92	245.906
2	142.865	171.438
1	35.86	43.032

Prior to analysis, it was assumed that columns are strong enough to take the lateral load and therefore will not fail. The stresses developed at the column were not considered. The foundation is fixed to the ground and the ground is assumed perfectly rigid.[3]

Kaushik and Jain (2007) highlighted that the direction of earthquake force which is deemed critical for maximum stresses to get developed in the infill wallswith openings is along the span of the wall of the room which is shorter in length and the value of maximum shear stress and maximum principal tensile stress so developed, increaseswith the increase in the aspect ratio of the building. There is a great influenceof the position of opening in the wall as well. It has been observed analytically and experimentally that the maximum principal tensile stress and maximum shear stress occurs in short and long wall respectively. [4]

The deflected shape of the structure under the application of seismic loads in lateral X& Y-directions are shown in Figure 4 & 5 respectively.



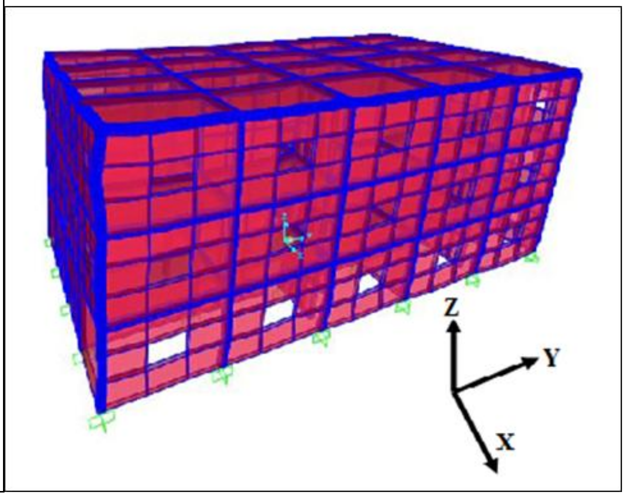


Fig. 4 Deflected Shape in Lateral X-Direction Fig. 5 Deflected Shape in Lateral Y-Direction

