IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Impact Factor: 6.252
Volume 2, Issue 2, February 2022

# Effect of Positions and Orientations of Shear Wall in Structure

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**Abstract:** *Shear wall systems are one of the most feasible and hence commonly used lateral loads resisting mechanism in high rise buildings. The position & orientation of these walls has effect on the stiffness of each floor in the structure, the diaphragm, centre of mass displacement, and the drift of floor. Stiffness and strength parameters can be utilized to resist large horizontal loads and support gravity loads simultaneously. Incorporation of shear walls has now become inevitable in multi-storey buildings so as to resist the lateral forces. Hence it is very necessary to determine the most effective location of shear walls. Structural engineers preferred to distribute the walls in buildings to make the centre of mass almost close enough to the centre of rigidity, but to make this condition satisfied, they have many choices construct the walls on the perimeter, or use intermediate walls, side wall, corner wall etc. Effectiveness of shear wall has been studied with the help of four different models. Model one is RCC frame structural system and other four models are shear wall orientation & positions structural system. Analysis is carried out by using ETAB. The comparison of these models for different parameters like Displacement, Storey Drift and Story Shear has been presented by adding shear wall with column. Shear walls possess adequate lateral stiffness to reduce inter-storey distortions due to earthquake-induced motions. In this chapter, analysis of shear walls with a moment resisting frame using the Khan and S barounis method is discussed. When two or more shear walls are connected by a system of beams or slabs total stiffness exceeds the summation of individual stiffness. Openings normally occur in vertical rows throughout the height of the wall and the connection between wall cross-sections is provided by connecting beams. Such shear walls are called coupled shear walls. The analysis of coupled shear walls by Rosman's continuous medium method is also discussed.*

**Keywords:** Progressive collapse, SAP2000, Alternate load path method, Through Type Bridge

## I. INTRODUCTION

Reinforced concrete shear walls are used in building to resist lateral force due to wind and earthquakes. Shear walls are usually provided near stair case, lift, in shafts that house other utilities. Shear wall provide lateral load resistance by transferring the wind or earthquake load to foundation. Besides, they impart lateral stiffness to the system and also carry gravity loads. Shear walls provide large strength and stiffness to buildings in the direction of their orientation, which significantly reduces lateral sway of the building and thereby reduces damage to structure. Shear wall behave like flexural members. They are usually provided in tall buildings to avoid collapse of buildings to lateral forces. Shear wall may become imperative from the point of view of economy and control of lateral deflection. When shear wall is situated in advantageous positions in the building, they can form an efficient lateral force resisting system.

Shear wall is a structural member used to resist lateral forces, that is, parallel to the plane of the wall. For slender walls where the flexural deformation is more, shear wall resists the loads due to cantilever action. In other words, shear walls are vertical elements of the horizontal force resisting system. In this type, concrete structures are generally designed in such a way that the lateral seismic load and gravity load is bearing by consistent shear walls. These structures have no beams or columns, and the earthquake-resistant system relies solely on concrete shear walls Shear wall is a structural member used to resist lateral forces i.e. parallel to the plane of the wall. For slender walls where the bending deformation is more, Shear wall resists the loads due to Cantilever Action. In other words, Shear walls are vertical elements of the horizontal force resisting system. In building construction, a rigid vertical diaphragm capable of transferring lateral forces from exterior walls, floors, and roofs to the ground foundation in a direction parallel to their planes. Examples are the reinforced-concrete wall. Lateral forces caused by wind, earthquake, and uneven settlement loads, in addition to the weight of structure and occupants; create powerful twisting (torsional) forces. This leads to the failure of the structures by shear. Shear walls are especially important in high-rise buildings subject to lateral wind and seismic forces. Generally, shear walls are either plane or flanged in section, while core walls consist of channel sections. They also provide adequate strength and stiffness to control lateral displacements.

The shape and plan position of the shear wall influences the behaviour of the structure considerably. Structurally, the best position for the shear walls is in the centre of each half of the building. This is rarely practical, since it also utilizes the space a lot, so they are positioned at the ends. It is better to use walls with no openings in them. So, usually, the walls around lift shafts and stairwells are used. Also, walls on the sides of buildings that have no windows can be used.

