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Comparative Analysis of an RC framed building under Seismic Conditions.

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Abstract - *India has suffered four great earthquakes of magnitudes 8.5 and greater, in the past hundred years yet human memory being short, it is generally not recognized that we continue to live under the long shadow of such future calamities. Due to Improper design of the structure without seismic resistance many buildings have collapsed and lives have lost during earthquakes. . Different shapes and materials of buildings have been used to achieve the strength required to withstand the earthquake. In modern era, lots of seismic force resisting techniques are being used to make a structure/building earthquake resistant. These techniques include introducing Shear walls, Bracings, base isolation, column jacketing etc. to enhance the structure. We discuss the work done by various authors on Different type of Failures due to Earthquake along with the Design and Analysis of Structure in Earthquake prone Area and present a Comparative analysis of earthquake resisting techniques on a G+10 story building with the help of different types of Shear walls & Bracings, using software. The comparison is done between: an un-Resisting structure, parallel shear walls, corner shear wall, X shaped bracing at bracings at middle bays, X-shaped bracings at corners and X shaped bracings in whole structure. The use of shear walls and bracings helps to strengthen the structure to make it more Earthquake resistant. The analysis in done on a G+10 building for Delhi region as per IS 1893:2016 provisions. The software that we have used to carry out this analysis is Staad pro v8.*

***Key Words*: Static Analysis, Comparative Analysis, STAAD pro, Shear Wall, Bracing, Seismic Conditions, Earthquake.**

1. INTRODUCTION

From the history of earth, Earthquake is sudden violent shaking or Vibrations of the ground. Earthquake caused by tectonic movement in earth Crust and also caused by sudden slip on a fault or rupture of geological faults, But also by other events (natural & artificial causes) such as volcanic activity, Landslides, mine blasts and nuclear tests. In recent studies geologist claim that global warming is one of the Reason for seismic activity. According to these studies melting glaciers and Rising sea level disturb the balance of pressure on earth tectonic plates thus causing increase in frequency and intensity of earthquakes results in Damages structure & property of nation. Hence, earthquake is a major problem by development of nation & great Challenge for structural engineer to construct building in seismic region (Zones). Hence, structure should be analyzed for earthquake forces to avoid the damages. Generally Structure having two types of loading that is static loading and dynamic loading. Static loads are Constant and dynamic loads are change with time. In maximum civil buildings or structures only static loads are considered and dynamic loads are not calculated because of more complications in calculation. . In India various previous examples can be noted including Bhuj 2005 where thousands of lives got suffered and thousands of structures got destroyed because of earthquake. Hence there was a need to make the structure earthquake resistant in order to minimize the destruction of structures and human life these various techniques are being implemented on structure to make them seismically resistant or earthquake resistant. These techniques include addition of various structural elements like share walls, bracings, base isolation dampers etc. In this paper I am discussing the comparative analysis of various earth quake resistant techniques on a 10-story building usingsoftware. In this paper complete static analysis is performed by using STAAD-Pro software.

1.1 SEISMIC RESISTANCE TECHNIQUES

Addition of Shear walls: Shear wall is a seismic restraint member used to oppose lateral forces parallel to the wall. Shear wall opposes the loads due to Cantilever Action. So, Shear walls are vertical components of the horizontal or lateral force resisting

Addition of Bracing: A braced frame is a framework used in structures to resist horizontal loads, for example, wind and seismic pressure. They are commonly made of basic steel, which when exposed both tension and compression, work efficiently. The beams and columns that form the frame carry vertical loads, and the bracing system carries the lateral loads. The shafts and sections that structure the frame convey vertical burdens, and the propping framework conveys the sidelong loads.