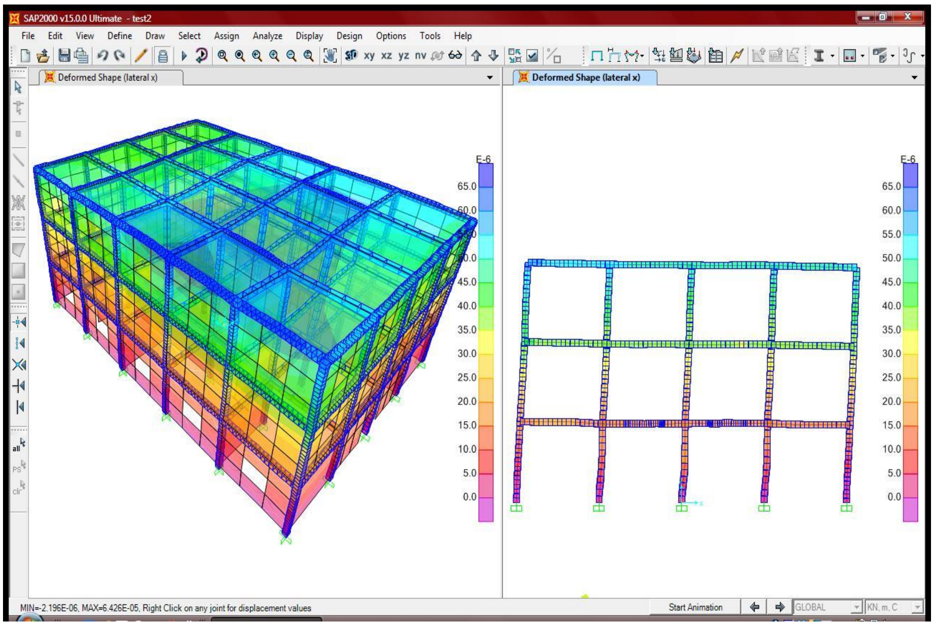


Fig. 6 Deflection Contours Due to Loading in Lateral X Direction

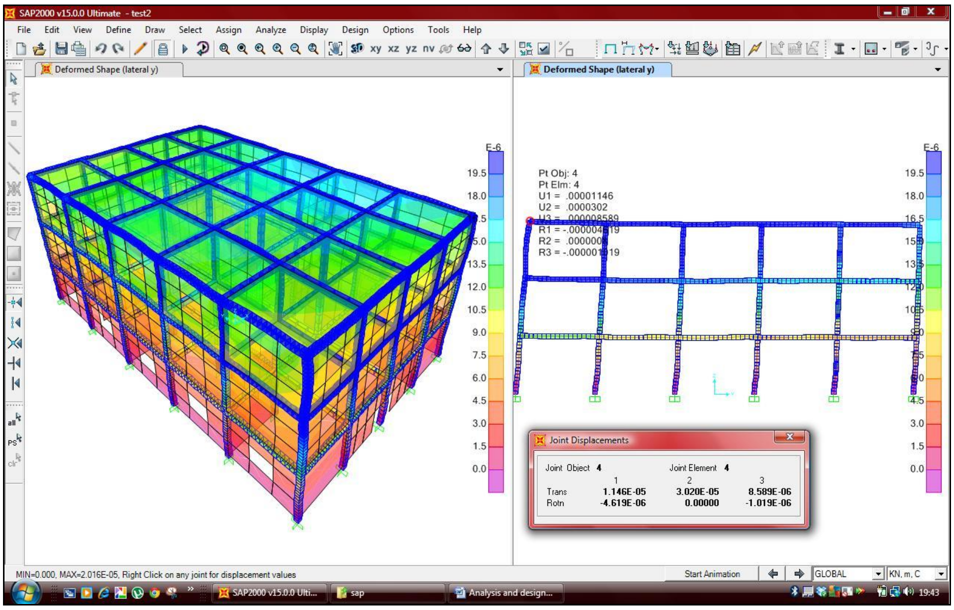


Fig. 7 Deflection Contours due to Loading in Lateral Y Direction

Figure 6 shows the displacement contour in X-direction subjected to loading in the same direction. The range of contours is from (0 to 70 x 10^{-6}) expressed in metres. The blue coloured portion in the figure is subjected to maximum deflection of 6.426 x 10^{-5}m and the pink coloured portion at the bottom of the frame is subjected to minimum deflection of -2.196 x 10^{-6}m.Figure 7 shows the displacement contour in Y-direction subjected to loading in the same direction. The range of contours is from (0 to 19.5 x 10^{-6}) expressed in metres. The blue coloured portion in the figure is subjected to maximum deflection of 2.016 x 10^{-5}m and the pink coloured portion at the bottom of the frame is subjected to zero deflection.

But to actually analyse and find out the vulnerable points such as joints, corners etc. under seismic loading, stress contours needs to be plotted for the shell elements.To evaluate the results of a linear static stress analysis, one can specify allowable stress values and then display factor of safety contours to see where stresses in the model are below and above those which are allowed. One can also decide whether a design needs modification or not bychecking the factor of safety contours.

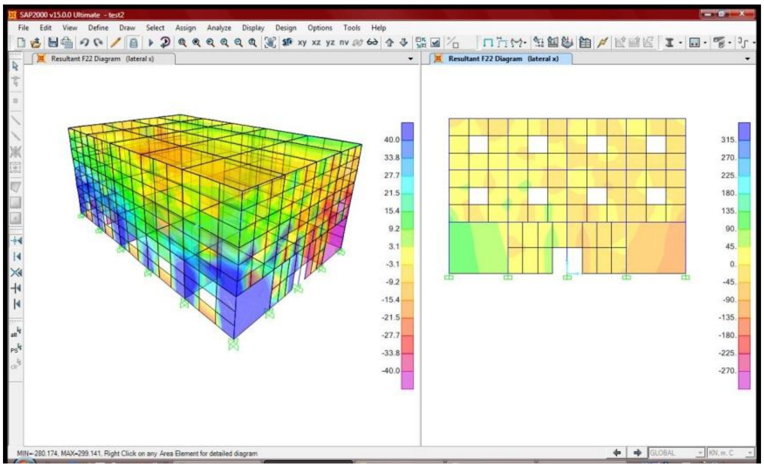


Fig. 8 Stress Contours for Lateral Loading in X-Direction

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The stress contours are plotted in limits ranging from -240 MPa to 280 Mpa. The blue colour represents maximum critical tensile stress of 268.160 MPa. The section represented in blue is therefore most vulnerable and is intended to fail under seismic load. The sections in red, yellow and pink colour are in compression and bear no tension. The minimum stress value is -271.445 MPa.

