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RETROFFITING OF BUILDING WITH STEEL BRACINGS USING ETABS

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Abstract: It is common practice to design reinforced concrete buildings to withstand both lateral and gravity loads. Therefore, the potential earthquake load that could bring down the structure must be taken into account during the design phase of such frames. The seismic behavior of the building can also be enhanced by using a bracing element. Steel supports are more space-efficient, and they can be made as stiff and strong as necessary. Bracings are also very cost effective and easy to install. Steel bracings can be used to retrofit a building. Several varieties of steel bracings are examined here. The effects of various loads on bracings are investigated. The results of combined bracings are analyzed and compared to those of unbraced frames. Several distinct bracing configurations are also covered. It is also observed that how steel bracings are used as the active part of the building. The purpose of this research is to analyze eccentric bracings and determine the optimal bracing pattern under various loading conditions. In this study, a G+12 story is modeled in ETABS, then subjected to a response spectrum analysis, and the results are compared to those of similar buildings that don't have bracings. Case 1: Bracings in an alternate position; Case 2: Bracings in a building with staggered levels; Case 3: Bracings in a building with staggered levels. Stories were compared in terms of their drift, shear, moment, torsion, period, and model stiffness.

Key words: Earthquake, response spectrum analysis, story drift, story shear, story moment, building torsion, time period, model stiffness.

1. INTRODUCTION:

Earthquake-proof constructions are strengthened in numerous ways. The purpose of earthquake-resistant building is to create structures that fare better than typical buildings during seismic activity, however no building can be guaranteed to be totally secure from earthquake damage. Earthquake-proof buildings must be sturdy enough to resist the strongest tremor that has a definite chance of striking. An earthquake of any magnitude may be mitigated by taking measures to keep buildings from collapsing, while weaker tremors often inflict only cosmetic damage.

Steel has rapidly increased in importance as a building element in recent years. It is crucial to plan a design to function effectively under earthquake stresses. Steel bracings included into the basic structure increase the design's shear limit. In order for a building to withstand horizontal forces like wind and seismic strain, a propped outline is often used as the main framework. Due of its excellent strength under both pressure and pressure, underlying steel is commonly used in propped designs.

The frame's beams and columns support the weight of the building vertically, while the bracing system bears the weight of the building laterally. However, the aesthetics of the façade and the arrangement of windows and doors can be compromised when braces are installed. This has led to bracing being incorporated into the design of many contemporary and postmodern structures.

Bracings can be used as retrofit as well. Different bracings, such as the X, V, inverted V, Forward, Backward, K, etc., are available to meet a wide range of needs. The ductility of the design is crucial for the seismic resistance of the building. Push over analysis is used to make ductility and other property estimates for each eccentric brace.

Engineers use a technique called response range investigation (RSA) to predict the worst possible seismic reaction of a flexible structure. RSA is based on direct unique factual evaluation and assesses the commitment from every regular way of vibration. The study of response ranges may provide insight into dynamic behavior by gauging the rate of rise, speed, or relocation of a pseudo-ghost for a certain time frame history and amount of dampening. To conveniently represent the maximum reaction at each recognition of the underlying time frame, reaction spectra may be wrapped as a smooth curve.

This project intends to investigate multi-story buildings in the ETABS program by means of reaction range examination, and to plan a quake-safe construction utilizing steel bracings in zone V, all of which are potential outcomes of earthquakes.

2. LITERATURE STUDIES

The following literature reviews discuss the use of bracing systems in earthquake-resistant building design in accordance with IS code requirements.

I. **Jayaram Nayak B[1], Kiran Kamath[2], Avinash A R[3]et al.,(2018)** Here, we look at how the seismic performance of a steel frame building changes when the height of the bracing is altered. There are three distinct phases during which the braces are put on: the first, second, and third levels. Aspect ratios (the difference between the height of a building and the width of its base) between one and four are examined, and the seismic performance of bare frame structures, X-braced frames, and Diamond braced frames are compared. According to the findings, all braced frame structures have better seismic performance compared to their bare-frame equivalents.