### 1.1 Advantages of Shear Wall

- Very good earthquake performance, if properly designed.
- They are easy in construction and implementation.
- These walls minimize the damages to structural and non-structural elements.
- It requires less construction time.
- Better performance than normal RCC structure.

### 1.2 Disadvantages of Shear Wall

- Shear walls are difficult to construct.
- They have a flimsy appearance.
- Also, loud banging sounds associated with the buckling of web plates.
- It has low stiffness and energy dissipation capacity.
- Also, requires large moment connections.

### 1.3 Applications of Shear Wall

Shear walls are designed to resist gravity / vertical loads and earthquake/wind lateral loads.

- These types are structurally combined with the roof or the floor. Other lateral walls run at right angles to provide three-dimensional stability to STR
- The walls have to resist uplift forces due to air drag.
- These walls resist the shear forces that try to push the walls up and the lateral forces of air that push the walls in and out of the structure.
- This shear walls structural system is extra stable.
- The supporting area is comparatively high compared to RCC framed structures.

## II. Structural & Geometrical Properties

Etabs software is used to prepare model and static analysis is performed using following structural & geometrical properties of the building as specified in Table No. 1.

**Table No 2.1:** Structural & Geometrical Properties

| Sr No. | Specification | Description |
|---|---|---|
| 1 | Plan Dimension | 17.4m*17.5m |
| 2 | Length along X direction | 17.5m |
| 3 | Length along Y direction | 17.5m |
| 4 | Floor to floor height | 3m |
| 5 | Total height of building | 45m (15 floors) |

<table>
<tr><td>6</td><td>Slab thickness</td><td colspan="6">0.130 m</td></tr>
<tr><td>7</td><td>Column (mm)</td><td colspan="6">350*600, 400*500</td></tr>
<tr><td>8</td><td>Beam (mm)</td><td colspan="6">300*500</td></tr>
<tr><td>9</td><td>Type of structure</td><td colspan="6">RCC</td></tr>
<tr><td>10</td><td>Soil type</td><td colspan="6">Medium (II)</td></tr>
<tr><td>11</td><td>Response reduction factor</td><td colspan="6">5</td></tr>
<tr><td>12</td><td>Importance factor</td><td colspan="6">1</td></tr>
<tr><td>13</td><td>Seismic zone factor</td><td colspan="6">0.16</td></tr>
<tr><td>14</td><td>Seismic zone</td><td colspan="6">2</td></tr>
<tr><td>15</td><td>Joints</td><td colspan="6">Fixed</td></tr>
<tr><td>16</td><td>Grade of concrete</td><td colspan="6">M30</td></tr>
<tr><td>17</td><td>Grade of steel</td><td colspan="6">Fe 500</td></tr>
<tr><td rowspan="2">18</td><td rowspan="2">Load Applied on slab (KN/m2)</td><td colspan="2">DL</td><td colspan="2">LL</td><td colspan="2">FF</td></tr>
<tr><td colspan="2">3.75</td><td colspan="2">3</td><td colspan="2">1</td></tr>
<tr><td>19</td><td>Brick Load on Beam (AAC block)</td><td colspan="6">3.6 KN/m</td></tr>
<tr><td rowspan="2">20</td><td rowspan="2">Mass source (Load factor)</td><td colspan="3">DL</td><td colspan="3">LL</td></tr>
<tr><td colspan="3">1.2</td><td colspan="3">0.5</td></tr>
<tr><td>21</td><td>Load comb for result</td><td colspan="6">1.2DL+1.2LL+0.9WL+0.9EQ</td></tr>
<tr><td rowspan="2">22</td><td rowspan="2">Response spectrum analysis</td><td colspan="3">Scale Factor (Sa/g)</td><td colspan="3">Combination method</td></tr>
<tr><td colspan="3">981</td><td colspan="3">CQC</td></tr>
<tr><td>23</td><td>Wind speed (m/s)</td><td colspan="6">39</td></tr>
<tr><td>24</td><td>Diaphragms</td><td colspan="6">D1</td></tr>
</table>

## III. Building Models

Different locations or positions of shear wall was placed for the structure as follows

1. Case 1: - Normal column RCC structure.
2. Case 2: - Shear wall at the corner.
3. Case 3: - Shear wall at the center.
4. Case 4: - Shear wall at the near center.
5. Case 5: - Shear wall at the outer middle side portion.