Table 4 Stresses Due to Lateral Loading in X-Direction

Stresses	Maximum stress	Minimum stress
Value	268.160 MPa	-271.445 MPa

Table 5 Stresses Due to Lateral Loading in Y-Direction

Stresses	Maximum stress	Minimum stress
Value	717.932 MPa	-862.023 MPa

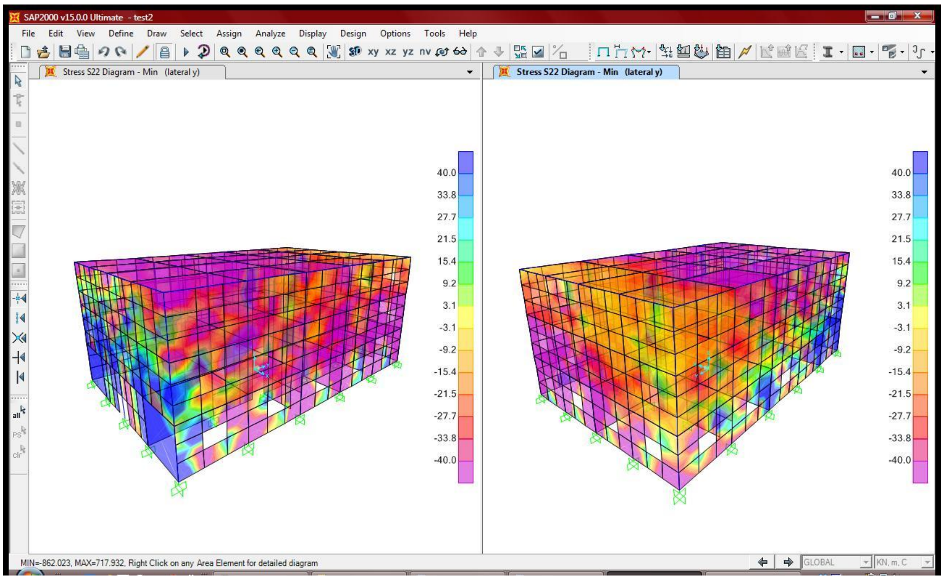

Fig. 9 Stress Contours for Lateral Loading in Y-Direction from Back and Front Face

The stress contours are plotted in limits ranging from -40 MPa to 40 MPa. The blue colour represents maximum critical tensile stress of 717.932 MPa. The section represented in blue is therefore most vulnerable in Y-direction. The sections in red, yellow and pink colour are in compression and bear no tension. The minimum stress value is -862.023 MPa.

Looking at the stress contours one can easily make out that how stress propagates through the shells from compression to tension and the amount of vulnerability of the section or joint. One can also predict the failure pattern and the crack propagation stream. The tension comes in that bottom part of the structure where the loads are applied and compression occurs in the opposite side of the structure. But, one cannot predict the direction of loads in real life modal subjected to seismic vibrations, any face or portion of the structure can subjected to reversal of stresses and hence should be designed for the same.

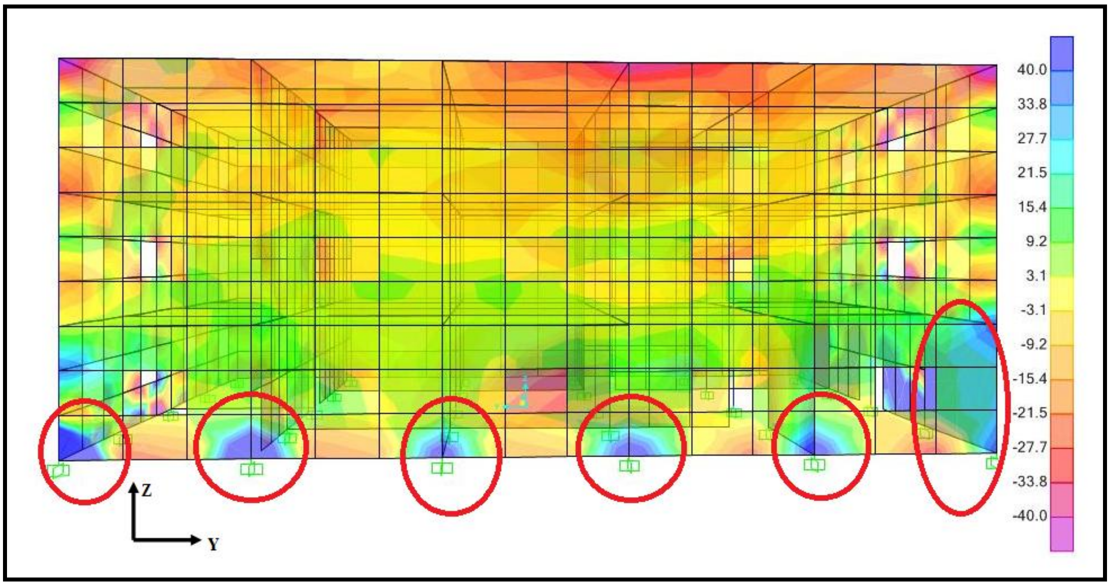

Fig. 10 Stress Contours at the Bottom of the Columns (Vulnerable Points in Tension)