II. **Swetha Sunil[1], Sujith P.S[2], et al.,(2017)** A retrofitting technique that strengthens and stiffens an existing building against lateral forces is a bracing system. Both eccentric and concentric forms of bracing are in use. Diagonal, X, V, and Inverted V configurations are just some of the many possible arrangements for steel bracings. The lateral drift is typically reduced and the natural frequency is raised as a result of bracing. Displacement, drift, and time period were identified as examples of bracing story responses and found to be unnecessary after analyzing the data presented here. X bracing outperforms alternative bracing because it exhibits a smaller seismic response.

III. **Kiran Kamath[1], Shruthi[2], Shashikumar Rao[3], et al.,(2015)** In this article, we examine the relationship between the aspect ratio (H/B, where H is the overall height of the building frame and B is the base width of the building frame) and the seismic performance of steel frame structures. Here, the structure's height is remained static while its base width is modified. This study examines the behavior of a 10-story steel frame building under seven various aspect ratios, from 1.0 to 3.75, with and without concentric bracing (in the form of X bracing). Both kinds of sections studied were shown to have a decreasing base shear bearing capability when the aspect ratio was increased. For frames with an aspect ratio of Type 1, roof displacement decreases as the aspect ratio grows, but for frames with an aspect ratio of Type 2, roof displacement grows dramatically. Bracing enhances a frame's resilience to base shear and minimizes the amount of roof displacement.

3. METHODOLOGY

3.1 Response spectrum analysis

An idealized one-degree-of-freedom system's maximum response to periodic and damping-dependent earthquake ground motions. IS 1893-2016 (part1) is the standard used for this analysis. Type of soil and seismic zone factor according to IS 1893-2016 (part1) should be entered here. The ETABS computer then examines the building using the usual response spectrum for the soil type in problem. In the illustration, time is plotted against the spectral acceleration coefficient (Sa/g) to illustrate the typical response spectrum for a medium soil type.

This method allows for the consideration (in the frequency domain) of the numerous possible modes of a building's response. Many rules need this, with the exception of the smallest and most complex constructions. The "harmonic" in a vibrating string is a collection of many different forms (modes), and a computer analysis may be used to determine which modes contribute to the response of a construction. The total response of the structure may be calculated by adding the responses of the different modes, which can be done using the design spectrum's modal frequency and modal mass. To accomplish so, one may add up the X, Y, and Z forces exerted on the building. The following are a few frequent applications of such hybrid approaches:

1. Absolute - peak values are added together
2. Square root of the sum of the squares (SRSS)
3. Complete quadratic combination (CQC)

An improvement over SRSS for modes with little separation. Since phase information is lost during computing the response spectrum, the result of a response spectrum analysis using a ground motion's reaction spectrum is not always the same as the result that would be obtained directly from a linear dynamic analysis using that ground motion.

Complex studies, such as non-linear static analysis or dynamic analysis, are often necessary when buildings grow too irregular, too tall, or too crucial to the community in the event of a disaster for the response spectrum approach to be successful.

4. MODELS USED IN THE STUDY AND INPUT DATA ASSUMED

Problem statement

The current research uses ETABS to perform a seismic analysis on a G+12 story building in a Zone V seismic zone.

The study is predicated on the following primary variables:

1. Grade of concrete, M40
2. Reinforcing steel HYSD Fe500.
3. Beam dimensions are 230 mm x 500 mm.
4. The slab is 150 millimeters thick.
5. The lowest floor (Bottom) is just 3m high.

6. The last storey is 3m in height.
7. 3.5 KN/m2 live load
8. 1.5 KN/m2 floor load
9. Concrete has a density of 25 KN/m3.
10. Zone 5 is the seismic zone.
11. Class II Site
12. Standard wind speed: 39 meters per second
13. Coefficient of risk (K1) = 1.08
14. Size coefficient of the terrain (K2) is 1.14
15. K3 Factor of Terrain: 1.36
16. IS 875: 1987 (Part 3) is the current version of the wind design code.
17. IS 456:2000 - RCC Design Code
18. Code for the design of steel structures (IS 800: 2007)
19. IS 1893: 2002 (Part 1), Earthquake Design Code

5. MODELS USED IN THIS STUDY

1. Building without bracings;

Instead of bracings, generic beams, columns, slab section, and shear wall section were used to depict the lift component of the structure.

