# Seismic resilience performance of braced ductile thin shear panel with and without stiffeners

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**Abstract -** *At the joint point of the X-braced system, a new seismic resistant system with a braced ductile shear panel (BDSP) was installed. Numerical study revealed that the BDSP performs the function of ductility and energy absorption while the X components continue to be elastic. A novel type of steel shear wall called shear panels combined with bracing eliminates heavily distributed stresses placed on main beams and columns.*

*The findings of an experimental program that compared shear panels with and without stiffeners are presented in this paper. The stiffening rib spacing as well as the specifications and dimensions of the shear panel thickness were taken into account. The maximum load-carrying capability of BDSPs can be strengthened by the addition of strengthening ribs. ANSYS 2021 R2 software was used to model, evaluate, and design the following. This study has shown that shear panels with stiffeners had outstanding ductility as well as appropriate hysteretic behavior, which increases the scatter of induced seismic energy.*

***Key Words***: *Earthquake resistant structures, Bracing, Energy dissipation, Finite-element method, Cyclic loading, Stiffening ribs,* etc

## 1. INTRODUCTION

In strong seismic areas, metal shear panels are an efficient means of resisting seismic forces and are frequently utilized to withstand wind or earthquake pressures. The enhancement in structural energy dissipation capacity brought on by the stable hysteretic behavior is the main advantage offered by the usage of metal shear panels. Many researchers have experimentally investigated a variety of shear panels made of various metals, including pure aluminum, low-yield-strength steel, regular carbon steel, and stainless steel. Prominent benefits, including preferable ductility, high initial stiffness, and high lateral load-carrying capacity, have been noted.

The steel plate with various opening forms, including circle-, ring-, and auxetic-shaped, was initially proposed and examined from a mechanical perspective. This paper includes a comparative experimental program on two types of steel shear panels with and without stiffeners. The stiffening rib spacing as well as the specifications and dimensions of the shear panel thickness were taken into account. The ultimate load-carrying capacity was greatly improved by the addition of strengthening ribs. ANSYS 2021 R2 software was used to model, evaluate, and design the following.

## 2. EXPERIMENTAL PROGRAM

### 2.1 TEST SPECIMENS

A total of seven BDSP specimens were modeled, analysed, and designed using ANSYS 2021 R2 software. The BDSP was used as the major lateral force resisting component for the prototype building, which was selected and designed according to the design approach in the Chinese seismic code. Models of BDSP with and without stiffeners were fabricated. BDSP stiffening ribs were modeled in Specimens 2-7 with varying numbers of ribs and thicknesses. Detailed information about the test specimens is listed in Tables 1 and 2.

### 2.2 MATERIAL PROPERTIES

The grade of the steel panel for all the specimens was made of Q345B with nominal yielding strength of 331.22 MPa. Table 1. Shows the properties of steel. The specimen types and their dimensional parameters are listed in table 2

**Table -1:** Properties of steel

| Steel |
|---|
| The material used - Q345B |
| Yield strength $f_y$ - 331.22 Mpa |
| Poisson's ratio- 0.3 |
| Bi linear property |

**Table -2:** Specimen parameters

| Specimen No. | Specimens type | Thickness of shear panel | Thickness of flange | Thickness of Stiffening ribs |
|---|---|---|---|---|
| 1. | BDSP without stiffeners | 3 | 6 | - |
| 2. | BDSP with 2H2V | 3 | 6 | 3 |
| 3. | BDSP with 2H2V | 3 | 6 | 6 |
| 4. | BDSP with 2H2V | 3 | 6 | 12 |
| 5. | BDSP with 2H2V | 3 | 6 | 3 |
| 6. | BDSP with 2H2V | 3 | 6 | 6 |
| 7. | BDSP with 2H2V | 3 | 6 | 12 |

In specimens 2–7, equally spaced ribs were arranged in two and three rows along the horizontal and vertical directions, respectively. To achieve the shear panel yielding prior to the failure of the surrounding components, the braces, loading frame, and shear panels were fabricated using the Chinese standard – conformant Q345B steel.

