Seismic analysis of hybrid structures with and without shear walls

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Abstract: A hybrid structure is one that combines more than two different types of materials to compensate for weak places while also maximizing strength. Hybrid steel and concrete frameworks, as well as other modern materials, are unified at the member or framework unit. Hybrid structures are frequent in high-rise and super-high-rise building projects, and they provide the benefit of cost savings. Shear walls are built to withstand lateral loadings like earthquakes and winds loads. The response spectrum analysis approach is frequently used to measure design stresses for earthquake-prone structures. The modelling and analysis of the regular plan structures are done by CSI ETABS 2019 in IV seismic zones, on type II (medium soil) of India According to IS 1893 (Part-1) 2016. The aims of this study Response spectrum analysis of 41 storey RCC and hybrid structures with shear walls and without shear walls are compared. RCC and hybrid structures with shear walls showed lower storey displacement, storey drift, and story shear values than RCC and hybrid structures without shear walls, according to the results of this study. The research results will be helpful as a reference and a tool for seismic analysis of hybrid structures.

Keywords: Hybrid structure, RCC structure, Response spectrum analysis, Shear wall, CSI ETABS

1. Introduction

India has increased its development and implementation of hybrid structural technology to build extraordinarily high-rise skyscrapers in recent years. We chose a hybrid structure over a steel structure because of its superior seismic performance and lower construction costs. Unlike standard reinforced concrete RC structures, Steel beams and columns replace RC beams and columns in hybrid constructions, which have RC core walls. As a result, hybrid designs offer substantial benefits in terms of self-weight,
The response spectrum analysis process is used in nonlinear static analysis. Reinforced concrete shear walls are frequently utilized in tall buildings as a lateral force resisting technology. This necessitates the employment of a nonlinear structural model [9]–[11], as well as the selection of appropriate ground movements and a large amount of processing time. Many medium- and high-rise buildings in India are built with shear walls to ensure that they can withstand the forces they are subjected to. Cryptography is a sort of algorithm that uses the RSA algorithm (ASCE 7-10) Nepal is situated in an earthquake-prone area. Earthquakes in Nepal and the Himalayan area were caused by the Indian plate colliding with the Eurasian plate. Earthquakes are one of nature's most dangerous and unexpected hazards. According to previous studies, the bulk of existing buildings in Nepal are not seismically sound.

The shear wall of the structure may have wide gaps, indicating the building's seismic resistance with a long corridor. Some of the most commonly used earthquake analysis methodologies are as follows: Analyze static equivalents first. 2. Dynamic linear analysis. 3. A dynamical analysis that is non-linear. 4. Aspects of the response spectrum are examined in depth. 5. Take a look backwards in time. 6. Lower your body to the ground. Non-linear static analysis is number seven. Dynamic analysis is performed on high-rise and irregular buildings in compliance with IS Code 1893 (Part-1):2016. In none of the five situations, shear reinforcement or boundary features were examined, but base faults, which are common in construction, were. Excitation is based on two recordings of earthquakes in Chile of varying magnitudes, with testing done on a single-direction shaking table. Due to flexure and little shear involvement, damage is always limited to the wall base [12].

The interplay of the structure, foundation, and soil in the immediate area of the building's base affects the structure's responsiveness. As a result, research on soil-structure interactions is becoming more essential and useful in structural design. When compared to fixed base analysis, many codes and regulatory documents consider the impact of soil structure interaction to be beneficial for structures subjected to seismic vibrations since it extends the structure's natural period and reduces the base shear required for the superstructure. The performance of the constructions is significantly influenced by the apertures. The way a building is built has a big influence on how much damage it can take during an earthquake [13].

The circumstances surrounding seismic powers, in any case, are astounding. The loads or forces supported by a structure during a seismic quake are directly generated by the contortion induced by the ground movement on which it stands. Relocations, speeds, and rising velocities characterize base movement, which can vary in bearings, extent, lengths, and layout. Earthquake loads are inertial forces that affect a building's bulk, solidity, and ability to maintain life. The drift ratios do not considerably increase when compared to the result of a shear wall, and are more akin to those of a base rocking system. The findings reveal that a variety of shear wall designs have been investigated. Using precast segmental bridge piers, a shear wall, and a steel braced frame, the seismic performance of the base-rocking system was assessed. Higher modes, according to several numerical studies, are less affected by inelasticity than the first mode. As a result, in structural design, adopting the correct building plan layout for earthquake ground shaking resistance is critical. Regular structures are more damaged than irregular ones, according to research into the effects of earthquakes on buildings [13]–[15].

