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The effect of edge stiffener on compressive behavior of Gusset plate

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Abstract

The Gusset plates are sheets that were utilizing for connection and transportation of force between brace and beam or column in frame. These plates have complex behavior subjected to compressive force because different failure modes. The edge buckling is one of the common failure modes in large dimension Gusset plates. The edge stiffeners have been recommended for against of edge buckling and increasing the ultimate bearing capacity and ductility of Gusset plate. In this paper, the model of Gusset plate has been simulated with considering of boundary members stiffness, nonlinear behavior of material and initially imperfection by ANSYS finite element software. These models have been verified to experimental activities of Yam and Cheng (1993). The effect of edge stiffeners on compressive behavior of Gusset plate and the thickness of Gusset plate effect on edge stiffener are studied. The result demonstrated that the edge stiffeners improve the behavior of Gusset plate and with increasing the Gusset plate thickness increased the effect of edge stiffener in total compressive behavior of steel Gusset plate.

Key words: compressive strength, edge stiffener, failure mode, gusset plate

1. Introduction

The Gusset plate connections were used steel structures for connecting the brace member to beam and column commonly. Monotonic applying loads can be studied in Gusset plate with dividing the cyclic loads to tensile and compressive specially. The shear is critical failure mode subject to tensile loads in Gusset plate but different failure mode are subject the compressive monotonic load and this problem complicated the behavior of Gusset plate and prediction of failure type were difficult. For identity relative rehabilitation of failure mode, according fig.1, Astaneh-Asl (1998) reported classified of failure modes base on suitable.

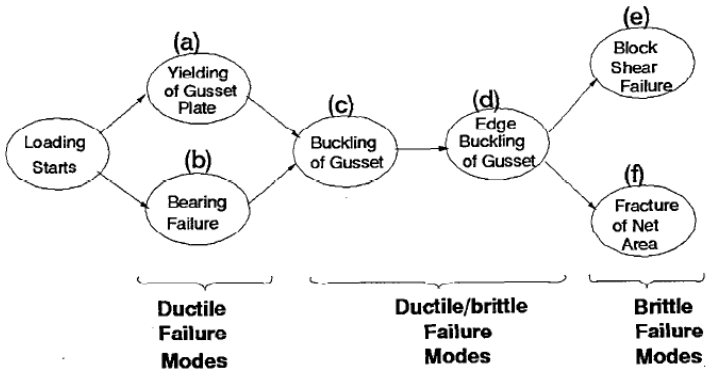


Fig.1: failure mode of Gusset plate base on suitable

In many cases, the buckling is critical failure mode on compressive behavior Gusset plate that according to define of Astaneh-Asl the buckling is brittle and ductile failure mode. One of recommendation ways is increasing the Gusset plate stiffness for rehabilitation of compressive behavior of Gusset plate with edge stiffeners. The study on edge stiffeners recommendated by Wiliams and Richard (1996) because these are weak. After them, initial investigation done by Rabinovitch and Cheng (1993) on edge stiffeners effect. Because weak of edges in diagonal brace Gusset plate, initial investigative recommended by Wiliams and Richard. After of them, initial study by Rabinovitch and Cheng were done on edge stiffeners effect. The investigation shown the edge stiffeners have any considerable effect on rehabilitation of tensile behavior of Gusset plate and only energy dissipation value of it rehabilitated the Nast, Grondin and Cheng (1998) investigations on stiffened gusset plate demonstrated that the edge stiffeners have any considerable effect on buckling strength of gusset plate. But these are useful for stability of Gusset plate in post buckling zone. In this investigation, the stiffened and unstiffened Gusset plate was compared and the role of Gusset plate thickness was studied on value of edge stiffener effect.

2. Buckling criteria of Gusset plate

The scanty investigation done for studying of edge buckling of Gusset plate and in every one of them considered a criteria for prevented of edge buckling mode in Gusset plate. Brown (1988) had done one of important investigation in edge buckling of Gusset plate that he reported the compressive experimental results and analysis of Gusset plate edge buckling. In this investigations recommended the eq.1 for prevented the Gusset plate edge buckling.

$$\frac{L_{fg}}{t} \le 0.83\sqrt{\frac{E}{F_Y}} \qquad (1)$$

Where E is elasticity modulus, t is thickness of Gusset, F_y is failure stress of materials and L_{fg} is the length of free edge in gusset plate. Eq.1 utilized for elastic buckling of free edge in thin Gusset plate subject to monotonic loads and Gusset plate subject to large cyclic tensile and compressive loads buckled in edges if eq.1 has existed.