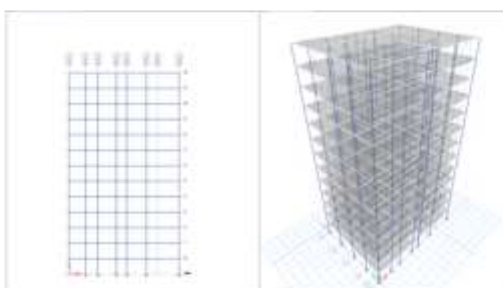

Fig 1: G+12 Building without bracings

2. Building with alternative bracings;

Case 1: Alternate bracings were developed for this structure using a bare frame of ISA 20020015 sections.

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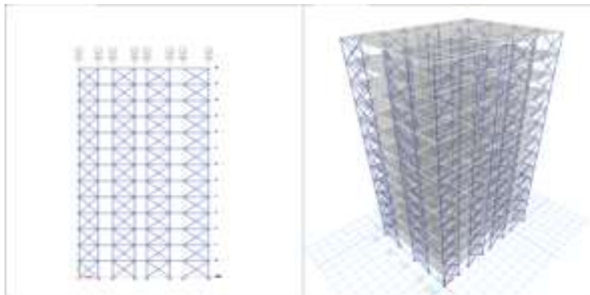

Fig 2: G+12 Building with alternative bracings 1

Case 2: As an alternative to the traditional "1in by bare frame wise with ISA 200X200X15" section, we designed the architecture with alternate bracings.

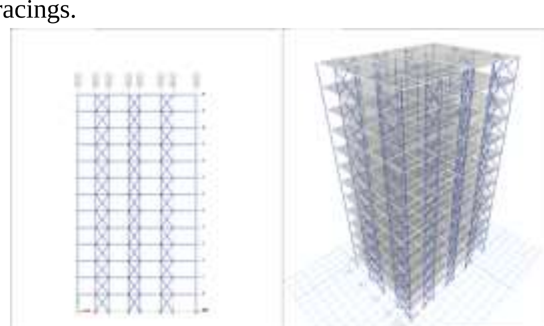

Fig 3: G+12 Building with alternative bracings 2

3 Building with story wise bracings;

Case 1: In this scenario, ISA 200X200X15 sections were used to depict the building's bracings along its storeys. Stories 1, 3, 5, 7, 9, 11, and 13 all take bracing into account.

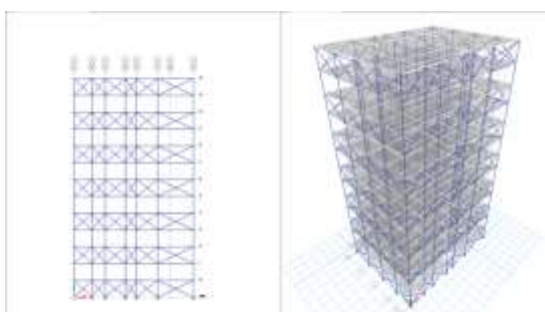

Fig 4: G+12 Building with storey wise bracings 1

Case 2: In this scenario, ISA 200X200X15 sections were used to depict the building's bracings along its storeys. Bracings is considered for Story 2, story 4, story 6, story 8, story 10, story 12.