### 3.1 CASE 1 (Normal column RCC Structure)

In normal RCC structure we have construct a building in simple manner like vertical loading is sustain by columns and load distribution sustain by beams transfer to the column. In that case through load distribution on structure may be not be appropriate in any extreme condition or case as compare to shear wall structure. Normal RCC Structure shows as follows:

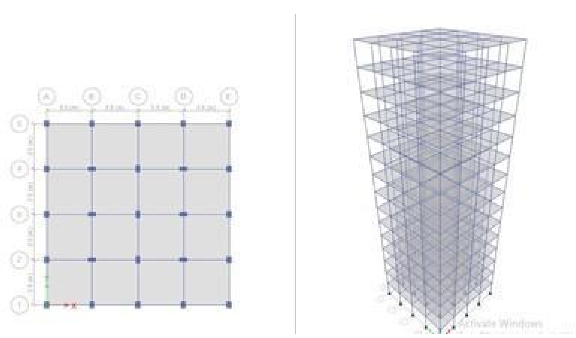

**Figure 3.1:** Case 1 Normal column RCC Structure

IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

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Impact Factor: 6.252

### 3.2 CASE 2 (Shear wall at Corner)

In such a case shear walls carry loads of structure like torsion, which is acting on corner of structure. Also this location of shear wall carries max load coming from wind & earthquake.

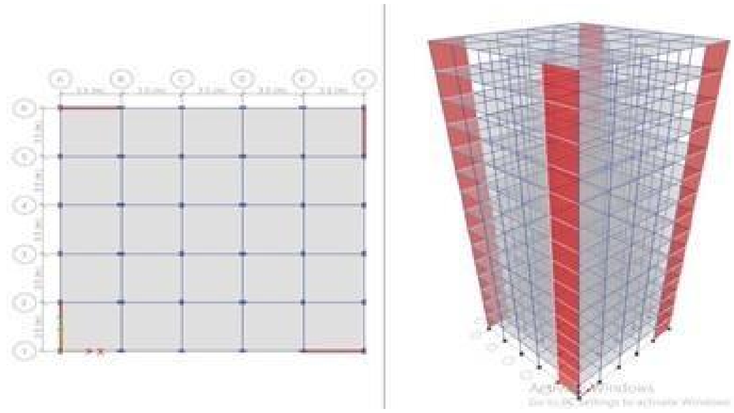

**Figure 3.2: Case 2 Shear wall at Corner**

### 3.3 CASE 3 (Shear wall Center)

In this case of shear wall in structure, structure resist more amount of forces which is coming on structure by various ways like Dead, live, wind, earthquake loads and stand within the limits of stresses of material.

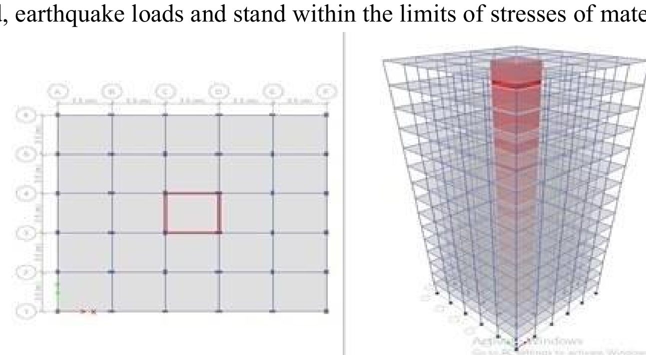

**Figure 3.3:** Case 3 Shear wall at the Center

### 3.4 CASE 4 (Shear wall at Near Center)

In this case of shear wall having the same function like SW putting in center of structure in structure, structure resist more amount of forces which is coming on structure by various ways like Dead, live, wind, earthquake loads and stand within the limits of stresses of material.

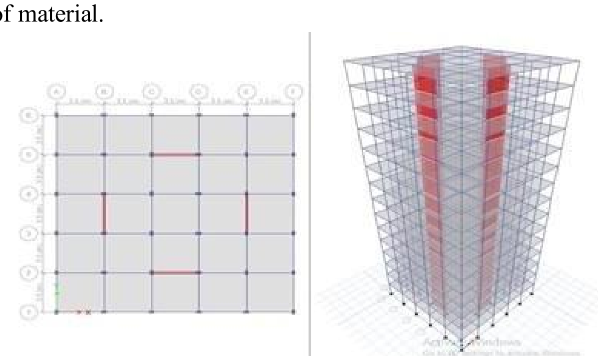

**Figure 3.4:** Case 4 Shear wall at Near Centre

**3.5 CASE 5 (Shear Wall at the Outer middle side of the Portion)**

In this case of shear wall structure, structure resist more amount of forces which is coming on structure by various ways like Dead, live, wind, earthquake loads and stand within the limits of stresses of material.

