

# Numerical Study of Circular Shear Damper on Beam Column Joint

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**ABSTRACT:** Experiments and previous studies show that the Beam Column Joints are impacted more in an event of earth quake. Brittle fractures are seen in the joints in most cases. Various studies are conducted on ways to improve seismic resistance of steel frames. In this paper, the seismic performance of the structure is analysed by introducing a circular shear damper in the beam column joint. Twenty three cycles of cyclic load are applied to determine the seismic performance. The result is compared with a rectangular slit damper in the beam column joint. The circular shear damper showed better seismic performance as compared to the rectangular slit damper.

**KEYWORDS:** Circular shear damper, rectangular slit damper, cyclic loading.

## I. INTRODUCTION

Researchers and engineers started focusing on damage control design concept mainly after the 1995 Kobe Japan earthquake disaster which caused huge damage, left 300000 homeless and killed 6300 people. Over the same period structural researchers shifted their attention towards seismic design with the goal of improving the ultimate resisting capacity of structures and thereby reducing the damage caused during earthquake. There are wide varieties of methods to improve resisting capacity of the structures and to reduce the damage during earthquake. Using Steel Damper is one of the methods to improve the resisting capacity of the structure. Steel damper is a type of passive control device. The source of energy dissipation of the steel damper is the hysteresis of the material. The concept and experimental work of metallic energy dissipating device was first devised by Kelly in 1972 and later Shinner in 1975. As the development of hysteretic damper proceeds, there are two types of dampers – axial yield type represents buckling restrained braces (BRB) and shear yield type represents shear panel damper (SPD). These two types of dampers come under passive energy control system, and this method is considered as the most effective and inexpensive way to reduce damage on earthquake.

At SSEEL (steel structure and earthquake engineering laboratory), Chosun University, evaluation of a circular shear panel hysteresis damper was conducted and its structural performance was analyzed. Inside circular shear panel damper, passive energy dissipation takes place by metallic deformation. The main advantage of a circular shear panel damper over other dampers is that it can resist loads in all directions owing to its circular shape. This property is much needed for resisting the multi-dimensional force during an earthquake.

The main purpose of this paper is to prevent damage to the building by using circular shear damper in beam column joint of a steel frame under cyclic reversible load configurations. The use of damper element will not only prevent serious damages to the structure and also loss of lives and property but also it will ensure that the structure can be repaired and made serviceable as soon as possible with minimum cost. It is anticipated that, during an earthquake the damage will occur only on the damper which can be easily replaced.

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The figure 1 shows the reference figure of a circular shear damper. The circular damper is connected with 2 plates at the top and the bottom.

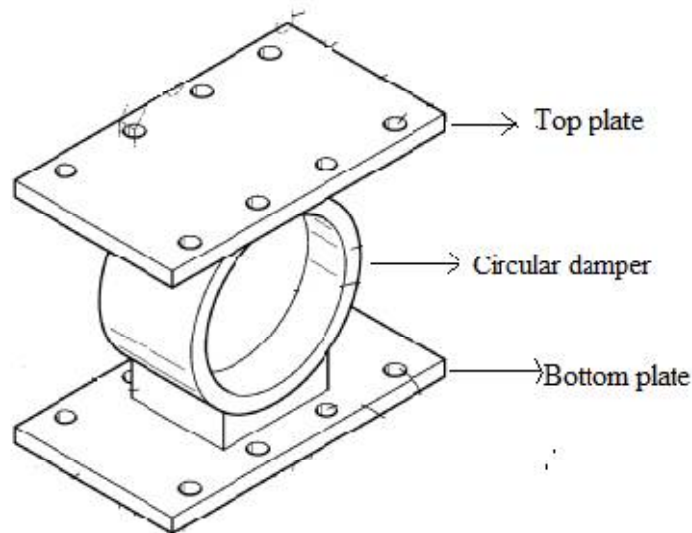


Fig1: Circular shear damper

The main objective of the paper is to understand the effect of circular damper used in beam column joint by applying cyclic load as per load protocol by using ANSYS 16.2 software. The material properties and loading conditions implemented by author in [1] is validated and the results were found satisfactory so that the same loading conditions and material properties are adopted.

