# COMPERATIVE ANALYSIS OF GEOPOLYMER CONCRETE WITH SHEAR WALL BY USING LINEAR STATIC METHOD & RESPONSE SPECTRUM METHOD IN ETAB'S.

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***Abstract:*** *This study compares geopolymer concrete shear walls using ETABS software, concentrating on linear static and response spectrum approaches. The goal is to assess the performance and efficiency of geopolymer concrete shear walls when used in various shear wall configurations. The study uses linear static analysis to determine that the shear wall structure of geopolymer concrete is smaller than that of conventional concrete, while the response spectrum approach yields larger values of displacement, axial forces, shear forces, overturning moment, maximum story drift, and story shear. For geopolymer concrete construction, the fundamental natural time period 't' (seconds) is the same in both the linear static and reaction spectrum methods. In this project, analyze the G+9 building using geopolymer concrete and compare different shear wall structures or patterns using etabs software, obtaining data such as displacement, stress distribution, and overall structural performance, thereby providing insights into the advantages and limitations of geopolymer concrete in seismic design compared to conventional concrete.*

***Keywords: Geopolymer concrete, shear wall, response spectrum method, linear static method, Etabs, fundamental natural time period, average response spectrum, acceleration coefficient.***

## 1. INTRODUCTION

### 1.1 GEOPOLYMER CONCRETE

Geopolymer concrete is a form of concrete made from alumino-silicate material (fly ash, blast furnace slag) mixed with an alkaline solution (sodium silicate, sodium hydroxide) and sent with aggregate. The alumino-silicate substance mixed with alkaline solution serves as the binding material in this concrete. The most essential feature here is that no cement is necessary.

### 1.2 HISTORY OF GEOPOLYMER CONCRETE

"Joseph Davidovits," a French material scientist, invented the notion of geopolymer in 1978. He discovered that some aluminum-silicate minerals might react with alkaline solutions to produce binders with cement-like characteristics. The initial research concentrated on the chemistry and potential applications of geopolymers, particularly in refractory materials and high-temperature ceramics. Growth and Research (1980s-1990s): Davidovits proceeded to

improve the geopolymer synthesis method, resulting in a greater knowledge of the chemical interactions involved and the potential for usage in building materials.
Scientists expanded their research globally, investigating the utilization of industrial wastes such as fly ash and slag as source materials for geopolymers. These projects sought to lessen the environmental impact of concrete production. Modern Development in the 2000s The formulation and application of geopolymer concrete have advanced significantly. The researchers concentrated on optimizing mix designs, enhancing mechanical qualities, and studying long-term durability. The first commercial-scale applications of geopolymer concrete were realized, including the construction of structural elements and pavements. The increased emphasis on sustainability resulted in a spike in interest in geopolymer concrete. Studies emphasized its decreased carbon footprint compared to typical Portland cement concrete.
Geopolymer concrete is now considered a viable alternative to traditional concrete in a variety of applications, particularly where sustainability and environmental impact are critical considerations. Ongoing research aims to improve its performance and expand its applications in the construction industry.

## 1.3 SHEAR WALL

A structural wall is a vertically oriented planar feature that is primarily intended to resist lateral force effects (axial force, shear force, and bending moment) in its own plane. The shear wall is a reinforced concrete wall that is resistant to lateral loads such as earthquakes and winds. Its purpose is to provide stability and prevent excessive sway or collapse during horizontally applied stresses. They are typically located strategically within a building's layout to properly distribute and transfer these pressures to the foundation.

## 1.4 ETAB'S SOFTWARE

Computers and Structures, Inc. developed ETABS (Extended Three-dimensional Analysis of Building Systems), a structural engineering software tool. It is used to analyze and design buildings and structures that exhibit both linear and nonlinear behavior. ETABS offers a comprehensive set of tools for modeling, analyzing, and constructing a variety of structural systems, such as skyscrapers, residential buildings, and industrial structures. It has advanced analysis capabilities, a user-friendly graphical interface, and compatibility with other engineering tools and standards.

## 1.5 FRAMED STRUCTURES

A framed structure is a construction design in which the load-bearing elements are generally made up of columns, beams, and, in some cases, braces. This framework supports the building's loads, including its weight, as well as external pressures like wind and seismic activity. The main advantage of framed structures is being flexible and efficient in terms of load distribution, allowing for huge open spaces without the requirement for load-bearing walls. High-rise buildings, commercial structures, and modern residential developments all adopt this design.

## 1.6 RESPONSE SPECTRUM

The response spectrum approach is a structural engineering seismic analysis tool that estimates a building's response to earthquake ground vibrations. Rather than analyzing the structure's response to a specific time-history of ground shaking, the response spectrum method employs a response spectrum, which is a plot depicting the maximum response (displacement, velocity, or acceleration) of a series of single-degree-of-freedom (SDOF) systems to a specific earthquake. This method simplifies the study of complicated structures under seismic stress, making it especially helpful for early design and evaluation in seismic design codes. The maximum response is shown against the undamped natural period and different damping levels, and it can be expressed as maximum absolute acceleration, maximum relative velocity, or maximum relative displacement.

### 1.7 G+9 BUILDING

A "G+9" building has a ground level (G) and nine more floors above it, for a total of ten floors. This form of designation is often used in real estate and construction to indicate the number of floors in a building.

## 2. AIM AND OBJECTIVE

### 2.1 AIM

The ETAB'S program was used to do a comparative analysis of a geopolymer concrete shear wall in various patterns utilizing linear static and response spectrum methods.

### 2.2 OBJECTIVES

1. Structural Integrity Assessment: Assess the geopolymer concrete shear walls' ability to withstand loads and stresses, ensuring they meet safety and performance requirements.

2. Performance Comparison: Evaluate the strength, durability, and resilience of geopolymer concrete shear walls in comparison to conventional concrete shear walls.

3. Sustainability Analysis: Compare the environmental benefits of geopolymer concrete to traditional concrete, such as a lower carbon footprint and material efficiency.

4. Optimize geopolymer concrete shear walls for structural and environmental conditions to maximize effectiveness of the structures.

5. Comply with relevant building codes and standards.

6. Analyze the practical viability and advantages of using geopolymer concrete in structural applications to promote sustainable and resilient building practices.

## 3. ANALYSIS OF G+9 GEOPOLYMER SHEAR WALL BUILDING

### 3.1 PROCESS OF ANALYSIS

1. Open etabs and open new model
   Set user built in setting (metric SI, Indian, IS.800:2007, IS457:2000)
2. Set quick template [16m×12m] size 4x4 grid of 4m H: 3m V [10 story, 3m building]
3. Define material properties
   a. Geopolymer concrete = Grade M-40
      Density = 2347.2 kg/$m^3$ (1:1.3:3.10)[3]
      Modulus of elasticity = 31622 KN/$m^2$
      Poisons ratio = 0.2
      Thermal expansion coefficient = 0.0000166
      Strain e = 0.00126
   b. Rebars -fe415 main bars [5.3.1][4]
      -fe250 tie bars. [5.3.1][4]

4. Define section property
   a. Beam size 400x300mm [d = l/10 to l/12 = 4000/10 to 4000/ 12 = 400 to 333.3mm W 200, W= 300][5]
   b. Column 300x600mm (for 10 storey building)[10]
   c. Slab 200 mm (using membrane type) not less than 100mm
   d. Shear wall - 200 mm not less than150 mm [10.1.2][4]
5. Define diaphragm and pier levels.
6. Define load patterns
   Dead load, live load, earthquake force (EQX, EQY)
7. Define response spectrum function (RSX, RSY) [IS1893 part1:2016][6]
   Seismic zone = II (in Chhattisgarh Bastar) [page 11]
   Zone factor Z =0.10 [table 3]
   Impact factor I= 1.2 (for residential and commercial building)
   Response reduction factor = 5 [table 9]
   Soil type 2 [table 4]
   Design horizontal seismic coefficient $A_h = ZIS_a/2Rg$

8. Draw plan of the structure (16x12), at different patterns of shear wall.

9. Assign joint reaction in floors as fixed support.

10. Assign joint forces (1 unit) and assign diaphragms for the joints.

11. Assign pier label for every shear walls.

12. Assign shell loads (UDL live load of 2 KN )[7]

13. Check model and then run analysis.

## 3.2 DATA FOR DIFFERENT PATTERNS

### 3.2.1 Frame without shear wall and without flat slab:

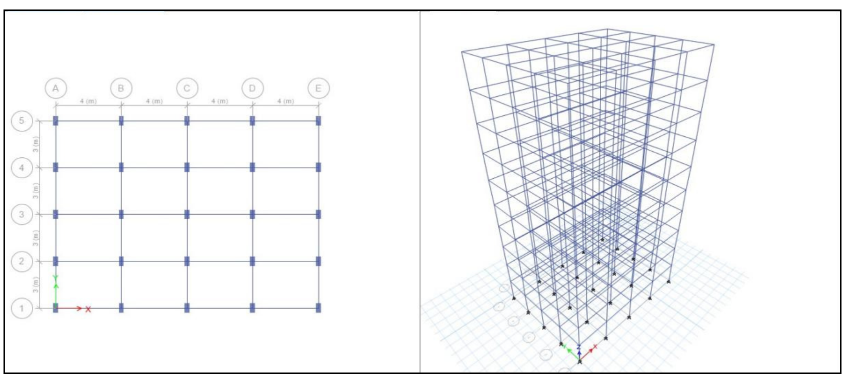



**Fig.-3.2.1.1 Conventional frame without shear wall and without flat slab.**

Table 3.2.1.1 Fundamental Natural time period and Average response acceleration coefficient ($S_a/g$)

| | FUNDAMENTAL NATURAL TIME PERIOD | | | | AVG RESPONSE ACCELERATION COFFICIENT | |
|---|---|---|---|---|---|---|
| case | period | frequency | 0.075h0.75 | Ta | linear static | Response spectrum |
| UX | 0.822 | 1.216 | 0.961 | 0.961 | 0.34 | 1.415 |
| UY | 0.609 | 1.642 | 0.961 | 0.961 | 0.34 | 1.415 |

Table 3.2.1.2 Maximum story displacement (sway)

| story | H | L | $DL_x$ | $DL_y$ | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| 10 | 30 | Top | 8.035 | 4.535 | 5.14 | 2.938 | 212.299 | 118.87 |
| 9 | 27 | Top | 7.81 | 4.398 | 4.957 | 2.799 | 207.611 | 114.946 |
| 8 | 24 | Top | 7.448 | 4.182 | 4.638 | 2.594 | 199.096 | 109.097 |
| 7 | 21 | Top | 6.942 | 3.881 | 4.202 | 2.327 | 186.49 | 101.068 |
| 6 | 18 | Top | 6.291 | 3.494 | 3.677 | 2.012 | 169.779 | 90.825 |
| 5 | 15 | Top | 5.496 | 3.022 | 3.086 | 1.663 | 148.969 | 78.392 |
| 4 | 12 | Top | 4.558 | 2.465 | 2.45 | 1.293 | 124.082 | 63.824 |
| 3 | 9 | Top | 3.479 | 1.831 | 1.787 | 0.911 | 95.151 | 47.257 |
| 2 | 6 | Top | 2.265 | 1.132 | 1.113 | 0.534 | 62.332 | 29.108 |
| 1 | 3 | Top | 0.962 | 0.432 | 0.455 | 0.193 | 26.781 | 11.016 |
| Base | 0 | Top | 0 | 0 | 0 | 0 | 0 | 0 |