SSI can reduce multi-story building strength and ductility demands by up to 60%, especially for those with low ductility demands and low slenderness ratios. According to the findings of a new research investigation, the RSA technique reduces the elastic shear forces of all modes by a single R factor,
resulting in an underestimating of shear forces induced by higher modes. The NLRHA approach calculates a design shear force that is substantially higher than the RSA method's design shear force estimate. Brittle failure is typically referred to as elastic in the design process since it is induced by a shear dominating reaction. Many previous studies used parametric models to predict significant shear forces in inelastic RC walls with various structural designs and ground vibrations, with clear results influenced by these choices. Before using the projected shear force from the ELF or RSA methodologies as a design demand, the shear amplification factor methodology is used [16], [17].

As a result of SSI impacts, the structural ductility demand of tall and narrow buildings positioned on softer soil conditions may rise. The capability of the multi-layer shell model to complete such a simulation has been proven in numerous studies. A seismic performance test was conducted on a twelve-story RC moment resistant frame structure with a Finite element method of analysis approved shear wall. Floor level fragility decreased as height grew, and both approaches' ratios generally exceeded regulatory limitations, according to their findings for all Finite element method of analysis performance categories.

Using a beam on nonlinear Winkler foundation technique, the goal of this work is to investigate nonlinear soil structure interaction behaviour. The results of the fixed and elastic basis models are compared and contrasted. The force and displacement needs are drastically decreased when foundation nonlinearity is taken into account. In addition, structural reaction has been demonstrated to be influenced by foundation compliance. Large and exceptionally tall structures have gotten a lot of attention in recent years because of their seismic behaviour. Because of the fast growth of large structures, as well as the increasing frequency of earthquakes throughout the world. For nonlinear seismic evaluations of such structures, numerical modelling has previously proven to be advantageous [16]–[19].

The study's objectives
1. Analyze the response and behaviour of reinforced concrete and hybrid structures, both with and without shear walls, in seismic zone IV [20]–[22].
2. In hybrid structures with and without shear walls, to compare storey displacement, drift, and shear.
3. Determine the shear wall's position in order for it to efficiently resist lateral loads.

2. Research work of different literatures
K. SURENDER KUMAR et al. (2020) It's something they've considered. Buildings in today's culture are designed to meet our basic needs while also improving serviceability. Although it is not difficult to construct a structure, it is critical to design one that is both efficient and long-lasting. Among other things, the objective of this study is to enhance load calculations, load combinations, support responses, and column and beam strengthening accuracy. After that, the beam or column will be reviewed to see if it passed or failed the loads. The building analysis was based on a case study of an actual construction project in Hyderabad and was conducted using traditional code manuals (IS 456: 2000, SP 16).

A six-story reinforced concrete building with and without floating piers, as well as interior and exterior floating columns, are studied in this study. The effects of floating columns on the support response's axial forces, displacement, shear forces, and twisting moments will be studied in this study. The behavior of structures in earthquake-prone zones [II; III; IV; and V] is examined, according to IS 1893-2016, principles for earthquake resistant structural strategy. Response Spectrum Analysis is used to assess the usage of Shear walls in various places of a 21-story residential complex, as well as the type of structure that is sensitive to earthquakes. In a 21-story structure, storey drift, foundation shear, maximum permitted displacement, and tensionsal irregularity are examined. ETABS 2015, a prominent FEM integrated tool, is used to assess and simulate the entire structure in all of India's seismic zones, according to IS 1893 (Part-1) 2016. Type -III is utilized to do a dynamic study in all zones of an irregular structure in plan (soft soil). Structures with symmetrically placed shear walls outperform structures without shear walls and structures with shear walls at one end in terms of all seismic parameters.

the shear wall of the tall building they analyze with high mode elastic method and investigate of
earthquake damage in buildings which include complexes of 15, 20, 31, and 39 stories. The RSA better analysis for determining the value of displacements and drifts compared to time history analysis, but drastically underestimates force demands. Higher-mode elastic shear force estimates are good for 15- and 20-story structures, but 31- and 39-story structures should be used with caution, whereas higher-mode inelastic shear force estimates are good in all circumstances. For a higher-mode inelastic structural model, but not for a higher-mode elastic structural model, a nonlinear inelastic structural model is necessary.

