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COMPARATIVE STUDY OF EARTHQUAKE RESISTANT DESIGN TECHNIQUES ON MULTISTOREY BUILDING

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ABSTRACT
From the beginning of life on Earth it is evident that natural catastrophes cause a lot of destructionto human life and property. One of the major natural phenomena is the Earthquake. Sudden shakingof ground is a difficult challenge to any structure standing on earth. Due to Improper design of thestructure without seismic resistance many buildings have collapsed and lives have lost during earthquakes. Different shapes & 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 introducingShear walls, Bracings, base isolation, column jacketing etc. to enhance the structure. In this paper,we 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 donebetween: an un-Resisting structure, parallel shear walls, X-shaped bracings. The use of shear wallsand bracings helps to strengthen then structure to make it more Earthquake resistant. The analysisin done on a G+10 building for seismic zone III as per IS 1893:2002 codal provisions. The softwarethat I have used to carry out this analysis is Staad pro v8i. It is found out that shear walls and bracing contribute largely in reducing the deflection by increasing the strength and stiffness of thebuilding. The results of this project can further be used to enhance the seismic strength of buildingsusing combination of seismic resistance techniques.

Keywords: Earthquake, Response factor, Bracing, Staad Pro

1. INTRODUCTION:

1. Earth it is evident that natural catastrophes cause a lot of destruction to human life and property.
2. One of the major natural phenomena is the Earthquake.
3. From ancient times earthquake has been a cause of major destruction of structure.
4. Earthquake is defined as a sudden shaking of ground due to a fault or slip in the tectonic plates.
5. Most earthquakes are caused by movement of the Earth's tectonic plates, human activity can also produce earthquakes. earthquakes are caused mostly by rupture of geological faults but also by other events such as volcanic activity, landslides, mine blasts, and nuclear tests.
6. A fault is nothing but a crack or weak zone inside the Earth. When two blocks of rock or two plates rub against each

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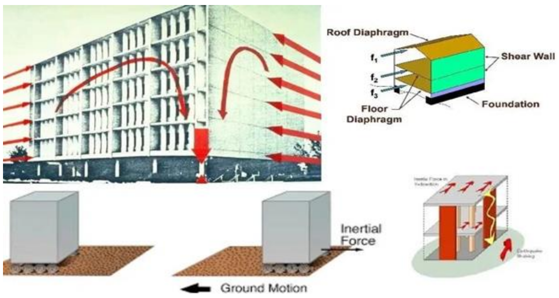
other along a fault, they don’t just slide smoothly.

1989 Loma prieta earthquake



1979 imperial valley earthquake

1.1.Based on the direction of slip, faults can be categorized as: Strike-slip: the fault surface (plane) is usually near rtical, and the footwall moves laterally either left or right with very little vertical motion **Dip-slip**: the fault plane is predominantly vertical and/or perpendicular to the fault trace and moves upward and downward side

a) Oblique-slip: it is combination of strike and dip slip

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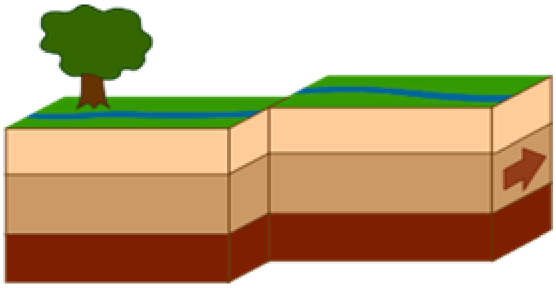
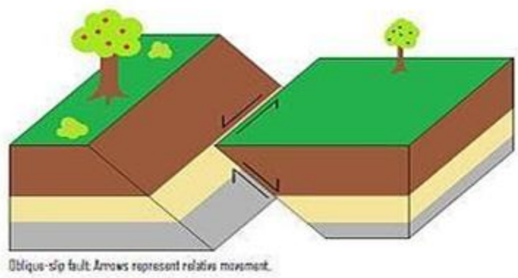
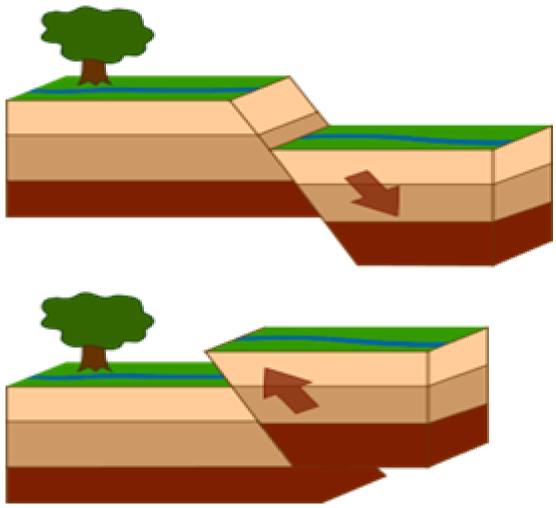