## 3. GEOMETRICAL DETAILS

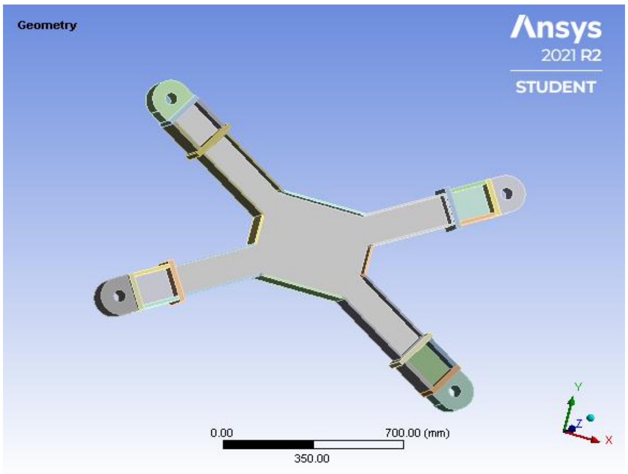


**Fig -1**: Geometry of BDSP without stiffening ribs

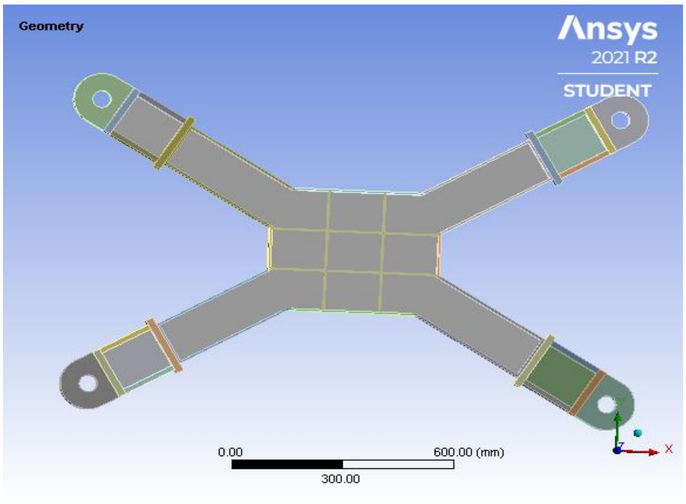


**Fig -2**: Geometry of BDSP with stiffening ribs 2H2V - 3mm

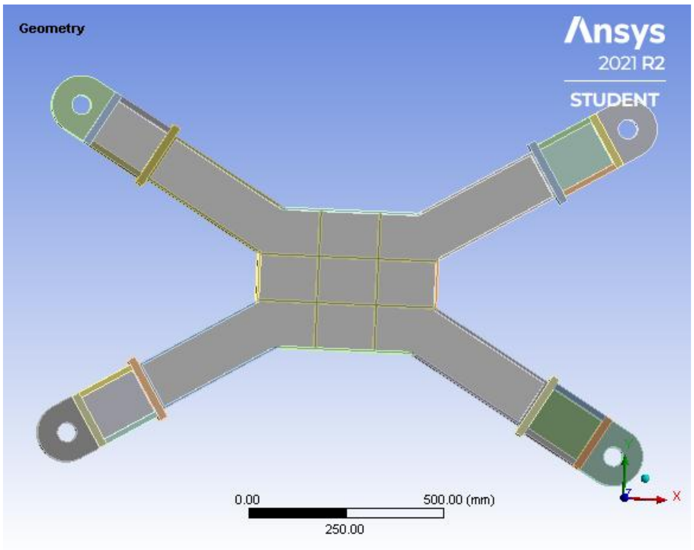


**Fig -3**: Geometry of BDSP with stiffening ribs 2H2V - 6mm

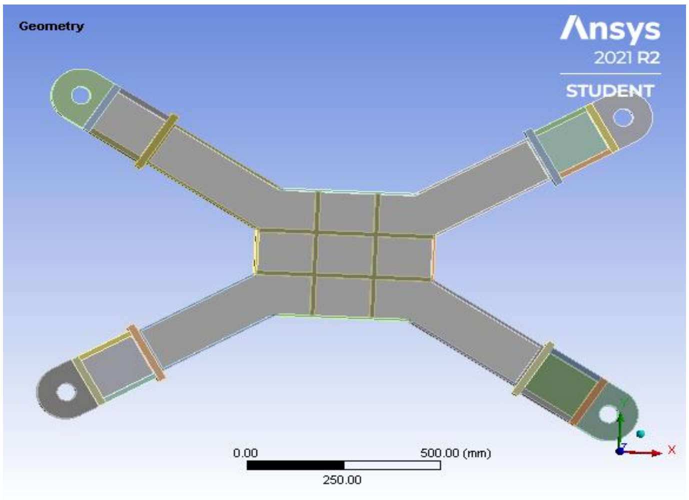


**Fig -4**: Geometry of BDSP with stiffening ribs 2H2V - 12mm

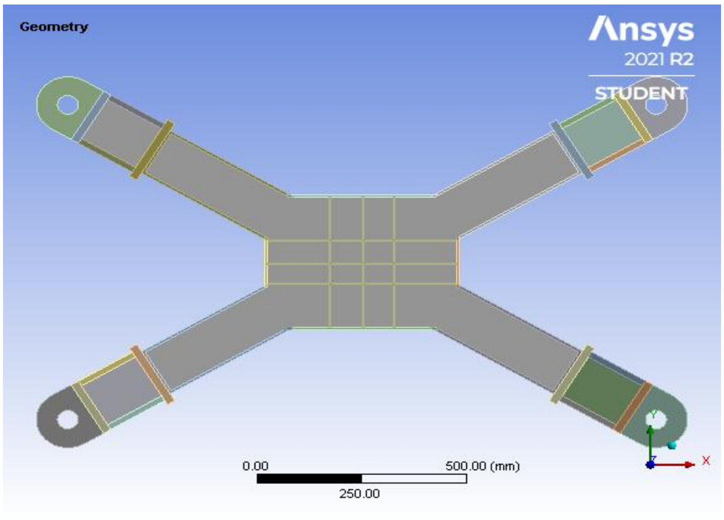


**Fig -5**: Geometry of BDSP with stiffening ribs 3H3V - 3mm

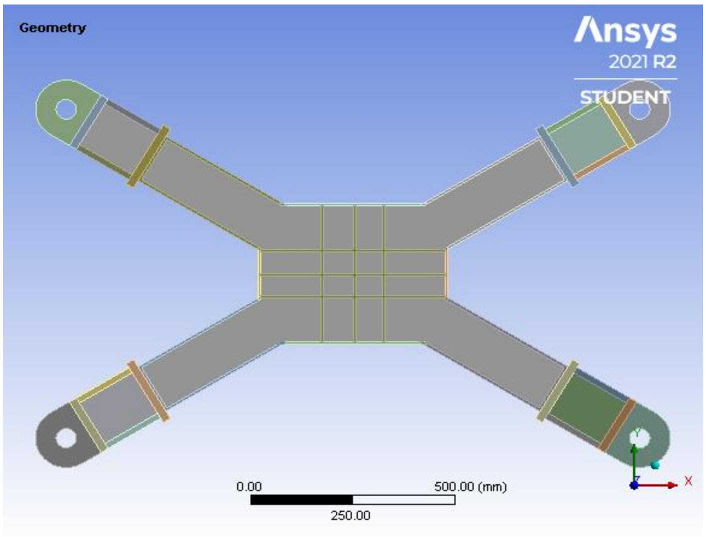


**Fig -6**: Geometry of BDSP with stiffening ribs 3H3V - 6mm

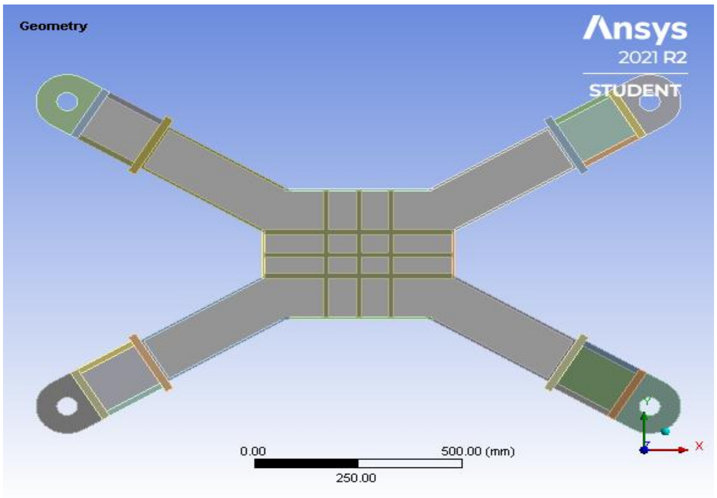