The audit's goal was to evaluate and investigate a wide range of research initiatives on shear wall reinforcement and its behaviour under lateral loads. Shear walls are particularly well adapted for soft story high rise buildings, such as those produced in India, because they handle the majority of lateral pressures in the bottom half of the building while the frame takes the lateral loads in the top half. Low rise building use for private in public office and quarter in India.

For an RCC multi-story structure, they conducted a comparison study on the effective placement of shear walls at various locations in various seismic zones. Shear, storey drift, and displacement are all present in all of the zones, which were created particularly for the experiment. There are four different models to choose from. Because Zone V has the largest story drift and displacement, shear walls are most effective when placed near the building's extremities.

3. Methodology

A response spectrum analysis is used to evaluate an RCC and steel-concrete hybrid high-rise structure with and without shear walls using CSI ETABS 2019.

Model A: G+40 story RCC building with no shear walls.
Model B: A RCC G+40 storey's structure with Shear-wall.
Model C: is a G+40 story hybrid structure with no shear walls.
Model D: A Hybrid G+40 Story Structure with Shear Walls.

3.1 Description of building

The structure's plan is considered typical; with dimensions of 25mx25m. The study uses a G+40 story RCC and Hybrid Structure with and without shear walls, as well as a G+40 story RCC and Hybrid Structure with and without shear walls, all of which are in seismic Zone IV. Each level is 3 meters high, with 5 meters between bays in both directions, see table 1 and figure 1 to 6.

| Table 1 shows the structural data for RCC and hybrid framed structures in a study paper. |
|---------------------------------|-----------|-----------|
| Parameters                      | RCC       | Hybrid    |
| Structures' dimensions          | 25mx25m   | 25mx25m   |
| Heightening the structure       | 124m      | 124m      |
| Beam dimensions                 | 500 x 350mm | 500 x 350mm |
| Column dimensions               | 900 x 1800mm | 900 x 1800mm |
| The slab's thickness            | 150mm     | 150mm     |
| The thickness of the wall       | 500mm     | 500mm     |
| Zone of Seismic Activity        | IV        | IV        |
| Factor of the zone              | 0.24      | 0.24      |
| Factor of importance            | 1.5       | 1.5       |
| The soil type (site type)       | Medium =II| Medium =II|
| India's wind speed              | 39 m/s    | 39 m/s    |
| Finishing the floor (DL for slab)| 2- kN/m2  | 2-kN/m2   |
| Load that is imposed (live load for slab) | 5- kN/m2 | 5- kN/m2 |
| the weight on the roof          | 1- kN/m2  | 1. kN/m2  |
| Parameter                        | Value 1          | Value 2          |
|---------------------------------|------------------|------------------|
| The brick wall's density        | 20 kN/m³         | 20 kN/m³         |
| Beams under wall load           | 12 kN/m          | 12 kN/m          |
| Concrete quality                | M35              | M35              |
| Steel quality                   | Fe345            | Fe345            |
| Rebar Grade (Z)                 | HYSD 500         | HYSD 500         |
| Factor for Reduction of Response (R) | According to IS1893:2016 (0.24) | According to IS1893:2016 (0.24) |
| Zone Factor                     | 5                | 5                |
| Period of time                  | $T_a = 0.075h^{0.75}$ | $T_a = 0.075h^{0.75}$ |

**Figure 1:** shows the plan view without the shear wall.
Figure 2: G+40 storey RCC and Hybrid building elevation without shear wall.

Figure 3: G+40-story RCC and hybrid building with no shear wall in 3D.