## II. RELATEDWORK

Using steel damper in beam column connection of steel frame, moments are carried to the beam capacity, dampers are first yielded and then reached the ultimate boundary condition preventing any damage to the beam or column [1]. The cumulative energy absorption capacity of low yield point steel is much higher than other grades of steel making it an effective material for horizontal elements resisting wind induced vibration, column and beam edges subjected to earth quake and structural members exposed to external forces of relatively small strain amplitude and high cumulative frequency. [4]. Constant stain loading is implemented for circular shear damper where the load is applied by controlling the displacement with displacement protocol [6]. Mild steel dampers absorb seismic energy only when they go through in-elastic deformation. Low yield strength steel is used as the material for hysteretic damper for its excellent ductility performance [9].

## III.GEOMETRY AND MATERIAL PROPERTY

The geometry of the damping members was prepared using workbench platform of ANSYS 16.2 Finite element Analysis software. The sizes and material properties of damping members are given below.

### 2-1 Dimensions

Column is of height 3000mm, length 400 mm and column flange of width 200 mm. Beam is of length 2000 mm, depth 270 mm and beam flange of width 200 mm. Two angle sections ISA 200x200 with thickness 25 mm are used to

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connect damper with beam and column. Diameter of circular damper is 100mm. Figure 2 shows the geometry of beam column joint attached with circular damper.

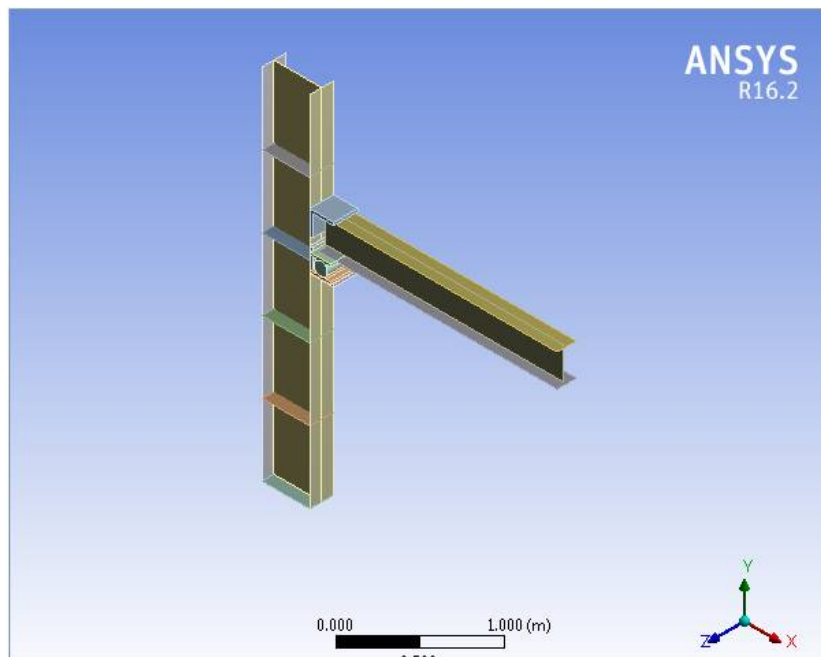


Fig 2: Geometry of beam column joint attached with circular damper

## 2-2Material Property

The material used for damper is low yield point steel because in hysteric dampers, steel must become plastic in an earthquake prior to other structural members, such as columns and beams. Low yield point steel reduces yield strain also.

Low cycle fatigue properties are also important since the damper is repeatedly exposed to high plastic strain at the time of earthquake. The manufacturing of low yield point steels is done by optimum temperature control during rolling. Material Property of the steel material is shown in table 1.

Table 1. Material property of steel materials.