**Fig -7**: Geometry of BDSP with stiffening ribs 3H3V - 12mm

## 4. MODELLING AND ANALYSIS

ANSYS workbench 2021 R2 was used to develop the three-dimensional BDSP model. Total 7 models are prepared for the study, 1 model prepared without stiffening ribs and 6 models with different arrangements of stiffening ribs with 3mm, 6mm, and 12mm thickness of ribs. The effective specimen among these specimens under cyclic loading is noted. And also found the panel optimization of BDSP without and with stiffening ribs.

### 4.1 MODELLING

The braced ductile shear panel (BDSP) system was modeled in ANSYS Workbench 2021 R2. For the panel optimization, the BDSP with & without stiffening ribs were also modeled. The stiffening ribs were provided with 2 & 3 numbers, and specimens modeled with stiffening ribs thickness of 3mm, 6mm & 12mm respectively. The analysis conducted herein was essentially a cyclic loading.

### 4.2 FINITE ELEMENT ANALYSIS

The ANSYS workbench 2021 R2 software was used to model all the specimens for nonlinear analysis. SOLID 186 from the ANSYS library was used for 3-D finite element modeling of the BDSPs models. All the models are studied using ANSYS workbench 2021 R2 under cyclic loading. Firstly, the load is applied on the top flanges, and in the next step eccentric loading with an eccentricity of 25mm is applied to the structure.

## 5. RESULTS AND DISCUSSIONS

### 5.1 DEFORMATION ALONG THE PATH

A path is created along the entire BDSP with the lower side of the BDSP as starting point and the upper side of the BDSP as an endpoint. The total deformation of all the best models along the path and graphical representation are shown in the figures given below.

