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# STATIC AND DYNAMIC ANALYSIS OF RCC STRUCTURE WITH FLAT SLAB AND X BRACING

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**Abstract -** *As there is rapid development in infrastructure, structure like hotels, museums and convention hall requires more floor height as it gives good asthetic look. So floor height is to be increased it cannot be achieved with normal beam and column structure. So building with flat slab is constructed to increase the floor height. Flat slab structure with certain height of structure is also stable for dynamic analysis. But for structure with greater height is not stable for dynamic analysis as compared to rc framed structure. Bracing are adopted for the flat slab structure to make good condition for dynamic analysis. So that it can resist lateral forces. In this study, flat slab rc structure of G+12 is modelled then static and dynamic analysis is carried out by using etabs software. Equivalent static method is used for static analysis and response spectrum method is used for dynamic analysis. G+12 flat slab rc structure with a floor height of 3.5m is considered for analysis. Loads considered for analysis is according to the IS codes. Analysis is carried out for structure without bracing for zone 2 and 5. Then steel bracing are provided to structure in X type pattern and analysis is carried out for structure with X bracing for zone 2 and 5. The parameters considered are storey displacement, storey drift and base shear. Results obtained are compared with structure with bracing and structure without bracing.*

***Key Words***: **Flat slab, X bracing, Lateral displacement, Storey drift, Storey shear.**

## 1. INTRODUCTION

Earthquakes cause varying shaking intensities at various location, as well as there is a differ in a damage occurred at these location. As a result, by knowing the intensity of shaking at that location a structure which to be constructed is resistant for earthquakes, and comprehend the effects from earthquake. Even when earthquakes of the same magnitude occur due to its varying intensity, resulting in differing devastating impacts in various locations. As a result, it is required to investigate changes in seismic behaviour of flat slab rc framed buildings for different magnitudes of earthquakes in terms of lateral displacements, storey drift and base shear. As a result, the earthquake behaviour of structures with identical layouts must be understood under various earthquake intensities. It is required to conduct a seismic analysis of the structure using several available technologies in order to determine seismic responses.

When rcc structures subjected to severe earthquakes then there will be possibility of failure of structure. So to reduce the failure of structure bracing are provided to the rcc structure such that the failure of structure can be reduced. Therefore, less damage of the rcc structures in earthquakes which often depends on the ability of the energy dissipation of the braces reduces the damages and increases their use. This is because the energy dissipation capacity enhances, the safety of the structures also improves. The ease of the application and effective performance of braces in rcc structures, have made them a suitable method of resisting lateral forces. Braces, as a passive control system, can play an effective role in creating structural resistance to lateral forces like earthquakes.

### 1.1 OBJECTIVES

- The goal of this project is to investigate and determining the various structural response of the rcc flat slab structure with bracing.
- To find the appropriate methods for dynamic analysis.
- To check the seismic response of building using etabs software.
- To study the dynamic performance of building with bracing and without bracing.
- To analyse base shear, lateral displacement, storey drift under loads.
- To analyse results between static and dynamic analysis (response spectrum method).

## 2. METHODOLOGY

- Study of dynamic analysis.
- Defining objective of the study.
- Literature review.
- Refering IS codes for design codes.
- Model generation using etabs.
- Model 1: G+12 structure with flat slab is modelled and prepared for seismic zone 2, then static and dynamic analysis by response spectrum method is carried out.
- Model 2: G+12 structure with flat slab is modelled and prepared for seismic zone 5, then static and dynamic analysis by response spectrum method is carried out.

- Model 3: G+12 structure with flat slab and X bracings are provided is modelled and prepared for seismic zone 2, then static and dynamic analysis by response spectrum method is carried out.
- Model 4: G+12 structure with flat slab is modelled and X bracings are provided and prepared for seismic zone 5, then static and dynamic analysis by response spectrum method is carried out.
- Analysis of building models to obtain the results.
- Comparison of the results and concluding the work with conclusion.