Table 3.2.1.3 Maximum story drift

| Story | H | L | $DL_x$ | $DL_y$ | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| 10 | 30 | Top | 0 | 0 | 0 | 0 | 0.001562 | 0.001308 |
| 9 | 27 | Top | 0.000121 | 0 | 0.000106 | 0 | 0.002838 | 0.00195 |
| 8 | 24 | Top | 0.000169 | 0.0001 | 0.000145 | 0 | 0.004202 | 0.002676 |
| 7 | 21 | Top | 0.000217 | 0.000129 | 0.000175 | 0.000105 | 0.005571 | 0.003414 |
| 6 | 18 | Top | 0.000265 | 0.000158 | 0.000197 | 0.000116 | 0.006936 | 0.004145 |
| 5 | 15 | Top | 0.000313 | 0.000185 | 0.000212 | 0.000124 | 0.008296 | 0.004856 |
| 4 | 12 | Top | 0.00036 | 0.000212 | 0.000221 | 0.000127 | 0.009643 | 0.005523 |
| 3 | 9 | Top | 0.000405 | 0.000233 | 0.000225 | 0.000126 | 0.01094 | 0.00605 |
| 2 | 6 | Top | 0.000434 | 0.000233 | 0.000219 | 0.000114 | 0.011851 | 0.006031 |
| 1 | 3 | Top | 0.000321 | 0.000144 | 0.000152 | 0 | 0.008927 | 0.003672 |
| Base | 0 | Top | 0 | 0 | 0 | 0 | 0 | 0 |

Table 3.2.1.4 Overturning moments

| Story | H | L | $DL_x$ | $DL_y$ | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| 10 | 30 | Top | 2686.916 | -3640.888 | 0 | 0 | 0 | 0 |
| 9 | 27 | Top | 7313.3758 | -9842.8658 | -81.0636 | 81.0369 | 1824.9225 | 1824.4593 |
| 8 | 24 | Top | 12015.016 | -16120.179 | -244.7986 | 244.6163 | 5946.8581 | 5942.7424 |
| 7 | 21 | Top | 16791.952 | -22473.036 | -474.0887 | 473.5461 | 12372.206 | 12358.328 |
| 6 | 18 | Top | 21644.297 | -28901.640 | -753.7849 | 752.6323 | 21107.248 | 21074.639 |
| 5 | 15 | Top | 26572.161 | -35406.193 | -1070.719 | 1068.682 | 32158.216 | 32094.967 |
| 4 | 12 | Top | 31575.647 | -41986.894 | -1413.718 | 1410.510 | 45531.270 | 45422.395 |
| 3 | 9 | Top | 36654.842 | -48643.938 | -1773.608 | 1768.939 | 61232.441 | 61059.485 |
| 2 | 6 | Top | 41809.769 | -55377.490 | -2143.221 | 2136.784 | 79266.974 | 79006.790 |
| 1 | 3 | Top | 47040.151 | -62187.478 | -2517.305 | 2508.746 | 99633.049 | 99255.739 |
| Base | 0 | Top | 49657.353 | -65430.202 | -2891.391 | 2880.872 | 122248.92 | 121753.83 |

Table 3.2.1.5 Story stiffness

| story | H | L | DLx | DLy | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| Base | 0 | Top | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 3 | Top | 0 | 0 | 271678.871 | 641405.643 | 279079.795 | 678564.994 |
| 2 | 6 | Top | 0 | 0 | 187309.229 | 360757.702 | 188780.86 | 371034.76 |
| 3 | 9 | Top | 0 | 0 | 180765.49 | 323394.096 | 181246.884 | 327809.947 |
| 4 | 12 | Top | 0 | 0 | 179284.718 | 311934.402 | 179225.434 | 313005.202 |
| 5 | 15 | Top | 0 | 0 | 178417.413 | 305816.61 | 177672.012 | 303582.284 |
| 6 | 18 | Top | 0 | 0 | 177576.743 | 300684.793 | 175824.513 | 294286.042 |
| 7 | 21 | Top | 0 | 0 | 176521.837 | 294751.785 | 173282.044 | 282743.008 |
| 8 | 24 | Top | 0 | 0 | 174778.053 | 285504.18 | 169203.904 | 265672.958 |
| 9 | 27 | Top | 0 | 0 | 170640.953 | 264990.189 | 160910.43 | 234252.417 |
| 10 | 30 | Top | 0 | 0 | 147345.338 | 193878.206 | 129588.693 | 154777.067 |

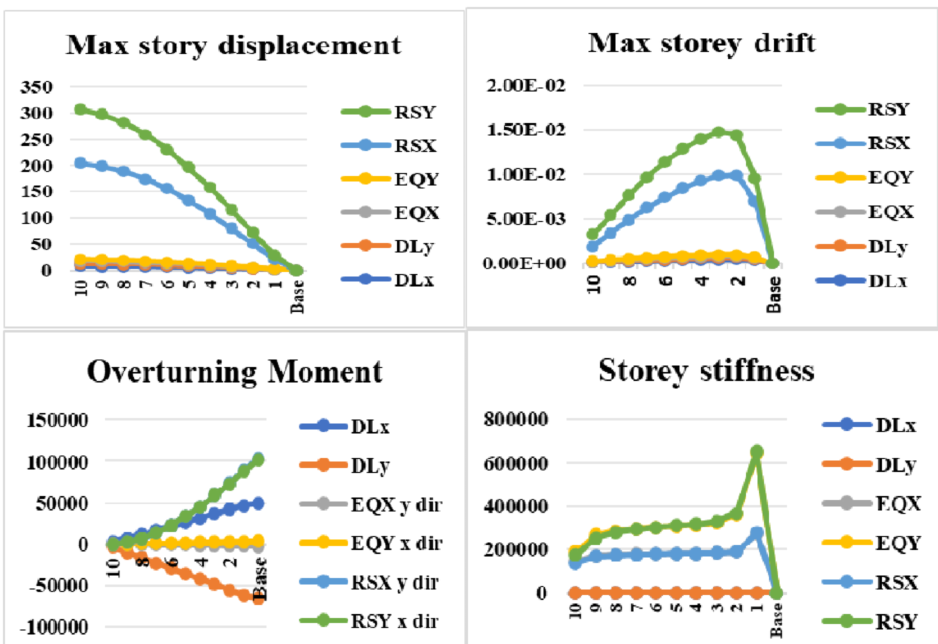



**Chart 3.2.1.1 displacement, storey drift, Overturning Moment, Storey stiffness for frame**

Table 3.2.1.6 Maximum Bending moment & Shear force:

| | COLUMN | | | | | BEAM | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | DL | EQX | EQY | RSX | RSY | DL | EQX | EQY | RSX | RSY |
| BM | 20.79 | 9.758 | 0.0014 | 581.63 | 0.001 | 15.906 | 9.504 | 7.33 | 509.93 | 0 |
| SF | 11.76 | 5.496 | 0.0008 | 330.723 | 0 | 16.35 | 4.83 | 6.095 | 256.9 | 0 |
| AF | 366.409 | 33.89 | 40.304 | 1390.871 | 0.0001 | 0 | 0 | 0 | 0 | 0 |
| T | 0.227 | 0.0006 | 0.0004 | 0.0324 | 0 | 0.1 | 0.0003 | 0.0002 | 0.0138 | 0 |

Table 3.2.1.7 Base shear:

| loads | Dead | EQX | EQY | RX | RY |
|---|---|---|---|---|---|
| Fx | -9.1545 | -4.1783 | 0 | 210.0302 | 2.69E-05 |
| Fy | -7.2662 | 0 | -5.5978 | 0 | 203.3248 |

### 3.2.2 Frame with flat slab without shear wall:

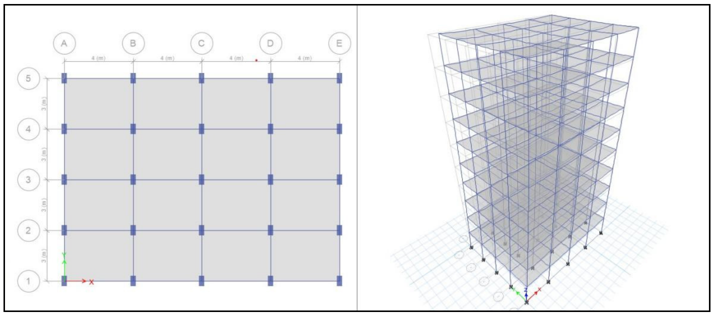


**Fig.3.2.2.1 Frame with flat slab without shear wall**

Table 3.2.2.1 Fundamental Natural time period and Average response acceleration coefficient ($S_a/g$)

| | FUNDAMENTAL NATURAL TIME PERIOD | | | | AVERAGE RESPONSE ACCELERATION COFFICIENT | |
|---|---|---|---|---|---|---|
| case | period | frequency | 0.09h/d | Ta | linear static | Response spectrum |
| UX | 1.212 | 0.825 | 0.675 | 0.675 | 0.34 | 2.01 |
| UY | 0.896 | 1.116 | 0.779 | 0.779 | 0.34 | 1.74 |

Table 3.2.2.2 Maximum story displacement (sway)

| story | H | L | DLx | DLy | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| 10 | 30 | Top | 8.115 | 4.56 | 7.544 | 4.296 | 460.063 | 256.515 |
| 9 | 27 | Top | 7.889 | 4.422 | 7.261 | 4.085 | 449.313 | 247.722 |
| 8 | 24 | Top | 7.526 | 4.206 | 6.784 | 3.779 | 430.361 | 234.8 |
| 7 | 21 | Top | 7.017 | 3.904 | 6.141 | 3.386 | 402.732 | 217.262 |
| 6 | 18 | Top | 6.361 | 3.515 | 5.371 | 2.926 | 366.38 | 195.045 |
| 5 | 15 | Top | 5.56 | 3.04 | 4.507 | 2.417 | 321.297 | 168.194 |
| 4 | 12 | Top | 4.613 | 2.481 | 3.579 | 1.877 | 267.497 | 136.827 |
| 3 | 9 | Top | 3.522 | 1.842 | 2.611 | 1.323 | 205.032 | 101.226 |
| 2 | 6 | Top | 2.293 | 1.139 | 1.626 | 0.776 | 134.218 | 62.291 |
| 1 | 3 | Top | 0.973 | 0.434 | 0.664 | 0.279 | 57.575 | 23.543 |
| Base | 0 | Top | 0 | 0 | 0 | 0 | 0 | 0 |

Table 3.2.2.3 Maximum story drift

| story | H | L | DLx | DLy | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| 10 | 30 | Top | 0 | 0 | 0 | 0 | 0.003583 | 0.002931 |
| 9 | 27 | Top | 0.000121 | 0 | 0.000159 | 0.000102 | 0.006317 | 0.004307 |
| 8 | 24 | Top | 0.00017 | 0.000101 | 0.000214 | 0.000131 | 0.00921 | 0.005846 |
| 7 | 21 | Top | 0.000218 | 0.00013 | 0.000257 | 0.000153 | 0.012117 | 0.007406 |
| 6 | 18 | Top | 0.000267 | 0.000158 | 0.000288 | 0.00017 | 0.015028 | 0.00895 |
| 5 | 15 | Top | 0.000316 | 0.000186 | 0.000309 | 0.00018 | 0.017933 | 0.010456 |
| 4 | 12 | Top | 0.000364 | 0.000213 | 0.000323 | 0.000185 | 0.020821 | 0.011867 |
| 3 | 9 | Top | 0.00041 | 0.000234 | 0.000328 | 0.000183 | 0.023605 | 0.012978 |
| 2 | 6 | Top | 0.00044 | 0.000235 | 0.000321 | 0.000165 | 0.025548 | 0.012916 |
| 1 | 3 | Top | 0.000324 | 0.000145 | 0.000221 | 0 | 0.019192 | 0.007848 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Base | 0 | Top | 0 | 0 | 0 | 0 | 0 | 0 |

