Analysis and Design of G+3 Building in Different Seismic Zones using E-tabs

Nilendu Chakrabortty[1], Akshit Lamba[2]

[1]Research Scholar, Civil Engineering Department, Kalinga University, Nawa Raipur, (C.G) India
[2]Assistant Professor, Civil Engineering Department, Kalinga University, Nawa Raipur, (C.G) India

---***---

Abstract - *As a structure is subjected to the earthquake, it results vibrating. The earthquake force subjected to structure will be resolved into three mutually perpendicular directions- the two horizontal directions (x and y) and therefore the vertical direction (z). Here the most essential thing is to consider the results of lateral loads induced from wind and earthquakes within the analysis of reinforced concrete structures, especially for high-rise buildings. Here the basic intent of analysis for the earthquake resistant structures is that buildings should be able to resist minor earthquakes without damage. To avoid the collapse during a major earthquake, the members are must have to be ductile enough to absorb and dissipate energy by post-elastic deformation. So redundancy within the structural system which permits redistribution of internal forces within the failure of key elements. The objectives of the current work is to study the behavior of a multi storied building subjected to earth quake load by adopting Response spectrum analysis. The current investigation is restricted to strengthened cement (RC) multi-celebrated business working with FOUR unique zones II, III, IV and V. The examination is administered the assistance of FEM programming's E-Tabs. The structure model within the examination has four stories' with consistent story stature of 3.5m. FOUR models are utilized to dissect with various cove lengths and also the quantity of Bays and also the straight width along two flat bearings are kept steady in each model for accommodation. Various estimations of SEISMIC ZONE FACTOR are taken and their comparing impacts are deciphered within the outcomes.*

Key Words: **E-tabs, Seismic Zone Factor, Response Spectrum Analysis.**

1. INTRODUCTION

The successful plan and development of seismic tremor safe structures have a lot more prominent significance in everywhere throughout the globe during this way designs are trying to utilize various materials to further their best potential benefit keeping in see the exceptional properties of each material basically powerful and stylishly satisfying structure are being built by joining the most effective properties at singular material and simultaneously meeting the actual prerequisites of huge length, building load, soil condition, time, adaptability and economy tall structures are most appropriate arrangement.

The Design of buildings wherein there's no damage during the strong but rare earthquake is named earthquake-proof design. The engineers don't attempt to make earthquake proof buildings which will not get damaged even during the rare but strong earthquake. Such buildings are going to be too robust and also too expensive. The aim of the earthquake resistant design is to have structures which will behave elastically and survive without collapse under major earthquakes which may occur during the lifetime of the structure. So here is to avoid the collapse during any major earthquake, the structural members must have to be ductile enough to absorb and dissipate energy by post-elastic deformation.

Many researchers are conducted on this topic and still, it's continuing because more we attempt to learn more we are able to minimize the damages and save the lives. As per studies that are made on the seismology about 90% earthquake happens because of tectonics. If we come to civil engineering, an engineer's job is to produce maximum safety within the structures designed and maintain the economy.

Prior to the analysis and design of any structure, necessary information regarding supporting soil should be collected by means of geotechnical investigation. Also a geotechnical site investigation may be a process of collecting information and evaluating the conditions of the location for the purpose of designing and constructing the foundation for a structure. Structural engineers face the challenges of striving for many efficient and economical design with accuracy in solution while ensuring that the ultimate design of a building and also the building must have be serviceable enough for its intended function over its own design lifetime. Currently there are various software packages that are available within the market for analysing and designing practically of every type of structures viz. RISA Software, STAADPRO Software, ETABS Software, STRUDL, MIDAS, SAP and RAM, etc. Software.

Here in the latest version of seismic zoning map of India given within the earthquake resistant design code of India [IS 1893 (Part1) 2002] assigns four levels of seismicity for India in terms of zone factors. Earthquake-zoning map of India divides India into basically 4 seismic zones (Zone 2, 3, 4 and 5) unlike its previous version, which consisted of 5 or six zones for the country. In the current zoning map, the

Zone 5 expects the highest level of seismicity whereas Zone 2 is related to the lowest level of seismicity.

