Optimization of Stability of Building by Changing Thickness of Shear Wall at Corners for Same Concrete Grade

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Abstract— Stability is to ensure the safety of structures from collapsing. Stability theory is crucial for structural engineering, aerospace, nuclear engineering, coastal, ocean and arctic engineering. It plays an important role in certain problems of space structures, geotechnical structures, geophysics and materials science .The project deals with the Response Spectrum Analysis of G+20 storeys Residential Apartment for different models. Total 12 models are modeled under the variations in thickness Shear Wall Provided at Corners from 0.130m to 0.150m thickness. The structure consists of 5 m. spacing of grid with total 6 bays in both major directions. The plinth area is taken 30mx30m (900 m²). The earthquake structure analysis for zone III with the help of analysis software. The project concluded that stability of structure is increases with increment in the thickness of shear wall. The lateral load capacity is much more in shear wall structure and increment in it also increases. The optimum structures observed for the current project is OSW10 & 11 in terms of stability with respect to result parameters.

Keywords—Concrete Grade, Dual System, Dimension Change, Shear wall, Stability.

I. INTRODUCTION

A building is with stand under the lateral loads effect (earthquake) only when the building component is satisfying the lateral loads response. The shear wall is one of the important components in to it. Reinforced concrete (RC) buildings next to slabs, beams and columns often have vertical RC slab-like walls called shear walls. These walls usually start at the level of the foundation and are continuous throughout the height of the building. Their thickness can be up to 130 mm, or up to 450 mm high in tall buildings. Sliding walls are usually provided along the length and width of buildings. Shear walls are like vertically oriented wide beams that carry earthquake loads down to the foundation. The use of shear wall or their equivalents become mandatory in some high-rise building if inter storey deflection is controlled due to lateral loading. Shear walls also provides the solution against expensive non-structural harm during moderate seismic disturbance. The shear wall is actually a misnomer as far as tall buildings are concerned, when the lateral loads are applied to a tapered shear wall resulting in mainly momentary deflection and only very trivial shear deformation. Analysis of shear wall may appear as an important design element because high rise structures are continuously becoming taller and slender. More often than not, shear walls are pierced by multiple openings. This type of sliding walls is known as connected sliding walls. The walls on either side of the opening are interconnected by short, often deep beams that form part of the wall or floor slab, or both. If these walls are installed systematically, then an improvement in stability will be achieved in them.

II. SHEAR WALL

A structural component added to the multistoried building structure made up of stiff R. C. C. wall, is an additional member used to resist lateral effects on it. This R.C.C. vertical wall starts from foundation base to the top of the building. Ordinary RC structural walls and Ductile RC structural walls are classified by the Indian standardization. As per IS 13920, one doesn’t meet the special detailing requirements for ductile behavior is considered as the former one meet the special detailing requirements for ductile behavior is considered as the later.
III. OBJECTIVES OF THE PROJECT

This research is based on the variation in thickness of shear wall in G+20 Storey building. The following objectives are taken for these project areas follows:

- To Study about shear wall behavior with variation in different parameters.
- To Modeled a G+20 storey multistory Building by software approach.
- To find different results parameters such as Maximum displacement, Base shear, axial force, bending moment, Torsional moment & Stresses in required X Y and Z directions.
- To compare the OSW0 (regular model) with OSW1 to OSW11 model (1 to 11 is changing the thickness of shear wall from 0.130 m. to 0.150 m. in the interval added 0.002 m.).
- To find the optimum structure & thickness of shear wall structure in G+20 Storey model.

IV. MODELING AND ANALYSIS

The Different cases of G+20 Storey Residential Apartment with variation in Shear Wall thickness provided at corner are modeled by using fem based software. The Notations of cases are described in the table no. by OSWO to OSW11. Table 1 shows the Descriptions of model.

| S. No | Model Cases | Descriptions |
|-------|-------------|--------------|
| 1     | OSW0        | G+20 storey with no Shear Wall (Regular Structure) |
| 2     | OSW1        | G+20 storey with Shear Wall 0.130 thickness |
| 3     | OSW2        | G+20 storey with Shear Wall 0.132 thickness |
| 4     | OSW3        | G+20 storey with Shear Wall 0.134 thickness |
| 5     | OSW4        | G+20 storey with Shear Wall 0.136 thickness |
| 6     | OSW5        | G+20 storey with Shear Wall 0.138 thickness |
| 7     | OSW6        | G+20 storey with Shear Wall 0.140 thickness |
| 8     | OSW7        | G+20 storey with Shear Wall 0.142 thickness |
| 9     | OSW8        | G+20 storey with Shear Wall 0.144 |

