# Dimensional Optimization of Frames in an RCC Structure with Different Elevations

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***Abstract: -To compete in the ever-growing world in the 21st century, a structural engineer needs to save time and cost for the construction of a structure that can play a crucial role in the present-day market. These can be done by optimizing the dimensions of the frames in a structure. For obtaining the optimized dimensions, we must analyze the structure with all possible loads to withstand against it. This project presents the dimensional optimization of frames in an RCC structure with gradually increasing the number of floors. Analysis of a structure is done with the help of ETABS software. ETABS stands for Extended Three-Dimensional Analysis of Building Systems.We conclude that ETABS is a very powerful tool which can save much time, cost by optimizing the dimensions of frames with very accurate Designs***

## I. INTRODUCTION

India is a developing country, from the past few years there is a tremendous growth in the construction of huge structures in developed and undeveloped cities. In the current century, many construction projects are in progress all over the world that cause time delay which in turn affects the growth of construction of huge projects. To avoid time, delay new techniques should be adopted. To economize the structure, dimensional optimization techniques should be used.

Structural optimization is necessary for large projects because it affects the cost of the project directly. Metropolitan cities like Chennai, Bangalore, Mumbai have a high population and in forthcoming years, the land availability problem will increase tremendously which will in turn affect the overall growth of the city. As we increase the number of stories or height of structure huge lateral forces acts on it, which tends to increase the construction cost of the project in terms of consumption of construction materials. Hence usually optimization techniques are adopted to economize the structure. In general, optimization includes the discretization of a structure into frames such as beams and columns.

ETABS (Extended Three-Dimensional Analysis of Building System) offers a single user interface to perform, Modeling, analysis, design, detailing, and reporting. It features a big choice of templates for quickly starting a replacement model. The user is allowed to define grid data, story data, default structural system section, loads frame sections, and other required data at this template stage.

The design is made using software on a structural analysis called ETABS. The structure is analyzed for bending moments and shear forces as per IS 456-2000.

**Key words:** optimization, tremendous, architecture, ETABS, discretization, shear force, bending moment.

## II. AIM AND OBJECTIVE

At present, ETABS is one of the leading analysis and detailing software in the market. we are analysing our structure using ETABS, by this, we studied various forces and factors affecting the structure. When the number of stories increases in a structure, there will be a change in the forces acting on the structure as same as changes in a dead load of a structure and live load varies gradually. We aim to determine the minimum dimensions of frames in structure to withstand the loads acting on a structure when the number of stories increases gradually.

This project is an analysis, design of the multi-storeyed building from the ground floor to G+10 by using ETABS. We aim to obtain optimized cross-sectional dimensions of a frame structure when there is a gradual increase in the number of stories.

## III. SCOPE

Based on aim and objective mentioned in the preceding section, scope of our present investigation is outlined as follows:

- We will come to know the software of civil engineering related to analysis and design of structure like ETABS with the help of this project.
- Detailing of whole structure is done by using this software includes frame dimensions, reinforcement values etc.,

## IV. LITERATURE REVIEW

**1.B. Anjaneyulu et.al. (2016):** studies the analysis and design of Flat Slab by Using ETABS Software, concludes that flat plate/slab can be designed and built either by conventional reinforced concrete or posttensioning. However, due to issues mentioned above with post-tensioning construction in India and its higher cost, conventional reinforced concrete design should be preferred choice for spans up to 10 meters.

**2. Maurat Saatcioglu and Jagmohan Humar (2003):** The present study stated that dynamic analysis of building design and detailing provisions of current building codes often ensure the elimination of undesirable features of response that translate into premature strength, decay, excessive pinching and inelastic behavior of brittle members or deformation modes

**3.Abrar Ahmed. Prof. Shaikh Abdulla and Prof. Syed Arfat(2017):** According to them the fundamental natural time period is observed to be the less for the model which is symmetry in shape as compared to asymmetry in shape. They conclude that the base shear yields low value in response spectrum analysis with compared with the equivalent static analysis.

**4. Abhay Guleria (2014)** presents the analysis of the multistoried building using ETABS reflectedthatthestoreyoverturningmomentvaries inverselywithstoreyheight.Moreover,L- shape, I- shape type buildings give almost similar response against the overturning moment.