strike-slip



Oblique-slip



Schematic diagram of faults

This fault or slip that takes place within the tectonic plates causes energy to be released which sets off various forms of waves from the epi-center in all directions. The various types of waves are body waves and surface waves. a broad distinction between bodywaves, which travel through the Earth, and surface waves, which travel at the Earth's surface.

2. LITERATURE REVIEW:

Javed Ul Islam, Mayank Mehandiratta , Rohit Yadav (2019) studied the comparative analysis of various bracing system with RC-frame this paper presents the analysis and design of only 10 storey structures using the software STAADPROV8i. In the Study different types of bracings are used. Like as a X – Bracing, Inverted v Bracing K bracing and single Diagonal bracing. These bracings are having steel-I section ISMB-100. Building is located in two types of earthquake-zones. ZONE- III and in ZONE V based on the Indian Standard IS 1893 (Part 1): 2002. Main focus of the study is to control the deflection using most suitable and economical bracing system in high rise buildings and make them safe against lateral forces as well as improvesthe bending moment. In addition to deflection criteria, centre of attention is also given to earthquake resistantdesign of structure. After analysing and comparing we have observed that Deflection and bending moment inbracing system is very less as compare to RC-frame Structure. Among all types of bracing system, X-type Bracing system is having less amount of bending moment most effective and economical. Among all models, braced structure has shown better resistance and stiffness than RC-frame structure Finally, it has been bserved that among all the structures considered, X-Bracing structure is the best suitable from the structural point of view.

Karnati Vijetha, Dr. B. Panduranga Rao (2019) investigated ‘’Comparative Study of Shear Walls and Bracings for A Multi-storeyed Structure Under Seismic Loading’’ In the present work G+15 multi-storey building is analysed by using shear wall and braced frame at outer most of the structure and Comparison with multi-storeyed structure with no protective measures. Main purpose of this study is to determine the effective location of shear wall and bracings on the basis of storey displacement under lateral loading and percentage reduction in storey displacement with different places of shear wall and Bracings at different locations on different models when compared to without shear wall. For this study, 15-story building with a 3.5 meters bottom storey height and 3 meters typical for each storey, regular in plan is modelled. These buildings were designed in compliance to the Indian Code of Practice for Seismic Resistant Design of Buildings i.e., IS1893:2002 for seismic loads and IS1875:1987 for wind loads. The buildings are modelled using software ETABS linear v 9.6.0-2015.From the above results introducing shear walls reduces the sway or displacement. Providing shear walls at adequate locations substantially reduces the displacements due to earthquake. Base shear of the above-mentioned structures heavily increases and makes the structure stable against seismic loading. The Natural Time period of the above designed Structures are highly reduced after placing of bracings and Shear walls with comparison to Normal structure. When comparing the above Structures Lateral displacements are minimal when Shear walls are applied. From the above Comparison of structures and through discussion it is concluded that Shear wall could improve the lateral Stability of the structures.