**Table -1:** Design data for analysis

| Particular | Details / Size |
|---|---|
| Plan dimension | 30.6x45.6 m |
| X-Direction grid spacing | 7.5m |
| Y-Direction grid spacing | 7.5m |
| Number of storey | 13 |
| Column dimension | 600x600 mm |
| Depth of slab | 275 mm |
| Depth of drop | 420 mm |
| Height of each storey | 3.5 m |
| Support condition | Fixed |
| Total height of building | 45.5 m |
| Thickness of wall | 230 mm |
| Seismic zone | II & V |
| Soil type | II |
| Material used | Concrete M40 & Reinforcement Fe 415 |
| Bracing property | ISA 200x150x12 |
| Dead load | 8 kN/m$^2$ |
| Live load | 4 kN/m$^2$ |
| Wall load | 16.1 kN/m |
| Earthquake load | As per IS 1893-2002 |
| Wind load | As per IS 875-3 (1987) |
| Response reduction factor | 5 |
| Damping ratio | 0.05 |
| Importance factor | 1 |
| Static analysis | Equivalent Lateral force method |
| Dynamic analysis | Response spectrum method |
| Software used | Etabs 2017 |

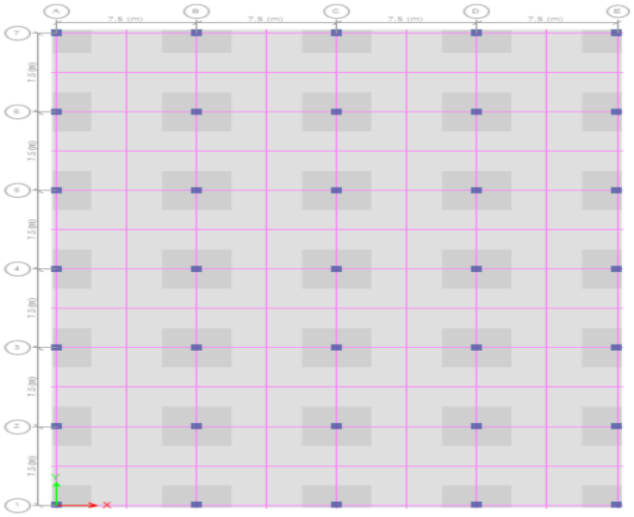

**Fig -1:** Plan of G+12 structure with flat slab and drop

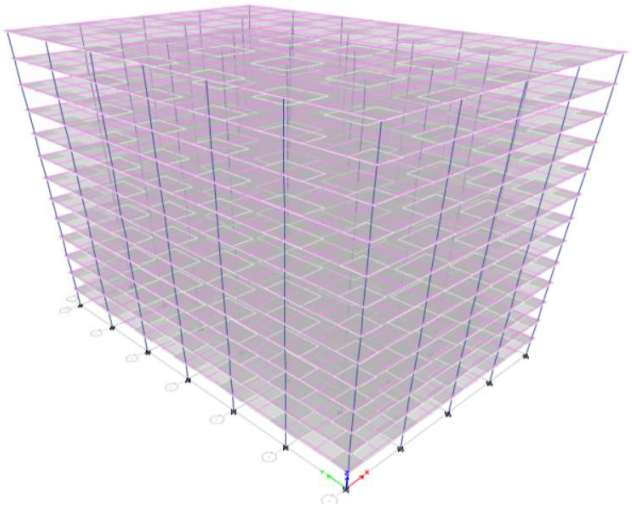

**Fig -2:** 3D of the structure

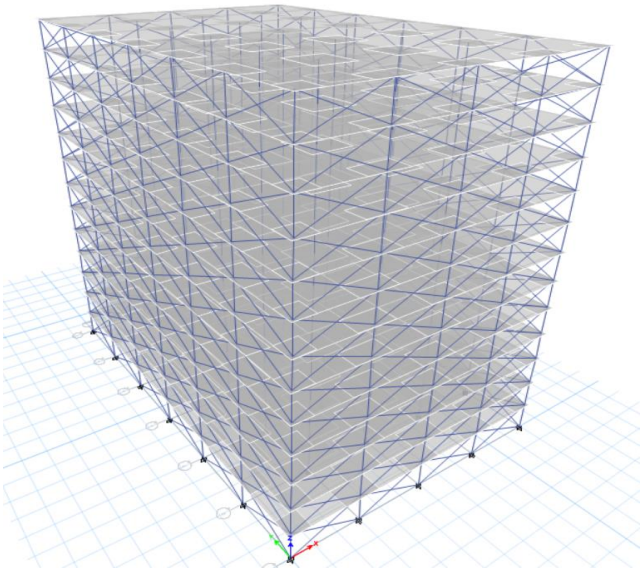

**Fig -3:** Structure with X bracing

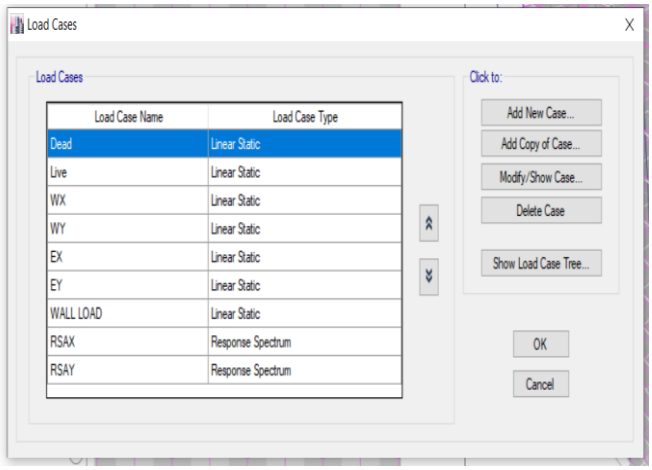


**Fig -4:** Load cases for static and dynamic analysis in etabs

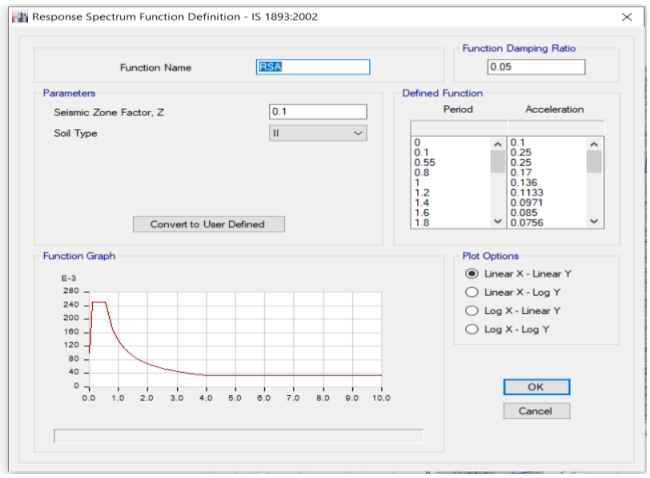