## V. LOADS ACTING ON A STRUCTURE

1. Dead load (DL)
2. Live load (LL)
3. Wind load (Wx & Wy)
4. Earthquake loads (Ex & Ey)
5. floor finish (FF) etc.,

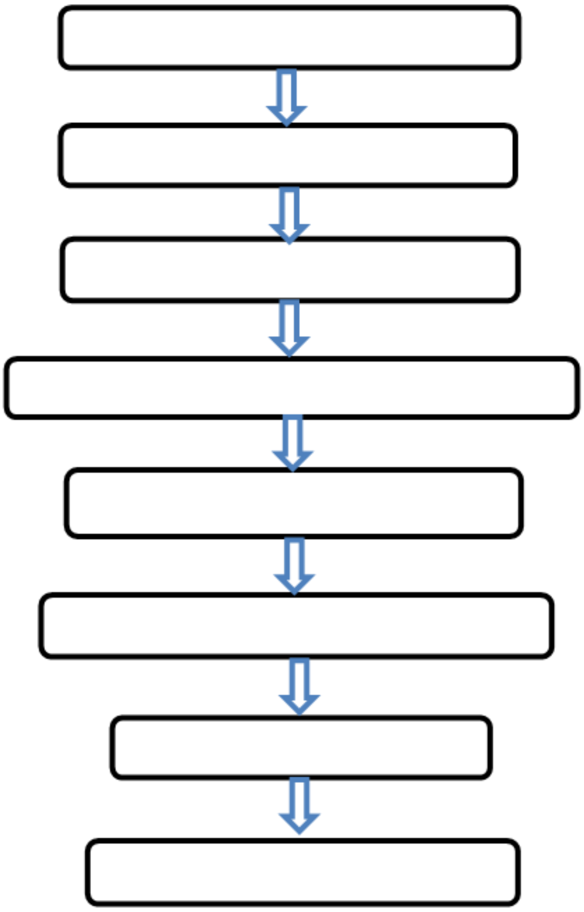
**LOAD COMBINATIONS:**

| SL.NO | LOAD COMBO |
|---|---|
| 1 | DL+FF+WL |
| 2 | DL+LL+FF+WL |
| 3 | 1.5(DL+LL) |
| 4 | 1.4(DL+FF+WL) |
| 5 | 1.5(DL+F.F+WL) |
| 6 | 1.5(DL+LL+FF+WL) |
| 7 | 1.2(DL+F.F+WL)+1.6LL |
| 8 | 1.5(DL+FF+WL+Wx) |
| 9 | 1.5(DL+FF+WL-Wx) |
| 10 | 1.5(DL+FF+WL+Wy) |
| 11 | 1.5(DL+FF+WL-Wy) |
| 12 | 1.5(DL+FF+WL+Ex) |
| 13 | 1.5(DL+FF+WL-Ex) |
| 14 | 1.5(DL+FF+WL+Ey) |
| 15 | 1.5(DL+FF+WL-Ey) |
| 16 | 1.2(DL+LL+FF+WL+Wx) |
| 17 | 1.2(DL+LL+FF+WL-Wx |
| 18 | 1.2(DL+LL+FF+WL+Wy) |
| 19 | 1.2(DL+LL+FF+WL-Wy) |
| 20 | 1.2(DL+LL+FF+WL+Ex) |
| 21 | 1.2(DL+LL+FF+WL-Ex) |
| 22 | 1.2(DL+LL+FF+WL+Ey) |
| 23 | 1.2(DL+LL+FF+WL-Ey) |