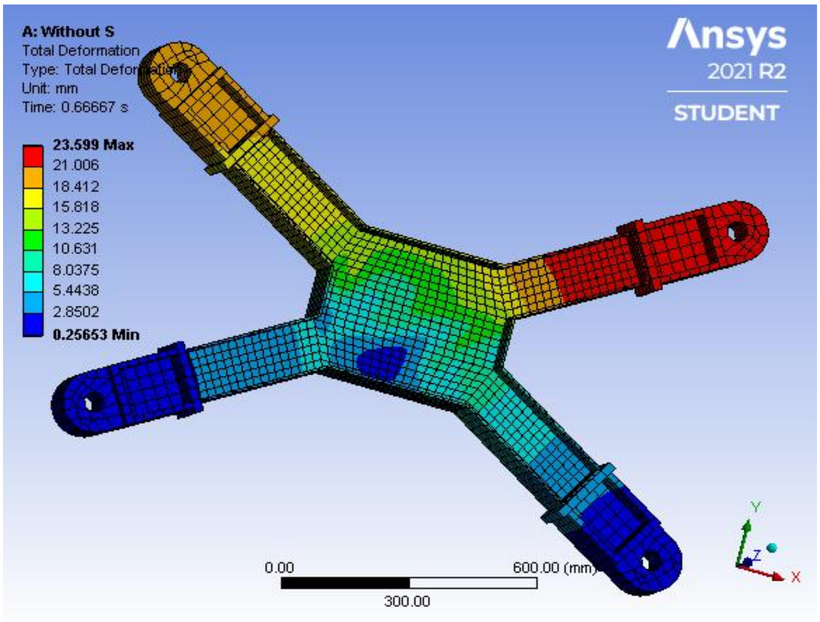


**Fig -8**: Total deformation of BDSP without stiffening ribs

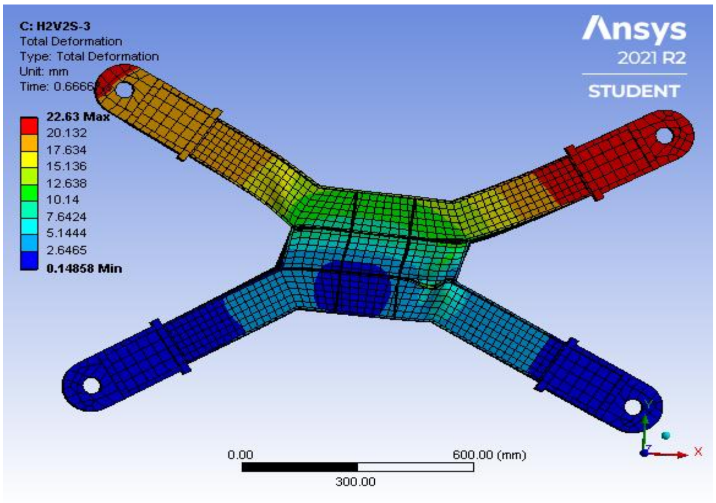


**Fig -8**: Total deformation of BDSP with stiffening ribs 2H2V - 3mm

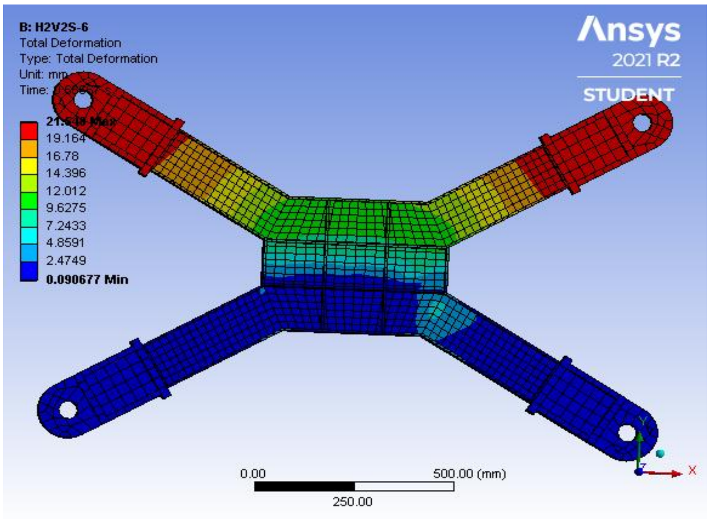


**Fig -9**: Total deformation of BDSP with stiffening ribs 2H2V - 6mm

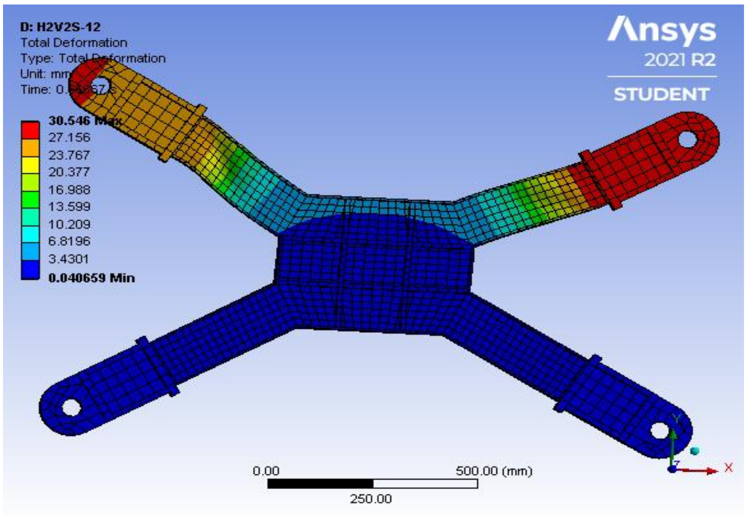


**Fig -9**: Total deformation of BDSP with stiffening ribs 2H2V - 12mm

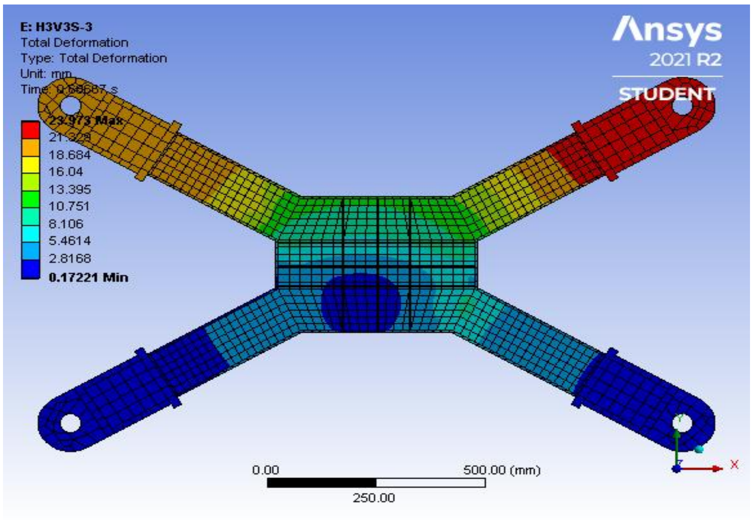


**Fig -10**: Total deformation of BDSP with stiffening ribs 3H3V - 3mm

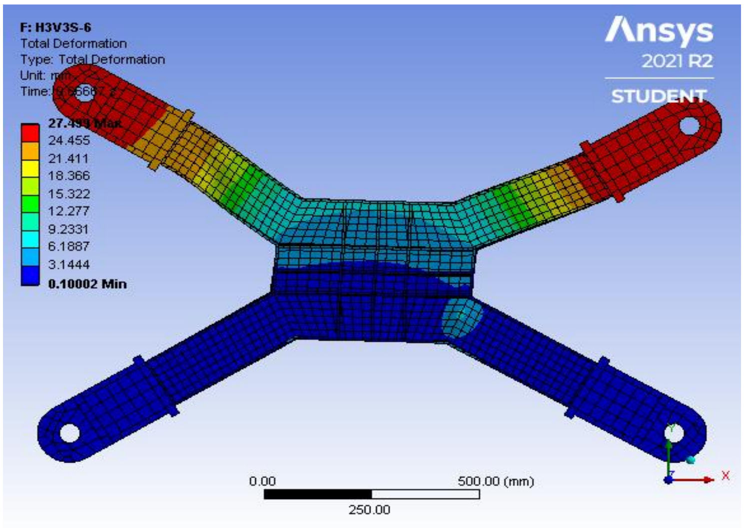