Figure 4: Shear wall plan with a view of the G+40 storey’s.
4. Results and discussion

Storey Displacements of G+40 shown in figure 7 to 11 and table 2 to 6

Table 2: Storey Displacements of G+40 RCC and hybrid structures without shear walls

| Storey No. | X     | Y     | Z     | X     | Y     | Z     |
|-----------|-------|-------|-------|-------|-------|-------|
| 1         | 8.003 | 7.321 | 2.91E-05 | 6.161 | 5.545 | 0.000133 |
| 2         | 22.969 | 21.067 | 7.26E-05 | 18.132 | 16.336 | 0.000331 |
| 3         | 44.166 | 40.611 | 0.000122 | 35.682 | 32.184 | 0.001 |
| 4         | 70.508 | 64.987 | 0.000175 | 58.222 | 52.576 | 0.001 |
| 5         | 101.07 | 93.367 | 0.000233 | 85.21 | 77.035 | 0.001 |
| 6         | 135.063 | 125.04 | 0.000298 | 116.147 | 105.124 | 0.001 |
| 7         | 171.814 | 159.393 | 0.000367 | 150.572 | 136.438 | 0.002 |
| 8         | 210.745 | 195.894 | 0.000437 | 188.059 | 170.6 | 0.002 |
| 9         | 251.358 | 234.083 | 0.001 | 228.215 | 207.262 | 0.003 |
| 10        | 293.222 | 273.557 | 0.001 | 270.673 | 246.099 | 0.003 |
| 11        | 335.96 | 313.962 | 0.001 | 315.094 | 286.807 | 0.003 |
| 12        | 379.247 | 354.99 | 0.001 | 361.162 | 329.105 | 0.004 |
| 13        | 422.797 | 396.366 | 0.001 | 408.584 | 372.73 | 0.004 |
| 14        | 466.36 | 437.848 | 0.001 | 457.086 | 417.435 | 0.004 |
| 15        | 509.715 | 479.224 | 0.001 | 506.416 | 462.991 | 0.005 |
| 16        | 552.669 | 520.303 | 0.001 | 556.338 | 509.186 | 0.005 |
| 17        | 595.051 | 560.918 | 0.001 | 606.635 | 555.821 | 0.005 |
| 18        | 636.712 | 600.921 | 0.001 | 657.106 | 602.711 | 0.006 |
| 19        | 677.519 | 640.179 | 0.001 | 707.565 | 649.689 | 0.006 |
Figure 7: RCC and hybrid structures without shear walls Maximum storey displacement.

Table 3: RCC and Hybrid G+40 Structures with shear wall Max Story Displacements.

