Abstract: Steel structures provide better resistance against lateral and various other combinations of loads. Steel structures have various advantages over RCC structures as they have high strength to weight ratio, uniformity, elasticity flexibility and take minimum time for erection (as large prefabricated structures are available). Steel is recyclable too. Bracing systems are well known to increase the stiffness of any type of structure. Using bracing system in steel structures increases the stiffness of the structures to a large extent. In present paper, the evaluation of different kinds of curved bracing system was carried out for steel framed structure while performing dynamic seismic analysis as per IS:1893:2016. The behavior and performance of various shaped curved bracing was analyzed in software staad.pro and results were collected and represented in the form of tables, graphs and figures. For this purpose, 14 storey regular building was chosen and different geometric and design parameters were taken as per the codal provisions. The height of each floor was considered as 3.6m. Whereas, the plan of the building entails 6 x 6 bays in both the direction and the size of each panel was taken as 5 x 5m. After scrutinizing the results gathered, it can be concluded that ‘AV Arc’ bracing system is the most effective bracing system and it can be used effectively to resist lateral loads such as earthquake loads. Keywords: Dynamic Seismic Analysis Curved Bracing, High-Rise Building, Steel Building.

I. INTRODUCTION
Steel structures provide better resistance against lateral and various other combinations of loads. Steel structures have various advantages over RCC structures as they have high strength to weight ratio, uniformity, elasticity flexibility and take minimum time for erection (as large prefabricated structures are available). Steel is recyclable too. Bracing systems are well known to increase the stiffness of any type of structure. Using bracing system in steel structures increases the stiffness of the structures to a large extent. It provides resistance against various types of loadings (dead load, live load, wind load, seismic load). This research is to study of behavior of different types of buildings, in plan (regular, irregular) using different types of bracing system. Different types of arched bracings and their combination are being used to study different parameters of buildings. Seismic loads and wind loads are the lateral loads from which at least one must be consider while designing (load with maximum magnitude). The magnitude of seismic loads is maximum at ground level and decreases as the height increases, whereas, the magnitude of wind loads is maximum at roof level of the building and decreases as the height decreases.

When earthquake forces hit the building from soil then they push the soil and foundation away in the force direction as shown in fig. 1.2. But the topmost portion of the building try to remain at its original place due to which cracks develop at the joints and failure occurs.

II. METHODOLOGY
The various steps which were entailed while performing the present research work are mentioned in the following section.

2.1. Modeling
For the purpose of modeling, total 4 models were prepared with the help of software Staad.Pro in order to analyze and design them. The detail description along with the pictorial representation of the models has been done and mentioned below:

![Figure 1. Construction of Steel Structure.](image1)

![Figure 2. Effect of shaking of ground on building.](image2)
Table 1. Description of Various Models

<table>
<thead>
<tr>
<th>Type</th>
<th>Storey</th>
<th>Struts (bracing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>14 storey Building</td>
<td>‘A Arc’ Type Bracing</td>
</tr>
<tr>
<td>Type 2</td>
<td>14 storey Building</td>
<td>‘AV Arc’ Type Bracing</td>
</tr>
<tr>
<td>Type 3</td>
<td>14 storey Building</td>
<td>Single Elliptical Bracing</td>
</tr>
<tr>
<td>Type 4</td>
<td>14 storey Building</td>
<td>Double Elliptical Bracing</td>
</tr>
</tbody>
</table>

The height of each floor remains the same and was taken as 3.6m. Whereas, the plan of the building entails 6 x 6 bays in both the direction and the size of each panel was taken as 5 x 5m. The pictorial representation has been done below:
Figure 7. Rendered View of Type 2 Building.

Figure 8. Elevation of Type 3 Building.

Figure 9. Rendered View of Type 3 Building.

Figure 10. Elevation of Type 4 Building.
Dynamic Analysis of Steel Frame Structure (Regular in Plan) using Curved Bracing Systems

2.2. Sectional Properties

After modeling the various structures, the cross-sectional properties of beams, columns and bracings were added and assigned to the models. The various properties which were assigned to different structural member are shown in the table below:

Table 2. Cross-Sectional Properties for all Structures.