Zone 5 is covering the areas with highest risks zone that suffers earthquakes of the intensity MSK IX or greater. In the IS code the assigned zone factor is 0.36 for Zone 5. The structural designers also use this factor to design earthquake resistant structures in Zone 5. Here, the zone factor which is 0.36, indicative of effective (zero periods) level of earthquake in this zone. It's mentioned because the Very High Damage Risk Zone. From the region of Kashmir, the western and central Himalayas, North and Middle Bihar, the North-East Indian region and also the Rann of Kutch, fall in this Zone.

Zone 4 is termed the High Damage Risk Zone and covers areas liable to MSK VIII. Here the IS code assigns the zone factor of 0.24 for Zone 4. The Indo-Gangetic basin and also the capital of the country (Delhi), Jammu and Kashmir fall in Zone 4. Here also in Maharashtra, the Patan area (Koyananager) is also recorded in Zone no 4. Also in Bihar, the northern part of the state like- Raksaul, near the border of India and Nepal, is also recorded in Zone no 4.

Zone 3 is the Andaman and Nicobar Islands, parts of Kashmir, Western Himalayas fall into this Zone. Here this zone is classified as the Moderate Damage Risk Zone, which is liable to MSK VII. Here the IS code assigns zone factor which is of 0.16 for Zone 3.

Zone 2 is liable to MSK VI or less and is classified because the Low Damage Risk Zone. Here the IS code assigns zone factor (the maximum horizontal acceleration that may be experienced by a structure in this Zone) that is 10% of gravitational acceleration for Zone 2.

1.1 Introduction of Software

ETABS is a software which stands for the Extended Three Dimensional Analysis of Building System. It's a building software product that takes under consideration multi-story building examination and plan. Demonstrating devices and formats, code-based burden remedies, examination strategies and arrangement methods, all organize with the network like geometry remarkable to the present class of structure.

ETABS is that the present day driving structure programming within the market. Many configuration organization's utilization this product for their task configuration reason. Along these lines, this paper for the foremost part manages the near examination of the outcomes got from the investigation of a multi celebrated structure when dissected physically and utilizing ETABS programming.

Basic reaction to tremor relies upon Dynamic qualities of the structures and power, length and recurrence substance of existing ground movement. Auxiliary investigation implies assurance of the general shape and all the particular elements of a specific structure in order that it play out the capacity for which it's made and will securely withstand the impacts which will follow up on it during its valuable life.

We have chosen ETABS due to the subsequent advantages:
- Easy to use interface,
- Confirmation with the Indian Standard Codes,
- Ver54satile nature of solving any sort of problem,
- Accuracy of the solution.

ETABS is the software which also has state-of-the-art user interface, visualization tools, powerful analysis and design engines with advanced finite element and also the dynamic analysis capabilities. This software provides model generation, analysis and design to visualization and result verification. ETABS is the professional's choice for steel, concrete, timber, aluminum and cold-formed steel design of low and also the high-rise buildings, culverts, petrochemical plants, tunnels, bridges, piles and much more.

1.2 Scope of Work

1. Based on project, study was undertaken with a view to determine the extent of possible changes within the seismic behaviour of RC Building Models.
2. The RC framed buildings are firstly designed for the gravity loads and then for the seismic loads.
3. The study introduced the symmetrical bare frame building models on different Zones using equivalent static method and Response spectrum analysis.
4. The study highlights the effect of seismic zone factor in different Zones that's in Zone II, Zone III, Zone IV and Zone V which is taken into account within the seismic performance evaluation of buildings.
5. The study emphasis and discusses the effect of seismic zone factor on the seismic performance of G+3 building structure.
6. The whole process of modelling, analysis and design of all the primary elements for all the models are carried by using ETABS Ultimate 18.1.1 version software.

1.3 Objective of work

Here the present work aims at the study of following objectives:

1. What is the process for the seismic evaluation of a building should be carried out.
2. Also is to study the behaviour of a building under the action of seismic loads and wind loads.
3. To match various analysis results of building under Zone II, III, IV and Zone V using ETABS Software.
4. The building model within the study has four storey's with constant storey height of 3m. Four models are used to analyse with constant bay lengths and also the number of

Bays and the bay width along two horizontal directions are kept constant in each model for convenience.