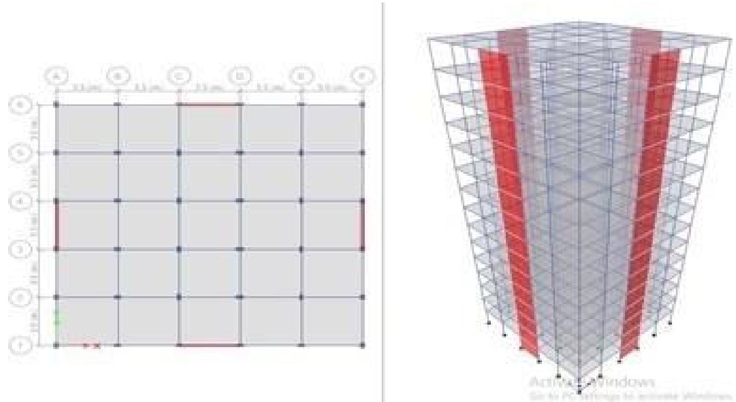

**Figure 3.5:** Case 5 Shear Wall at the Outer middle side of the Portion

## IV. Analysis

### 4.1 Types of Seimic Analysis

**A. Response Spectrum analysis**

This method is applicable for those structures where other than the fundamental one affect significantly the response of the structure. The response of the structure can be defined as the combination of modes. The modes of structure can be analyzed by any software. A response of mode can be analyzed from design spectrum, based on modal mass and modal frequency. Magnitude of forces in all directions is calculated based upon the different combinations as follows:

1. Absolute – peak values
2. Square root of sum of the squares (SRSS)
3. Complete quadratic combination (CQC) – for closely spaced modes,

A method improved on Square root of sum of the squares . In this case structures are too tall, too irregular or of significance to a community in disaster management, and more complex analysis are required, such as non-linear static or dynamic analysis.

**B. Elastic Time History Analysis**

A linear time history overcomes all the drawbacks of modal response spectrum analysis, provided non-linear behavior is not involved. It requires greater computational efforts for calculating the response at discrete intervals. One interesting advantage of such procedure is that the relative signs of response quantities are preserved in the response histories. This is important when interaction effects are considered in design among stress resultants.

The analysis of proposed model was carried out for following parameter.

1. Drift
2. Storey displacement
3. Shear force
4. Bending moment
5. Stiffness

## V. Result and Discussion

The results show the shear wall implementation in structure gives us the better results than the normal ordinary structure. The stability of the structure is more effective in the shear wall structure and reduces the displacement, drift, bending movement in structure.

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### 5.1 Maximum Final Results

**Table 5.1:** Final Result (Max Only)

| | CASE 1 | CASE 2 | CASE 3 | CASE 4 | CASE 5 |
|---|---|---|---|---|---|
| **Avg. Drift (X&Y)** | 0.002792 | 0.0015295 | 0.001476 | 0.0016 | 0.001657 |
| **Displacement** | 90.385 | 46.518 | 54.377 | 55.347 | 58.835 |
| **Shear force** | 124.2 | 31.66 | 31.66 | 33.43 | 31.53 |
| **Bending moment** | 209.14 | 47.4 | 47.4 | 52.07 | 50.06 |
| **Avg. Stiffness (X&Y)** | 380609.4 | 1534355.2 | 2090911 | 1784693 | 1695546 |

### A. Drift Result

Drift is one of the concerns meanwhile wind & earthquake forces acting on the building. As below result shear wall at Fig. 6, case 3 (centre) provides most feasible condition to reduce the drift of the building. According to provision of IS code 1893- 2002 (cl 7.11.1, pg. 27) claims that storey drift should be limited to (0.004*H).