<table>
<thead>
<tr>
<th>Floors</th>
<th>Column size (mm)</th>
<th>Beam size (mm)</th>
<th>Strut Size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st to 4th</td>
<td>700 x 700 x 16</td>
<td>ISMB 600 (2-T&amp;B plates-550 x 10 mm)</td>
<td>400 x 400 x 12</td>
</tr>
<tr>
<td>5th to 8th</td>
<td>2 x ISWB 600</td>
<td>ISMB 550 (2-T&amp;B plates-400 x 10 mm)</td>
<td>350 x 350 x 10</td>
</tr>
<tr>
<td>9th to 12th</td>
<td>2 x ISWB 600</td>
<td>ISMB 450 (2-T&amp;B plates-400 x 10 mm)</td>
<td>300 x 300 x 10</td>
</tr>
<tr>
<td>13th to 14th</td>
<td>2 x ISB 500</td>
<td>ISMB 450 (2-T&amp;B plates-300 x 8 mm)</td>
<td>350 x 350 x 10</td>
</tr>
</tbody>
</table>

2.3. Seismic Analysis

Various seismic parameters were considered as per the codal provisions of IS:1893-2016 in order to evaluate the structural models under seismic analysis. As the seismic zone of the structures was taken as V, the dynamic seismic analysis was carried out as per the code. Following are the seismic parameters taken for the present study:

- Response Reduction Factor: 5
- Importance Factor: 1.2
- Type of Building: Steel
- Type of Soil: Medium Soil

III. RESULTS AND DISCUSSION

A. The results of corner column (A) and internal column (B) were taken for the present study in order to evaluate the performance of various models of 14 storey building with different bracing system. The results were gathered from Staad. pro’s output file as well as post-processing and presented in various forms in the following section.

B. The displacement of column of different models are shown below:

Figure 1 2. Displacement of Type 1 Building.
Figure 13. Displacement of Type 2 Building.

Figure 14. Displacement of Type 3 Building.

Figure 15. Displacement of Type 4 Building.

Figure 16. Maximum Displacement of various models of 14 Storey Building.

Table 3. Total Steel Quantity of 14 Storey Building.

<table>
<thead>
<tr>
<th>Type of Building</th>
<th>Material Quantity (kn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>17077.44</td>
</tr>
<tr>
<td>Type 2</td>
<td>18125.069</td>
</tr>
<tr>
<td>Type 3</td>
<td>17422.92</td>
</tr>
<tr>
<td>Type 4</td>
<td>18909.757</td>
</tr>
</tbody>
</table>
Figure 17. Total Material quantity of Steel.

IV. CONCLUSION

The evaluation of different kinds of curved bracing system was done for steel framed structure while performing dynamic seismic analysis. The behavior and performance of various shaped of curved bracing was analyzed and results were collected and represented in the form of tables, graphs and figures. The final conclusions of the present study are as follows:

- Maximum displacement at corner columns for type 1, type 2, type 3 and type 4 comes out to be 39.824 mm, 33.961 mm, 38.005 mm and 34.570 mm respectively and it can be concluded that type 2 building which uses ‘AV Arc’ bracing has the least maximum displacement. Therefore, ‘AV Arc’ type bracing has been proved to be the most effective bracing system in resisting lateral loads.

- While comparing the ‘AV Arc’ bracing system (in type 2) with other bracing, it was found that type 1 showed 17.9% more displacement value than type 2, type 3 building showed 12% higher value of displacement than type 2 building and type 4 building showed 2% more displacement than type 2 building.

- Whereas, the maximum displacement at internal column for type 1, type 2, type 3 and type 4 comes out to be 52.594 mm, 52.782 mm, 53.333 mm and 53.491 mm respectively. It is noticed that there was very slight variation in the displacement of internal columns and it can be concluded that if the bracing system is provided at the edges of the building, then the internal columns remained unaffected.

- The results of material quantity of steel showed that type 1 uses minimum quantity of steel i.e. 17077.44 KN whereas, maximum quantity was used by type 4 i.e. 18909.76 KN. Therefore, type 2 showed moderate quantity of steel i.e. 18125.07.

In the end, from the analysis report of the present study, it can be concluded that ‘AV Arc’ bracing system (Type 2 building) is the most effective curved bracing system and it can be used effectively to resist lateral loads such as earthquake loads.

REFERENCES


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