2. METHEDOLOGY

The methodology worked out to achieve the mentioned objectives is as follows:

1. Modeling of the selected building in Staad pro. V8i Software.
2. Five models as per the Indian code specification were prepared. Models including Bare frame, frames with shear walls and frames with bracings.
3. Load combinations as per IS 875- part 1 and IS 1893-2016(part 10 were appliedand all the models analyzed for axial forces, moments, lateral displacements, max shear, storey displacement, storey drift and graphical and tabular representation ofthe data is presented

3. ANALYSIS TECHNIQUES USED ON STAAD PRO.

1. Max deflection: Max deflection can also be called the Top deflection of the structure. It is the maximum extent to which the structure displaces in X & Z direction under earthquake loads in both perpendicular directions.
2. Story drift: Story displacement is the absolute value of displacement of the storey under action of the lateral forces
3. Story shear: The design seismic force to be applied at each floor level is called storey shear.
4. Maximum Axial force: The Axial Force is generally defined as the Force acting along the axis of a member. The maximum axial force is mostly experienced at the base of the structure, at the bottom most columns.

4. BUILDING MODELLING.

4.1 General

In this project we modelled a G+10 storey building with same floor plan with 4 bays having same lengths of 3 m along the longitudinal and the transverse direction as shown in figure. The buildings are modelled using software -STAAD-PRO V8i.

4.2 Input Data

4.3 Loading Details

- Dead Load Slab: Thickness assume = 150 mm Floor Finish = 75mm
- Live Load All Floor = 2 kN/m 2
- Wall loads external wall: 230mm thick wall for 3.0 heights Thickness of wall 'b' - 0.23m Height of walls 'h' - 3.0 m
- Unit weight of brick masonry γ - 19.2kN/m3 = 0.23 x 3.0 x 19.2 Total load h*b* γ = -13.248 kN/m3
- Internal or partition walls: 150mm thick wall for height 3.0m Thickness of wall 'b' - 0.12m Height of walls 'h' - 3.0m
- Unit weight of brick masonry 'γ' - 19.2kN/m3 = 0.12 x 3.0 x 19.2 Total load h*b* γ = -6.912 kN/m3

Type of structure:	multi-storey fixed jointed plane frame.
Number of stories	11 (G+10).
Floor height	3 m
Seismic zone	IV(DELHI region) (IS 1893 (part1):2016).
Materials Concrete	(M 35)
Reinforcement	(Fe415).
Bay sizes in the X-direction	3m, 3m, 3m & 3m - 4 bays
Bay sizes in the Z-direction	3m, 3m, 3m & 3m 3 bays.
Thickness of Wall Externalwall	230mm
Thickness of Internal wall	150mm
Column	450 x 450 mm (for all columns)
Beam	300 x 300 mm (for all beams).
Type of soil	medium soil

4.4 Load Combination

The analysis has been done for the dead load (DL), live load (IL), & earthquake load(EL) in all the directions i.e. sway to left (-EL) and sway to right (EL) by using software Staad pro. The combination of loads has been made according to cl 6.3 of IS 1893 (Part 1) Load Combination for Earthquake Design

Load combinations that are to be used for Limit state Design of reinforced concrete structure are listed below. (1) 1.5(DL + LL),(2) 1.2(DL + LL ± EQ - X),(3) 1.2(DL + LL ± EQ - Y), (4) 1.5(DL ± EQ - X),(5) 1.5(DL ± EQ - Y),(6) 0.9DL ± 1.5EQ – X,(7) 0.9DL ± 1.5EQ – Y.

4.5 Earthquake Loads

Loads are calculated as per IS 1893:2016 (Part 1)Seismic parameters considered for analysis are Table-2:

Table -1: Earthquake load table

Seismic Intensity	Zone IV
Zone factor (Z)	0.24
Response Reduction Factor (R)	5
Importance factor	Soil type Medium soil Damping 5 % The design horizontal seismic coefficient Ah for the structure shall be calculated as follows, (IS:1893- 2002, Cl.6.4.2)

5. ANALYSIS

Analysis of building is one using STAAD Pro.The models were prepared in the STADD Pro. Software by using different types of RC shear wall viz. Parallel Shearwall and Cornered shear wall and these are located at different location such as along periphery and at corner. And also, analysis is done by modelling structure with Diagonal and Cross type Bracings.