Table 3.2.2.4 Overturning moments

| story | H | L | DLx | DLy | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| 10 | 30 | Top | 7150.3022 | -9592.0696 | 0 | 0 | 0 | 0 |
| 9 | 27 | Top | 16240.248 | -21745.406 | -128.9833 | 128.8791 | 4357.3265 | 4354.4943 |
| 8 | 24 | Top | 25405.586 | -33974.474 | -374.3394 | 373.712 | 13564.780 | 13543.559 |
| 7 | 21 | Top | 34646.557 | -46279.716 | -712.3501 | 710.5594 | 27650.857 | 27582.686 |
| 6 | 18 | Top | 43963.402 | -58661.568 | -1121.952 | 1118.224 | 46643.653 | 46487.064 |
| 5 | 15 | Top | 53356.352 | -71120.463 | -1584.780 | 1578.262 | 70571.176 | 70271.326 |
| 4 | 12 | Top | 62825.623 | -83656.833 | -2085.196 | 2075.002 | 99461.251 | 98949.184 |
| 3 | 9 | Top | 72371.398 | -96271.098 | -2610.318 | 2595.545 | 133341.21 | 132531.98 |
| 2 | 6 | Top | 81993.719 | -108963.62 | -3150.024 | 3129.71 | 172234.82 | 171021.86 |
| 1 | 3 | Top | 91691.990 | -121734.24 | -3696.669 | 3669.712 | 216132.89 | 214379.31 |
| Base | 0 | Top | 94312.253 | -124984.76 | -4241.550 | 4208.495 | 264659.17 | 262365.54 |

Table 3.2.2.5 Story stiffness

| story | H | L | DLx | DLy | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| 10 | 30 | Top | 0 | 0 | 151525.189 | 203264.759 | 134633.491 | 0 |
| 9 | 27 | Top | 0 | 0 | 170238.142 | 265678.073 | 160935.897 | 0 |
| 8 | 24 | Top | 0 | 0 | 173788.99 | 284476.671 | 168405.98 | 0 |
| 7 | 21 | Top | 0 | 0 | 175226.145 | 293190.125 | 172088.088 | 0 |
| 6 | 18 | Top | 0 | 0 | 176010.05 | 298836.837 | 174318.611 | 0 |
| 5 | 15 | Top | 0 | 0 | 176586.437 | 303752.022 | 175878.609 | 0 |
| 4 | 12 | Top | 0 | 0 | 177191.962 | 309684.114 | 177154.737 | 0 |
| 3 | 9 | Top | 0 | 0 | 178421.141 | 320984.415 | 178913.923 | 0 |
| 2 | 6 | Top | 0 | 0 | 184755.755 | 358171.449 | 186228.703 | 0 |
| 1 | 3 | Top | 0 | 0 | 268413.461 | 637607.721 | 275731.15 | 0 |
| Base | 0 | Top | 0 | 0 | 0 | 0 | 0 | 0 |

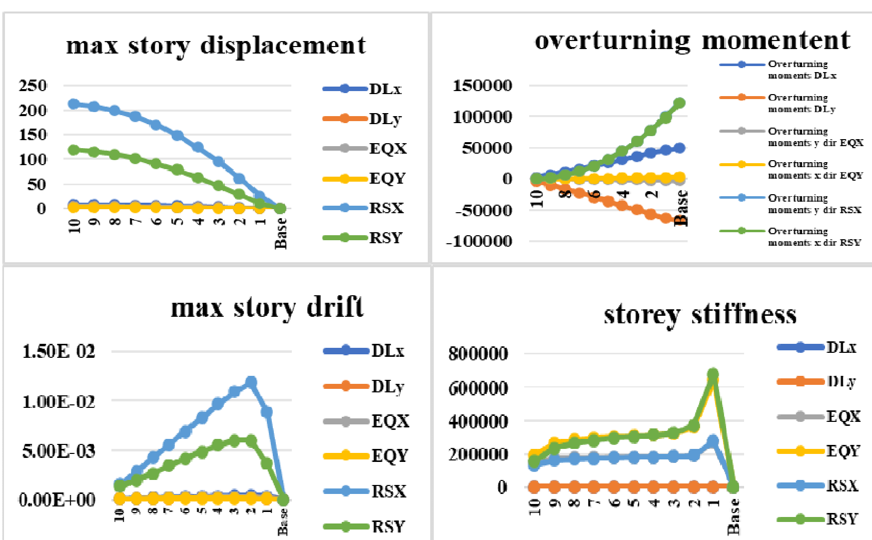


**Chart 3.2.2.2 displacement, storey drift, Overturning Moment, Storey stiffness for frame with flat slab without shear wall**

Table 3.2.2.6 Maximum Bending moment & Shear force

| | COLUM | | | | | BEAM | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | DL | EQX | EQY | RSX | RSY | DL | EQX | EQY | RSX | RSY |
| BM | 20.981 | 14.21 | 0.0021 | 1248 | 0.171 | 32.31 | 0.008 | 0.002 | 0.64 | 788.05 |
| SF | 12.17 | 8.66 | 0.0019 | 699.04 | 0.15 | 32.25 | 0 | 8.66 | 0.26 | 640.4 |
| AF | 817.38 | 49.73 | 58.91 | 3014.51 | 3544.47 | 0 | 0 | 0 | 0 | 0 |
| T | 0.228 | 0.0009 | 0.0005 | 0.07 | 0.04 | 0.38 | 0.0004 | 0.0003 | 0.03 | 0.013 |

Table 3.2.2.7 Base shear

| loads | Dead | EQX | EQY | RX | RY |
|---|---|---|---|---|---|
| Fx | -8.1526 | -6.0885 | -0.0008 | 547.6555 | 0.0679 |
| Fy | -6.6312 | -0.0055 | -6.0223 | 0.4895 | 543.6616 |

### 3.2.3 Frame with shear wall and flat slab:

**a. rectangular pattern**

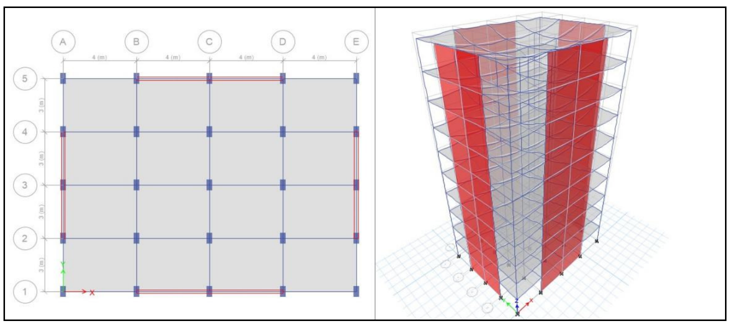


**Fig.3.2.3.1 Rectangular pattern frame with shear wall and flat slab**

Table 3.2.3.1 Fundamental Natural time period and Average response acceleration coefficient ($S_a/g$)

| | FUNDAMENTAL NATURAL TIME PERIOD | | | | AVERAGE RESPONSE ACCELERATION COFFICIENT | |
|---|---|---|---|---|---|---|
| case | period | frequency | 0.09h/d | Ta | linear static | Response spectrum |
| UX | 0.405 | 2.472 | 0.675 | 0.675 | 0.34 | 2.01 |
| UY | 0.487 | 2.052 | 0.779 | 0.779 | 0.34 | 1.74 |

Table 3.2.3.2 Overturning moments

| story | H | L | DLx | DLy | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| 10 | 30 | Top | 7150.3022 | -9592.0696 | 0 | 0 | 0 | 0 |
| 9 | 27 | Top | 18560.492 | -24838.904 | -329.478 | 329.652 | 4933.334 | 4937.1395 |
| 8 | 24 | Top | 30045.926 | -40160.945 | -982.711 | 983.305 | 15849.40 | 15862.482 |
| 7 | 21 | Top | 41606.623 | -55558.194 | -1891.89 | 1893.17 | 32748.69 | 32777.386 |
| 6 | 18 | Top | 53242.594 | -71030.648 | -2997.14 | 2999.40 | 55631.14 | 55682.722 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 5 | 15 | Top | 64953.830 | -86578.285 | -4246.51 | 4250.01 | 84495.55 | 84577.692 |
| 4 | 12 | Top | 76740.291 | -102201.06 | -5595.95 | 5600.92 | 119339.1 | 119458.95 |
| 3 | 9 | Top | 88601.893 | -117898.91 | -7009.32 | 7015.87 | 160157.0 | 160319.57 |
| 2 | 6 | Top | 100538.48 | -133671.74 | -8458.38 | 8466.45 | 206941.5 | 207147.77 |
| 1 | 3 | Top | 112549.86 | -149519.38 | -9922.77 | 9932.08 | 259682.0 | 259925.78 |
| Base | 0 | Top | 117485.35 | -155849.57 | -11390.0 | 11399.9 | 318362.5 | 318625.53 |

Table 3.2.3.3 Story stiffness

| story | H | L | DLx | DLy | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| 10 | 30 | Top | 0 | 0 | 374644.023 | 274879.132 | 245092.254 | 181805.84 |
| 9 | 27 | Top | 0 | 0 | 721497.517 | 521495.289 | 527065.601 | 384330.967 |
| 8 | 24 | Top | 0 | 0 | 992690.915 | 708129.458 | 799112.01 | 573098.329 |
| 7 | 21 | Top | 0 | 0 | 1218539.876 | 856147.073 | 1072221.285 | 754018.911 |
| 6 | 18 | Top | 0 | 0 | 1430906.725 | 990490.396 | 1367280.597 | 942736.289 |
| 5 | 15 | Top | 0 | 0 | 1665774.873 | 1136949.733 | 1718061.688 | 1162787.237 |
| 4 | 12 | Top | 0 | 0 | 1977430.359 | 1332826.537 | 2186614.15 | 1456411.633 |
| 3 | 9 | Top | 0 | 0 | 2478851.601 | 1655157.631 | 2910304.215 | 1917852.288 |
| 2 | 6 | Top | 0 | 0 | 3503938.045 | 2336821.651 | 4281192.626 | 2826534.079 |
| 1 | 3 | Top | 0 | 0 | 7029433.9 | 4923764.301 | 8382605.899 | 5911302.031 |
| Base | 0 | Top | 0 | 0 | 0 | 0 | 0 | 0 |

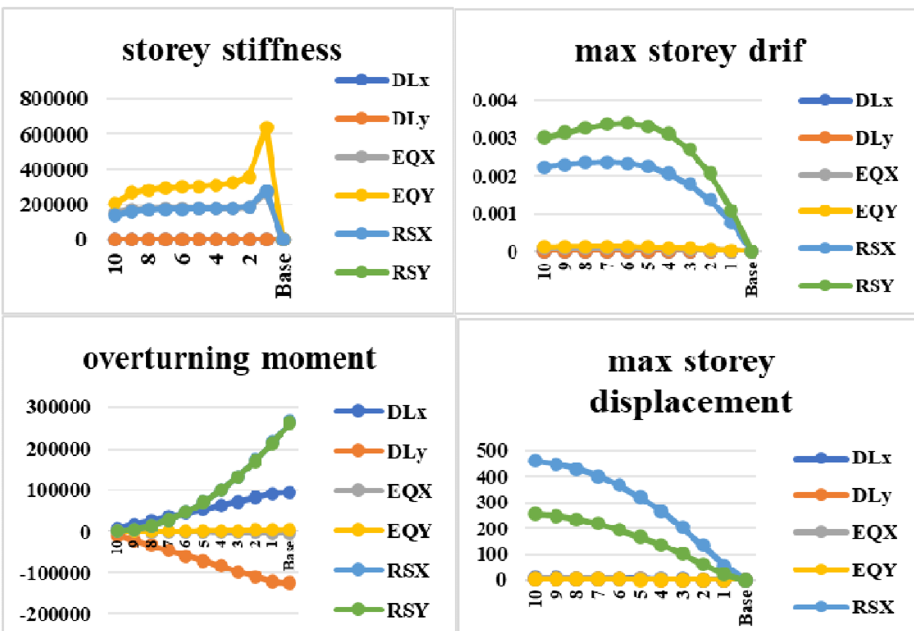



**Chart.3.2.3.1 displacement, storey drift, Overturning Moment, Storey stiffness of rectangular pattern.**

Table 3.2.3.4 Max Bending moment & Shear force

| | COLUMN | | | | | BEAM | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | DL | EQX | EQY | RSX | RSY | DL | EQX | EQY | RSX | RSY |
| BM | 18.99 | 5.44 | 2.05 | 95.83 | 49.88 | 26.38 | 6.76 | 14.55 | 154.88 | 214.19 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| SF | 14.11 | 2.56 | 1.39 | 94.59 | 31.8 | 27.05 | 5.24 | 11.83 | 129.21 | 288.77 |
| AF | 790.4 | 191.56 | 230.93 | 5377.31 | 6683.37 | 0 | 0 | 0 | 0 | 0 |
| T | 0.084 | 0 | 0.01 | 0.01 | 0.01 | 0.116 | 0.5 | 0.3 | 11.56 | 8.62 |