5. Different values of zone factor are taken and their corresponding effects are interpreted within the results.

6. Also the different values of wind speeds are taken for the wind analysis and their corresponding effects of building structure are also interpreted within the results.

2. LITERATURE REVIEW

1. **Structural Analysis of a Multi-Storeyed Building using ETABS for various Plan Configurations {Abhay Guleria} [1];** during this paper, the case study mainly emphasizes on structural behavior of multi- story building for various plan configurations like rectangular, C, L and I-shape. Modeling of 15-story R.C.C. framed building is completed on the ETABS software for analysis. Here for the post analysis of structure, maximum shear forces, bending moments and maximum story displacement are computed then compared for all the analyzed cases.

Conclusions

• Here the analysis of multi-Storeyed building shows that the story overturning moment varies inversely with story height. Here also, L-shape, I-shape type buildings give almost the similar response against the overturning moment.

• Story drift displacement increased with story height, up to 6th story getting to maximum value then started decreasing.

• With the help of dynamic analysis, the mode shapes are generated and also it will be concluded that asymmetrical plans undergo more deformation than symmetrical plans.

2. **Design and Analysis of Multi-Storeyed Building Under Static and Dynamic Loading Conditions Using ETABS {Balaji.U. A, Mr. Selvarasan M.E. B.} [2];** in this paper work a residential building of G+13 is studied for earthquake loads using ETABS software. Assuming that material property is linear, static and dynamic analyses are performed. These non-linear analyses are administered by considering severe seismic Zones and therefore the behavior is assessed by taking types II soil condition. Here also Different response like, displacements, base shear are plotted.

Conclusions

• From this work, it's observed that, in first five stories, the difference between the results obtained with different methods is insignificant.

• It's observed that, the utmost displacement is increasing from first storey to last one.

• Here the maximum displacement of the center of mass, which is obtained by time history also analysis for both earthquakes.

3. **Seismic Analysis of Multistoreyed Building, {Mahesh N. Patil and Yogesh N. Sonawane} [3];** in this paper work the earthquake response of the symmetric multistoreyed building is studied by manual calculation and with the assistance of ETABS 9.7.1 software. This method includes seismic coefficient method as recommended by IS 1893:2002. The responses obtained by manual analysis also as by soft computing are compared. It provides complete guide line for manual also as software analysis of seismic coefficient method.

4. IS 456:2000 [4]; this standard is essentially used for the plain and reinforced structure. It deals with the design of building as per their requirements. during this code, it's been assumed that the design of plan and reinforced cement concrete work is entrusted to a professional engineer which the execution of cement concrete work is administered under the direction of a professional and experienced supervisor.

3. METHODOLOGY

As discussed within the previous chapters, a structure must be analysed and designed to resist the lateral earthquake forces. In this chapter here, the analysis and design procedure of the G+3 storey building is discussed with the assistance of ETABS Software by response spectrum method. Here in this process, computational advantages found in using the response spectrum method of seismic analysis for the prediction of displacements and member forces in structural systems. This kind of tactic involves the calculation of the only utmost values of the displacements and member forces in each mode using smooth design spectra that's the typical of several earthquake motions. In these different seismic Zones are taken to induce the results of building, how it reacts to different Zones.

3.1 Seismic analysis as per IS Code

At the purpose when a structure is exposed to seismic tremor, it reacts by vibrating. A seismic tremor power are often settled into three commonly opposite bearings the 2 even headings (x and y) and therefore the vertical course (z). This movement makes the structure vibrate or shake in all of the three bearings; the overwhelming heading of shaking is even. All of the structures is essentially intended for gravity loads-power like mass time's gravity within the vertical heading. In light of the natural factor of wellbeing utilized within the plan particulars, most structures will generally be enough secured against vertical shaking. Vertical increasing speed need to likewise be considered in structures with huge ranges, those during which dependability for plan, or for generally speaking strength examination of structures.

IS 1893 (section 1) code suggests that time by point dynamic examination, or pseudo static investigation need to be completed relying upon the importance of the difficulty. IS 1893(part1): 2002 code suggests the utilization of the modular investigation which utilizing reaction range

technique and proportionate sidelong power strategy for working of tallness under 40 m in every single seismic Zone.

3.2 Wind Analysis

Basic wind speed in the India map, applicable at 10 m height above mean ground level for various Zones of the country selected from the code taken into consideration.