**Fig -11**: Total deformation of BDSP with stiffening ribs 3H3V - 6mm

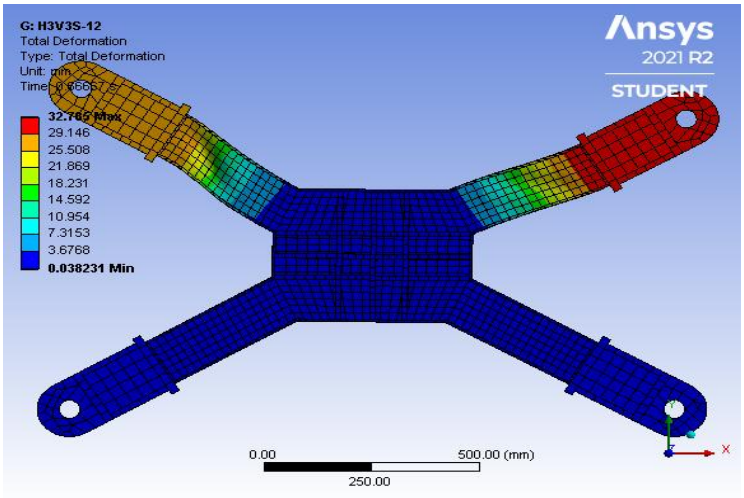


**Fig -12**: Total deformation of BDSP with stiffening ribs 3H3V - 12mm

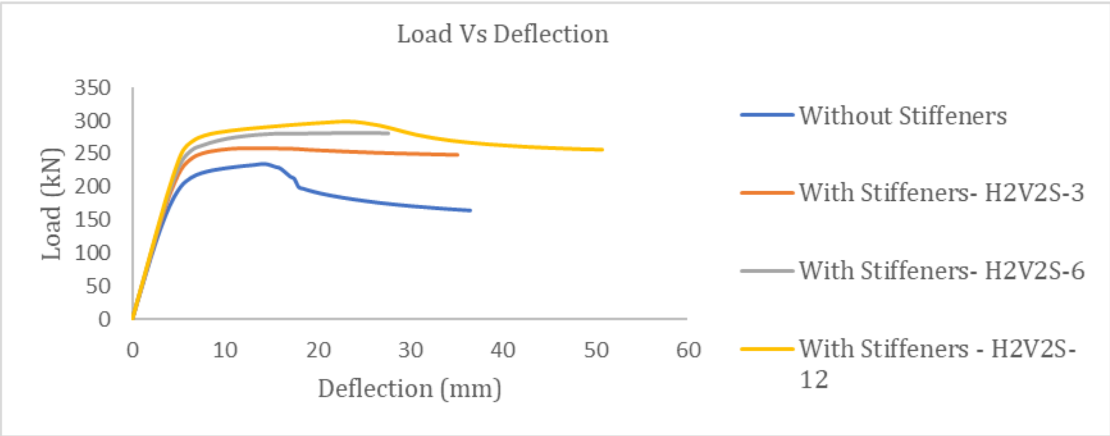


**Chart -1**: Load Vs Deflection curve without stiffeners and with stiffeners of 2H2V

Chart.1 shows the load Vs deflection curve of BDSP without stiffeners and with stiffeners of 2H2V. In that BDSP without stiffeners, the ultimate load and ultimate deflection show very little effectiveness. When comparing 2H2V stiffeners with thicknesses of 3 mm, 6 mm, and 12 mm, the ultimate load and ultimate deflection are greater for stiffeners with a thickness of 12 mm.

**Table -3:** Percentage decrease in load of without stiffeners and with stiffeners of 2H2V

| MODELS | DEFLECTION | LOAD | % DIFFERENCE IN LOAD |
|---|---|---|---|
| Without Stiffeners | 14.313 | 234.07 | 1 |
| With Stiffeners- H2V2S-3 | 12.639 | 257.47 | 9.997009442 |
| With Stiffeners- H2V2S-6 | 23.108 | 280.71 | 19.92566326 |
| With Stiffeners - H2V2S-12 | 23.168 | 299.15 | 27.80364848 |

From table 3, the ultimate load and ultimate deflection values for stiffeners with 2H2V with 3 mm, and 6 mm thicks are less than that of 12 mm thick stiffeners. The ultimate load and ultimate deflection for 2H2V with 12 mm thick is 299.15 kN & 23.168 kN.