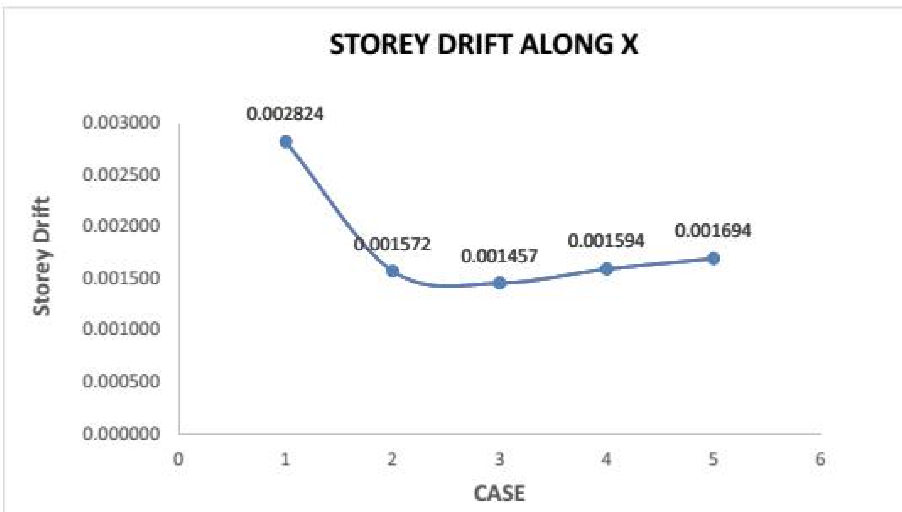


**Figure 5.1:** Comparative Graph for Story Drift Along X Direction

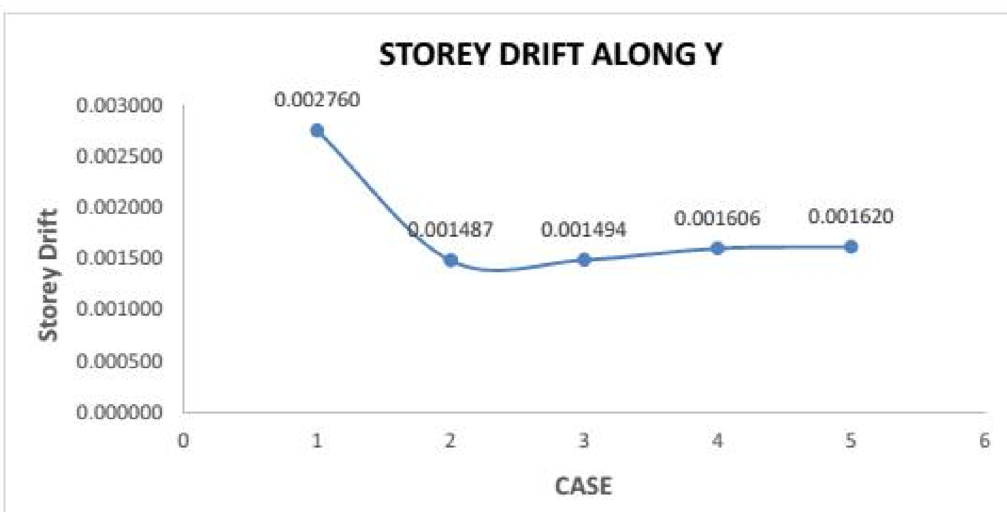


**Figure 5.2:** Comparative Graph for Story Drift Along Y Direction

**B. Storey Displacement**

According to provision of the IS codes 1893-2002, It permits max storey displacement up to (H/500). In displacement analysis case 2 (corner) has the best result for stability of structure.