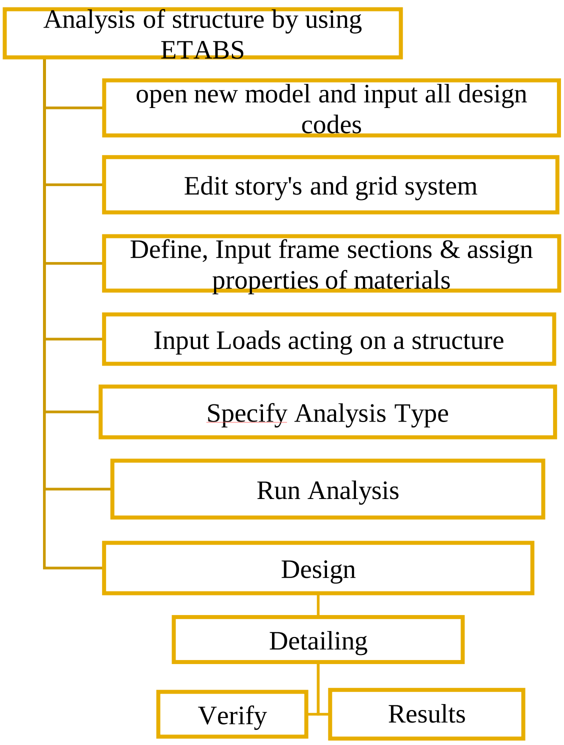
## VI. DESCRIPTION OF STRUCTURE

| | |
|---|---|
| Type of structure | Multi-story rigid jointed frame |
| Purpose of building | Residential building |
| Area of project | Bangalore |
| Shape of building | Regular(rectangular) |
| No. of stories | Ground floor to G+10 |
| Type of wall | Brick wall |
| Floor height | 3m |
| Live load | IS 875:1987-PART 2 |
| Dead load | IS 875:1987-PART 1 |
| Floor finish | IS 875:1987-PART 1 |
| Wind load | IS 875:1987-PART3 |
| Seismic load | IS 1893:2002 |
| Concrete design code | IS 456:2000 |
| Steel design code | IS 800:2007 |
| Grade of concrete | $M_{20}$& $M_{25}$ |
| Grade of steel | Fe 415 |
| Size of column | Based on the number of stories |
| Size of column | 230X230 & 230X300 mm |
| Depth of slab | 150mm |
| **SEISMIC DATA** | |
| Seismic zone | II |
| Zone factor | 0.36 |
| Response reduction | 5 |
| Importance factor | 1 |

**FLOW CHART:**



**ETABS ANALYSIS:**




**PROCEDURE:**

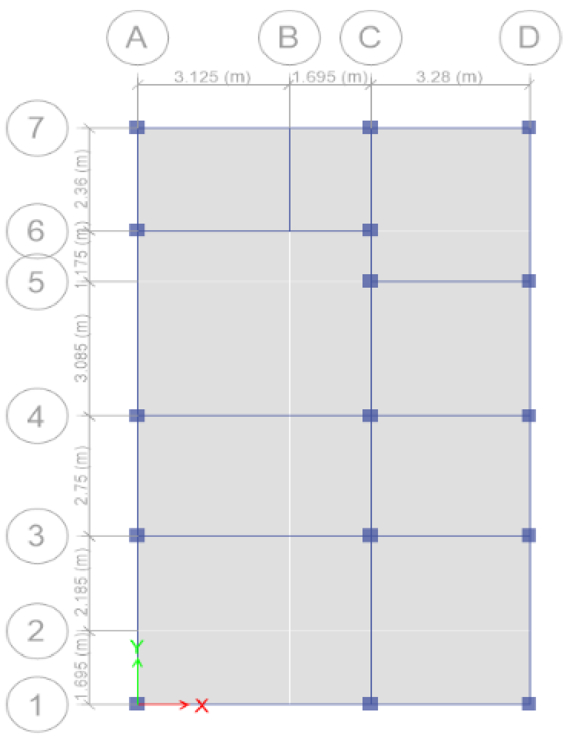
1. Define stories and grid systems.
2. Define materials required.
3. Define properties of beams, columns, slab and other required elements of a structure.
4. Draw beams, columns, slab and other required elements of a structure.
5. Create and assign all the necessary loads acting on a structure like dead load, live load, wind load and seismic load.
6. Create all necessary load combinations with its equivalent magnitude multipliers.
7. Check the model and run analysis.
8. Select load combinations for design and start design check.
9. Start detailing of a structure.
10. Drawings and reports

## VII. BUILDING ANALYSIS

For the analysis of building to acquire the minimum dimensions of frames, we used ETABS software which works faster than manual analysis in turn reduces the time consumption for the analysis and reduction in cost by reducing frame dimensions.

While analyzing, we considered all the possible loading conditions occurring on the structure. To check the results shear force, bending moment, axial force and torsion are considered. Finally, structure is checked safety against all the possible loadings.