**Fig -5:** Response spectrum function in etabs

## 3. RESULTS AND DISCUSSION

After completion of modelling and analysis part results are discussed. Results obtained are displacement, drift, base shear of the structure. Then results are compared with zone 2 and zone 5, then it is compared with structure without bracing and structure with X bracing. Then graphs are plotted.

### 3.1 DISPLACEMENT

It is total displacement of any storey with respect to the ground.

**Table -2:** Displacement values in x direction for zone 2, without bracing and with X bracing for Static and dynamic analysis

| Storey | Zone 2 (x direction) without bracing (mm) | | Zone 2 (x direction) with X bracing (mm) | |
|---|---|---|---|---|
| | Static | Dynamic | Static | Dynamic |
| 13 | 58.775 | 11.553 | 24.230 | 7.490 |
| 12 | 57.947 | 11.296 | 23.853 | 7.285 |
| 11 | 56.474 | 10.889 | 23.123 | 6.989 |
| 10 | 54.266 | 10.339 | 22.117 | 6.607 |
| 9 | 51.319 | 9.662 | 20.839 | 6.150 |
| 8 | 47.646 | 8.871 | 19.298 | 5.625 |
| 7 | 43.267 | 7.976 | 17.503 | 5.041 |
| 6 | 38.209 | 6.982 | 15.467 | 4.402 |
| 5 | 32.500 | 5.893 | 13.206 | 3.714 |
| 4 | 26.176 | 4.711 | 10.736 | 2.982 |
| 3 | 19.286 | 3.442 | 8.076 | 2.212 |
| 2 | 11.946 | 2.108 | 5.247 | 1.412 |
| 1 | 4.643 | 0.806 | 2.279 | 0.600 |