Shahzeb Khan, Vishal Yadav, Sandeep Singla (2019) studied the comparative analysis of a G+10 story residential building with base model and by considering addition of shear walls and bracings as earthquake resistant technique. In this modelling and analysis is carried

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out using STAAD.PRO program they considered load calculations from IS 1893:2002 (part 1) and seismic parameters specified in zone 3. They have conducted by considering different locations of shear walls viz parallel shear walls, corner shear walls and different shape forms of bracing viz diagonal, crossed. They had done comparation and observed that deflection in X and Z directions and found in both directions and least value of maximum displacement in crossed bracing system. Story shear effectively decreased by introducing Shear Walls and Bracings at different locations. lateral deflection of column for building with cross bracing is reduced maximum as compared to all models. They found that by using earthquake resistant techniques stiffness and strength of the building will be increased and earthquake effects will be minimized.

Shahid Ul Islam, Rajesh Goel, Pooja Sharma (2018) studied on comparative analysis of a G+10 story commercial building with base model and by considering addition of shear walls and bracings as earthquake resistant technique. In this they made a RCC commercial building of 11 Storey (G+10) by using STAAD.PRO V8i program. In this they made a study on base model, shear walls, bracing and combination of different locations of shear walls and X-bracing. building is located in earthquake ZONE V. Soil condition are considered medium and importance factor is taken as 1. The lateral loads and Earthquake loads are applied as per IS 1893 (Part -1) 2002 and the seismic parameters in terms of base shear and storey displacement were compared. The base shear of buildings with shear wall and RCC bracing system is more as compared to the buildings without shear wall and bracing system which results in the increase of stiffness of building. The storey displacement of the building is reduced by the use of shear wall and RCC bracing system. The top storey displacement for The RCC X-bracing system paced at the 4 corners on both transverse as well as longitudinal bays is reduced by 58.7 %, for model with shear wall system at corners is reduced by 69 %, andthat for model having both shear wall and RCC X-bracing system is reduced by 67% when compared to base model. hence these models safest and show least storey displacement. Finally, the model with shear wall placed at two transverse bays at corner 1, and at two transverse bays at corner 4, while as RCC X-bracing system is placed in similar way as shear wall at corner 2 and 3 is the safest and most economical of all the models analysed.

Syed Muhammad Bilal Haider, Zafarullah Nizamani, and Chun Chieh Yip (2018) investigated the behavioural study of Shear Wall with Correlational to Bracing under Seismic Loading , bracing and shear wall are the mainstream strategies for reinforcing the structures against their poor seismic behaviours. It is seen before that shear wall gives higher horizontal firmness to the structure when coupled with bracing however it will be another finding that in building model, which location is most suitable for shear wall and bracing to get better horizontal stability. In the study, a 15 story residential reinforced concrete building is assessed and analyzed using building code ACI 318-14 for bracing and shear wall placed at several different locations of the building model. The technique used for analysis is Equivalent Static Method by utilizing a design tool, finite element software named ETABS. The significant parameters examined are lateral displacement, base shear, story drift, and overturning moment. It is evident from the

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results of the analysis that both retrofitting technique, Bracing and Shear wall improve the performance of building model. The parameters like storey displacement, storey shear, overturning moment has been minimized during the earthquake . It is concluded that building model with shear wall and bracing will show more stability and stiffness.

3. METHODOLOGY:

STAADPRO

STAAD or (**STAAD.Pro**) is a structural analysis and design software application originally developed by Research Engineers International in 1997. In late 2005, Research Engineers International was bought by Bentley systems.

STAAD. Pro is one of the most widely used structural analysis and design software products worldwide. It supports over 90 international steel, concrete, timber & aluminium design codes.