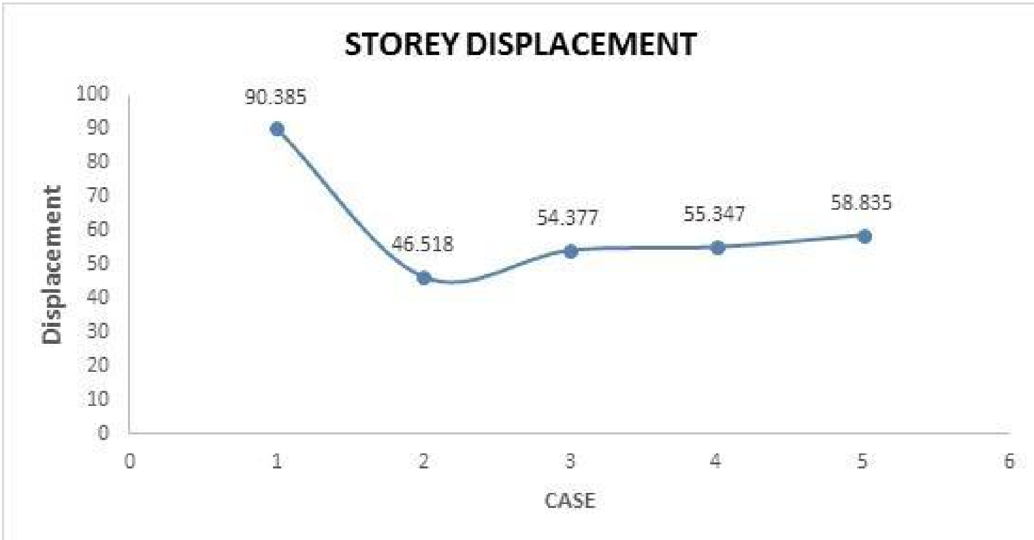


**Figure 5.3:** Comparative Graph for Story Displacement

**C. Shear Force**

Shear force in the column at the ground storey is maximum in rigid frame structure as compare to another model analysis. Shear wall significantly minimizes the shear forces develop in structure.

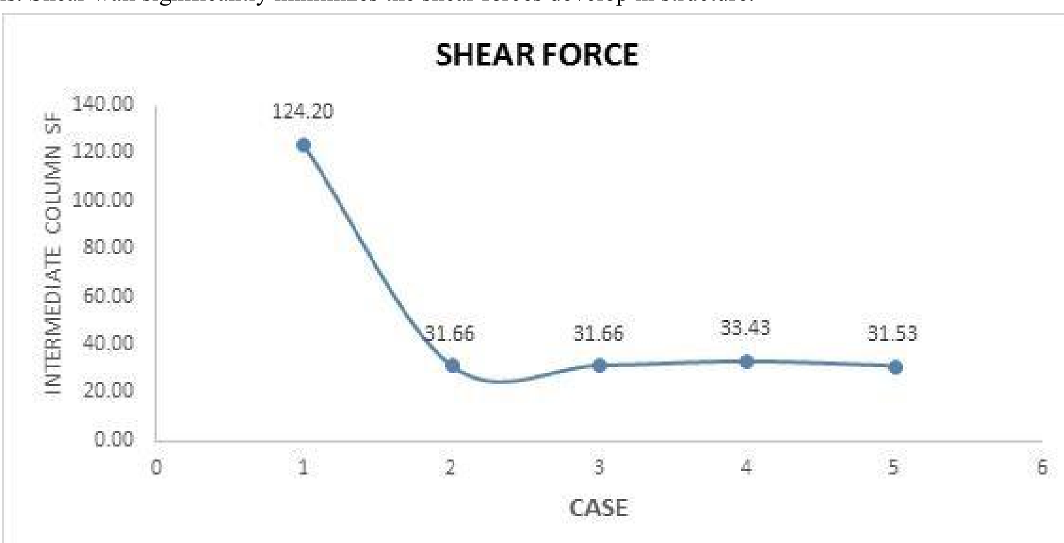


**Figure 5.4:** Comparative Graph for Shear Force

**D. Bending Moment**

Bending moment in column at the ground level always has maximum value and it reduces significantly by providing shear wall.