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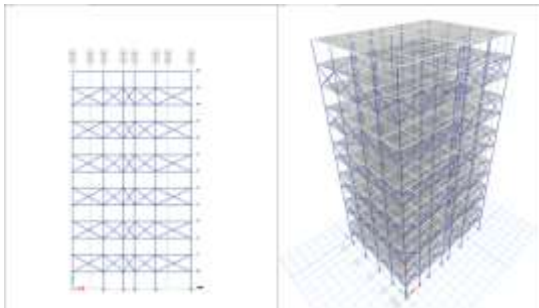


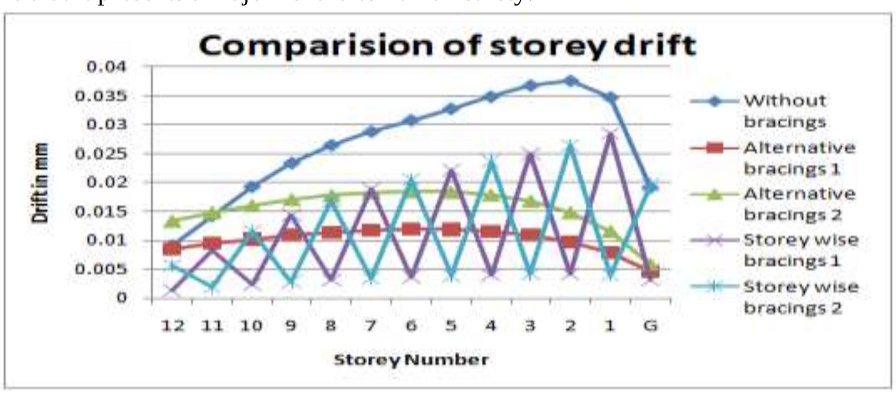
Fig 5: G+12 Building with storey wise bracings 2

6. RESULTS AND ANALYSIS:

6.1 Response spectrum analysis (RSA X) Results:

A. Drift:

A "drift" is a horizontal or sideways motion. "Story drift," or vertical movement in multi-story structures, is a real phenomenon. The inter-story drift of a building is the horizontal distance between the normalized vertical displacements of its roof and floor during an earthquake. More devastation is likely the larger the drift. If the peak inter-story drift is larger than 0.06, considerable damage has occurred, and if it is greater than 0.025, the damage might be so severe that it presents a major hazard to human safety.



Comparison of storey drift value RSX

Buildings with alternative storey-wise bracings (cases 1 and 2) have lower values for story drift (lateral displacement) than the General Building and Buildings with Alternative Bracings (cases 1 and 2). Earthquake loads have less of an impact on the case 2 building because of the alternative bracings.

B. Storey shear:

Overturning moments are recorded at global coordinates P, VX, VY, T, MX, and MY, while story shears are reported at global locations P, VX, VY, T, MX, and MY. The forces are reported right under the tale level at the beginning of the story and directly above the story level at the conclusion of the story.

The story's forces follow the same sign convention as the frame element's, with the story's conclusion correlating to the frame element's end and the story's starting correlating to the frame element's j-end.

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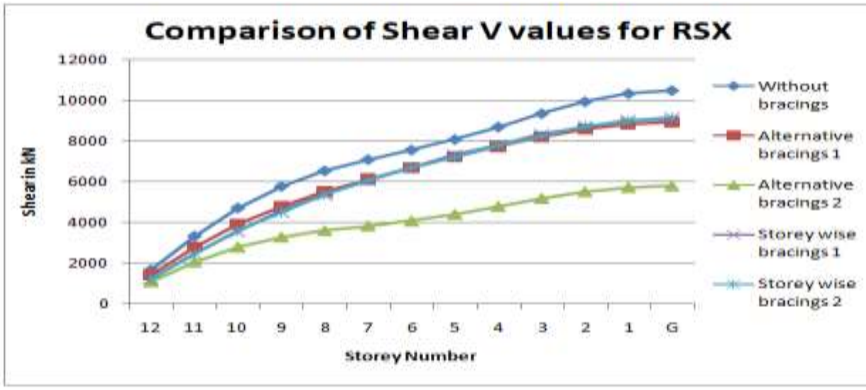
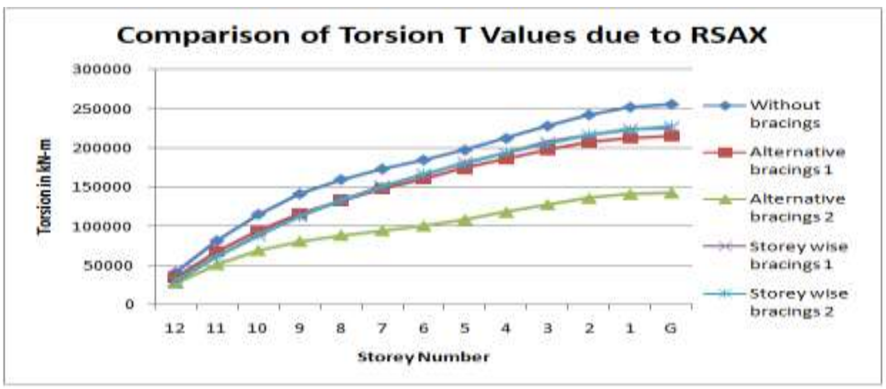