Table 3.2.3.5 Base shear

| loads | Dead | EQX | EQY | RX | RY |
|---|---|---|---|---|---|
| Fx | 0.4442 | -0.7762 | 0.0947 | 26.454 | 2.4043 |
| Fy | -1.2788 | 0.0643 | -2.2691 | 1.6098 | 83.1286 |

**b. L pattern**

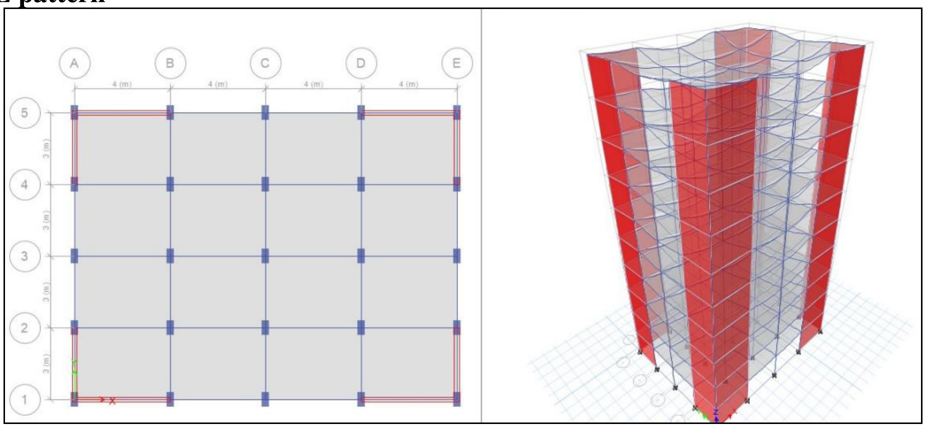



**Fig.3.2.3.2 L pattern frame with shear wall and flat slab**

Table 3.2.3.6 Fundamental Natural time period and Average response acceleration coefficient ($S_a/g$)

| | FUNDAMENTAL NATURAL TIME PERIOD | | | | AVG RESPONSE ACCELERATION COFFICIENT | |
|---|---|---|---|---|---|---|
| case | period | frequency | 0.09h/d | Ta | linear static | Response spectrum |
| UX | 0.501 | 1.997 | 0.675 | 0.675 | 0.34 | 2.01 |
| UY | 0.552 | 1.812 | 0.779 | 0.779 | 0.34 | 1.74 |

Table 3.2.3.7 Overturning moments

| story | H | L | DLx | DLy | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| 10 | 30 | Top | 7150.3022 | -9592.0696 | 0 | 0 | 0 | 0 |
| 9 | 27 | Top | 18560.5327 | -24838.997 | -329.7607 | 329.8093 | 4939.7992 | 4940.5388 |
| 8 | 24 | Top | 30046.0656 | -40161.245 | -983.6273 | 983.8365 | 15870.438 | 15874.094 |
| 7 | 21 | Top | 41606.9319 | -55558.8181 | -1893.789 | 1894.329 | 32792.603 | 32803.061 |
| 6 | 18 | Top | 53243.1559 | -71031.7078 | -3000.351 | 3001.449 | 55706.096 | 55729.253 |
| 5 | 15 | Top | 64954.736 | -86579.8822 | -4251.303 | 4253.215 | 84608.971 | 84652.383 |
| 4 | 12 | Top | 76741.628 | -102203.274 | -5602.507 | 5605.480 | 119496.72 | 119568.79 |
| 3 | 9 | Top | 88603.7258 | -117901.773 | -7017.682 | 7021.905 | 160361.41 | 160469.66 |
| 2 | 6 | Top | 100540.836 | -133675.209 | -8468.393 | 8473.925 | 207190.67 | 207339.45 |
| 1 | 3 | Top | 112552.646 | -149523.338 | -9934.038 | 9940.711 | 259966.44 | 260152.85 |
| Base | 0 | Top | 117488.337 | -155853.726 | -11401.78 | 11409.02 | 318661.54 | 318868.01 |

Table 3.2.3.8 Story stiffness

| story | H | L | DLx | DLy | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| 10 | 30 | Top | 148329.309 | 0 | 0 | 238856.389 | 222483.095 | 156155.193 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 9 | 27 | Top | 311490.729 | 0 | 0 | 463232.873 | 420072.971 | 337595.734 |
| 8 | 24 | Top | 459001.046 | 0 | 0 | 639375.725 | 564977.664 | 513235.835 |
| 7 | 21 | Top | 596401.738 | 0 | 0 | 786565.358 | 676517.625 | 690344.687 |
| 6 | 18 | Top | 736412.183 | 0 | 0 | 925349.186 | 775349.214 | 882666.025 |
| 5 | 15 | Top | 897596.224 | 0 | 0 | 1079687.452 | 882111.97 | 1113216.088 |
| 4 | 12 | Top | 1112308.723 | 0 | 0 | 1286559.353 | 1025585.792 | 1425444.162 |
| 3 | 9 | Top | 1453089.566 | 0 | 0 | 1625436.109 | 1265044.749 | 1919587.654 |
| 2 | 6 | Top | 2149083.588 | 0 | 0 | 2347379.639 | 1787678.632 | 2908996.151 |
| 1 | 3 | Top | 4799711.451 | 0 | 0 | 5181866.692 | 3959924.578 | 6401052.212 |
| Base | 0 | Top | 0 | 0 | 0 | 0 | 0 | 0 |

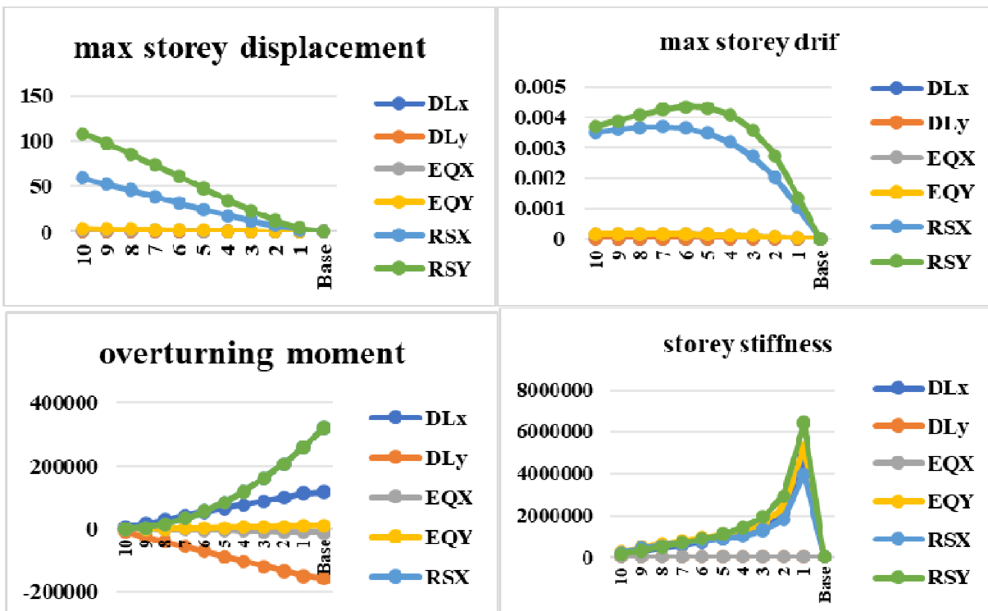



**Chart 3.2.3.2 displacement, storey drift, Overturning Moment, Storey stiffness of L pattern**

Table 3.2.3.9 Max Bending moment & Shear force

| | COLUMN | | | | | BEAM | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | DL | EQX | EQY | RSX | RSY | DL | EQX | EQY | RSX | RSY |
| BM | 16.93 | 12.91 | 2.222 | 296.23 | 50.03 | 16.46 | 12.91 | 2.22 | 296.23 | 50.03 |
| SF | 12.28 | 9.392 | 0.151 | 215.41 | 36.72 | 30.08 | 6.92 | 2.306 | 139.11 | 159.12 |
| AF | 803.41 | 208.32 | 216.95 | 5927.04 | 6476.04 | 0 | 0 | 0 | 0 | 0 |
| T | 0.021 | 0 | 0 | 0.003 | 0.003 | 2.53 | 0.7 | 0.32 | 15.99 | 7.21 |

Table 3.2.3.10 Base shear

| loads | Dead | EQX | EQY | RX | RY |
|---|---|---|---|---|---|
| Fx | 53.6305 | -41.9097 | -20.3956 | 1889.4341 | 464.0594 |
| Fy | 53.7780 | -25.9971 | -36.1572 | 637.5661 | 1656.6161 |

**c. I pattern**

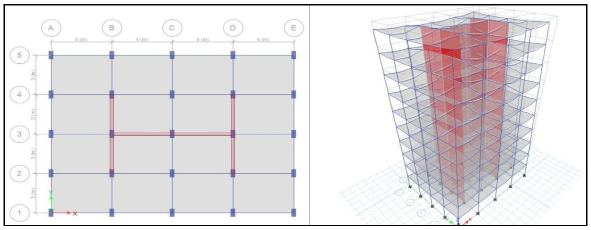


**Fig.3.2.3.3 I pattern frame with shear wall and flat slab**

Table 3.3.2.11 Fundamental Natural time period and Average response acceleration coefficient ($S_a/g$)

| | FUNDAMENTAL NATURAL TIME PERIOD | | | | AVG RESPONSE ACCELERATION COFFICIENT | |
|---|---|---|---|---|---|---|
| case | period | frequency | 0.09h/d | Ta | linear static | Response spectrum |
| UX | 0.336 | 2.972 | 0.675 | 0.675 | 0.34 | 2.01 |
| UY | 0.475 | 2.106 | 0.779 | 0.779 | 0.34 | 1.74 |

Table 3.3.2.12 Overturning moments

| story | H | L | DLx | DLy | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| 10 | 30 | Top | 7150.3022 | -9592.0696 | 0 | 0 | 0 | 0 |
| 9 | 27 | Top | 17897.563 | -23954.931 | -317.1312 | 1143.0022 | 4761.9758 | 4770.3911 |
| 8 | 24 | Top | 28720.055 | -38392.913 | -938.8014 | 3383.9445 | 15168.465 | 15195.628 |
| 7 | 21 | Top | 39617.797 | -52906.022 | -1801.196 | 6493.0968 | 31220.305 | 31276.935 |
| 6 | 18 | Top | 50590.799 | -67494.261 | -2847.981 | 10267.595 | 52918.063 | 53015.043 |
| 5 | 15 | Top | 61639.054 | -82157.629 | -4030.298 | 14531.320 | 80261.796 | 80409.181 |
| 4 | 12 | Top | 72762.525 | -96896.112 | -5306.762 | 19134.842 | 113250.87 | 113456.28 |
| 3 | 9 | Top | 83961.13 | -111709.68 | -6643.460 | 23955.363 | 151883.79 | 152150.04 |
| 2 | 6 | Top | 95234.730 | -126598.30 | -8013.957 | 28896.661 | 196157.92 | 196479.83 |
| 1 | 3 | Top | 106583.11 | -141561.92 | -9399.290 | 33889.065 | 246069.31 | 246429.59 |
| Base | 0 | Top | 110855.65 | -147008.34 | -10787.88 | 38889.155 | 301608.83 | 301973.94 |