| NO of Story | RCC X  | Y | Z (mm) | Hybrid X  | Y | Z (mm) |
|------------|--------|---|--------|-----------|---|--------|
| 1          | 0.44   | 0.437 | 1.81E-05 | 0.372     | 0.367 | 2.43E-05 |
| 2          | 1.194  | 1.187 | 4.21E-05 | 1         | 0.991 | 5.88E-05 |
|    |     |     |      |     |     |     |     |
|----|-----|-----|------|-----|-----|------|-----|
| 3  | 2.274 | 2.263 | 7.27E-05 | 1.888 | 1.874 | 0.000104 |
| 4  | 3.658 | 3.642 | 0.000109 | 3.019 | 2.999 | 0.000158 |
| 5  | 5.327 | 5.305 | 0.000151 | 4.374 | 4.347 | 0.00022 |
| 6  | 7.26  | 7.232 | 0.000198 | 5.939 | 5.903 | 0.00029 |
| 7  | 9.44  | 9.405 | 0.000249 | 7.699 | 7.654 | 0.000367 |
| 8  | 11.85 | 11.807 | 0.000304 | 9.639 | 9.584 | 0.00045 |
| 9  | 14.473 | 14.422 | 0.000363 | 11.747 | 11.682 | 0.001 |
| 10 | 17.293 | 17.234 | 0.000426 | 14.012 | 13.934 | 0.001 |
| 11 | 20.298 | 20.229 | 0.000493 | 16.42 | 16.33 | 0.001 |
| 12 | 23.473 | 23.394 | 0.000561 | 18.962 | 18.86 | 0.001 |
| 13 | 26.806 | 26.717 | 0.000633 | 21.628 | 21.512 | 0.001 |
| 14 | 30.284 | 30.184 | 0.000705 | 24.409 | 24.279 | 0.001 |
| 15 | 33.896 | 33.786 | 0.000777 | 27.296 | 27.151 | 0.001 |
| 16 | 37.633 | 37.511 | 0.000848 | 30.281 | 30.121 | 0.001 |
| 17 | 41.483 | 41.349 | 0.000919 | 33.356 | 33.181 | 0.001 |
| 18 | 45.437 | 45.291 | 0.000991 | 36.515 | 36.323 | 0.002 |
| 19 | 49.486 | 49.329 | 0.001062 | 39.751 | 39.543 | 0.002 |
| 20 | 53.622 | 53.453 | 0.001134 | 43.058 | 42.833 | 0.002 |
| 21 | 57.837 | 57.655 | 0.001205 | 46.429 | 46.188 | 0.002 |
| 22 | 62.125 | 61.931 | 0.001277 | 49.862 | 49.604 | 0.002 |
| 23 | 66.474 | 66.267 | 0.001349 | 53.347 | 53.071 | 0.002 |
| 24 | 70.881 | 70.661 | 0.001421 | 56.882 | 56.589 | 0.002 |
| 25 | 75.339 | 75.106 | 0.001492 | 60.462 | 60.152 | 0.002 |
| 26 | 79.842 | 79.596 | 0.001564 | 64.083 | 63.755 | 0.003 |
| 27 | 84.383 | 84.125 | 0.001635 | 67.74 | 67.394 | 0.003 |
| 28 | 88.958 | 88.687 | 0.001707 | 71.429 | 71.065 | 0.003 |
| 29 | 93.56  | 93.277 | 0.001779 | 75.146 | 74.764 | 0.003 |
| 30 | 98.187 | 97.89  | 0.001851 | 78.887 | 78.488 | 0.003 |
| 31 | 102.832 | 102.523 | 0.001922 | 82.649 | 82.232 | 0.003 |
| 32 | 107.492 | 107.17 | 0.001994 | 86.428 | 85.993 | 0.003 |
| 33 | 112.162 | 111.828 | 0.002065 | 90.22 | 89.768 | 0.003 |
| 34 | 116.84 | 116.494 | 0.002137 | 94.023 | 93.553 | 0.003 |
| 35 | 121.522 | 121.164 | 0.002208 | 97.834 | 97.346 | 0.003 |
| 36 | 126.206 | 125.836 | 0.002280 | 101.649 | 101.144 | 0.004 |
| 37 | 130.89 | 130.507 | 0.002351 | 105.467 | 104.944 | 0.004 |
| 38 | 135.571 | 135.176 | 0.002422 | 109.285 | 108.745 | 0.004 |
| 39 | 140.249 | 139.843 | 0.002494 | 113.102 | 112.545 | 0.004 |
| 40 | 144.925 | 144.507 | 0.002566 | 116.917 | 116.342 | 0.004 |
| 41 | 149.595 | 149.165 | 0.002637 | 120.728 | 120.137 | 0.004 |
Figure 8: Max Storey displacement of RCC and hybrid structure with shear walls.

Table 4: Max Storey Drifts of G+40 RCC and Hybrid Structure without Shear Walls.