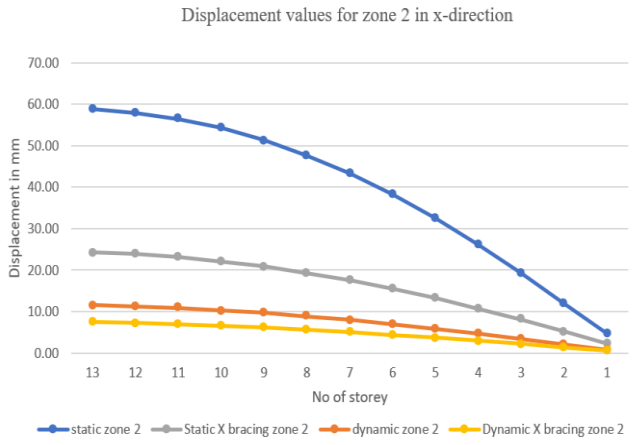


**Fig -6:** Displacement values for zone 2 in x-direction for static and dynamic analysis

**Table -3:** Displacement values in y direction for zone 2, without bracing and with X bracing for Static and dynamic analysis

| Storey | Zone 2 (y direction) without bracing (mm) | | Zone 2 (y direction) with X bracing (mm) | |
|---|---|---|---|---|
| | Static | Dynamic | Static | Dynamic |
| 13 | 39.016 | 11.460 | 12.007 | 6.395 |
| 12 | 38.525 | 11.223 | 11.816 | 6.245 |
| 11 | 37.599 | 10.836 | 11.493 | 6.015 |
| 10 | 36.176 | 10.304 | 11.028 | 5.709 |
| 9 | 34.252 | 9.642 | 10.424 | 5.333 |
| 8 | 31.837 | 8.864 | 9.685 | 4.894 |
| 7 | 28.943 | 7.979 | 8.815 | 4.399 |
| 6 | 25.587 | 6.992 | 7.820 | 3.852 |
| 5 | 21.787 | 5.907 | 6.707 | 3.260 |
| 4 | 17.565 | 4.726 | 5.484 | 2.626 |
| 3 | 12.953 | 3.455 | 4.158 | 1.959 |
| 2 | 8.029 | 2.117 | 2.738 | 1.265 |
| 1 | 3.121 | 0.809 | 1.226 | 0.553 |

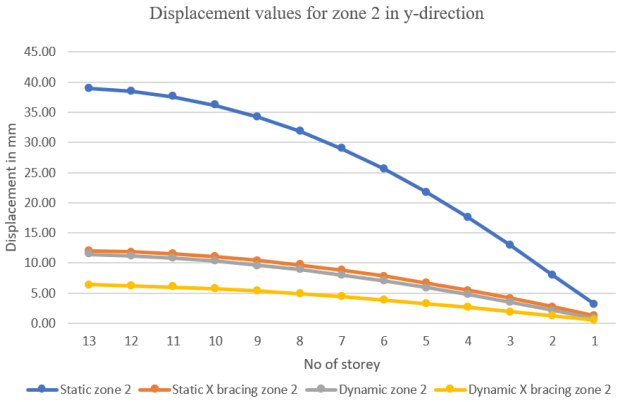


**Fig -7:** Displacement values for zone 2 in y-direction for static and dynamic analysis

**Table -4:** Displacement values in x direction for zone 5, without bracing and with X bracing for Static and dynamic analysis

| Storey | Zone 5 (x direction) without bracing (mm) | | Zone 5 (x direction) with X bracing (mm) | |
|---|---|---|---|---|
| | Static | Dynamic | Static | Dynamic |
| 13 | 82.941 | 41.592 | 50.010 | 27.275 |
| 12 | 80.758 | 40.664 | 48.429 | 26.535 |
| 11 | 77.213 | 39.201 | 46.097 | 25.463 |
| 10 | 72.487 | 37.222 | 43.105 | 24.078 |
| 9 | 66.744 | 34.784 | 39.572 | 22.417 |
| 8 | 60.178 | 31.936 | 35.611 | 20.510 |
| 7 | 52.969 | 28.714 | 31.324 | 18.384 |
| 6 | 45.277 | 25.136 | 26.804 | 16.060 |
| 5 | 37.243 | 21.215 | 22.136 | 13.554 |
| 4 | 28.992 | 16.960 | 17.394 | 10.884 |
| 3 | 20.638 | 12.391 | 12.641 | 8.073 |
| 2 | 12.349 | 7.587 | 7.932 | 5.151 |
| 1 | 4.643 | 2.900 | 3.333 | 2.183 |