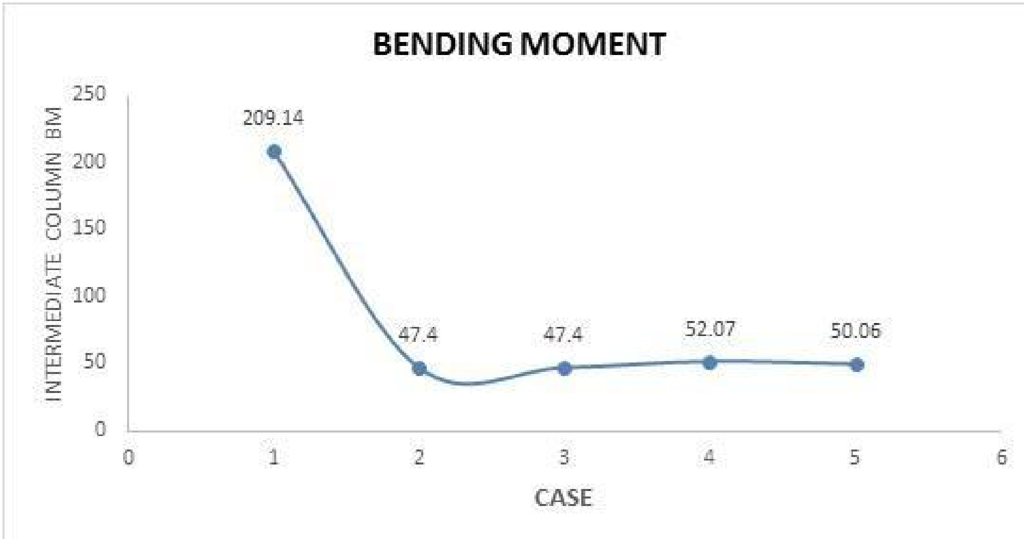


**Figure 5.5:** Comparative Graph for Bending Moment

**E. Stiffness**

Stiffness of the structure plays the important role in stability of structure. According to results below shear wall provides complementary stiffness results than normal RCC structure.

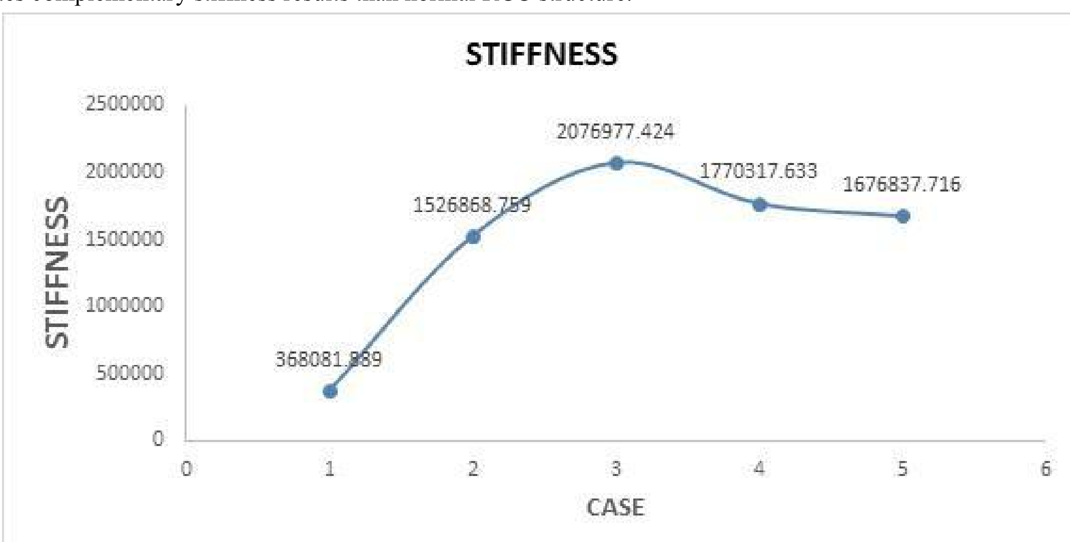


**Figure 5.6:** Comparative Graph for Stiffness

## VI. Conclusion

1. Following conclusions were obtained from the results discussion
2. Shear wall implementation in rigid frame structure gives us more complementary results for appropriate stability.
3. Shear wall system benefits the (% term) result as follows
   a. Drift – 45% approx.
   b. Displacement – 41% approx.
   c. Shear force – 73% approx.

d. Bending moment – 76% approx.
**e.** Stiffness – 78% approx.

4. We get the key idea about shear wall orientation & positions effectiveness in structure.
5. Shear wall highly resisting the lateral forces acting on the structural and also shear wall significantly increased the storey stiffness in all the storey level.
6. The higher values of storey shear were observed in CASE 3 as compared to all other Models.
7. Storey drift was more reduced by the presence of shear wall in the building and CASE 3 has the lower value of storey drift in comparison to all other Models.
8. As we place shear wall nearer to center or C.G. of structure get better result with standing all possibilities.
9. Providing shear wall near to center gives better result stiffness.
10. Overall shear force & bending moment as well reduces by implementing shear wall.

At different positions & orientations shear wall gives different result for various parameters.

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