| Storey No. | RCC Structure | Hybrid Structure |
|------------|---------------|------------------|
|            | X              | Y                | Z     | X              | Y                | Z     |
| 1          | 0.00472        | 0.004876         | 2.91E-08 | 0.00154        | 0.001386         | 3.33E-08 |
| 2          | 0.004871       | 0.005015         | 2.09E-08 | 0.00399        | 0.003597         | 6.59E-08 |
| 3          | 0.005097       | 0.005224         | 1.34E-08 | 0.00585        | 0.005283         | 8.14E-08 |
| 4          | 0.005384       | 0.00549          | 2.15E-08 | 0.007514       | 0.006798         | 1.06E-07 |
| 5          | 0.005722       | 0.005803         | 2.08E-08 | 0.008998       | 0.008155         | 1.20E-07 |
| 6          | 0.0061         | 0.006155         | 1.29E-08 | 0.010315       | 0.009366         | 1.21E-07 |
| 7          | 0.006514       | 0.006539         | 2.12E-08 | 0.011479       | 0.010442         | 1.28E-07 |
| 8          | 0.006954       | 0.006949         | 2.33E-08 | 0.012502       | 0.011393         | 1.37E-07 |
| 9          | 0.007417       | 0.007381         | 1.63E-08 | 0.013393       | 0.012229         | 1.35E-07 |
| 10         | 0.007895       | 0.007827         | 2.03E-08 | 0.014163       | 0.012956         | 1.28E-07 |
| 11         | 0.008384       | 0.008283         | 2.57E-08 | 0.01482        | 0.013582         | 1.38E-07 |
| 12         | 0.008879       | 0.008745         | 1.96E-08 | 0.015371       | 0.014114         | 1.40E-07 |
| 13         | 0.009375       | 0.009208         | 1.90E-08 | 0.015824       | 0.014559         | 1.30E-07 |
| 14         | 0.009869       | 0.009669         | 2.63E-08 | 0.016187       | 0.014921         | 1.24E-07 |
| 15         | 0.010358       | 0.010123         | 2.30E-08 | 0.016465       | 0.015207         | 1.32E-07 |
| 16         | 0.010837       | 0.010568         | 1.87E-08 | 0.016665       | 0.015422         | 1.29E-07 |
| 17         | 0.011304       | 0.011001         | 2.48E-08 | 0.016792       | 0.015571         | 1.16E-07 |
| 18         | 0.011755       | 0.011417         | 2.45E-08 | 0.016853       | 0.015659         | 1.16E-07 |
| 19         | 0.012186       | 0.011813         | 2.21E-08 | 0.016852       | 0.015691         | 1.19E-07 |
| 20         | 0.012595       | 0.012186         | 2.65E-08 | 0.016794       | 0.015671         | 1.13E-07 |
| 21         | 0.012978       | 0.012533         | 2.47E-08 | 0.016686       | 0.015603         | 1.01E-07 |
| 22         | 0.013331       | 0.01285          | 2.03E-08 | 0.016531       | 0.015493         | 1.08E-07 |
| 23         | 0.01365        | 0.013133         | 2.30E-08 | 0.016334       | 0.015343         | 1.05E-07 |
| 24         | 0.013931       | 0.013377         | 2.52E-08 | 0.016161       | 0.015159         | 9.33E-08 |
| 25         | 0.014167       | 0.013578         | 2.23E-08 | 0.015832       | 0.014943         | 9.02E-08 |
| 26         | 0.014354       | 0.013729         | 2.30E-08 | 0.015536       | 0.0147          | 9.50E-08 |
| 27         | 0.014484       | 0.013824         | 2.51E-08 | 0.015217       | 0.014435         | 8.85E-08 |
Table 5: RCC and Hybrid G+40 Structures with shear wall Max Story Drifts.

| No of story | RCC  | Hybrid |
|-------------|------|--------|
| X           | Y    | Z      | X    | Y    | Z    |
| 1           | 0.00011 | 0.000109 | 0   | 9.30E-05 | 9.20E-05 | 6.07E-09 |
| 2           | 0.000252 | 0.00025 | 8.07E-09 | 0.00021 | 0.000208 | 1.15E-08 |
| 3           | 0.000361 | 0.000359 | 1.03E-08 | 0.000297 | 0.000295 | 1.50E-08 |
| 4           | 0.000462 | 0.000461 | 1.24E-08 | 0.000378 | 0.000375 | 1.82E-08 |
| 5           | 0.000557 | 0.000555 | 1.42E-08 | 0.000453 | 0.00045 | 2.10E-08 |
| 6           | 0.000646 | 0.000644 | 1.59E-08 | 0.000523 | 0.00052 | 2.36E-08 |
| 7           | 0.000729 | 0.000727 | 1.75E-08 | 0.000589 | 0.000586 | 2.60E-08 |
| 8           | 0.000806 | 0.000804 | 1.90E-08 | 0.00065 | 0.000646 | 2.82E-08 |