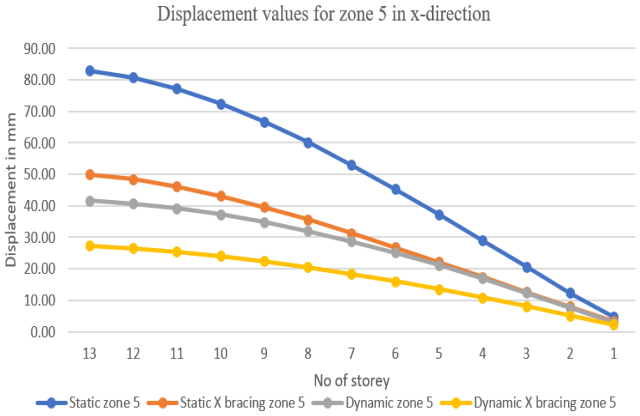


**Fig -8:** Displacement values for zone 5 in x-direction for static and dynamic analysis

**Table -5:** Displacement values in y direction for zone 5, without bracing and with X bracing for Static and dynamic analysis

| Storey | Zone 5 (y direction) without bracing (mm) | | Zone 5 (y direction) with X bracing (mm) | |
|---|---|---|---|---|
| | Static | Dynamic | Static | Dynamic |
| 13 | 75.620 | 41.256 | 41.471 | 23.335 |
| 12 | 73.701 | 40.404 | 40.281 | 22.791 |
| 11 | 70.574 | 39.011 | 38.447 | 21.956 |
| 10 | 66.324 | 37.095 | 36.044 | 20.842 |
| 9 | 61.129 | 34.712 | 33.177 | 19.473 |
| 8 | 55.169 | 31.910 | 29.938 | 17.874 |
| 7 | 48.607 | 28.723 | 26.413 | 16.068 |
| 6 | 41.591 | 25.171 | 26.804 | 14.074 |
| 5 | 34.249 | 21.265 | 22.136 | 11.911 |
| 4 | 26.693 | 17.014 | 17.394 | 9.598 |
| 3 | 19.028 | 12.440 | 12.641 | 7.158 |
| 2 | 11.403 | 7.621 | 7.932 | 4.618 |
| 1 | 4.287 | 2.913 | 3.333 | 2.013 |

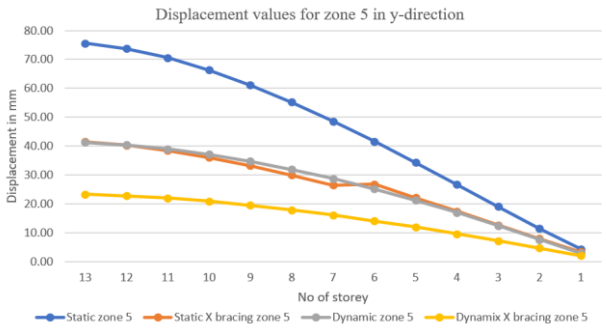


**Fig -9:** Displacement values for zone 5 in y-direction for static and dynamic analysis

### 3.2 STOREY DRIFT

It is specified as ratio of displacement of two consecutive floors to height of that floor. Drift is a major term used in dynamic analysis.

**Table -6:** Drift values in x direction for zone 2, without bracing and with X bracing for Static and dynamic analysis

| Storey | Zone 2 (x direction) without bracing (m) | | Zone 2 (x direction) with X bracing (m) | |
|---|---|---|---|---|
| | Static | Dynamic | Static | Dynamic |
| 13 | 0.000237 | 0.000097 | 0.000134 | 0.000066 |
| 12 | 0.000421 | 0.000154 | 0.000209 | 0.000098 |
| 11 | 0.000631 | 0.000201 | 0.000288 | 0.000126 |
| 10 | 0.000842 | 0.000238 | 0.000365 | 0.000148 |
| 9 | 0.001050 | 0.000267 | 0.000440 | 0.000166 |
| 8 | 0.001251 | 0.000291 | 0.000513 | 0.000181 |
| 7 | 0.001445 | 0.000311 | 0.000582 | 0.000194 |
| 6 | 0.001631 | 0.000331 | 0.000646 | 0.000204 |
| 5 | 0.001807 | 0.000350 | 0.000706 | 0.000214 |
| 4 | 0.001969 | 0.000369 | 0.000760 | 0.000223 |
| 3 | 0.002097 | 0.000383 | 0.000808 | 0.000229 |
| 2 | 0.002087 | 0.000372 | 0.000848 | 0.000232 |
| 1 | 0.001327 | 0.000230 | 0.000651 | 0.000171 |