Structural Parameters used in G+ 20 storey: Table 2 & Table 3 shows the basic parameters used in the analysis of building.

| S. No | Element Name | Description |
|-------|--------------|-------------|
| 1     | Building Types | Residential |
| 2     | No. of Storey | G+20 |
| 3     | Plinth Area  | 900 m² |
| 4     | Floor Height | 4.5 GF & 3.66 each floor |
| 5     | Dimensions of Beam | 0.50 m. x0.38 m. |
| 6     | Dimensions of Column | 0.55 m. x 0.60 m. |
| 7     | Slab Thickness | 0.150 m. |
| 8     | Shear wall | 0.130 m. thick(around lift area) At Corners: 0.130m, 0.132m, 0.134m, 0.136m. |
Earthquake Parameters used:
Table 3: Earthquake Parameters

| S. No. | Parameters          | Description                     |
|-------|--------------------|---------------------------------|
| 1     | Earthquake Code    | IS 1893(1):2016                 |
| 2     | Earthquake Zone    | III                             |
| 3     | Response Factor(IF) | 4                               |
| 4     | Importance Factor(IF) | 1.2                           |
| 5     | Soil Types         | Medium                          |
| 6     | Damping            | 0.05 (5%)                       |
| 7     | Time Period        | 1.3944 second.                  |
| 8     | Structural Type    | RCC Framed Building             |
| 9     | Earthquake method  | Response Spectrum Method        |

V. RESULTS AND DISCUSSION

The following results are to be obtained from the modeling and analysis of Multi storey building of G+20 Storey building in software. The results are as follows:

Table 4: Maximum Displacement for G+20 Storey for different Models

| Shear Wall Stability Case | Maximum Displacement(mm) For X Direction | Maximum Displacement(mm) For Z Direction |
|---------------------------|------------------------------------------|------------------------------------------|
| Case OSW0                 | 268.583                                  | 349.03                                   |
| Case OSW1                 | 242.32                                   | 323.801                                  |
| Case OSW2                 | 242.174                                  | 323.925                                  |
| Case OSW3                 | 242.03                                   | 324.049                                  |
| Case OSW4                 | 241.888                                  | 324.174                                  |
| Case OSW5                 | 241.746                                  | 324.299                                  |
| Case OSW6                 | 241.607                                  | 324.425                                  |
| Case OSW7                 | 241.468                                  | 324.551                                  |

Table 5: Base Shear for all Optimum Shear Wall Stability Case

| Shear Wall Stability Case | Base Shear (KN) |
|---------------------------|------------------|
|                           | X direction      | Z direction      |
| Case OSW0                 | 4957.557         | 4957.5451        |
| Case OSW1                 | 5146.7824        | 5146.7754        |
| Case OSW2                 | 5149.5729        | 5149.5649        |
| Case OSW3                 | 5152.3638        | 5152.3523        |
| Case OSW4                 | 5155.1486        | 5155.1414        |
| Case OSW5                 | 5157.9389        | 5157.9331        |
| Case OSW6                 | 5160.7287        | 5160.7212        |
| Case OSW7                 | 5163.5153        | 5163.5078        |
| Case OSW8                 | 5163.5153        | 5163.5074        |
| Case OSW9                 | 5169.0983        | 5169.0846        |
| Case OSW10                | 5171.8813        | 5171.8750        |
| Case OSW11                | 5174.6694        | 5174.6635        |
Fig. 3: Base Shear in X direction for all Optimum Shear Wall Stability Case

Fig. 4: Base Shear in Z direction for all Optimum Shear Wall Stability Case

Table 6: Maximum Axial Forces in Column for all Optimum Shear Wall Stability Case

| Shear Wall Stability Case | Column Axial Force (KN) |
|---------------------------|-------------------------|
| Case OSW0                 | 9189.2016               |
| Case OSW1                 | 8854.1918               |
| Case OSW2                 | 8856.7936               |
| Case OSW3                 | 8859.4052               |
| Case OSW4                 | 8862.0302               |
| Case OSW5                 | 8864.6715               |
| Case OSW6                 | 8867.3191               |
| Case OSW7                 | 8869.9753               |
| Case OSW8                 | 8875.3271               |
| Case OSW9                 | 8878.0194               |
| Case OSW10                | 8880.7201               |