**A. PLAN:**



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**B. RESULTANT DIAGRAMS FOR GROUND FLOOR:**

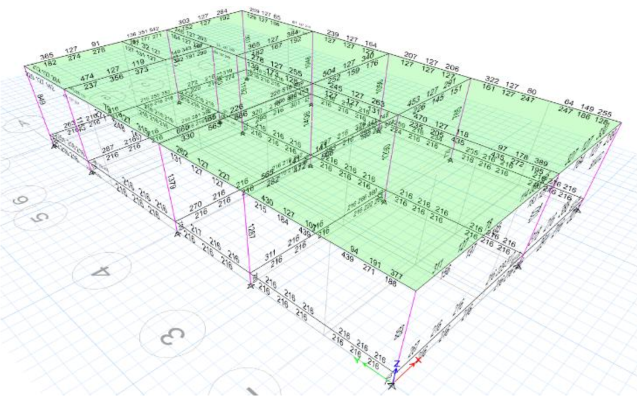

**Fig. design diagram**

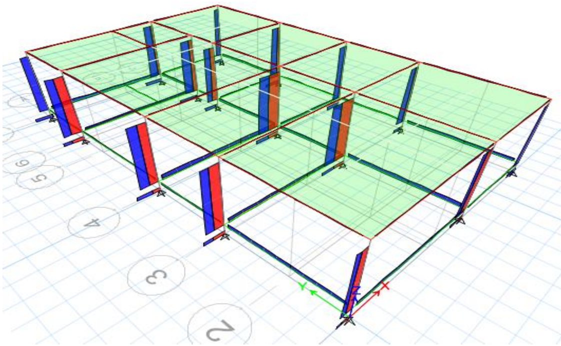

**Fig. Axial force**

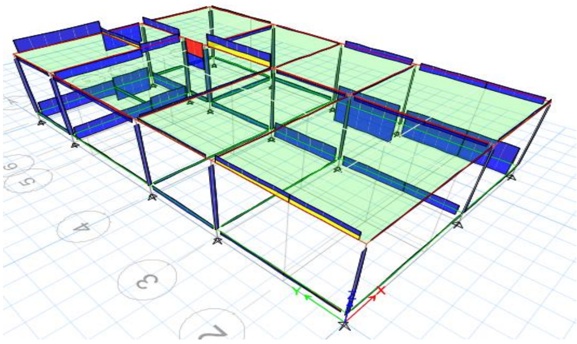

**Fig. Torsion**

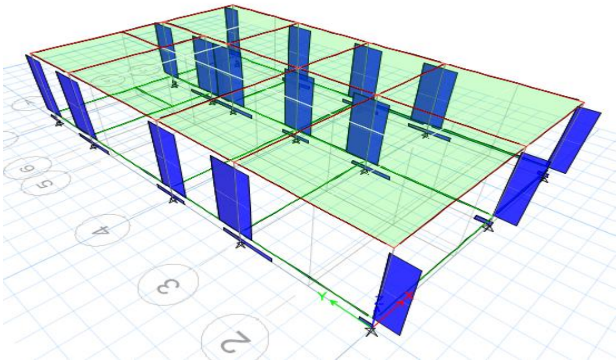

**Fig. Shear force**

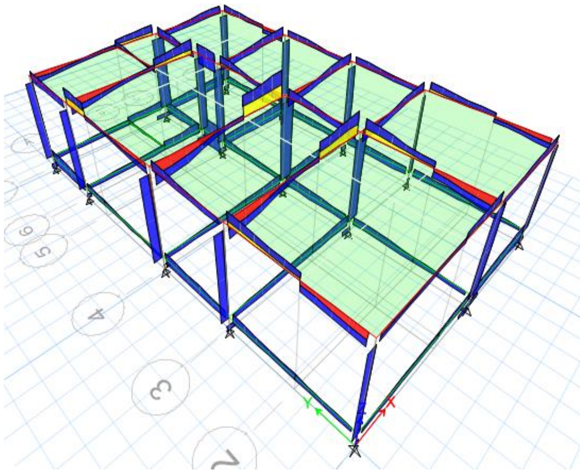

**Fig. Bending moment**

**B. RESULTANT DIAGRAMS FOR G+10:**

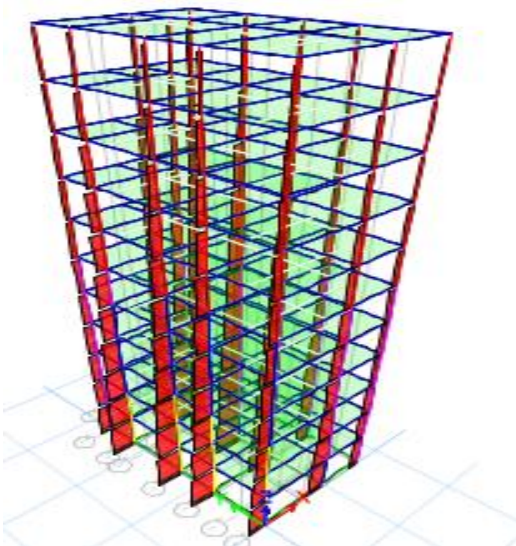

**Fig. Axial force**

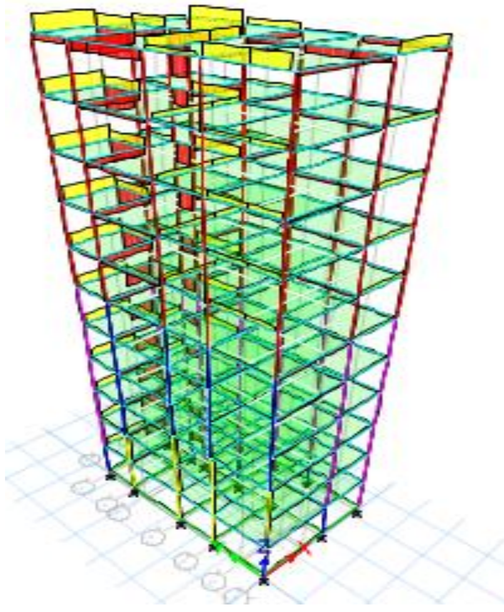

**Fig. Torsion**

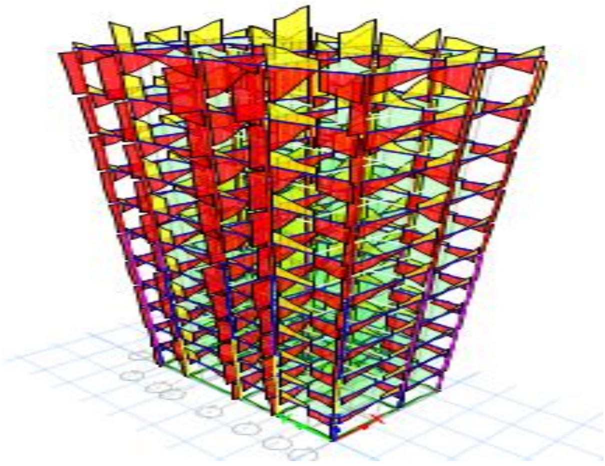

Fig. Shear force

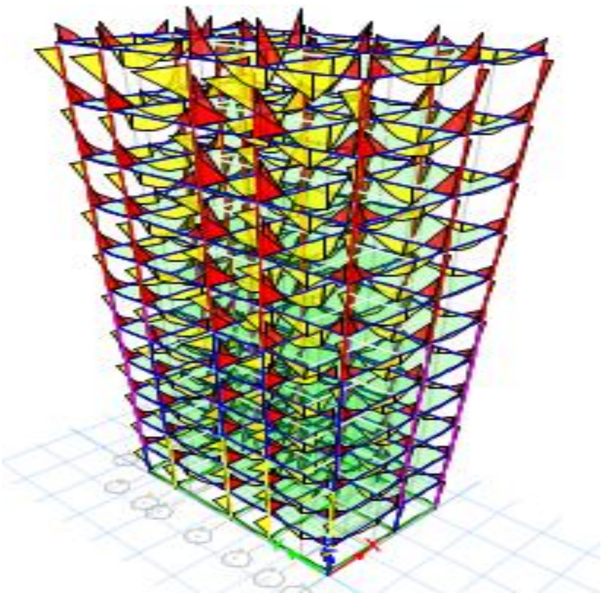

Fig. Bending moment

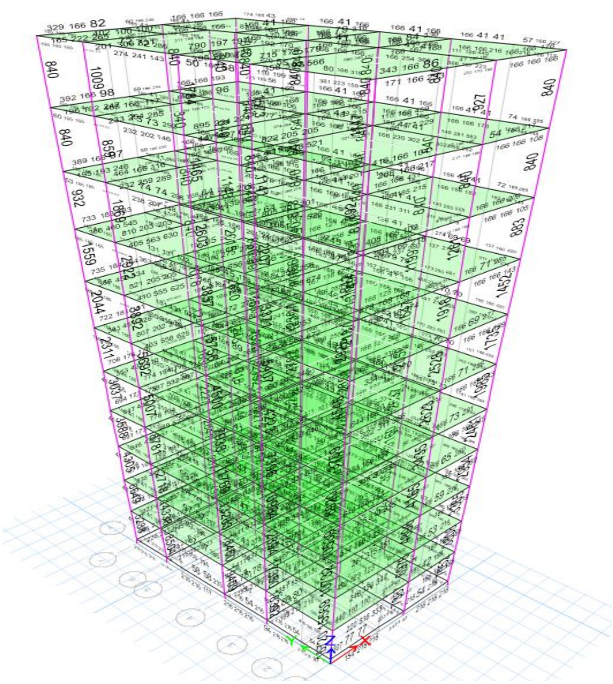

Fig. Design