Specimen		Steel Grade	Yield Strength	Ultimate strength	Elastic modulus
Beam	web	St44	315	445	$2.1 \times 10^5$
	flange	St44	315	445	$2.1 \times 10^5$
Column	web	St44	315	445	$2.1 \times 10^5$
	flange	St44	315	445	$2.1 \times 10^5$
Steel angle		St44	315	445	$2.1 \times 10^5$
Damper		St37	305	410	$1.98 \times 10^5$

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## IV. BOUNDARY CONDITIONS AND LOADING

The boundary condition used is fixed boundary condition that is the two ends of the column are restricted. Cyclic loading is adopted to find the seismic resistance of the circular damper. Cyclic load is applied on beam end on both positive and negative directions by applying displacement on the beam end. 23 cycles of loading are done. Figure 3 shows the loading regime graph obtained from [1].

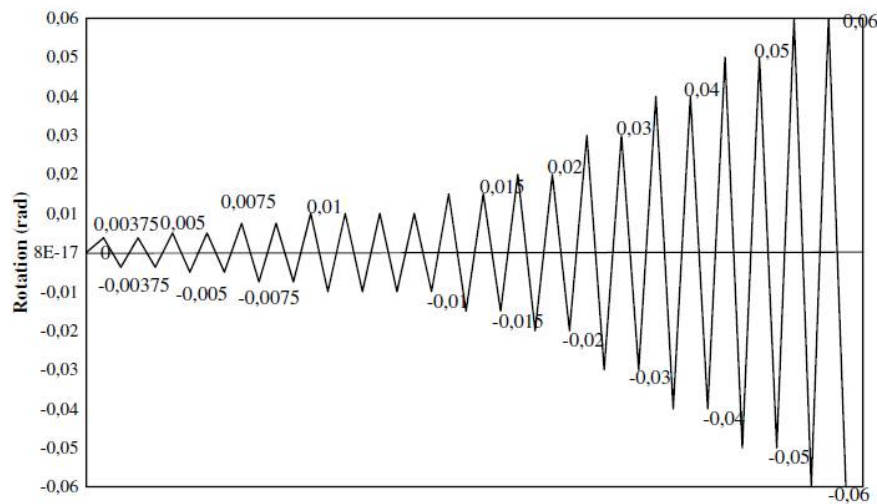


Fig3: Loading regime

The figure 4 shows the displacement versus rotation graph obtained from ANSYS 16.2 as per loading protocol. Twenty three cycles of loading are applied. The table shows the time and displacement of each cycle. Two cycles are performed for each displacement except for fourth displacement where four cycles are performed.

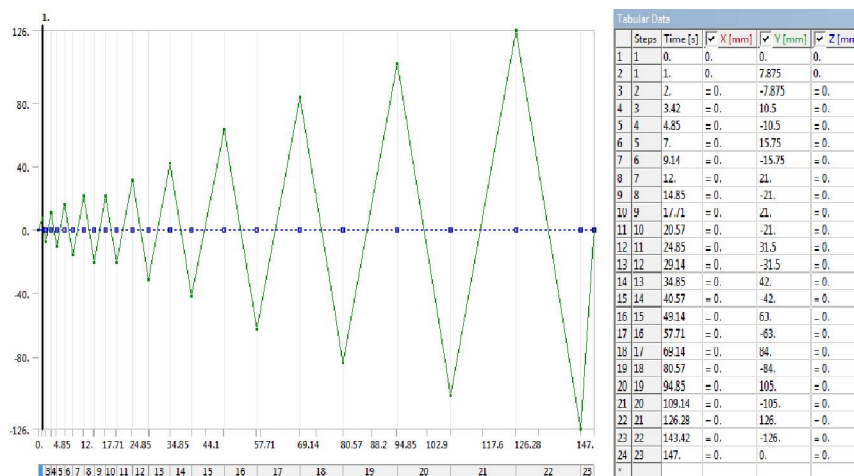


Fig4: Graph plotted in ANSYS 16.2 with corresponding displacement.