Table 3.3.2.13 Story stiffness

| story | H | L | DLx | DLy | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| 10 | 30 | Top | 0 | 0 | 656929.764 | 278542.472 | 439514.192 | 184656.83 |
| 9 | 27 | Top | 0 | 0 | 1183161.718 | 523294.154 | 891691.801 | 386116.2 |
| 8 | 24 | Top | 0 | 0 | 1559952.809 | 708707.453 | 1295018.356 | 574081.244 |
| 7 | 21 | Top | 0 | 0 | 1854459.039 | 856349.615 | 1670858.018 | 754814.022 |
| 6 | 18 | Top | 0 | 0 | 2116729.945 | 990798.085 | 2046323.945 | 943777.707 |
| 5 | 15 | Top | 0 | 0 | 2388809.002 | 1137677.355 | 2452206.019 | 1164410.006 |
| 4 | 12 | Top | 0 | 0 | 2719594.724 | 1334184.873 | 2930499.304 | 1458863.276 |
| 3 | 9 | Top | 0 | 0 | 3188621.85 | 1657352.603 | 3551218.232 | 1921359.445 |
| 2 | 6 | Top | 0 | 0 | 3962122.531 | 2340218.117 | 4443612.654 | 2831401.304 |
| 1 | 3 | Top | 0 | 0 | 5850581.683 | 4929567.94 | 6308527.272 | 5918124.679 |
| Base | 0 | Top | 0 | 0 | 0 | 0 | 0 | 0 |

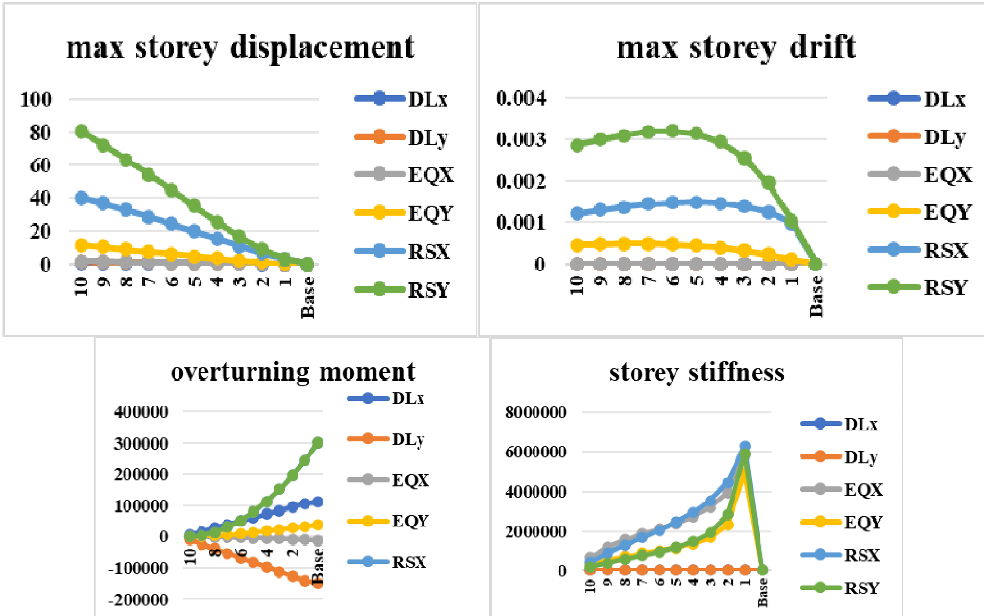



**Chart 3.2.3.3 displacement, storey drift, Overturning Moment, Storey stiffness I pattern**

Table 3.3.2.14 Maximum Bending moment and shear force

| | COLUM | | | | | BEAM | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | DL | EQX | EQY | RSX | RSY | DL | EQX | EQY | RSX | RSY |
| BM | 7.06 | 2.77 | 8.68 | 61.56 | 54.55 | 11.38 | 4.63 | 0 | 127.47 | 334.14 |
| SF | 5.24 | 1.92 | 6.51 | 48.24 | 40.8 | 24.96 | 2.81 | 40.14 | 65.22 | 272.06 |
| AF | 622.69 | 100.4 | 783.98 | 783.98 | 6301.73 | 0 | 0 | 0 | 0 | 0 |
| T | 0.084 | 0 | 0 | 0.0004 | 0.0004 | 0.37 | 0.23 | 0.807 | 5.49 | 5.49 |

Table 3.3.2.15 Base shear

| loads | Dead | EQX | EQY | RX | RY |
|---|---|---|---|---|---|
| Fx | 0.4248 | -0.1699 | 29.0293 | 1.2271 | 1.2271 |
| Fy | -0.5065 | -6.136 | 0.3149 | 65.3932 | 65.3932 |

**d. C pattern**

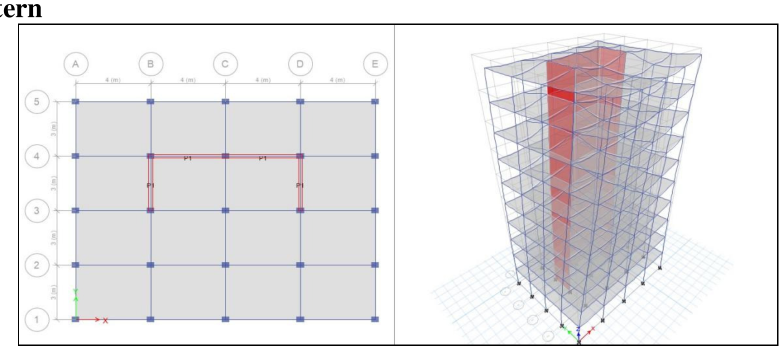


**Fig.3.2.3.4 C pattern frame with shear wall and flat slab**

Table 3.3.2.16 Fundamental Natural time period and Average response acceleration coefficient ($S_a/g$)

| | FUNDAMENTAL NATURAL TIME PERIOD | | | | AVG RESPONSE ACCELERATION COFFICIENT | |
|---|---|---|---|---|---|---|
| case | period | frequency | 0.09h/d | Ta | linear static | Response spectrum |
| UX | 0.859 | 1.164 | 0.675 | 0.675 | 0.34 | 2.01 |
| UY | 0.786 | 1.272 | 0.779 | 0.779 | 0.34 | 1.74 |

Table 3.3.2.17 Overturning moments

| story | H | L | DLx | DLy | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| 10 | 30 | Top | 9520.594 | -12752.459 | 0 | 0 | 0 | 0 |
| 9 | 27 | Top | 21974.51 | -28784.384 | -810.7195 | -810.7195 | 5394.252 | 5413.2593 |
| 8 | 24 | Top | 34502.94 | -44891.687 | -2352.132 | -2352.132 | 16786.850 | 16849.626 |
| 7 | 21 | Top | 47106.09 | -61074.465 | -4471.866 | -4471.866 | 34183.934 | 34315.051 |
| 6 | 18 | Top | 59784.20 | -77332.806 | -7035.308 | -7035.308 | 57591.169 | 57814.331 |
| 5 | 15 | Top | 72537.55 | -93666.771 | -9925.517 | -9925.517 | 87012.401 | 87348.213 |
| 4 | 12 | Top | 85366.34 | -110076.36 | -13043.13 | -13043.13 | 122447.77 | 122910.42 |
| 3 | 9 | Top | 98270.76 | -126561.47 | -16306.27 | -16306.27 | 163891.12 | 164484.19 |
| 2 | 6 | Top | 111250.8 | -143121.85 | -19650.39 | -19650.39 | 211325.90 | 212037.72 |
| 1 | 3 | Top | 124306.4 | -159756.94 | -23027.98 | -23027.98 | 264718.92 | 265517.79 |
| Base | 0 | Top | 127916.4 | -163713.22 | -26407.76 | -26407.76 | 324004.28 | 324834.95 |

Table 3.3.2.18 Story stiffness

| story | H | L | DLx | DLy | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| 10 | 30 | Top | 0 | 0 | 260414.645 | 260414.645 | 186452.65 | 83919.766 |
| 9 | 27 | Top | 0 | 0 | 441037.886 | 441037.886 | 348493.753 | 167689.811 |
| 8 | 24 | Top | 0 | 0 | 548981.389 | 548981.389 | 467979.274 | 241155.971 |
| 7 | 21 | Top | 0 | 0 | 616229.503 | 616229.503 | 558457.147 | 307803.196 |
| 6 | 18 | Top | 0 | 0 | 667105.237 | 667105.237 | 636896.698 | 374181.508 |
| 5 | 15 | Top | 0 | 0 | 718800.617 | 718800.617 | 718977.478 | 449612.848 |
| 4 | 12 | Top | 0 | 0 | 789775.515 | 789775.515 | 824643.691 | 549682.085 |
| 3 | 9 | Top | 0 | 0 | 914041.937 | 914041.937 | 987194.396 | 708639.78 |
| 2 | 6 | Top | 0 | 0 | 1192377.767 | 1192377.767 | 1323057.075 | 1035148.944 |
| 1 | 3 | Top | 0 | 0 | 2300393.922 | 2300393.922 | 2590050.943 | 2276576.784 |
| Base | 0 | Top | 0 | 0 | 0 | 0 | 0 | 0 |


**Chart 3.2.3.3 displacement, storey drift, Overturning Moment, Storey stiffness C pattern**

Table 3.3.2.19 Maximum Bending moment & Shear force

| | COLUM | | | | | BEAM | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | DL | EQX | EQY | RSX | RSY | DL | EQX | EQY | RSX | RSY |
| BM | 17.28 | 40.773 | 40.773 | 481.71 | 109.71 | 46.28 | 32.74 | 32.74 | 394.78 | 855 |
| SF | 11.9 | 26.78 | 26.78 | 316.48 | 77.78 | 44.55 | 22.52 | 22.52 | 256.91 | 538.03 |
| AF | 886.19 | 427.24 | 427.24 | 1245.64 | 9807.1 | 0 | 0 | 0 | 0 | 0 |
| T | 0.38 | 1.89 | 1.89 | 23.21 | 0.0034 | 0.51 | 1.98 | 1.98 | 24.18 | 13.3 |

Table 3.3.2.20 Base shear

| loads | Dead | EQX | EQY | RX | RY |
|---|---|---|---|---|---|
| Fx | -0.4284 | -8.0124 | -8.0124 | 133.4179 | 0.1705 |
| Fy | 0.7554 | 3.8704 | 3.8704 | 62.9983 | 54.3607 |

**e. Plus pattern**

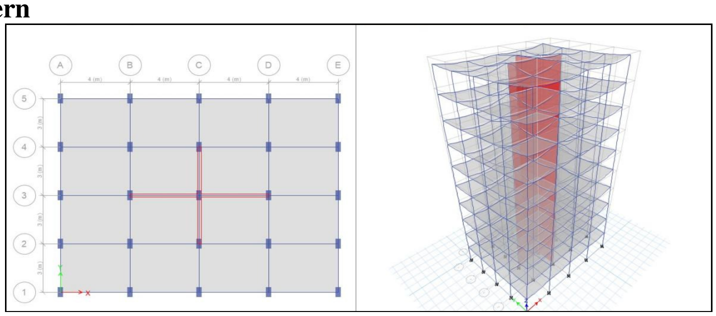


**Fig.3.2.3.5 Plus pattern frame with shear wall and flat slab**

Table 3.3.2.21 Fundamental Natural time period and Average response acceleration coefficient ($S_a/g$)

| | FUNDAMENTAL NATURAL TIME PERIOD | | | | AVG RESPONSE ACCELERATION COFFICIENT | |
|---|---|---|---|---|---|---|
| case | period | frequency | 0.09h/d | Ta | linear static | Response spectrum |
| UX | 0.499 | 2.003 | 0.675 | 0.675 | 0.34 | 2.01 |
| UY | 0.576 | 1.735 | 0.779 | 0.779 | 0.34 | 1.74 |