Fig. 5: Maximum Axial Forces in Column for all Optimum Shear Wall Stability Case

Table 7: Maximum Shear Force in Column for all Shear Wall Stability Cases

| Shear Wall Stability Case | Column Shear Force (KN) | Shear along Y | Shear along Z |
|---------------------------|-------------------------|---------------|---------------|
| Case OSW0                 | 121.1855                | 122.829       |
| Case OSW1                 | 122.7198                | 121.8681      |
| Case OSW2                 | 122.9672                | 121.8993      |
| Case OSW3                 | 123.2112                | 121.9307      |
| Case OSW4                 | 123.4517                | 121.9623      |
| Case OSW5                 | 123.689                 | 121.8142      |
| Case OSW6                 | 123.923                 | 122.0263      |
| Case OSW7                 | 124.1539                | 122.0585      |
| Case OSW8                 | 124.1539                | 121.883       |
| Case OSW9                 | 124.6065                | 122.1238      |
| Case OSW10                | 124.8282                | 122.1567      |
| Case OSW11                | 125.0471                | 122.1898      |

Fig. 6: Maximum Shear Force in Column for all Optimum Shear Wall Stability Case
Table 8: Maximum Bending Moment in Column

| Shear Wall Stability Case | Column Bending Moment (KN.m) | Moment along Y | Moment along Z |
|---------------------------|-----------------------------|----------------|----------------|
| Case OSW0                 | 208.5969                    | 220.4408       |                |
| Case OSW1                 | 207.521                     | 202.4762       |                |
| Case OSW2                 | 207.8065                    | 202.8719       |                |
| Case OSW3                 | 207.8612                    | 203.2622       |                |
| Case OSW4                 | 207.9163                    | 203.6469       |                |
| Case OSW5                 | 207.9719                    | 204.0266       |                |
| Case OSW6                 | 208.0278                    | 204.4011       |                |
| Case OSW7                 | 208.0839                    | 204.7706       |                |
| Case OSW8                 | 208.0839                    | 204.7706       |                |
| Case OSW9                 | 208.1974                    | 205.4952       |                |
| Case OSW10                | 208.2547                    | 205.8502       |                |
| Case OSW11                | 208.3124                    | 206.2007       |                |

Fig.7: Maximum Bending Moment in Column

Table 9: Maximum Shear Force in Beam for all Optimum Shear Wall Stability Case

| Shear Wall Stability Case | Beam Shear Force (KN) | Shear along Y | Shear along Z |
|---------------------------|-----------------------|---------------|---------------|
| Case OSW0                 | 155.6581              | 1.1827        |               |
| Case OSW1                 | 147.4593              | 0.2535        |               |
| Case OSW2                 | 147.5962              | 0.2526        |               |
| Case OSW3                 | 147.7309              | 0.2517        |               |
| Case OSW4                 | 147.8633              | 0.2508        |               |

Fig.8: Representation of Maximum Shear Force in Beam

Table 10: Maximum Bending Moment in Beam for all Optimum Shear Wall Stability Case

| Shear Wall Stability Case | Beam Bending Moment (KN.m) | Moment along Y | Moment along Z |
|---------------------------|-----------------------------|----------------|----------------|
| Case OSW0                 | 147.9938                    | 0.25           |                |
| Case OSW6                 | 147.1222                    | 0.2492         |                |
| Case OSW7                 | 148.2485                    | 0.2484         |                |
| Case OSW8                 | 148.2485                    | 0.2485         |                |
| Case OSW9                 | 148.4955                    | 0.2469         |                |
| Case OSW10                | 148.616                     | 0.2461         |                |
| Case OSW11                | 148.7347                    | 0.2454         |                |
Table 11: Maximum Torsional Moments in Beam & Column Results

| Shear Wall Stability Case | Beam Torsional Moments (KN.m) | Column Torsional Moments (KN.m) |
|---------------------------|-------------------------------|-------------------------------|
| Case OSW0                 | 8.7148                        | 19.8112                       |
| Case OSW1                 | 9.5852                        | 4.5013                        |
| Case OSW2                 | 9.5909                        | 4.4919                        |
| Case OSW3                 | 9.7109                        | 4.4826                        |
| Case OSW4                 | 9.6023                        | 4.4734                        |
| Case OSW5                 | 9.6079                        | 4.4642                        |
| Case OSW6                 | 9.6136                        | 4.4551                        |
| Case OSW7                 | 9.6192                        | 4.446                         |
| Case OSW8                 | 9.6192                        | 4.446                         |
| Case OSW9                 | 9.6304                        | 4.4281                        |
| Case OSW10                | 9.6359                        | 4.4193                        |
| Case OSW11                | 9.6415                        | 4.4105                        |