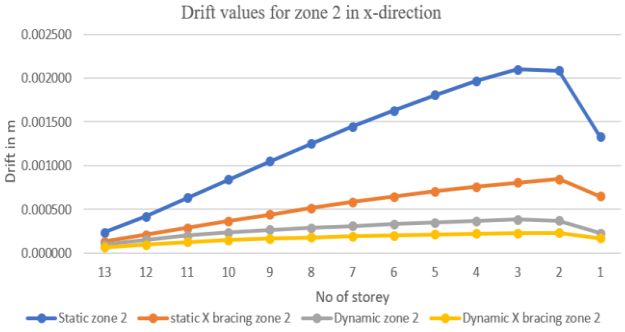


**Fig -10:** Drift values for zone 2 in x-direction for static and dynamic analysis

**Table -7:** Drift values in y direction for zone 2, without bracing and with X bracing for Static and dynamic analysis

| Storey | Zone 2 (y direction) without bracing (m) | | Zone 2 (y direction) with X bracing (m) | |
|---|---|---|---|---|
| | Static | Dynamic | Static | Dynamic |
| 13 | 0.000153 | 0.000091 | 0.000094 | 0.000048 |
| 12 | 0.000265 | 0.000148 | 0.000144 | 0.000075 |
| 11 | 0.000407 | 0.000196 | 0.000188 | 0.000099 |
| 10 | 0.000549 | 0.000234 | 0.000244 | 0.000119 |
| 9 | 0.000690 | 0.000263 | 0.000253 | 0.000136 |
| 8 | 0.000827 | 0.000288 | 0.000276 | 0.000151 |
| 7 | 0.000959 | 0.000309 | 0.000292 | 0.000163 |
| 6 | 0.001087 | 0.000329 | 0.000318 | 0.000174 |
| 5 | 0.001206 | 0.000350 | 0.000350 | 0.000184 |
| 4 | 0.001318 | 0.000369 | 0.000379 | 0.000192 |
| 3 | 0.001407 | 0.000384 | 0.000406 | 0.000199 |
| 2 | 0.001402 | 0.000374 | 0.000432 | 0.000203 |
| 1 | 0.000892 | 0.000231 | 0.000350 | 0.000158 |

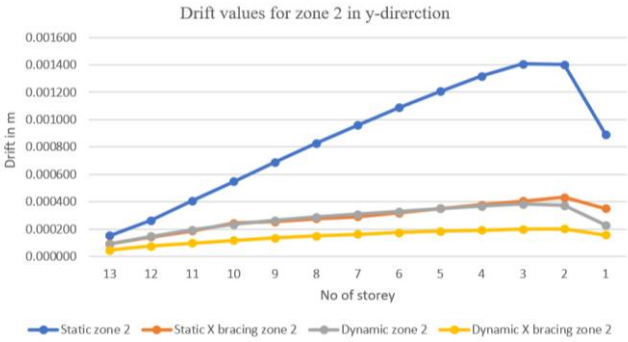


**Fig -11:** Drift values for zone 2 in y-direction for static and dynamic analysis

**Table -8:** Drift values in x direction for zone 5, without bracing and with X bracing for Static and dynamic analysis

| Storey | Zone 5 (x direction) without bracing (m) | | Zone 5 (x direction) with X bracing (m) | |
|---|---|---|---|---|
| | Static | Dynamic | Static | Dynamic |
| 13 | 0.000633 | 0.000348 | 0.000452 | 0.000240 |
| 12 | 0.001006 | 0.000553 | 0.000667 | 0.000356 |
| 11 | 0.001353 | 0.000725 | 0.000856 | 0.000458 |
| 10 | 0.001644 | 0.000857 | 0.001010 | 0.000540 |
| 9 | 0.001880 | 0.000962 | 0.001133 | 0.000607 |
| 8 | 0.002064 | 0.001047 | 0.001226 | 0.000661 |
| 7 | 0.002202 | 0.001121 | 0.001292 | 0.000706 |
| 6 | 0.002300 | 0.001191 | 0.001335 | 0.000745 |
| 5 | 0.002362 | 0.001260 | 0.001356 | 0.000781 |
| 4 | 0.002391 | 0.001327 | 0.001359 | 0.000813 |
| 3 | 0.002373 | 0.001379 | 0.001347 | 0.000838 |
| 2 | 0.002209 | 0.001340 | 0.001315 | 0.000848 |
| 1 | 0.001327 | 0.000829 | 0.000952 | 0.000624 |