1. Base Structure (without seismic restraints) A base structure is modelled onlywith the use of columns and beams, and no additional seismic restraints are used. This the plain or base structure that will be further used for comparisonwith other models with additional seismic restraints. The following structure is a G+10 story building designed on staad pro having no seismic restraints.

2. Parallel Shear Walls Model is prepared using staad pro software where the high rise structure is embedded & supported with shear wall on all four sides.The plan dimensions the shear wall is given as (8m x 0.200m) from the base to the roof i.e. 33 m. As the Shear walls are in parallel direction with respect to the two directions of earthquake EQX &EQZ, it is names as Parallel Shearwalls.

3. Corner Shear Walls Model is prepared using staad pro software where the high rise structure is embedded & supported with shear wall on all four Corners of the building .The shear wall installed here is a L-Shaped shear wall with plan dimensions given as (4m x 0.200m)+(4m x 0.200m) from the base to the roof i.e. 33 m.

4. Bracing- Crossed Model is prepared using staad pro software where the high rise structure framework is embedded & supported with steel bracings. The steel bracing used is an angle section having dimensions ISA 100x100x12. The bracings are connected diagonally throughout the framework from one columnbeam joint to another.

5. Bracing- Crossed Model is prepared using staad pro software where the high rise structure framework is embedded & supported with steel bracings. The steel bracing used is an angle section having dimensions ISA 100x100x12. The bracings are connected diagonally at middle portion of the framework from at all sides of the frame.

6. Bracing- Crossed Model is prepared using staad pro software where the high rise structure framework is embedded & supported with steel bracings. The steel bracing used is an angle section having dimensions ISA 100x100x12. The bracings are connected at all corners of the framework.

7. Combination of bracing and shear wall is used to prepare two models as perconfigurations given in diagram.

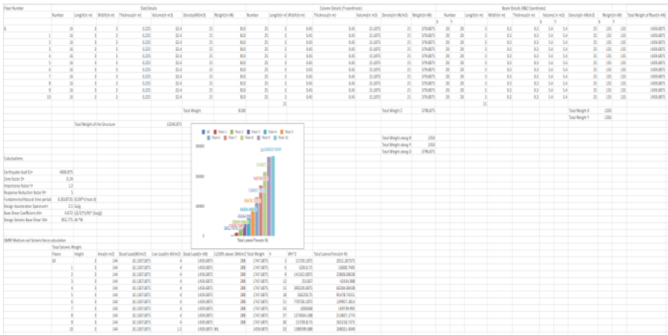

Figure 1: Static Analysis on Excel

Link: https://docs.google.com/spreadsheets/d/1fiY2eBzZ2P40-vZsiMlKAoiP9zNP4eGofAtJdh4f5C8/edit?usp=sharing