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## V. SIMULATION & RESULTS

The hysteretic curve obtained after the analysis is compared with the validation result. Even though both results show a stable hysteretic curve, the specimen with circular damper shows much better result. The figure 5 shows the hysteretic curve of the circular damper obtained after the cyclic load analysis.

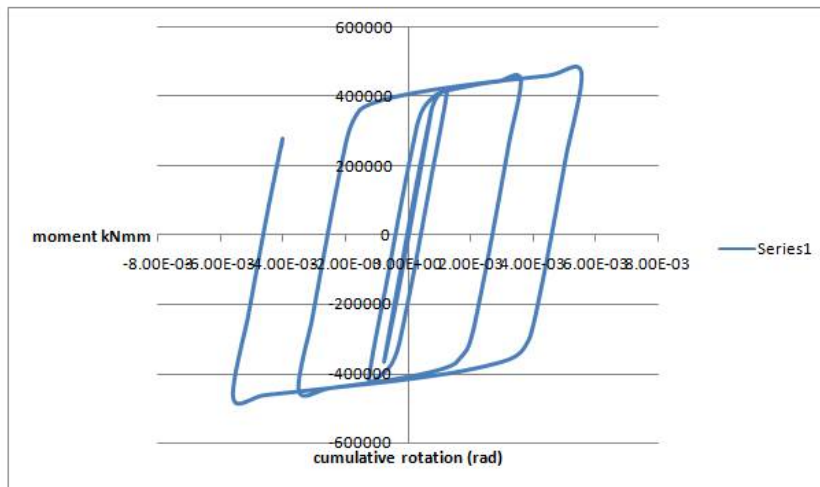


Fig5: Hysteretic curve of circular damper

The figure 6 shows the validation result obtained by using Slit Damper in the beam column joint in place of circular damper. The validation was carried out using ANSYS 16.2 software.

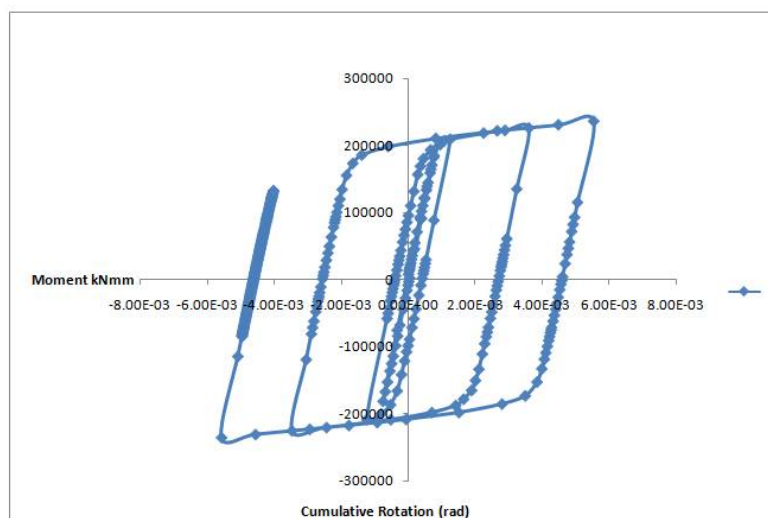


Fig6: Hysteretic curve of slit damper

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The application of circular damper in beam column joint is a better option for earthquake resistance. Also as the circular damper is replaceable, it is more economical.

### IV. CONCLUSION

This study reveals the ability of circular damper to resist earthquake. The validation is done by placing the rectangular steel slit damper of St37. The hysteretic curve plotted after validation is given above the value ranges from 200 to 250 kNm. The hysteretic curve plotted after analysis of circular damper is between 400 to 450 kNm. Even though both the dampers give stable hysteretic curve, circular damper gives much better hysteretic curve. Also by comparing the area of two curves, the circular damper has more area which means it has better efficiency for energy dissipation than the Slit damper.

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