Fig.9: Representation of Maximum Bending Moment in Beam

Fig.10: Bar chart of Maximum Torsional Moments in Beams

Fig.11: Bar chart of Maximum Torsional Moments in Columns

Table 12: Maximum Principal Stresses for all Optimum Shear Wall Stability Case

| Shear Wall Stability Case | Maximum Principal Stresses (Smax Top) (N/sq. mm) | Maximum Von Mises Stresses (SVM Top) (N/sq. mm) | Maximum Shearing Stresses (S12) (N/sq. mm) |
|---------------------------|--------------------------------------------------|--------------------------------------------------|---------------------------------------------|
| Case OSW0                 | 20.66                                            | 25.75                                            | 8.2                                         |
| Case OSW1                 | 18.75                                            | 24.18                                            | 4.46                                        |
| Case OSW2                 | 18.76                                            | 24.19                                            | 4.47                                        |
| Case OSW3                 | 18.77                                            | 24.2                                             | 4.47                                        |
| Case OSW4                 | 18.78                                            | 24.2                                             | 4.47                                        |
| Case OSW5                 | 18.79                                            | 24.2                                             | 4.47                                        |
| Case OSW6                 | 18.8                                             | 24.2                                             | 4.47                                        |
| Case OSW7                 | 18.8                                             | 24.2                                             | 4.48                                        |
| Case OSW8                 | 18.8                                             | 24.2                                             | 4.48                                        |
| Case OSW9                 | 18.8                                             | 24.2                                             | 4.48                                        |
| Case OSW10                | 18.83                                            | 24.25                                            | 4.48                                        |
| Case OSW11                | 18.84                                            | 24.26                                            | 4.48                                        |
VI. CONCLUSIONS

The following conclusions are obtained based the different results obtained of model OSW0 to model OSW11.

The Response spectrum approach is adopted in it. The entire conclusion are valid only and only for this project. The conclusions are as follows:

1. There is decrement in storey displacement of 9.78%, 9.83%, 9.89%, 9.90%, 9.94%, 10.04%, 10.10%, 10.20%, 10.30% is observed in model OSW1 to OSW11 with respect to OSW0 (reference model) in X direction. Similarly 7.23%, 7.19%, 7.16%, 7.12%, 7.09%, 7.055%, 7.01%, 7.01%, 6.94%, 6.90%, 6.86% with respect to OSW0 (reference model) in Z-direction.

2. There is increment is observed in base shear which is 3.82%, 3.87%, 3.93%, 3.99%, 4.04%, 4.10%, 4.15% 4.15% 4.27%, 4.32%, 4.38% in OSW1 to OSW11 models with reference to basic model in both major direction.

3. The axial forces value is also reduces in OSW1 to OSW11 which is 3.65%, 3.62%, 3.59%, 3.56%, 3.53%, 3.50%, 3.47%, 3.47%, 3.42%, 3.39%, 3.36% with references to OSW0.

4. There is increment in column shear force in OSW1 to OSW11 which is 1.27%, 1.47%, 1.67%, 1.87%, 2.07%, 2.26%, 2.45%, 2.45%, 2.82%, 3.01%, 3.19%, with respect to basic structure in X direction. Similarly in Z direction decrement is observed 0.78%, 0.76%, 0.73%, 0.71%, 0.71%, 0.83%, 0.65%, 0.63%, 0.77%, 0.57%, 0.55%, 0.52%.

5. There is minute reduction of 0.14% to 0.50% observed in bending moment in column in the models having shear wall variation with thickness in x Direction. But in case of z direction decrement value is observed in between 6 to 8 % with respect to normal model.

6. There is reduction in beam shear force is observed. The average 5% & 78 % reduction in Y & Z direction respectively in shear wall models with reference to regular model.

7. There is reduction in bending moment in beam is observed. The average 76.50 % & 2.65 % reduction in Y & Z direction respectively in shear wall models with reference to regular model.

8. The increment in value of Torsional moment in beam is observed which is 9.99%, 10.05%, 11.43%, 10.18%, 10.25%, 10.31%, 10.38%, 10.38%, 10.51%, 10.57%, 10.63%, in OSW1 to OSW11 models with respect to basic model.

9. The decrement in value of Torsional moment in column is observed which is 77.28%, 77.33%, 77.37%, 77.42%, 77.47%, 77.51%, 77.56%, 77.56%, 77.65%, 77.69%, 77.74% in OSW1 to OSW11 models with respect to regular model(OSW).

10. The reduction is observed in stresses when increment in shear wall thickness in models. The avg. 9%, 6%, 45% reduction in stresses i.e. Maximum Principal Stresses Maximum, Von Mises Stresses, Maximum Shearing Stresses respectively with reference to regular model stresses.
The final concluded that there is decrement is observed on affected parameters on the structure with increment in shear wall thickness. The lateral loads resisting capacity is improved with increment in thickness in shear wall. The optimum structure is observed is OSW10 & 11.

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