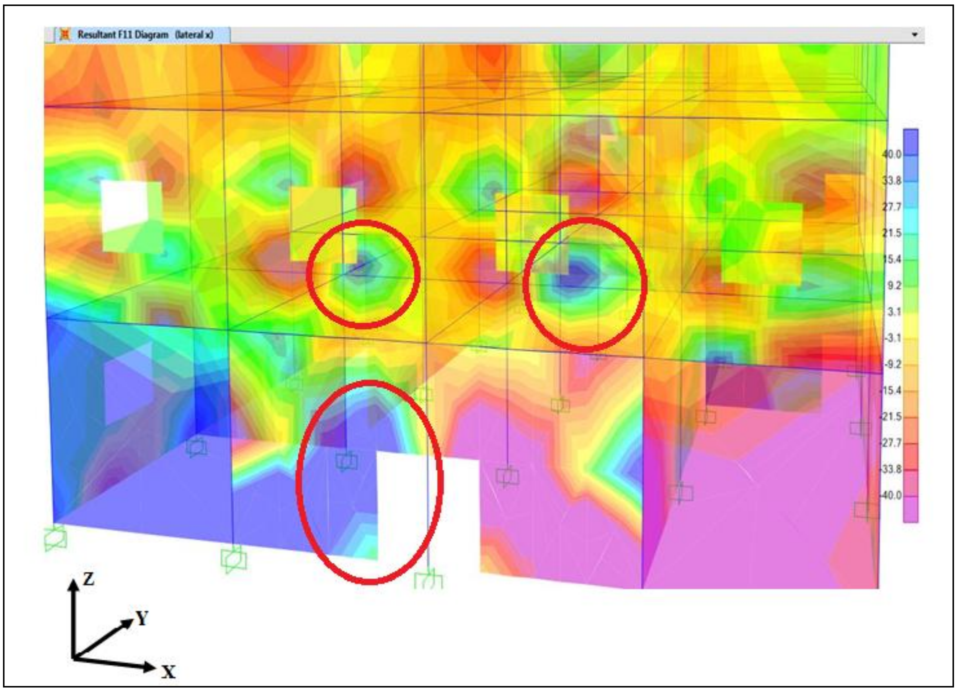

Fig. 11 Stress Contours at the Edge of the Windows (Vulnerable Points in Tension)

Vulnerable structures get damaged to different levels of deterioration when they are subjected to loading in extreme range like in earthquakes of higher magnitude for which they have not been designed. There exists an impression that high rise buildings are seismically not safe in comparison to buildings of small heights. But the truth is, when properly designed and constructed, high rise buildings are much safer owing to adherence of building bylaws and codal provisions. It shall be noted that many people died in Kachchh (Gujarat) earthquake (2001) in low-rise,one and two storeyed residential complexes. Hence, it becomes of foremost importance to build allbuildings safe.

VI. CONCLUSION

Most of the buildings in developing countries are non-engineered which are not safe from safety point of view. During the study of non-engineered buildings using SAP2000 it has been found that the stresses are not uniformly distributed. Most of the areas, especially joints and corners in the building analysed, were weak and vulnerable. The inception and further propagation of cracks takes place at these unguarded locations leading to eventual collapse of the structure. A structure which is expected to be subjected to strong ground motion, these portions of high stress concentration should be spliced or detailed with ductile reinforcement beforehand. The frequency, intensity, and magnitude of earthquakes are increasing due to over exploitation of nature to fulfil human's insatiable demands. The main reasons for increased intensity of earthquake, being construction of dams, sky scrapper etc. Therefore, it is need of the hour to reside in a building designed & constructed under the supervision of an engineer.

REFERENCES

[1]. Boen, T., (2006) "Yogya Earthquake-Structural Damage Report" Indonesia.

[2]. Kusumastuti, D., Pribadi, K.S., and Rildova. (2008) "Reducing Earthquake Vulnerability of Non-Engineered Buildings: Case study of retrofitting of school building in Indonesia", 14th World Conference on Earthquake Engineering, Beijing, China

[3]. Choudhury, T., (2009) "Thesis on Linear and Non-Linear Analysis of Structures and 3-D Modelling of the same to suggest effective retrofitting techniques".

[4]. Kaushik, H.B., & Jain, S.K., (2007) "Impact of Great December 26, 2004 Sumatra Earthquake and Tsunami on Structures in Port Blair" Journal of Performance of Constructed Facilities, 21(2), ASCE, pp. 120-142.

[5]. http://www.visualphotos.com/image/2x4005046/traditional_mud_houses_%20near_jaisalmer_india [Last visited on 15.09.2015]