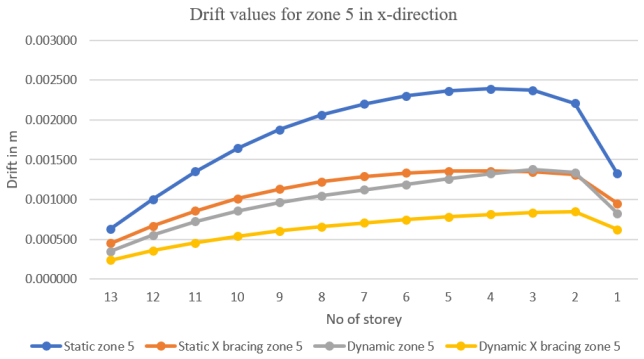


**Fig -12:** Drift values for zone 5 in x-direction for static and dynamic analysis

**Table -9:** Drift values in y direction for zone 5, without bracing and with X bracing for Static and dynamic analysis

| Storey | Zone 5 (y direction) without bracing (m) | | Zone 5 (y direction) with X bracing (m) | |
|---|---|---|---|---|
| | Static | Dynamic | Static | Dynamic |
| 13 | 0.000549 | 0.000329 | 0.000340 | 0.000174 |
| 12 | 0.000895 | 0.000534 | 0.000524 | 0.000272 |
| 11 | 0.001216 | 0.000707 | 0.000687 | 0.000360 |
| 10 | 0.001486 | 0.000841 | 0.000820 | 0.000434 |
| 9 | 0.001705 | 0.000948 | 0.000926 | 0.000497 |
| 8 | 0.001877 | 0.001036 | 0.001008 | 0.000551 |
| 7 | 0.002008 | 0.001113 | 0.001068 | 0.000596 |
| 6 | 0.002101 | 0.001186 | 0.001108 | 0.000637 |
| 5 | 0.002162 | 0.001258 | 0.001130 | 0.000673 |
| 4 | 0.002193 | 0.001328 | 0.001138 | 0.000703 |
| 3 | 0.002182 | 0.001383 | 0.001134 | 0.000728 |
| 2 | 0.002036 | 0.001346 | 0.001123 | 0.000745 |
| 1 | 0.001225 | 0.000832 | 0.000852 | 0.000575 |

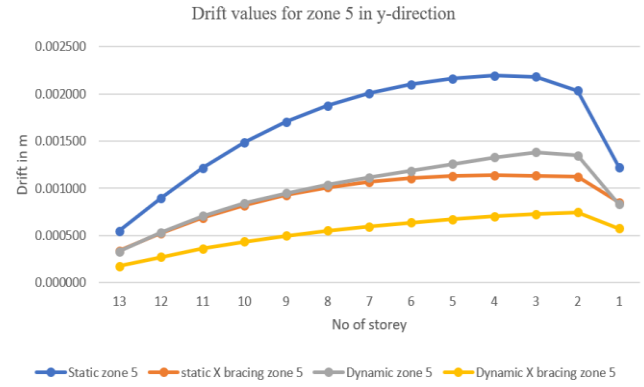


**Fig -13:** Drift values for zone 5 in y-direction for static and dynamic analysis

### 3.3 BASE SHEAR

Base shear is the sliding force that is generated at the base of the structure especially due to earthquake forces.

**Table -10:** Base shear values in x & y direction for zone 2 & 5, without bracing and with X bracing for Static and dynamic analysis

| Zone | Base shear in kN | | | |
|---|---|---|---|---|
| | Static | | Dynamic | |
| | Fx | Fy | Fx | Fy |
| Zone 2 (Without bracing) | 1576.92 | 1583.31 | 1122.77 | 1125.73 |
| Zone 2 (With X bracing) | 2416.81 | 2777.25 | 1713.53 | 1971.86 |
| Zone 5 (Without bracing) | 5653.10 | 5683.91 | 4041.98 | 4052.64 |
| Zone 5 (With X bracing) | 8463.20 | 9800.75 | 6090.39 | 6981.22 |