Comparison of Shear V values for RSX

According to the data presented above, the story shear is smaller in the building with building with alternative bracings case 2 compared to the buildings in cases 1 and 3, and the buildings in cases 1 and 2 compared to the buildings in case 2.

C. Building torsion:

When applied to a mass, torque causes that mass to rotate around its center of gravity or a fixed point. The word "torque" may also be used to describe the amount of force needed to rotate a shaft or gear.



Comparison of Torsion T values for RSX

From the above graph, it can be seen that the torsion (T) of a building is lower in the case where no bracings are present than in the cases where alternative bracings are present, where alternative bracings are present, where story-wise bracings are present, and where there are no story-wise bracings present.

D. Bending moment

The bending moment at the cross section of the beam may be defined as the algebraic sum of the moments of the forces to the right or left of the section

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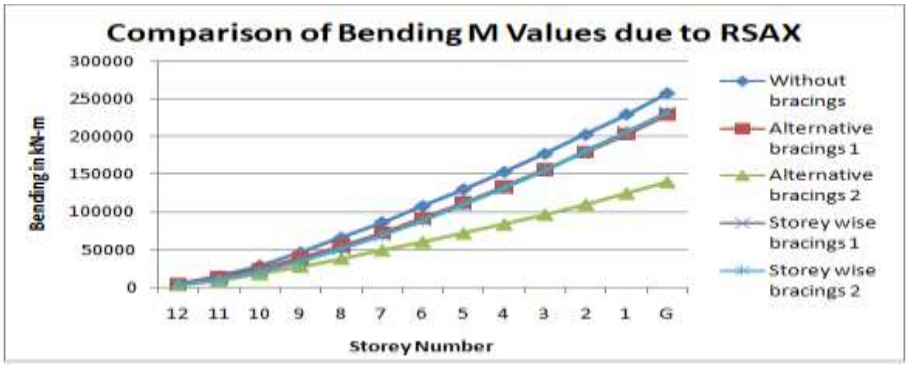
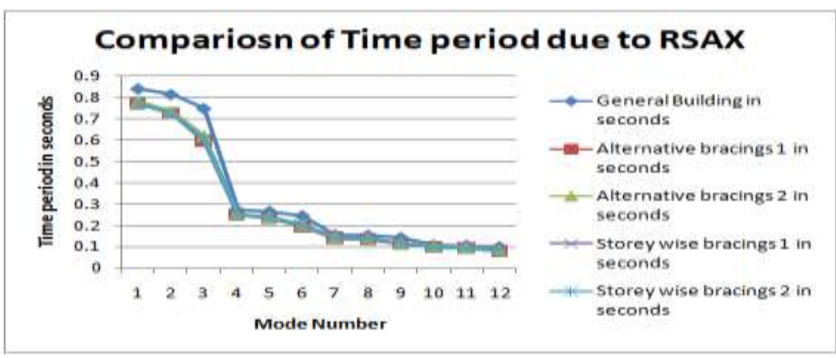