$V_z = V_b \, k_1 k_2 \, k_3$

Where, V_z = at any height, the design wind speed 'z' in m/s,

V_b = Basic wind speed in m/s,

k_1 = probability factor (risk coefficient),

k_2 = the terrain roughness and the height factor, and

k_3 = topography factor.

NB: The designe wind pressure at any height above mean ground level shall be obtained by the subsequent relationship between wind pressure and wind velocity.

$P_z = 0.6 \, V_z 2$

Where, P_z = the wind pressure which is in N/m^2 at the height z, and

V_z = the designed wind speed which is in m/s at the height z.

3.3 Building Data for Analysis

The proposed building considered for the project is of G + 3. The considered building data is shown below:

Building information:

Building importance categories: For all other buildings = 1.0

Number of storeys: G+3, 4 Storey building.

Length of building in X direction: 12.0m

Length of building in Y direction: 12.0m

Inter storey height provided in the building: 3.5m (storey to storey height)

Floor load: dead load which considered for the building is 10 KN.

Live load which considered for the building is 3 KN.

Structure both in X and Y direction, here the resisting systems are considered and are then subjected to earthquake load and identification of safety conditions are made.

Structure in X direction: ferroconcrete (RCC) shear wall / reinforced masonry shear wall.

Structure in Y direction: ferroconcrete (RCC) shear wall / reinforced masonry shear wall.

The structure was analyzed for all the cases of Zones II, III, IV and V.

Here wind load data considered for the analysis of building:

The wind region considered for the building is Zone I.

The basic wind speed of the wind in Zone I is of 33.0m/s.

Terrain category of the building is made up towns.

The site shape is flat in the conditions and not hill slopes.

Here the analysis process of the structure that was made using resist software used for the analysis of multi storied building in Indian conditions for application of earthquake intensities for all Zones, also for application of wind effects.

The results obtained for the analysis of the building are given within the next section.

3.4 SOFTWARE ANALYSIS

Step 1. New model - Use built in setting a dialogue box will appear where we entered the details of grid dimensions and story dimension of our building.

Step 2. Define property - Now we have to define properties of materials. After material property defined, define section property.

Step 3. Assigning property - after defining material and section properties, we draw the structural components using commands like Quick draw beam, Quick draw column, Draw rectangular floor (slab) & walls.

Step 4. Assigning of support,

Step 5. Assigning of Dead loads & Live loads,

Step 6. Assigning of stiffness & property modifiers,

Step 7. Assigning of Seismic Properties,

Step 8. Assigning of Wind loads,

Step 9. Assigning of load combination,

Step 10. Check Model- After completion of all the steps now performs the analysis and checks all the errors. Analyse - check model.
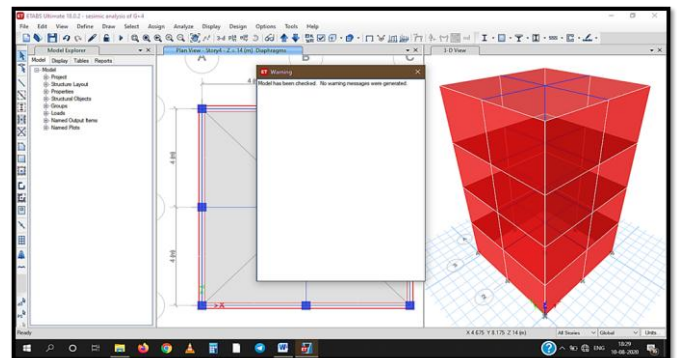

Fig -1: Check Model

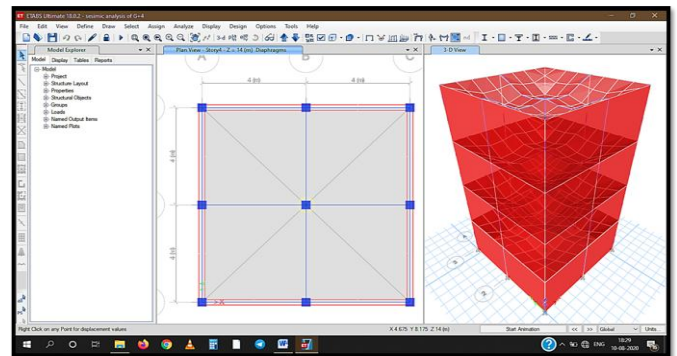Step 11. Run Analysis – Analyze - Run analysis – save the file.