5.1 Bending Moment

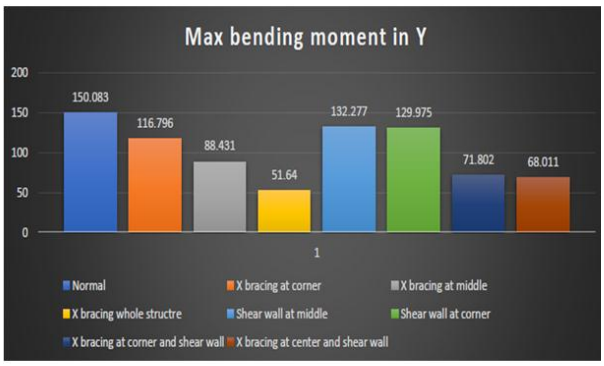

Fig -2: Max bending moment in Y

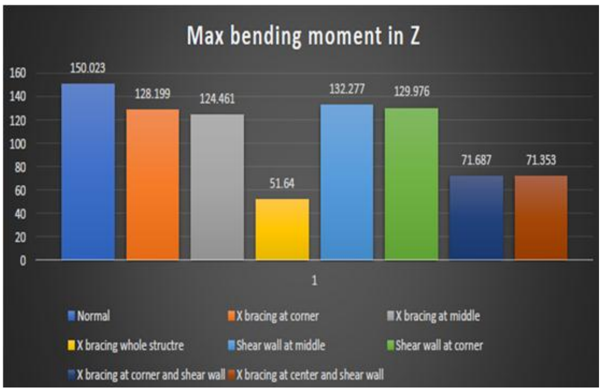

Fig -3: Max bending moment in Z

The maximum reduction in bending moment is in case of bracing and least in case of shear wall. Thiscan be explained form the fact that shear walls reduce the lateral displacements more as compared to the corresponding bracing structures as a result larger overturning moments develop in them as compared to structures with bracing. Overall there is reduction in bending moments with respect tobare frame but the best seismic restraints in the case is X bracing.

5.2 Max Shear Force

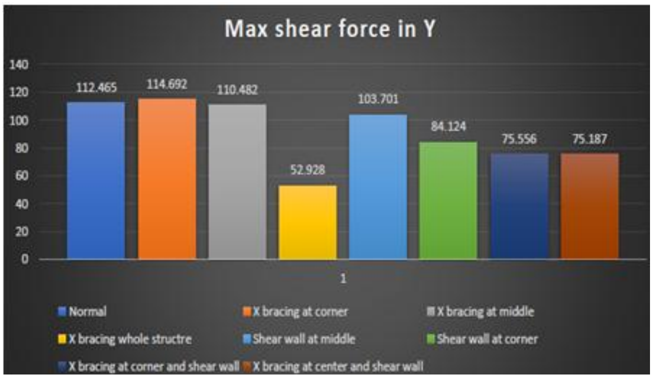

Fig -4: Max shear force in Y

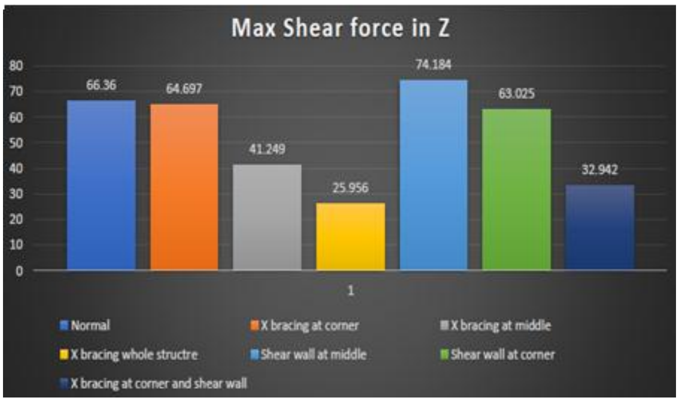

Fig -5: Max Shear force in Z

Significant reduction in shear force is observed in case of structures with X bracings as compared to those with shear walls. In structures with X bracing the best placement of bracings among corner and middle is middle of the frame as observed form the graph above. Combination of X bracing at corner with shear wall also reduces the shear force by large amounts.

5.3 Axial Force

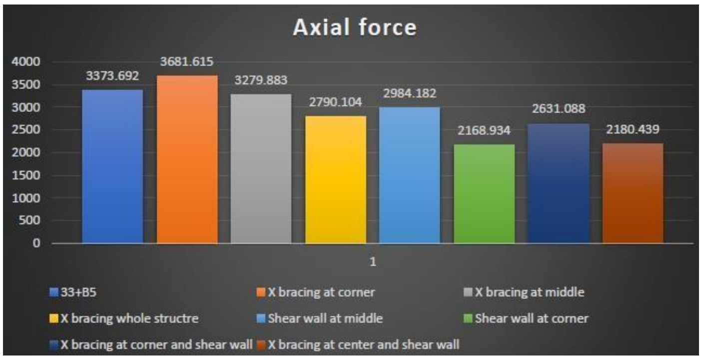

Fig -6: Axial force

Max axial force represent the axial force through columns at the base of the structure.. The max axial force is observed in the model with X bracings and least is observed in the Model with shear wall signifying implying shear walls are capable of reducing axial forces.