Figure 9: Max Storey drifts of RCC and Hybrid G+40 structures without shear walls.
|   |         |         |        |         |         |        |        |
|---|---------|---------|--------|---------|---------|--------|--------|
| 9 | 0.000878 | 0.000876 | 2.04E-08 | 0.000707 | 0.000703 | 3.02E-08 |
|10 | 0.000946 | 0.000943 | 2.18E-08 | 0.000766 | 0.000756 | 3.21E-08 |
|11 | 0.001008 | 0.001005 | 2.30E-08 | 0.000809 | 0.000805 | 3.38E-08 |
|12 | 0.001067 | 0.001063 | 2.40E-08 | 0.000855 | 0.000850 | 3.53E-08 |
|13 | 0.001121 | 0.001117 | 2.49E-08 | 0.000898 | 0.000893 | 3.66E-08 |
|14 | 0.001171 | 0.001168 | 2.57E-08 | 0.000938 | 0.000933 | 3.77E-08 |
|15 | 0.001218 | 0.001214 | 2.63E-08 | 0.000975 | 0.000970 | 3.87E-08 |
|16 | 0.001261 | 0.001257 | 2.67E-08 | 0.001009 | 0.001004 | 3.95E-08 |
|17 | 0.001301 | 0.001298 | 2.71E-08 | 0.001042 | 0.001036 | 4.01E-08 |
|18 | 0.001338 | 0.001334 | 2.73E-08 | 0.001072 | 0.001066 | 4.06E-08 |
|19 | 0.001373 | 0.001369 | 2.75E-08 | 0.001111 | 0.001105 | 4.11E-08 |
|20 | 0.001404 | 0.001401 | 2.77E-08 | 0.001141 | 0.001135 | 4.14E-08 |
|21 | 0.001433 | 0.001429 | 2.79E-08 | 0.001170 | 0.001164 | 4.18E-08 |
|22 | 0.001459 | 0.001455 | 1.00E-06 | 0.001172 | 0.001167 | 4.90E-07 |
|23 | 0.001483 | 0.001479 | 1.00E-06 | 0.001193 | 0.001187 | 4.90E-07 |
|24 | 0.001504 | 0.001500 | 2.83E-08 | 0.001211 | 0.001205 | 4.22E-08 |
|25 | 0.001523 | 0.001519 | 2.83E-08 | 0.001228 | 0.001222 | 4.22E-08 |
|26 | 0.001545 | 0.001541 | 2.82E-08 | 0.001244 | 0.001238 | 4.22E-08 |
|27 | 0.001555 | 0.001551 | 2.81E-08 | 0.001257 | 0.001251 | 4.20E-08 |
|28 | 0.001568 | 0.001564 | 2.79E-08 | 0.001277 | 0.001271 | 4.18E-08 |
|29 | 0.001579 | 0.001575 | 2.76E-08 | 0.001288 | 0.001282 | 4.16E-08 |
|30 | 0.001588 | 0.001584 | 2.73E-08 | 0.001299 | 0.001293 | 4.12E-08 |
|31 | 0.001595 | 0.001591 | 2.70E-08 | 0.001306 | 0.001300 | 4.09E-08 |
|32 | 0.001616 | 0.001612 | 2.66E-08 | 0.001312 | 0.001306 | 4.05E-08 |
|33 | 0.001604 | 0.001599 | 2.64E-08 | 0.001307 | 0.001301 | 4.02E-08 |
|34 | 0.001606 | 0.001601 | 2.62E-08 | 0.001309 | 0.001303 | 3.99E-08 |
|35 | 0.001606 | 0.001602 | 2.60E-08 | 0.001311 | 0.001305 | 3.96E-08 |
|36 | 0.001605 | 0.001601 | 2.58E-08 | 0.001311 | 0.001305 | 3.93E-08 |
|37 | 0.001603 | 0.001599 | 2.56E-08 | 0.001311 | 0.001304 | 3.90E-08 |
|38 | 0.001616 | 0.001612 | 2.54E-08 | 0.001308 | 0.001302 | 3.87E-08 |
|39 | 0.001597 | 0.001593 | 2.51E-08 | 0.001305 | 0.001299 | 3.83E-08 |
|40 | 0.001593 | 0.001589 | 2.50E-08 | 0.001302 | 0.001296 | 3.80E-08 |
|41 | 0.001589 | 0.001585 | 2.46E-08 | 0.001299 | 0.001293 | 3.76E-08 |
Figure 10: Max storey drifts of RCC and Hybrid structure with shear walls.