Fig -2: Run Analysis

4. RESULTS

Result Analysis for Zone 5,4,3,2 shown below respectively.
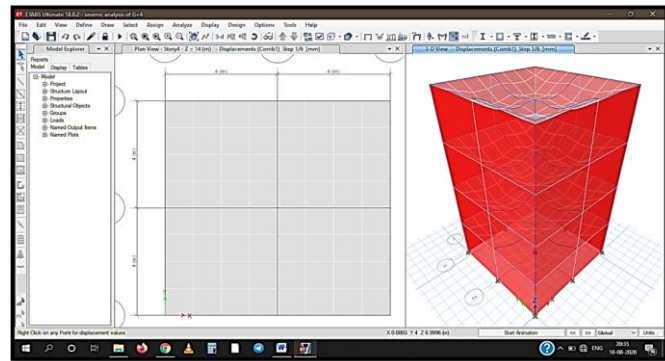
4.1 Result Analysis of - Zone V

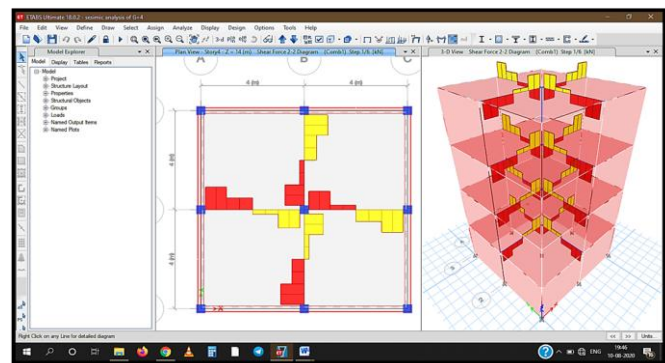**Fig -3**: Deformed shape - Combo (DL-1.5, LL-1.5, WL-1.2, EQ-1.2)

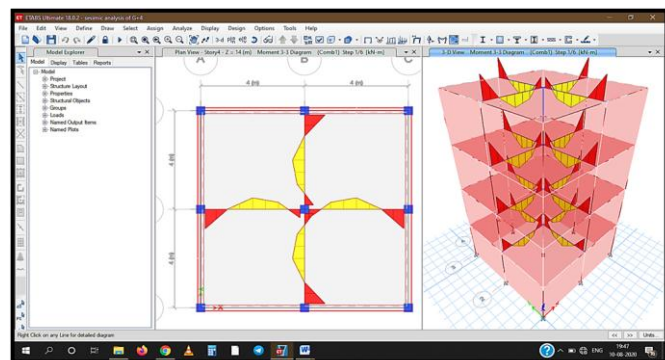**Fig -4**: Member Force Diagram - Combo (Shear 2-2)

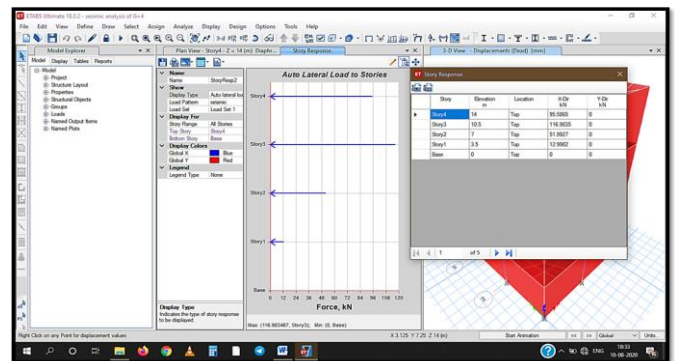**Fig -5**: Member Force Diagram - Combo (Moment 3-3)