## VIII. RESULTS

**RESULTANT SF & BM:**

| SL NO | BUILDI-NG TYPE | RESULTANT VALUES | | | |
|---|---|---|---|---|---|
| | | SHEAR FORCE(KN) | | BENDING MOMENT (KN-M) | |
| | | column | beam | column | beam |
| 1 | G.F | 70.46 | 52.94 | 105.69 | 79.41 |
| 2 | G+1 | 72.13 | 55.9 | 108.20 | 83.85 |
| 3 | G+2 | 74.15 | 62.71 | 111.23 | 94.07 |
| 4 | G+3 | 81.04 | 67.58 | 121.56 | 101.37 |
| 5 | G+4 | 103.04 | 71.22 | 154.56 | 106.84 |
| 6 | G+5 | 136.39 | 73.62 | 204.59 | 110.43 |
| 7 | G+6 | 170.82 | 77.02 | 256.24 | 115.53 |
| 8 | G+7 | 195.31 | 85.56 | 292.97 | 128.35 |
| 9 | G+8 | 219.09 | 95.84 | 328.64 | 143.77 |
| 10 | G+9 | 251.03 | 101.56 | 376.55 | 152.35 |
| 11 | G+10 | 274.44 | 124.22 | 411.66 | 186.33 |

**RESULTANT DIMENSIONS OF FRAMES:**

| SL NO | BUILDING TYPE | OPTIMIZED DIMENSIONS | | |
|---|---|---|---|---|
| | | PLINTH BEAM | MAIN BEAMS | COLUMNS |
| 1 | G.F | 300X300 | 230X300 | 300X300 |
| 2 | G+1 | 300X300 | 230X300 | 300X300 |
| 3 | G+2 | 300X300 | 230X300 | 300X300 |
| 4 | G+3 | 300X300 | 230X300 | 350X300 |
| 5 | G+4 | 300X300 | 230X300 | 350X300 |
| 6 | G+5 | 450X300 | 230X300 | 350X300<br>350X350 |
| 7 | G+6 | 450X300 | 230X300 | 350X350<br>350X400 |
| 8 | G+7 | 450X300 | 230X300 | 350X300<br>350X350<br>400X400<br>450X400 |
| 9 | G+8 | 450X300 | 230X300 | 350X300<br>350X350<br>400X400<br>450X450 |
| 10 | G+9 | 450X300 | 230X300 | 400X350<br>400X400 |

| | | | | |
|---|---|---|---|---|
| | | | | 450X450<br>500X500<br>550X500 |
| 11 | G+10 | 450X300 | 230X300 | 350X300<br>350X350<br>400X400<br>450X450<br>500X500<br>600X600 |