Comparison of bending M values for RSX

E. Time period:

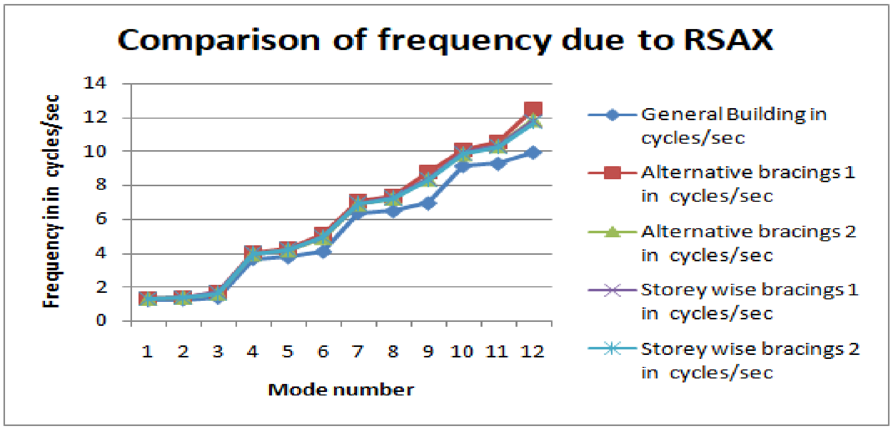
The time it takes an object to vibrate at a given frequency, which is determined by the mass and stiffness of the object, is called its natural period. A steel foot ruler will begin vibrating at a certain frequency if you hold one end firmly and tap the other. This frequency also characterizes its antipodal counterpart, the natural period. A longer ruler or one made of a different material, like plastic, will vibrate at a different frequency.



Comparison of Time period due to RSAX

Based on the data presented in the table and graph above, it is clear that the value of time is reduced for buildings with bracings in both the case 1 and case 2 scenarios, and that it is increased for buildings without bracings in both scenarios.

F. Frequency;

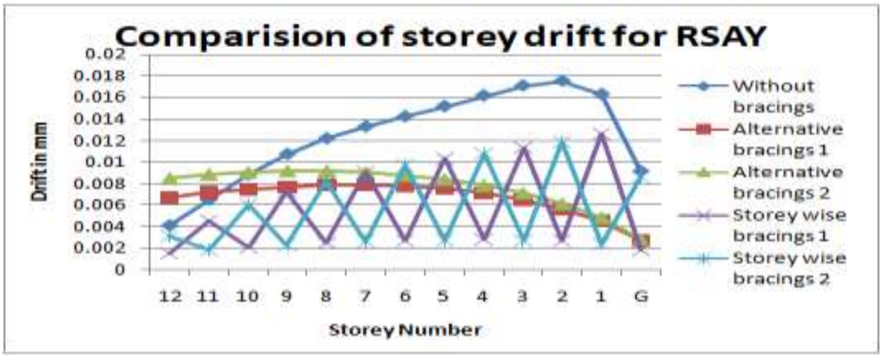


Comparison of frequency due to RSA

Frequency is defined as the rate of repetition in one second. Frequency is measured in hertz (Hz), a SI unit. Exactly one cycle per second equates to one hertz. The frequency value is lower for the general building than for the alternative bracings case 2, the building with bracings in story wise case 1, and the building with bracings in story wise case 2, as shown in the table and graph above.

6.2 Response spectrum analysis (RSA Y) Results:

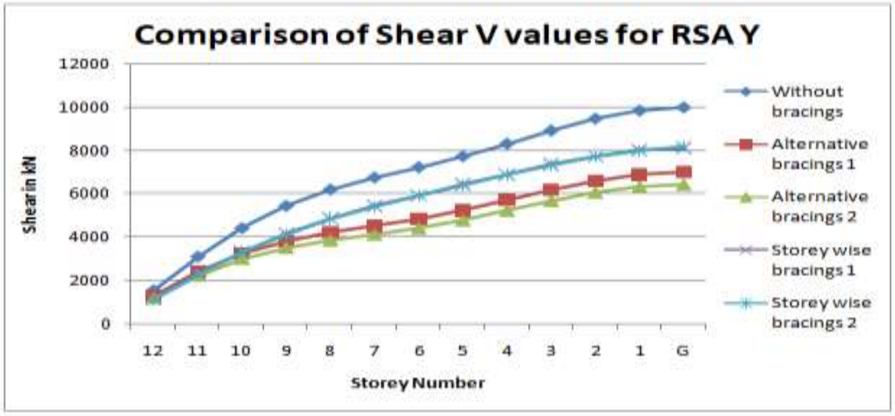
a. Comparison of storey drift:



Comparison of storey drift for RSAY

It can be seen from the above graph that the values of story drift (lateral displacement) are smallest in the General Building, the Building with Alternative Bracings, and the Building with Alternative Bracings, Case 2. Earthquake loads have less of an impact on the case 2 building because of the alternative bracings.

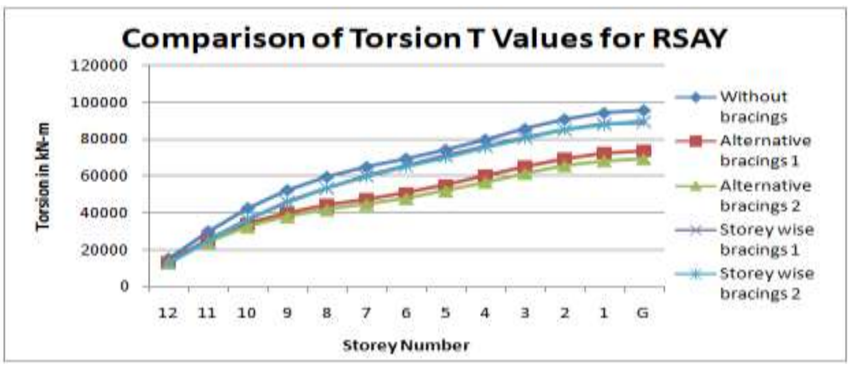
b. Story shear:



Comparison of Shear V values for RSA Y

According to the data presented above, the story shear is smaller in the building with building with alternative bracings case 2 compared to the buildings in cases 1 and 3, and the buildings in cases 1 and 2 compared to the buildings in case 2.

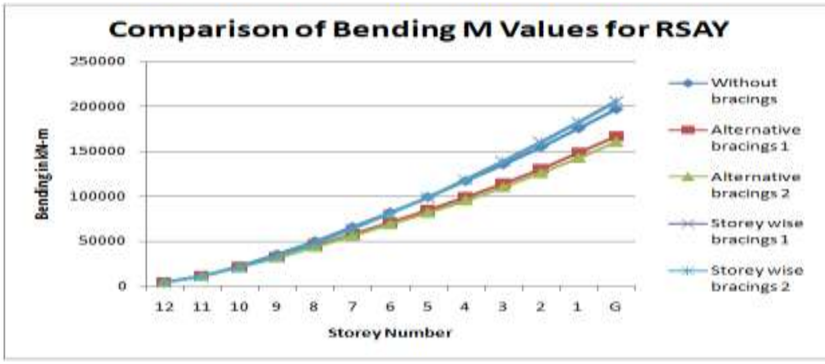
c. Building Torsion T values:



Comparison of Torsion T values for RSA Y

Building with alternative bracings case 2 has lower torsion T values than Building with alternative bracings case 1, Building with alternative bracings case 2, Building with story wise bracings case 1 and Case 2 of the same study.