Fig -6: Story response for zone – V
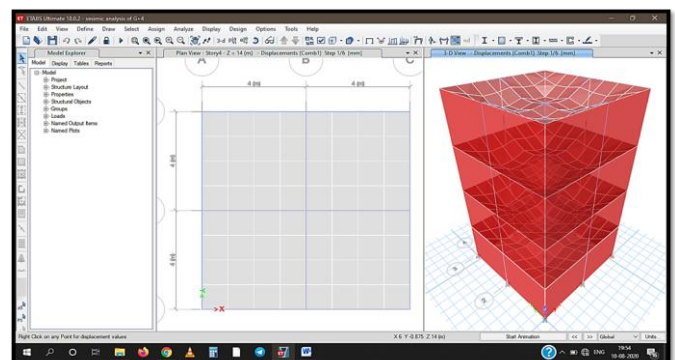
4.2 Result Analysis of - Zone V

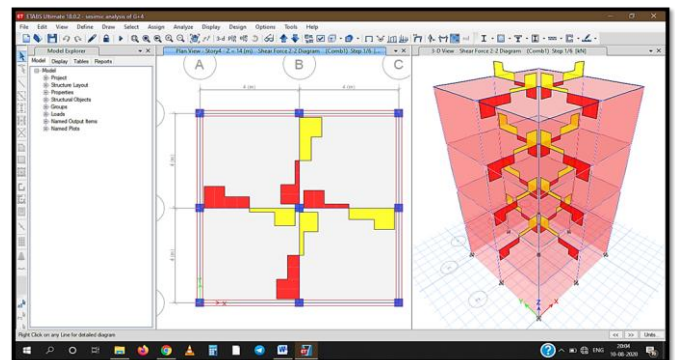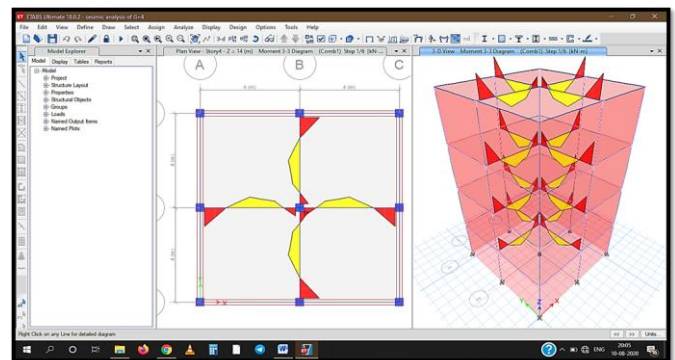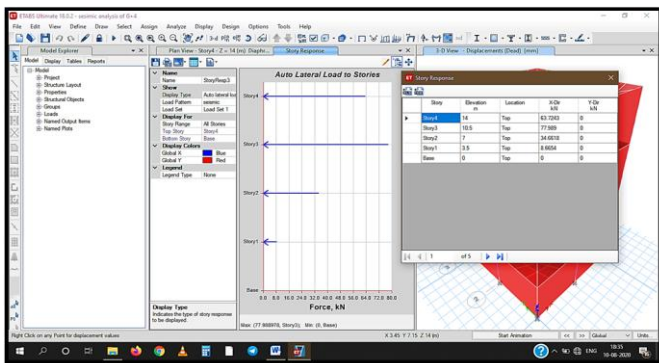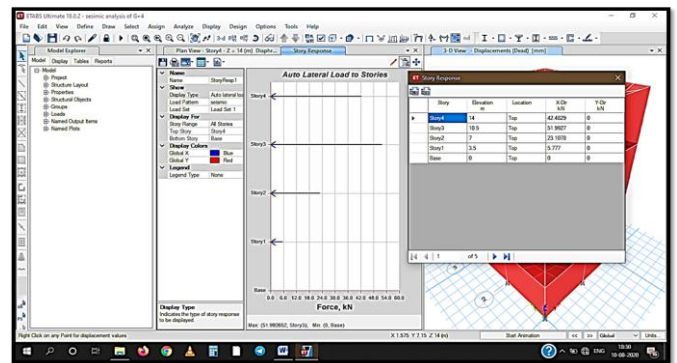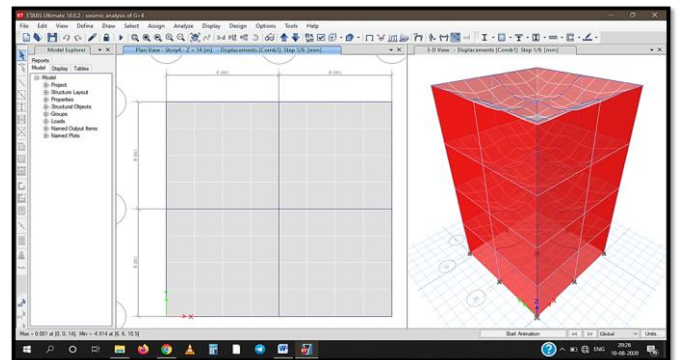**Fig -7**: Deformed shape - Combo (DL-1.5, LL-1.5, WL-1.2, EQ-1.2)