Table 3.3.2.22 Overturning moments

| story | H | L | DLx | DLy | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| 10 | 30 | Top | 7150.3022 | -9592.0696 | 0 | 0 | 0 | 0 |
| 9 | 27 | Top | 17400.428 | -23292.148 | -308.429 | 308.5674 | 4646.906 | 4649.7405 |
| 8 | 24 | Top | 27725.862 | -37067.526 | -907.684 | 908.1752 | 14700.78 | 14711.085 |
| 7 | 21 | Top | 38126.644 | -50918.211 | -1736.92 | 1738.029 | 30162.81 | 30186.596 |
| 6 | 18 | Top | 48602.808 | -64844.205 | -2742.42 | 2744.440 | 51033.59 | 51078.546 |
| 5 | 15 | Top | 59154.364 | -78845.488 | -3877.52 | 3880.762 | 77312.24 | 77387.208 |
| 4 | 12 | Top | 69781.276 | -92922.006 | -5102.64 | 5107.370 | 108995.6 | 109109.61 |
| 3 | 9 | Top | 80483.445 | -107073.66 | -6385.25 | 6391.633 | 146077.6 | 146237.99 |
| 2 | 6 | Top | 91260.678 | -121300.29 | -7699.83 | 7707.885 | 188548.0 | 188757.88 |
| 1 | 3 | Top | 102112.66 | -135601.67 | -9027.95 | 9037.405 | 236391.9 | 236646.30 |
| Base | 0 | Top | 105888.53 | -140385.41 | -10358.1 | 10368.21 | 289585.7 | 289862.57 |

Table 3.3.2.23 Story stiffness

| story | H | L | DLx | DLy | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| 10 | 30 | Top | 0 | 0 | 245832.391 | 202090.993 | 163160.329 | 163160.329 |
| 9 | 27 | Top | 0 | 0 | 457588.993 | 367416.977 | 338307.298 | 338307.298 |
| 8 | 24 | Top | 0 | 0 | 618370.045 | 487273.408 | 502288.052 | 502288.052 |
| 7 | 21 | Top | 0 | 0 | 747884.499 | 577472.921 | 661308.333 | 661308.333 |
| 6 | 18 | Top | 0 | 0 | 866590.028 | 656259.231 | 828116.825 | 828116.825 |
| 5 | 15 | Top | 0 | 0 | 996031.311 | 740652.996 | 1022115.064 | 1022115.064 |
| 4 | 12 | Top | 0 | 0 | 1167044.177 | 853450.86 | 1277396.282 | 1277396.282 |
| 3 | 9 | Top | 0 | 0 | 1441724.078 | 1039854.957 | 1667188.799 | 1667188.799 |
| 2 | 6 | Top | 0 | 0 | 1998100.404 | 1430913.188 | 2393640.487 | 2393640.487 |
| 1 | 3 | Top | 0 | 0 | 3866435.035 | 2917221.183 | 4518709.198 | 4518709.198 |
| Base | 0 | Top | 0 | 0 | 0 | 0 | 0 | 0 |

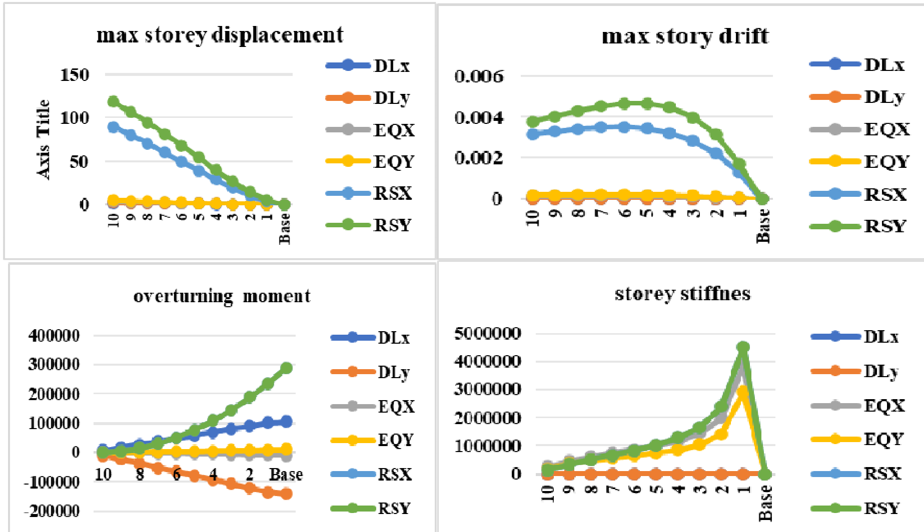



**Chart 3.2.3.4 displacement, storey drift, Overturning Moment, Storey stiffness of plus pattern**

Table 3.3.2.24 Maximum Bending moment & Shear force

| | COLUM | | | | | BEAM | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | DL | EQX | EQY | RSX | RSY | DL | EQX | EQY | RSX | RSY |
| BM | 9.99 | 7.5 | 2.95 | 133.85 | 68.4 | 28.41 | 10.4 | 10.81 | 236.64 | 29.04 |
| SF | 9.28 | 5.67 | 2.14 | 91.85 | 48.1 | 33.44 | 8.39 | 16.06 | 119.66 | 315.8 |
| AF | 665.65 | 297.61 | 336.4 | 8509.39 | 9967.85 | 0 | 0 | 0 | 0 | 0 |
| T | 0.229 | 0.0001 | 0.0001 | 0.0032 | 0.003 | 0.69 | 0.66 | 0.406 | 15.19 | 9.09 |

Table 3.3.2.25 Base shear

| loads | Dead | EQX | EQY | RX | RY |
|---|---|---|---|---|---|
| Fx | 0.0521 | -0.8991 | -0.0048 | 33.4193 | 0.0957 |
| Fy | 0.2488 | -0.0147 | -2.8488 | 0.3563 | 110.9278 |

**f. Box pattern**

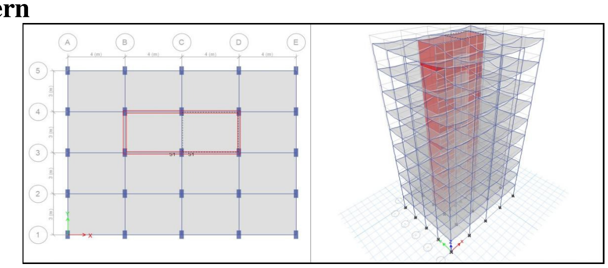


**Fig 3.2.3.6 Box pattern frame with shear wall and flat slab**

Table 3.3.2.26 Fundamental Natural time period and Average response acceleration coefficient ($S_a/g$)

| | FUNDAMENTAL NATURAL TIME PERIOD | | | | AVG RESPONSE ACCELERATION COFFICIENT | |
|---|---|---|---|---|---|---|
| case | period | frequency | 0.09h/d | Ta | linear static | Response spectrum |
| UX | 0.715 | 1.399 | 0.675 | 0.675 | 0.34 | 2.01 |
| UY | 0.585 | 1.711 | 0.779 | 0.779 | 0.34 | 1.74 |

Table 3.3.2.27 Overturning moments

| story | H | L | DLx | DLy | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| 10 | 30 | Top | 9454.3022 | -12664.069 | 0 | 0 | 0 | 0 |
| 9 | 27 | Top | 23126.988 | -30319.953 | -376.625 | 377.2 | 5672.0344 | 5684.7109 |
| 8 | 24 | Top | 36874.853 | -48051.004 | -1108.140 | 1110.069 | 17940.703 | 17983.327 |
| 7 | 21 | Top | 50697.955 | -65857.227 | -2120.191 | 2124.330 | 36806.505 | 36898.900 |
| 6 | 18 | Top | 64596.353 | -83738.620 | -3347.130 | 3354.368 | 62269.436 | 62433.887 |
| 5 | 15 | Top | 78570.088 | -101695.17 | -4732.007 | 4743.173 | 94328.554 | 94588.361 |
| 4 | 12 | Top | 92619.16 | -119726.84 | -6226.562 | 6242.319 | 132981.62 | 133358.79 |
| 3 | 9 | Top | 106743.55 | -137833.60 | -7791.220 | 7811.941 | 178224.75 | 178736.50 |
| 2 | 6 | Top | 120943.12 | -156015.36 | -9395.093 | 9420.707 | 230051.95 | 230705.40 |
| 1 | 3 | Top | 135217.64 | -174272.03 | -11015.97 | 11045.76 | 288454.88 | 289238.89 |
| Base | 0 | Top | 140112.24 | -179939.34 | -12640.29 | 12672.33 | 353419.68 | 354281.39 |

Table 3.3.2.28 Story stiffness

| story | H | L | DLx | DLy | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| 10 | 30 | Top | 0 | 0 | 538940.836 | 233790.867 | 355458.743 | 157061.051 |
| 9 | 27 | Top | 0 | 0 | 1004323.078 | 423424.919 | 740520.822 | 316927.692 |
| 8 | 24 | Top | 0 | 0 | 1363040.402 | 561626.542 | 1107751.853 | 460930.822 |
| 7 | 21 | Top | 0 | 0 | 1660182.219 | 667684.678 | 1472994.306 | 594037.739 |
| 6 | 18 | Top | 0 | 0 | 1938042.481 | 761547.851 | 1862355.837 | 728082.784 |
| 5 | 15 | Top | 0 | 0 | 2241077.106 | 861364.554 | 2314661.748 | 878426.811 |
| 4 | 12 | Top | 0 | 0 | 2632255.896 | 990953.991 | 2896098.772 | 1069885.753 |
| 3 | 9 | Top | 0 | 0 | 3233886.872 | 1196349.349 | 3741197.412 | 1354102.772 |
| 2 | 6 | Top | 0 | 0 | 4366125.233 | 1608590.145 | 5177255.923 | 1874898.544 |
| 1 | 3 | Top | 0 | 0 | 7733104.34 | 3146973.651 | 8824381.87 | 3629022.358 |
| Base | 0 | Top | 0 | 0 | 0 | 0 | 0 | 0 |

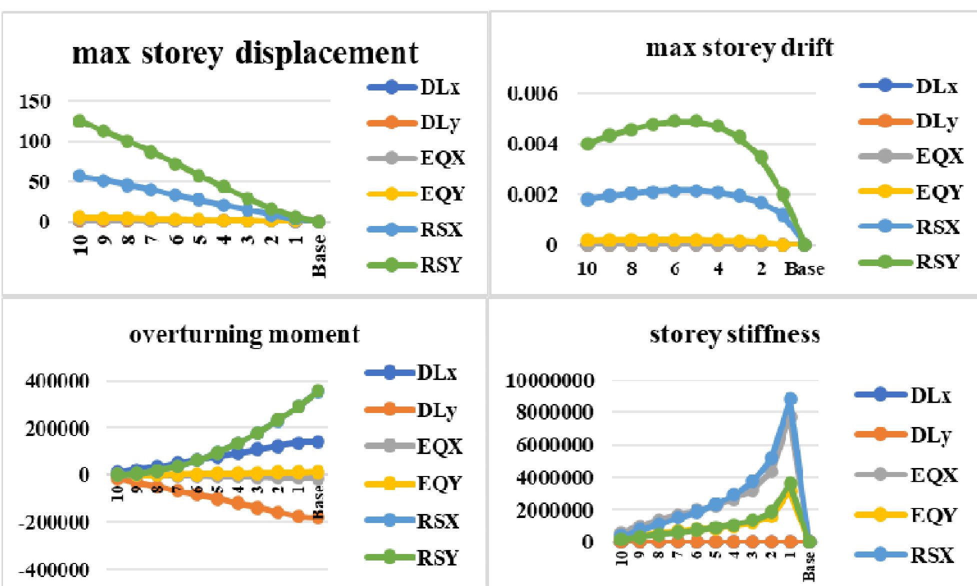



**Chart 3.2.3.5 displacement, storey drift, Overturning Moment, Storey stiffness of Box Pattern**

Table 3.3.2.29 Maximum Bending moment & Shear force

| | COLUM | | | | | BEAM | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | DL | EQX | EQY | RSX | RSY | DL | EQX | EQY | RSX | RSY |
| BM | 12.05 | 4.06 | 1.33 | 329.72 | 51.26 | 23.89 | 7.89 | 15.17 | 302.55 | 493.71 |
| SF | 9.16 | 6.01 | 1.213 | 216.6 | 35.45 | 28.24 | 6.88 | 12.1 | 244.43 | 399.01 |
| AF | 672.31 | 170.08 | 189.88 | 6762.4 | 7508.6 | 0 | 0 | 0 | 0 | 0 |
| T | 0.593 | 0.83 | 0.0001 | 30.61 | 0.0022 | 0.93 | 0.458 | 0.343 | 16.78 | 9.991 |