5.4 Base Shear

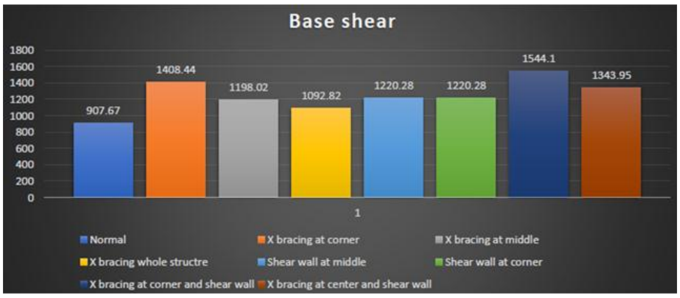

Fig -7: Base shear

Base shear is dependent upon the weight of structure that is more the weight more is the value of base shear. The minimum value is obtained in case of bear frame while maximum value in case of X- bracing at corner with shear wall. The trend shows that structures with shear wall have higher baseshear as compared to those with bracings due to more weight in case of shear wall.

5.5 Weight of Structure

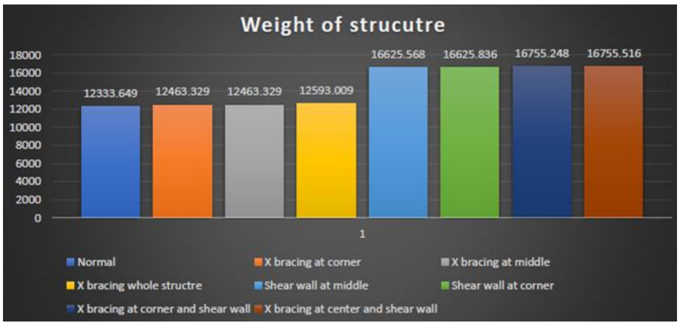

Fig -8: Weight of structure

The maximum increase in weight of structure is observed in case of shear walls where as in case of bracings there is no significant increase in weight of structurethat again signifies that bracing are better seismic restraints as the give more stability without significant increase in weight ofstructure.

6. CONCLUSIONS

1. Eight RC framed models have been observed and analyzed by introducing various earthquake resisting members, like: Parallel shear walls, Corner Shear walls, & Cross Bracings in various configurations.

2. By providing shear walls and bracings to the high-rise structure, seismic behaviour will be affected to a great extent and also the stiffness and the strength of the buildingsis increased.

3. It is found out that shear walls and bracing contribute largely in reducing the deflection by increasing the strength and stiffness of the building. The results of this project can further be used to enhance the seismic strength of buildings using combination of seismic resistance techniques.

4. It is observed from the above analysis that the displacement observed in the models, which are without shear walls & bracings is more as compared to the models having shear walls and bracings at different locations.

5. It has been observed that the Max deflection is significantly reduced after providing the shear walls or bracings in the RC frame in X-direction as well as in Z direction.

6. The best location of shear wall in multi-storey building is parallel shear walls Andthe best type of bracings that can be used is cross bracing on whole structure.

7. The lateral deflection of column for building with cross bracing on whole structure is reduced maximum followed by those with shear walls as compared toall models.

8. Finally, it is concluded that, optimization using cross bracings is the best procedure,in present work mode for maximum earthquake resistance

9. Shear wall elements are very much efficient in reducing lateral displacement of frameas drift and horizontal deflection induced in shear wall frame are much less than that induced in corresponding braced frame(i.e comparing shear wall at middle with X bracing at middle and shear wall at corner with X bracing at corner) and plane frame.

10. The combination of bare frame with coupled shear wall in combination with x-bracing also provides good result about reducing the stresses and lateral forces overthe structure. This implies that these type of structure provide better stability during the seismic activity.

11. Overall the frames can be arranged in order of their seismic stability (consideringmoments, storey drift, storey displacements and deflections) as

X bracing on whole structure> X bracing at middle with shear wall> X bracing at corner with shear wall> Shear wall at middle>Shear wall at corner> X bracing at middle> X bracing at corner> Bare frame

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