Fig -8: Member Force Diagram - Combo (Shear 2-2)

Fig -9: Member Force Diagram - Combo (Moment 3-3)

Fig -10: Story response for zone – IV

4.3 Result Analysis of **- Zone III**

Fig -11: Deformed shape - Combo (DL-1.5, LL-1.5, WL-1.2, EQ-1.2)

Fig -8: Member Force Diagram - Combo (Shear 2-2)

Fig -9: Member Force Diagram - Combo (Moment 3-3)

Fig -10: Story response for zone – III

4.3 Result Analysis of - Zone II
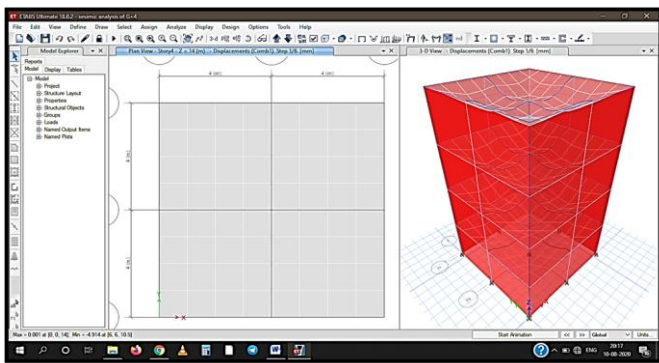
Fig -11: Deformed shape - Combo (DL-1.5, LL-1.5, WL-1.2, EQ-1.2)
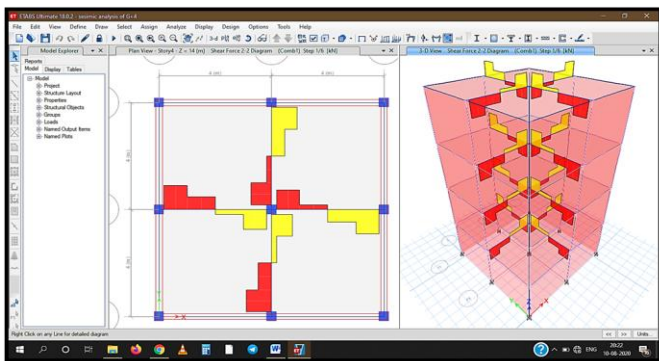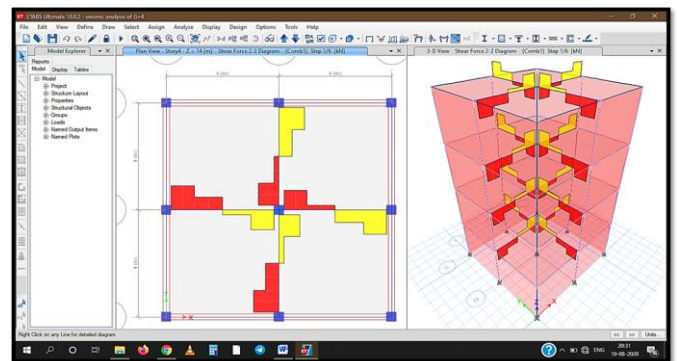
Fig -8: Member Force Diagram - Combo (Shear 2-2)
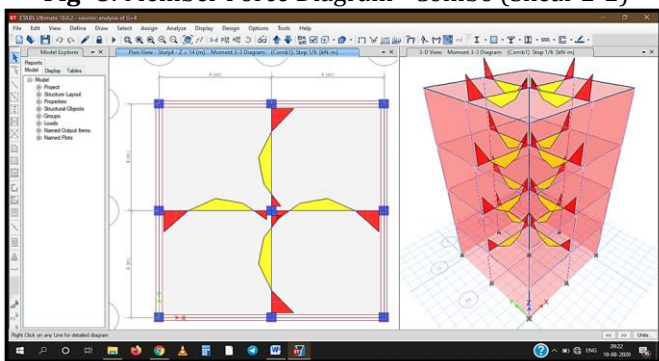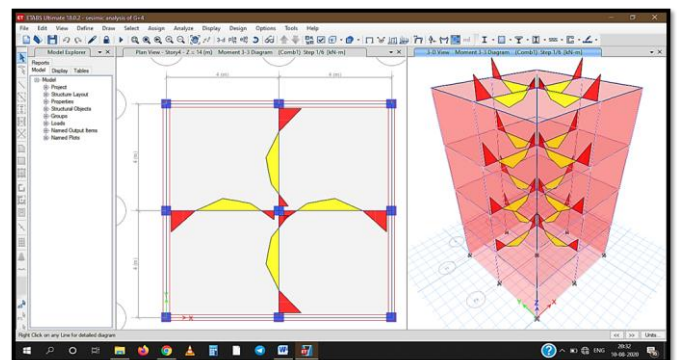