It can make use of various forms of analysis from the traditional static analysis to more recent analysis methods like p-delta analysis, geometric non-linear analysis, Pushover analysis (Static-Non Linear Analysis) or a buckling analysis. It can also make use of various forms of dynamic analysis methods from time history analysis to response spectrum analysis. The response spectrum analysis feature is supported for both user defined spectra as well as a number of international code specified spectra. STAAD Pro programming is broadly utilized as a part of the structural analysis and designing structures – towers, buildings, bridges, transportation facilities, utility and industrial structures. Designs can include building structures incorporating culverts, petrochemical plants, bridges, tunnels, piles; and construction materials such as timber, steel, concrete, aluminum and cold-formed steel. it is extremely useful for buildings and other such structures insignificant of their uses varying from residential to commercial to hospitals to offices. This software can be used for all kinds of buildings of various architectural drawings under a plethora of loads. other than buildings, it is also useful for bridges to some extent and also foundation design and analysis. Shear wall is another feature incorporated into it for design facilitation. Steel buildings and connections can also be designed and successfully rendered to view the real-life resembling images for detailed clarity.

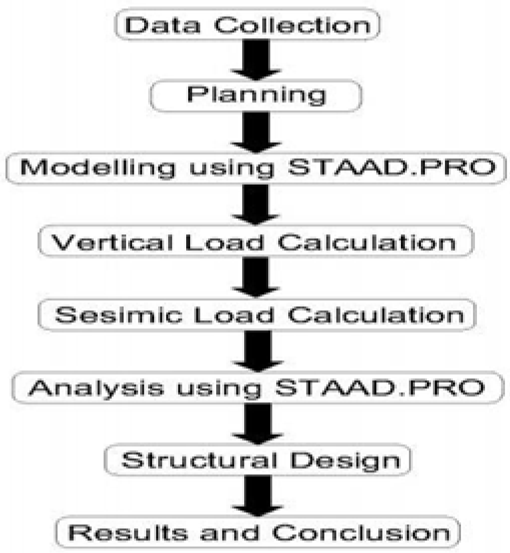
3.1. Design Methodology:

General:

For the purpose of study, a plan of G+10 storeyed frame was considered. For linear elastic study, RC plane frames with and without shear wall and bracing were analysed and designed for gravity loads as per IS 456:2000 and lateral loads (earthquake loads) as per IS 1893 (part-1):2002.

Design procedure:

The methodology for this study is shown below as follows: -



3.1.1 Data Collection - Authentic data was collected such as

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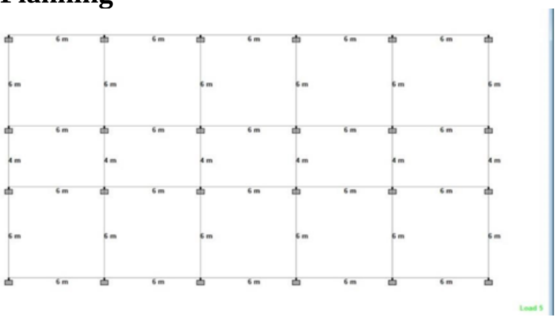
dimensions of building, thickness of wall size of columns. It was made sure that this project was made and completed according to standards set by governmentof India.

- Seismic zone: 3
- Number of Storey's: G+10
- Floor Height: 3m
- Size of beam: Inner beam (400X300) mm
- Outer beam (400X230) mm
- Size of column: Outer corner column - Top floor (500X500) mm, Bottom floor (700X700)mm, Outer middle – Top floor (500X600)mm, GF (600X750)mm, Inner middle-Top floor(600X500)mm, GF(750X600)mm
- Live load on Floor: 4KN/m2
- Floor finish: 50mm
- Materials M30 Concrete, Fe 415 Steel
- Wall thickness: 230 mm
- Density of Concrete: 30KN/m3
- Type of soil: Medium
- Seismic Load: As per IS 1893(Part-1): 2002.
- Design Building according IS 456

Planning



3.2 Modelling using STAAD.PRO:

Materials: Model-1 after assigning beams, column and slab dimensions, reinforcement details and the type of material. The modulus of elasticity of reinforced concrete as per IS 456:2000 is given by. for the steel rebar, the necessary information is yield stress, modulus of elasticity and ultimate strength. High yield strength deformed bars (HYSD) having yield strength 415 N/mm2 is widely used in design practice and is adopted for the present study. Cement used is of grade M30.