**REINFORCEMENT VALUES:**

| SL NO | BUILD \ING TYPE | AMOUNT OF REINFORCEMENT ($mm^2$) | | | |
|---|---|---|---|---|---|
| | | **COLUMN** | | **BEAM** | |
| | | **Longit udinal** | **Shear** | **Longit udinal** | **Shear** |
| 1 | G. F | 1299 | 309.50 | 789 | 180.64 |
| 2 | G+1 | 1379 | 332.53 | 854 | 210.75 |
| 3 | G+2 | 1538 | 350.53 | 896 | 224.67 |
| 4 | G+3 | 2571 | 387.95 | 1026 | 249.85 |
| 5 | G+4 | 4629 | 387.95 | 1435 | 256.50 |
| 6 | G+5 | 7153 | 387.95 | 1938 | 283.75 |
| 7 | G+6 | 8050 | 443.37 | 2140 | 314.73 |
| 8 | G+7 | 9115 | 498.64 | 2780 | 345.46 |
| 9 | G+8 | 11999 | 564.65 | 3470 | 368.50 |
| 10 | G+9 | 16435 | 609.64 | 3976 | 398.97 |
| 11 | G+10 | 19459 | 665.06 | 4536 | 402.60 |

## IX. DISCUSSIONS

In this paper, it is proposed that buildings with a gradual increase in the plan elevations concerning the floors are prone to earthquake damages, wind effects, etc., The structure is considered to safe against all damages (natural and artificial).

A three-dimensional analysis of a building using general-purpose using computer programs can take care of eccentricity. However, there is no general-purpose computer program which can account for the design eccentricity, because there is no direct method o compute the center of rigidity or shear at each floor of a building. This is the main reason as to why most of the designers adopt approximate methods for the torsional analysis of a building. Several studies reveal that the torsion is the most critical factor for the damage or complete collapse of a structure during the past wind storms and earthquakes. It is, therefore, necessary that irregular elevation in a building should be carefully analyzed for torsion and shear.

Different elevations in a structure overviewed which offers to overcome the failures in the direction of X, Y, and Z in terms of failure in frames. This analysis helps us to identify a particular failure region in a structure. Vertical irregularities will affect both vertical and horizontal directions in terms of displacement. Many kinds of literature would have been studied that to solve either any one problem pf damage occurred in a structure.

This study enables ton to identify the minimum dimensions of a frame required for a structure to withstand all the loadings which cause damages (natural & artificial) to it. When the increase in floors results in the modification of Frame dimensions by considering shear force, bending moment, axial force, and torsion.

## X. STUDY RESULT

- When no of floors increases from 1 to 10, there is an increase in the shear force, bending moment.
- There is a gradual increase in the shear force up to G+4 and rapid increase occurs after G+4 to G+10.
- Up to G+4, bending moment increases gradually in a structure due to increase in the number of floor.
- After G+4, there is a rapid increase in bending moment as the frame dimensions increases.
- Longitudinal reinforcement is nearly four times of the shear reinforcement in a structure.
- Shear force and bending moment is minimum in one floor building and maximum in G+10 building.

## XI. CONCLUSION

Based on the completion of this project on the dimensional optimization of RCC structure with different elevations, the following conclusions are made:

1. Our project deals in obtaining minimum dimensions of a framed structure which is economic.
2. Minimum sizes of the beams and columns were provided as B230mmX450mm for plinth, B230mmX300mm for main beam and C300mmX300 mm, after analysis only the failed column dimensions were changed gradually up to C600mmX600 mm which comes under economic for the G+10 building.

3. There is a gradual increase in the value of lateral forces from bottom floor to top floor in software analysis.
4. From this work, it's observed that, up to G+4 there is no any changes in the minimum dimensions because those minimum dimensions withstand all the loads acting on a structure.
5. From G+5 failure of columns occurs which leads to the changes in the dimensions to withstand the loads.
6. There is a clear difference between the results obtained with different elevation is significant.
7. Amount of steel reinforcement for the critical frame section is obtained by using ETAB software.
8. Software reduces lots of time in design work to obtain minimum dimensions of frames in a structure
9. Use of software in analysis of multi-storeyed building improves accuracy in work.
10. Cost of structure reduces by obtaining minimum dimensions of frames.
11. All the List of failed beams can be obtained and also better Section is given by the software.
12. Shear force and bending moment values increases for both beams and columns as the number of storeys increases.

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