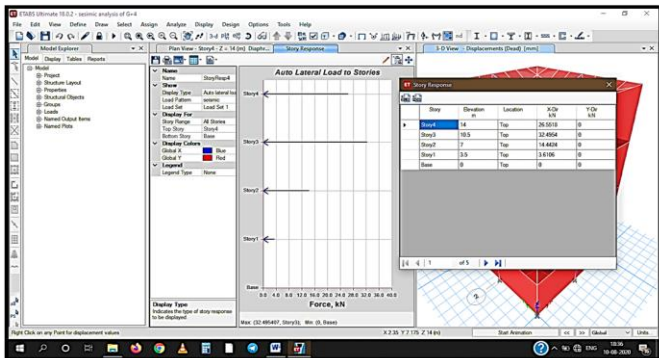**Fig -9**: Member Force Diagram - Combo (Moment 3-3)

Fig -10: Story response for zone – III

5. CONCLUSIONS

1. The Structure analyzed in several seismic Zones of India, than we discover out the leads to base shear of the building is more in seismic Zone-V has compare to Zone-II, Zone-III and Zone-IV.

2. Base shear of seismic Zone-V is more than 72.2%, 55.56% and 33.33% as compared to Zone-II, Zone-III, and Zone-IV respectively.

3. Now for the Floor Displacements, Zone-V has higher displacement value than compared to Zone-II, Zone-III and Zone-IV.

4. In Maximum Floor Displacements seismic Zone-V is more than 39.79 mm, 30.77 mm, and 18.52 mm as compared to Zone-II, Zone-III, and Zone-IV respectively.

5. Support reactions Zone-V as higher value as compare to Zone-II, Zone-III, and Zone-IV.

6. Steel quantity of seismic Zone-V is more than 53.84%, 13.89% and 8.31% as compared to Zone-II, Zone-III and Zone-IV.

7. From the above results Zone-V is critical for the G+3 structure.

8. Seismic force acts on the structure it reflects additional force working on the structure, due to these addition forces structure behave different way than normal condition.

9. involves seismic zones Zone-V has higher zone factor than other zones. So Zone-V values are over then compare other zones.

10. As the factors like Displacements, support reactions, Base shear, and steel quantity all these are Depends on zone factor, so as a result these values are more in Zone-V.

REFERENCES

[1] D. Kornack and P. Rakic, "Cell Proliferation without Neurogenesis in Adult Primate Neocortex," Science, vol. 294, Dec. 2001, pp. 2127-2130, doi:10.1126/science.1065467.

[2] M. Young, the Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[3] Mahesh N. Patil, Yogesh N. Sonawane. "Seismic analysis of multi-storeyed building" International Journal of Engineering and Innovative Technology (IJEIT) Volume 4, Issue 9, March 2015.

[4] IS: 456-2000, Code of Practice Plain and Reinforced concrete.

BIOGRAPHIES

Nilendu Chakrabortty
Research Scholar
Civil Engineering Department,
Kalinga University, Nawa Raipur,
(C.G) India

Akshit Lamba
Assistant Professor
Civil Engineering Department,
Kalinga University, Nawa Raipur,
(C.G) India