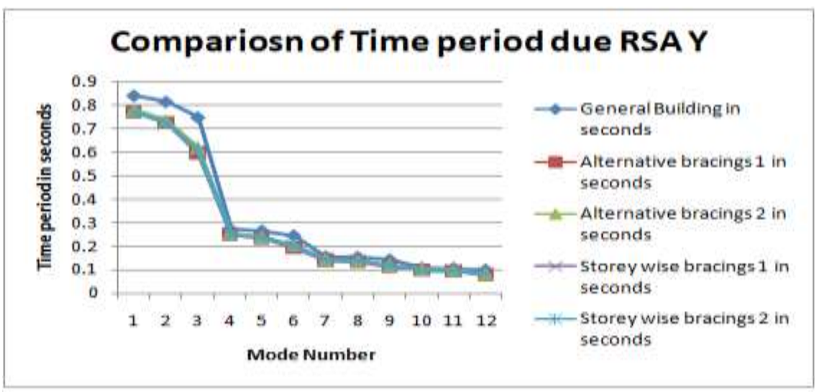
d. Bending moment M values



Comparison of Bending M values for RSAY

It can be seen from the above graph that the building moment has lower values in case 2 of alternative bracings compared to case 1 of alternative bracings, case 2 of story-wise bracings, and case 3 of general construction.

e. Time period due to RSAY



Comparison of Time period due RSA Y

Based on the data presented in the table and graph above, it is clear that the value of time is reduced for buildings with bracings in both the case 1 and case 2 scenarios, and that it is increased for buildings without bracings in both scenarios.

f. Frequency due to RSAY:

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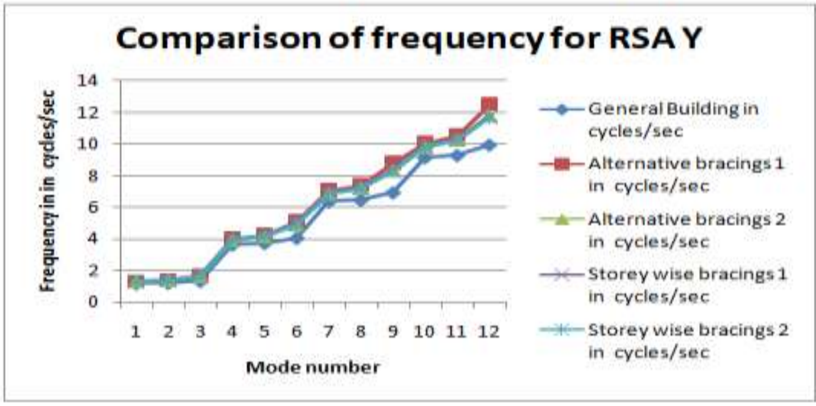

Comparison of frequency for RSAY

Frequency is defined as the rate of repetition in one second. Frequency is measured in hertz (Hz), a SI unit. Exactly one cycle per second equates to one hertz. The frequency value is lower for the general building than for the alternative bracings case 2, the building with bracings in story wise case 1, and the building with bracings in story wise case 2, as shown in the table and graph above.

7. CONCLUSIONS:

The following inferences were drawn from this investigation.

1. The performance points of braced structures were shown to be in less susceptible damage states than those of un braced structures
2. Bracing improves a frame's resistance to base shear and reduces the amount of roof displacement.
3. In comparison to General Buildings, Individual Floor Braced Buildings, and Individual Floor Braced Buildings, Buildings with Alternative Bracings on Individual Floors have lower values for story drift (lateral displacement). Case Therefore, the effect of an earth quack load is lessened in a structure with storey-wise bracings.
4. Case 2 of the alternative bracings construction method yields lower story shear values compared to the general construction method, Case 1 of the alternative bracings construction method, Case 1 of the story wise bracings construction method, and Case 2 of the alternative bracings construction method.
5. Case 2 buildings with alternative bracings, including both Case 1 and Case 2 structures with bracings down the length of the building, are worth less in the long run than Case 1 buildings without bracings.
6. Case 1 without bracings is the most valuable, whereas Case 2 with alternative bracings, Case 1 with bracings in a story-wise configuration, and Case 2 with bracings in a story-wise configuration all have a lesser value.
7. When comparing Case 1 (no bracings) to Case 2 (bracings), Case 2 (story-wise) has lower values for Building moment in X, Y direction and Building torsion (T) than Case 1 (no bracings).
8. Constructing with alternative bracings case 2 provides superior outcomes than constructing with alternative bracings case 1 and building without bracings in case 2, as evidenced by the findings of this research.

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