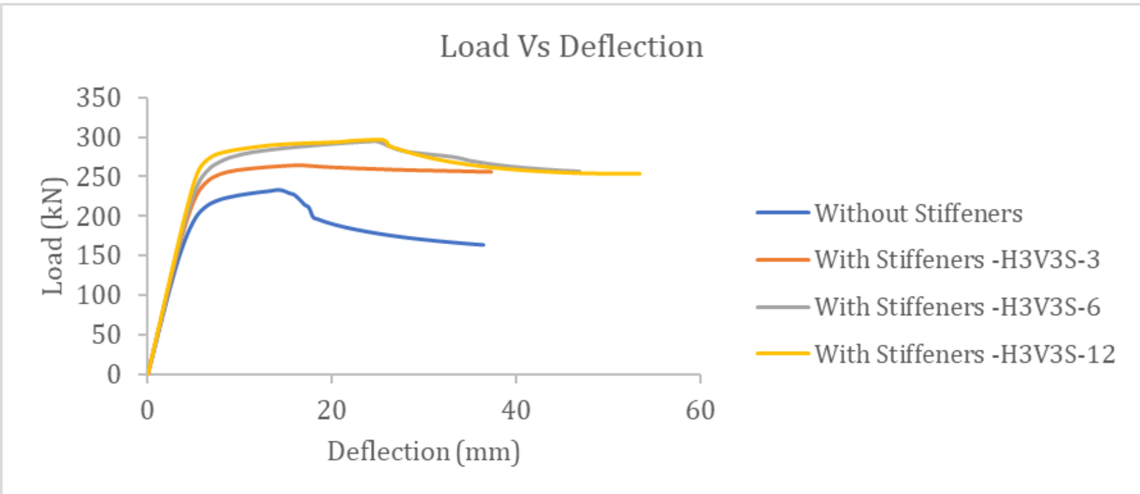


**Chart -2**: Load Vs Deflection curve without stiffeners and with stiffeners of 3H3

**Table -4:** Percentage decrease in load of without stiffeners and with stiffeners of 3H3V

| MODELS | DEFLECTION | LOAD | % DIFFERENCE IN LOAD |
|---|---|---|---|
| Without Stiffeners | 14.313 | 234.07 | 1 |
| With Stiffeners- H3V3S-3 | 16.451 | 263.9 | 12.74405092 |
| With Stiffeners- H3V3S-6 | 24.772 | 295.68 | 26.32118597 |
| With Stiffeners – H3V3S-12 | 24.99 | 297.49 | 27.09445892 |

From table 5.2, the ultimate load and ultimate deflection values for stiffeners with 3H3V with 3 mm, and 6 mm thicks are less than that of 12 mm thick stiffeners. The ultimate load and ultimate deflection for 3H3V with 12 mm thick is 27.094 kN & 24.99 kN.

By comparing table 5.1 & table 5.2, The ultimate load and ultimate deflection values for stiffeners 12 mm thick show nearly the same values when compared with both 2H2V and 3H3V. So in the case of the increasing thickness of stiffening ribs in 3H3V, no further improvements occur.

## 3. CONCLUSIONS

Using metal shear panel dampers, it was demonstrated that it had good low-cycle fatigue properties and super seismic behavior. The shear panel thickness specifications and dimensions, as well as the spacing of the stiffening ribs, were taken into consideration in order to reduce damage to all structural components other than the sacrificial panels during earthquakes. The ultimate load-carrying capacity was greatly improved by the addition of strengthening ribs. The data will also be utilized to forecast the real ductility and energy dissipation capacity of various geometries by adding a damage and failure criterion to the finite element model. Braced ductile thin shear panels with stiffening ribs exhibit the best panel optimization. The ultimate load and ultimate deflection are higher for BDSP with stiffeners as compared to BDSP without. This has a greater capacity for hauling loads. The ultimate load and ultimate deflection are higher for stiffeners with a thickness of 12 mm when compared to stiffeners with thicknesses of 3 mm, 6 mm, and 12 mm. The ultimate load and ultimate deflection are higher for 3H3V stiffeners with a thickness of 12 mm when compared to stiffeners with thicknesses of 3 mm, 6 mm, and 12. When compared with both 2H2V and 3H3V, stiffeners 12 mm thick exhibit almost the same values for ultimate load and ultimate deflection. There are therefore no further advancements in the case of the thickening stiffening ribs in 3H3V. The outcomes show that the BDSP system has the potential for reducing structures' lateral displacements.

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