Table 3.3.2.30 Base shear

| loads | Dead | EQX | EQY | RX | RY |
|---|---|---|---|---|---|
| Fx | 1.0394 | -0.8662 | -0.0061 | 33.5093 | 0.1501 |
| Fy | -0.0969 | 1.0897 | -3.4017 | 44.6943 | 133.6515 |

**g. E pattern**

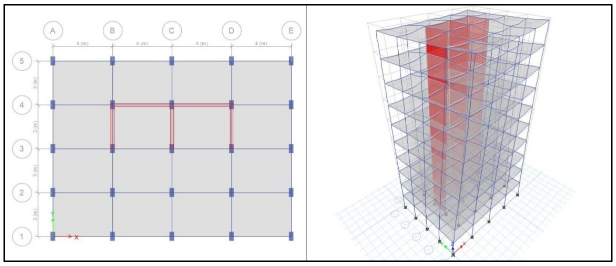


**Fig.3.2.3.7 E-pattern frame with shear wall and flat slab**

Table 3.3.2.31 Fundamental Natural time period and Average response acceleration coefficient ($S_a/g$)

| | FUNDAMENTAL NATURAL TIME PERIOD | | | | AVG RESPONSE ACCELERATION COFFICIENT | |
|---|---|---|---|---|---|---|
| case | period | frequency | 0.09h/d | Ta | linear static | Response spectrum |
| UX | 0.376 | 2.656 | 0.675 | 0.675 | 0.34 | 2.01 |
| UY | 0.594 | 1.683 | 0.779 | 0.779 | 0.34 | 1.74 |

Table 3.3.2.32 Overturning moments

| story | H | L | DLx | DLy | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| 10 | 30 | Top | 7150.302 | -9592.069 | 0 | 0 | 0 | 0 |
| 9 | 27 | Top | 18166.51 | -23623.63 | -238.260 | 238.4318 | 4707.921 | 4713.1069 |
| 8 | 24 | Top | 29257.54 | -37730.48 | -703.294 | 703.8912 | 14945.043 | 14963.609 |
| 7 | 21 | Top | 40423.50 | -51912.69 | -1347.74 | 1348.971 | 30715.704 | 30754.536 |
| 6 | 18 | Top | 51664.51 | -66170.33 | -2129.76 | 2131.803 | 52023.570 | 52088.516 |
| 5 | 15 | Top | 62980.68 | -80503.43 | -3013.04 | 3016.006 | 78871.096 | 78965.973 |
| 4 | 12 | Top | 74372.11 | -94912.00 | -3966.73 | 3970.663 | 111258.22 | 111383.60 |
| 3 | 9 | Top | 85838.86 | -109395.9 | -4965.50 | 4970.299 | 149180.74 | 149332.48 |
| 2 | 6 | Top | 97380.92 | -123955.1 | -5989.41 | 5994.848 | 192627.63 | 192795.75 |
| 1 | 3 | Top | 108998.1 | -138589.0 | -7023.94 | 7029.626 | 241577.10 | 241745.94 |
| Base | 0 | Top | 113539.9 | -143705.0 | -8059.73 | 8065.221 | 295984.65 | 296137.95 |

Table 3.3.2.33 Story stiffness

| story | H | L | DLx | DLy | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| 10 | 30 | Top | 0 | 0 | 295395.542 | 197435.101 | 208166.422 | 133249.827 |
| 9 | 27 | Top | 0 | 0 | 511752.066 | 363288.933 | 400666.674 | 271934.202 |
| 8 | 24 | Top | 0 | 0 | 643558.236 | 481863.438 | 545883.237 | 393911.722 |
| 7 | 21 | Top | 0 | 0 | 727858.52 | 570093.942 | 658523.054 | 503863.4 |
| 6 | 18 | Top | 0 | 0 | 792787.812 | 646470.83 | 757468.131 | 613330.198 |
| 5 | 15 | Top | 0 | 0 | 858406 | 728569.242 | 860588.357 | 738145.233 |
| 4 | 12 | Top | 0 | 0 | 946338.298 | 840116.221 | 990922.484 | 904959.031 |
| 3 | 9 | Top | 0 | 0 | 1096079.549 | 1029354.968 | 1193193.042 | 1172728.583 |
| 2 | 6 | Top | 0 | 0 | 1421405.517 | 1446680.165 | 1593786.717 | 1724517.076 |
| 1 | 3 | Top | 0 | 0 | 2675983.875 | 3178565.28 | 2999449.124 | 3822350.353 |
| Base | 0 | Top | 0 | 0 | 0 | 0 | 0 | 0 |

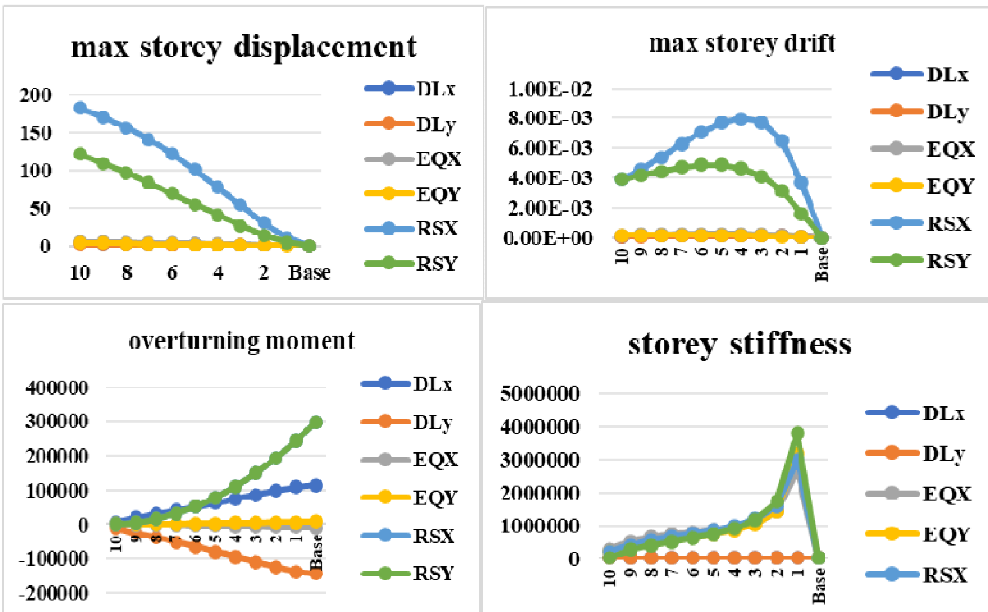



**Chart 3.2.3.5 displacement, storey drift, Overturning Moment, Storey stiffness of E-Pattern**

Table 3.3.2.34 Maximum Bending moment & Shear force

| | COLUM | | | | | BEAM | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | DL | EQX | EQY | RSX | RSY | DL | EQX | EQY | RSX | RSY |
| BM | 14.99 | 4.14 | 1.784 | 95.42 | 40.27 | 40.79 | 5.37 | 18.068 | 128.67 | 437.92 |
| SF | 11.35 | 3.14 | 1.31 | 72.28 | 29.68 | 28.34 | 4.45 | 14.46 | 104.75 | 351.05 |
| AF | 838.95 | 147.27 | 180.26 | 4138.87 | 5409.7 | 0 | 0 | 0 | 0 | 0 |
| T | 0.07 | 0.096 | 0 | 3.448 | 0.0008 | 0.844 | 0.299 | 0.493 | 8.34 | 11.042 |

Table 3.3.2.35 Base shear

| loads | Dead | EQX | EQY | RX | RY |
|---|---|---|---|---|---|
| Fx | -0.6161 | -0.006 | 91.841 | 0.1941 | 0.1941 |
| Fy | 1.7531 | -1.8206 | 136.5097 | 91.2058 | 91.2058 |

**h. Unsymmetric pattern**

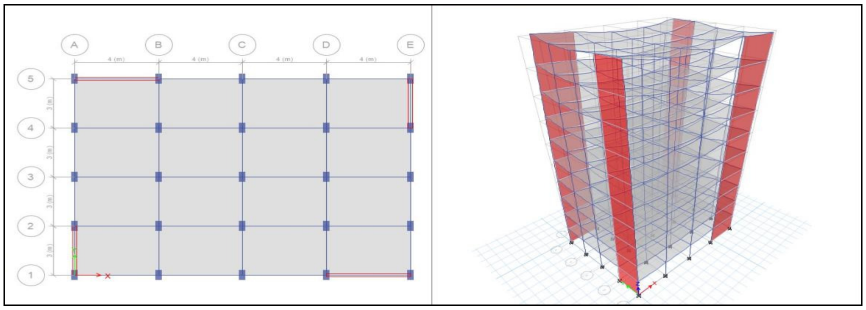


**Fig.3.2.3.8 Unsymmetric pattern frame with shear wall and flat slab**

Table 3.3.2.36 Fundamental Natural time period and Average response acceleration coefficient ($S_a/g$)

| | FUNDAMENTAL NATURAL TIME PERIOD | | | | AVG RESPONSE ACCELERATION COFFICIENT | |
|---|---|---|---|---|---|---|
| case | period | frequency | 0.09h/d | Ta | linear static | Response spectrum |
| UX | 0.736 | 1.359 | 0.675 | 0.675 | 0.34 | 2.01 |
| UY | 0.751 | 1.331 | 0.779 | 0.779 | 0.34 | 1.74 |

Table 3.3.2.37 Overturning moments

| story | H | L | DLx | DLy | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| 10 | 30 | Top | 7150.3022 | -9592.069 | 0 | 0 | 0 | 0 |
| 9 | 27 | Top | 17444.633 | -23351.31 | -229.262 | 228.9569 | 4676.797 | 4676.797 |
| 8 | 24 | Top | 27814.411 | -37186.19 | -675.248 | 674.3694 | 14806.28 | 14806.28 |
| 7 | 21 | Top | 38259.742 | -51096.78 | -1292.82 | 1291.229 | 30392.14 | 30392.14 |
| 6 | 18 | Top | 48780.739 | -65083.09 | -2042.10 | 2039.784 | 51436.91 | 51436.91 |
| 5 | 15 | Top | 59377.474 | -79145.09 | -2888.36 | 2885.448 | 77939.56 | 77939.56 |
| 4 | 12 | Top | 70049.935 | -93282.69 | -3802.00 | 3798.758 | 109893.0 | 109893.0 |
| 3 | 9 | Top | 80797.973 | -107495.6 | -4758.53 | 4755.312 | 147281.5 | 147281.5 |
| 2 | 6 | Top | 91621.217 | -121783.4 | -5738.54 | 5735.694 | 190077.1 | 190077.1 |
| 1 | 3 | Top | 102518.97 | -136145.6 | -6727.60 | 6725.362 | 238236.3 | 238236.3 |
| Base | 0 | Top | 106339.70 | -140989.0 | -7716.24 | 7714.406 | 291693.3 | 291693.3 |

Table 3.3.2.38 Storey stiffness

| story | H | L | DLx | DLy | EQX | EQY | RSX | RSY |
|---|---|---|---|---|---|---|---|---|
| 10 | 30 | Top | 0 | 0 | 108518.794 | 148257.362 | 72583.119 | 104184.129 |
| 9 | 27 | Top | 0 | 0 | 203782.037 | 262206.712 | 151089.229 | 203000.54 |
| 8 | 24 | Top | 0 | 0 | 274583.202 | 332935.707 | 222797.453 | 278362.88 |
| 7 | 21 | Top | 0 | 0 | 329859.957 | 377967.214 | 290433.281 | 337146.978 |
| 6 | 18 | Top | 0 | 0 | 379258.975 | 412799.918 | 360073.897 | 390032.469 |
| 5 | 15 | Top | 0 | 0 | 433159.494 | 449444.607 | 441332.236 | 448071.323 |
| 4 | 12 | Top | 0 | 0 | 506539.097 | 501734.579 | 551551.486 | 526649.716 |
| 3 | 9 | Top | 0 | 0 | 631050.202 | 596462.52 | 730686.669 | 657910.955 |
| 2 | 6 | Top | 0 | 0 | 909311.326 | 819322.322 | 1108943.44 | 945152.534 |
| 1 | 3 | Top | 0 | 0 | 2099458.245 | 1833414.68 | 2600487.304 | 2166624.409 |
| Base | 0 | Top | 0 | 0 | 0 | 0 | 0 | 0 |