3.2.1Beams and Columns:

Beams and columns were modelled as frame elements. The elements represent the strength, stiffness and deformation capacity of the members. While modelling the beams and columns, the properties to be assigned are cross sectional

3.2.2 Supports:

Applied the supports which are fixed to stop the rotation. Every 3D Point have 6 degree of freedom, three are linear and three are rotational. In this analysis applied fix support at bottom node. Fix support means fully constraint, behave as node cannot move or rotate any direction. The 2D sketch was then imported into STAAD.PRO and a 3D model was created for analysis of beams and columns in the building. Fig. 3.6 Showsthe Floor plan view and isometric Plan view of the building. After importing the file into STAAD.PRO the plan drawing was vertically dragged upwards in positive Y direction to create a G+10 building plan.

2.2.3Vertical Load Calculation

Calculation for the load exerted on the structure such as beams columns and slabs on the column due to Gravitational forces. Dead load of building work as Vertical load.

3.2.4 Seismic Load Calculation

Seismic load is one of earthquake engineering's basic concepts, which means applying an earthquake-generated agitation to a building

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structure or design. This happens either with the ground or neighboring structures or with tsunami gravity waves on the contact surfaces of a building. Applied Seismic Load according IS 1893- 2002/2005 for both cases. In this analysis applied seismic, wind, live and dead load according to IS 456, IS 1893- 2002/2005.

3.2.5Analysis using STAAD.PRO

Using STAAD. Pro completed analysis and solution process. After that STAAD. Pro generated results of building such as total deformation, stress, shear force, bending moment, and required concrete for building and required steel bar for building. Completed analysis and Design process using IS 456, IS 1893- 2002/2005.

4. Results & Discussion:

4.1 Maximum Deflection:

a) Maximum deflection of the base model is 142 mm to144 mm higher than the models containing shear wall and bracing in x-direction.

b) In z-direction the deflection difference between base model and shear wall model is 23.3 and with bracing is 42 mm respectively

c) The deflection has been reduced by introduction of shear wall and bracings. the least deflection i.e 63.342 and 146.184 is seen in model containing cross bracings when compared to shear wall model and base model.

d) So the model having bracings has less deflection compared to other two models.

4.2 Storey Shear:

a) The base shear of the structure increases for shear wall and bracing model compared to base model and makes the structure more stable against seismic force.

b) Shear wall model has 202.96 KN ,216.7 KN more base shear than the bracing model and base model respectively

c) The base shear of the structure increases for shear wall i.e, 5.72% and bracing model i.e, is 0.31% compared to base model.

4.3. Storey Drift:

a) In case of story drift, the introduction of shear wall and bracing reduced drift to 67.5% and 79.02% respectively when compared to base model.

b) The least storey drift is seen in model containing bracings.

4.4 Maximum Axial force:

a) In case of maximum axial force, the axial force is more in base model but when shear walls and bracings are introduced there is a reduction in axial force in shear wall model i.e 3.85% and bracing model i.e is 3.82%

b) The maximum axial force is less in shear wall model compared to other two models.

5. CONCLUSION:

From the result observed,

a) The lateral force resisting system has also been well performed while placing shear wall and bracing.

b) The addition of shear-wall and brace member has significant effect on the seismic response of the shear-wall frame and braced frame respectively.

c) Addition of shear walls increases the base shear making the structure more stable and reduces the axial force.

d) Addition of brace elements equally reduces the actions, horizontal

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deflection and drift induced in the frame.

e) Brace elements are very much efficient in reducing lateral displacement of frame as drift and horizontal deflection induced in braced frame are much less than that induced in shear-wall frame and plane frame. Though column axial force induced in braced frame is more than that in shear-wall frame and plane frame, however, the column and beam moments, and drift induced in braced frame are very less. Hence, braced model is very efficient in resisting seismic force than shear-wall model and plane model.

f) It is found that the structure with the bracings will give minimum deflection than the shear wall modeland base model.

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