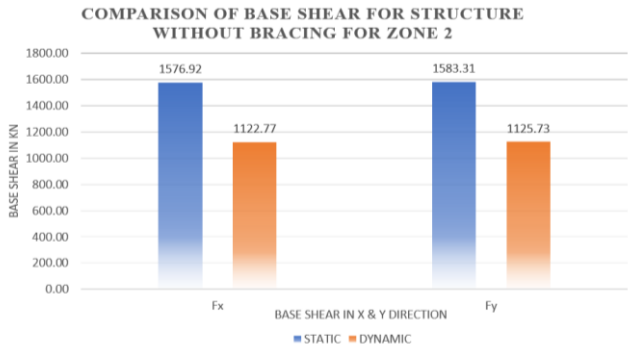


**Fig -14:** Comparison of base shear for structure without bracing for zone 2 for static and dynamic analysis

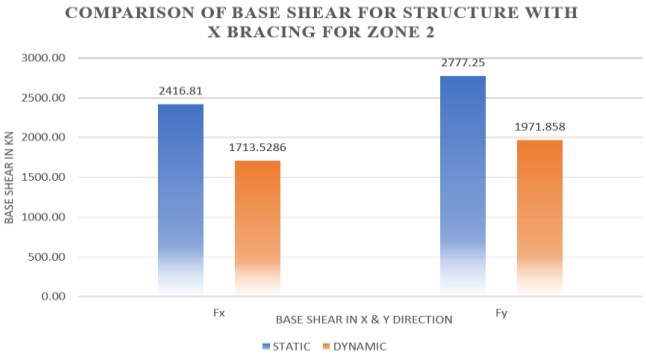


**Fig -15:** Comparison of base shear for structure with X bracing for zone 2 for static and dynamic analysis

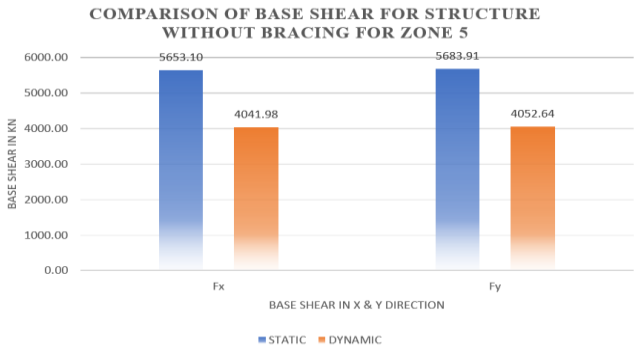


**Fig -16:** Comparison of base shear for structure without bracing for zone 5 for static and dynamic analysis

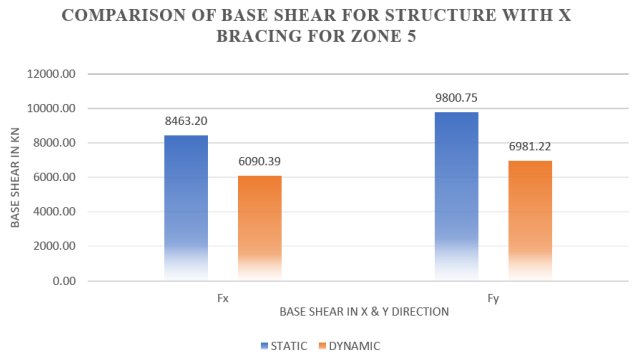


**Fig -17:** Comparison of base shear for structure with X bracing for zone 5 for static and dynamic analysis

## 4. CONCLUSIONS

In this present study, comparative analysis is carried out for static and dynamic loadings. The analysis is done for structure without bracing and with X bracing for zone (2 and 5). The graph clearly shows storey displacement, drift and base shear. The following conclusion are written based on investigation.

- Displacement of structure is more for equivalent static analysis as compared to response spectrum method for zone 2&5. Zone 5 will give higher displacement as compared to zone 2 for static and dynamic analysis.
- Decrease in displacement values for structure with X bracing as compared to without bracing for static and dynamic analysis.
- Drift of structure is more for equivalent static analysis as compared to response spectrum method for zone 2 and 5. Zone 5 will give higher drift as compared to zone 2 for static and dynamic analysis.
- Decrease in drift values for structure with X bracing as compared to without bracing for static and dynamic analysis.
- Response spectrum method shows lower base shear as compared to equivalent static method for zone 2&5.
- Base shear will be more in structure with X bracing as compared to structure without bracing for static and dynamic analysis.

### 4.1 SCOPE FOR FUTURE STUDY

Many researches where done on rc framed structure with bracing for dynamic analysis. But this project is done on dynamic analysis for rcc structure with flat slab and X bracing and this is a unique project. I have got good output from results. Further, this project can be extend for other types of bracing.

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