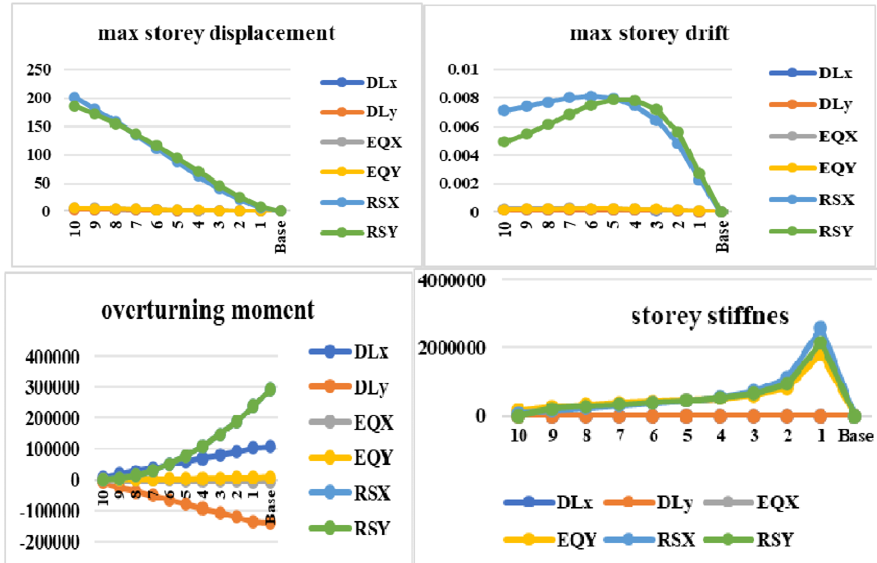


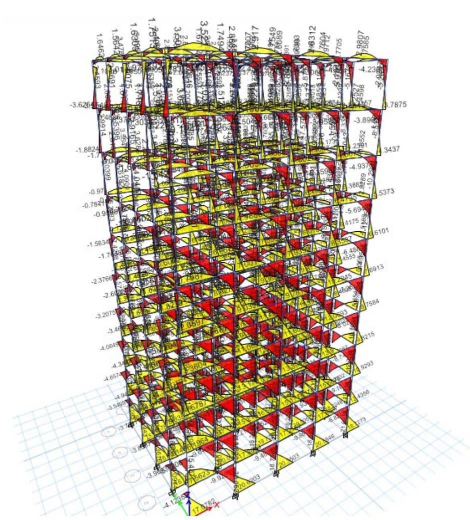

**Chart 3.2.3.5 displacement, storey drift, Overturning Moment, Storey stiffness of unsymmetric pattern**

Table 3.3.2.39 Max Bending moment & Shear force

| | COLUM | | | | | BEAM | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | DL | EQX | EQY | RSX | RSY | DL | EQX | EQY | RSX | RSY |
| BM | 21.625 | 12.22 | 1.19 | 384.96 | 48.895 | 35.2 | 7.525 | 17.7 | 253.35 | 724 |
| SF | 13.05 | 8.725 | 0.982 | 265.43 | 36.97 | 40.645 | 6.297 | 15.793 | 210.45 | 566.89 |
| AF | 808.18 | 241.47 | 222.004 | 9555.78 | 9290.43 | 0 | 0 | 0 | 0 | 0 |
| T | 0.237 | 0.0001 | 0.0001 | 0.0028 | 0.0026 | 2.32 | 1.144 | 0.309 | 34.589 | 12.711 |

Table 3.3.2.40 Base shear

| loads | Dead | EQX | EQY | RX | RY |
|---|---|---|---|---|---|
| Fx | 0.7101 | -0.9256 | 0.191 | 43.3155 | 8.7899 |
| Fy | 44.1123 | -6.0618 | -73.6146 | 202.398 | 3882.9569 |



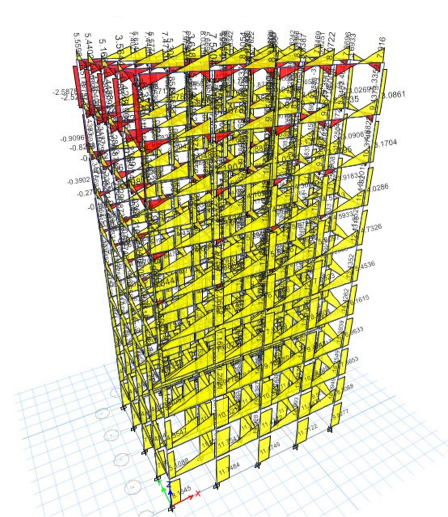


Fig.3.2.3.9 Bending moment & Shear force diagram

# 4. RESULT

**4.1 RESULT**

Comparison of linear static method (LS) and response spectrum method (RS) in different parameters as follows:

I. **Fundamental natural time period:** The approximate fundamental translation natural period TA of oscillation in second, shall be calculated by the etabs and check by the upper criteria given in IS1893 part 1:2016 and get result.

II. **Avg. Response Acceleration coefficient: (Sa/g):** design acceleration coefficient for different soil types, normalized with peak ground acceleration, corresponding to natural period T of structure. This provisions criterion is given in IS1893 part 1:2016 clause 6.4.

III. **Sway**: This refers to a gentle, often oscillatory movement from side to side or back and forth. It is typically used to describe the motion of objects or structures due to forces like wind or to indicate a change in influence or opinion.

Table 4.1.1 Fundamental natural time period (sec) and Avg. Response Acceleration coefficient

| Type of structure | Fundamental natural time period (sec) | | Average Response Acceleration coefficient | | Sway (mm) | |
|---|---|---|---|---|---|---|
| | LS | RS | LS | RS | LS | RS |
| Structure 1 | 0..916 | 0.916 | 0.34 | 1.415 | 5.14 | 212.29 |
| Structure 2 | 0.779 | 0.779 | 0.34 | 2.01 | 7.54 | 460.06 |
| Structure 3a | 0.779 | 0.779 | 0.34 | 2.01 | 3.438 | 85.46 |
| Structure 3b | 0.779 | 0.779 | 0.34 | 2.01 | 3.438 | 108.817 |
| Structure 3c | 0.779 | 0.779 | 0.34 | 2.01 | 11.725 | 80.984 |
| Structure 3d | 0.779 | 0.779 | 0.34 | 2.01 | 22.093 | 249.125 |
| Structure 3e | 0.779 | 0.779 | 0.34 | 2.01 | 4.698 | 117.771 |
| Structure 3f | 0.779 | 0.779 | 0.34 | 2.01 | 4.983 | 125.199 |
| Structure 3g | 0.779 | 0.779 | 0.34 | 2.01 | 5.403 | 182.282 |
| Structure 3h | 0.779 | 0.779 | 0.34 | 2.01 | 6.013 | 201.928 |

IV. **Base shear:** Base shear refers to the total horizontal force that is exerted at the base of a structure due to seismic activity. It is a critical parameter in earthquake engineering, used to assess the structural response and design requirements of buildings and other structures to ensure they can withstand seismic forces. The base shear is typically calculated based on factors such as the building's weight, seismic zone, and structural characteristics.

Table 4.2.2 Base shear

| Type of structure | Height | LS | RS |
|---|---|---|---|
| Structure 1 | 30 | 203.3248 | 210.0302 |
| Structure 2 | 30 | 543.6616 | 547.6555 |
| Structure 4a | 30 | 26.454 | 83.1286 |
| Structure 4b | 30 | 1656.6161 | 1889.4341 |
| Structure 4c | 30 | 29.0293 | 65.3932 |
| Structure 4d | 30 | 54.3607 | 133.4179 |

| | | | |
|---|---|---|---|
| Structure 4e | 30 | 33.4193 | 110.9278 |
| Structure 4f | 30 | 136.5097 | 91.2058 |
| Structure 4g | 30 | 44.6943 | 133.6515 |
| Structure 4h | 30 | 202.398 | 3882.9569 |

V. **bending moment** is a measure of the internal forces within a structural element that cause it to bend. It is the result of external loads applied to the structure, such as weights or forces, which create a moment around a specific point or section of the structure.

VI. **Shear force** is a measure of the internal force within a structural element that acts parallel to the cross-section of the element. It results from external loads or forces applied perpendicular to the length of the element.

VII. **Axial force** is the force that acts along the length of a structural member or component. It is directed parallel to the axis of the member and can either be tensile (stretching the member) or compressive (squeezing the member).

VIII. **Torsion** refers to the twisting force or moment applied to an object, typically a shaft or beam, around its longitudinal axis.

Table 4.2.3 Bending moment, Shear force, Axial force, Torsion

| Type of structure | BM | | SF | | AF | | Torsion | |
|---|---|---|---|---|---|---|---|---|
| | LS | RS | LS | RS | LS | RS | LS | RS |
| Structure 1 | 9.758 | 581.63 | 6.095 | 330.72 | 40.304 | 1390.871 | 0.0006 | 0.0324 |
| Structure 2 | 14.21 | 1248 | 8.66 | 699.04 | 58.91 | 3544.47 | 0.0009 | 0.07 |
| Structure 4a | 14.55 | 214.19 | 11.83 | 288.77 | 230.93 | 6683.37 | 0.5 | 11.56 |
| Structure 4b | 12.91 | 296.23 | 9.392 | 215.41 | 216.95 | 6476.04 | 0.7 | 15.99 |
| Structure 4c | 8.68 | 334.14 | 40.14 | 272.06 | 783.98 | 6301.73 | 0.807 | 5.49 |
| Structure 4d | 40.773 | 855 | 26.78 | 538.03 | 427.24 | 9807.1 | 1.98 | 24.18 |
| Structure 4e | 10.81 | 236.64 | 16.06 | 315.8 | 336.4 | 9967.85 | 0.66 | 15.19 |
| Structure 4f | 15.17 | 493.71 | 12.1 | 399.01 | 189.88 | 7508.6 | 0.83 | 30.61 |
| Structure 4g | 18.068 | 437.92 | 14.46 | 351.05 | 180.26 | 5409.7 | 0.493 | 11.042 |
| Structure 4h | 17.7 | 724 | 15.793 | 566.89 | 241.47 | 9555.78 | 1.144 | 34.58 |

## 4.2 Conclusion

I. The fundamental natural time period if different patterns show differs in seconds but the check by linear static and check by response spectrum method both give same result.

II. Dy the analysis of different structure response spectrum method gives higher value as compared to linear static method.

III. Result shows that the bending moment data in 3d is more as compared to other structural patterns.

IV. Geopolymer concrete demonstrates promising performance in shear wall applications, showing comparable or even superior structural behaviour compared to traditional Portland cement-based concrete.

V. The analysis indicates that geopolymer concrete shear walls exhibit effective load-bearing capacity, enhanced durability, and improved resistance to environmental degradation.

### 4.3 Scope

I. Enhanced Structural Performance: Geopolymer concrete can offer high compressive strength and improved fire resistance, which is beneficial for the structural integrity of tall buildings.
II. Regulatory Acceptance: As more data and successful case studies emerge, regulatory bodies may develop guidelines and standards for the use of geopolymer concrete in high-rise construction, further facilitating its adoption.
III. Cost Efficiency: As technology advances and production methods improve, the cost of geopolymer concrete may decrease, making it a more economically viable option for large-scale projects.
IV. Design Flexibility: Advances in formulation and mixing can lead to better performance characteristics, allowing for more innovative design solutions in building construction.

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