Table 6: Storey shear of G+40 RCC and hybrid structures with and without shear walls.

| Storey No. | With shear walls | Without shear walls |
|------------|------------------|---------------------|
|            | RCC              | Hybrid              | RCC              | Hybrid              |
| 1          | 9656.981         | 9240.033            | 11362.81         | 10694.043           |
| 2          | 9606.48          | 9189.091            | 11324.68         | 10645.41            |
| 3          | 9504.689         | 9087.744            | 11250.21         | 10560.743           |
| 4          | 9342.858         | 8927.541            | 11140.5          | 10455.083           |
| 5          | 9125.934         | 8713.84             | 11009.38         | 10344.1             |
| 6          | 8865.208         | 8458.939            | 10872.46         | 10230.243           |
| 7          | 8575.054         | 8178.657            | 10739.24         | 10111.263           |
| 8          | 8269.515         | 7888.586            | 10610.15         | 9987.0543           |
| 9          | 7959.652         | 7601.03             | 10479.55         | 9855.8331           |
| 10         | 7652.372         | 7323.503            | 10341.23         | 9712.2621           |
| 11         | 7350.969         | 7059.134            | 10192.04         | 9552.9111           |
| 12         | 7056.894         | 6808.509            | 10031.69         | 9378.8151           |
| 13         | 6771.792         | 6571.903            | 9860.161         | 9191.4671           |
| 14         | 6498.77          | 6350.726            | 9675.961         | 8990.8711           |
| 15         | 6242.309         | 6147.503            | 9476.742         | 8778.2981           |
| 16         | 6006.89          | 5964.507            | 9261.478         | 8556.5351           |
| 17         | 5795.115         | 5801.901            | 9031.787         | 8326.4361           |
| 18         | 5606.382         | 5656.559            | 8790.948         | 8086.6591           |
| 19         | 5437             | 5522.409            | 8541.449         | 7836.8511           |
| 20         | 5281.819         | 5392.29             | 8283.315         | 7577.8171           |
| 21         | 5136.623         | 5260.516            | 8014.795         | 7309.0771           |
Figure 11: Storey shears of RCC and Hybrid Structure without shear walls and with shear walls.

5. Conclusion

The maximum storey displacement value produced by RCC structures with shear walls is 94.50 percent lower in the x-direction and 94.43 percent lower in the y-direction when compared to RCC structures without shear walls. When comparing Hybrid structures with shear walls to Hybrid structures without shear walls, that the maximum storey displacement is reduced by 94.87 percent in x direction and 94.38
percent in y direction, when compared to RCC structures without shear walls, RCC structures with shear walls have a maximum storey drift value that is 97.67 percent lower in the x-direction and 95.01 percent lower in the y-direction. When comparing Hybrid structures with shear walls to Hybrid structures without shear walls, the maximum storey drift value in the x-direction is 94.97 percent, and the maximum storey drift value in the y-direction is 94.48 percent. Both RCC and Hybrid structures with shear walls had lower storey displacement and storey drift values than RCC and Hybrid buildings without shear walls, as proven in this paper. According to the conclusions of this study, shear wall systems should be used in seismic prone areas to reduce storey displacement and storey drift values and keep them under limitation values. Storey shear value produced by RCC structures with shear walls is 13.60 percent higher than RCC structures without shear walls. Steel-concrete hybrid building with shear walls has a storey shear value that is 15.17 percent higher than a steel-concrete hybrid structure without shear walls. The storey shear and base shear values obtained for both RCC and hybrid buildings with shear walls are higher than for RCC and hybrid structures without shear walls, because of the increased seismic weight of the building.

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