Eq.2 recommended by Astaneh-Asl (1998) for prevented the free edge buckling of Gusset plate before it reaches to maximum compressive capacity:

$$\frac{L_{fg}}{t} \le 0.75\sqrt{\frac{E}{F_Y}} \qquad (2)$$

3. Finite element modeling of Gusset plate

3.1. Modeling and verifying

The solid45 element utilized for modeling of different portion of Gusset plate connection consist of beam, column, bounding member and edge and middle stiffeners according to fig.2 in ANSYS10.0 software. This element has eight nodes and each node has ability of creep, plasticity, swelling, stress stiffening, strain stiffening and large displacement. The MPC184 element utilized for bolt in brace member connection in all models, the material nonlinear behavior and numeral and initial imperfection considered. Whereas material of models is from steel type then the von misses criteria and kinematic hardening laws utilized for study of results. For studying of ANSYS result verifying with experimental work, the experimental result of Yam and Chang (1993) with 6.5, 9.8 and 13.3 mm thickness of Gusset plate were used. According to fig.3 shown that verifying of model with 9.8mm thickness of Gusset plate. This result in table.1 has shown that results have acceptable accuracy.

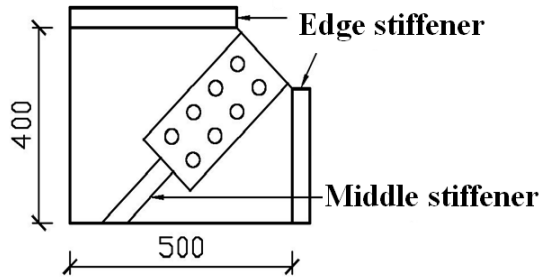


Fig. 2. Properties of stiffened gusset plate

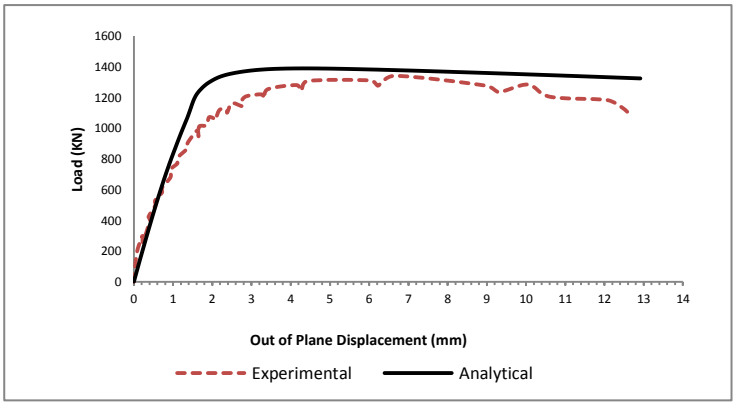


Fig. 3. The verifying of analytical result with Yam and Cheng experimental work

Thickness (mm)	P_{EXP} (KN)	P_{ANSYS} (KN)	$P_{Thornton}$ (KN)	$P_{Whitmore}$ (KN)	$\frac{P_{EXP}}{P_{ANSYS}}$
6.5	742	766	460	555	0.97
9.8	1356	1389	855	928	0.97
13.3	1956	2057	1164	1218	0.95

Table. 1. Comparing of verifying results

3.2. Properties of models

According to detail of modeling fig.4 and dimension of fig.2 and fig.5, the verifying model simulated with edge and middle stiffeners specially. In these models end of beam and column are fixed and prevented of out of plane in Gusset plate. In these models, the monotonic compressive load was applying in location of brace member to bonding member connection.

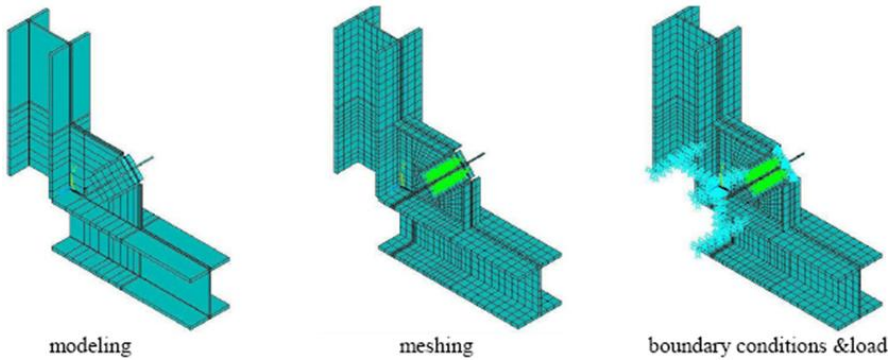


Fig. 4. Detail of modeling

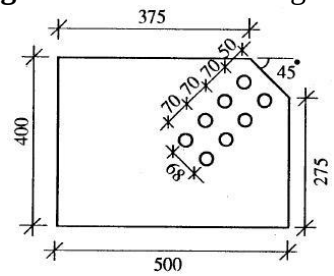


Fig.5. propertice of dimansion

The beam and column members were W250X67 and the bonding member were used T shape of WT125X22.5. The consumption steel in modeling of connection and boundary members were type of W300. Table.2 has shown the full properties of consumption material for modeling the models with different thickness of Gusset plate.

Thickness (mm)	Modulus of elasticity (MPa)	Ultimate load (KN)	Failure stress (MPa)
6.5	196000	467	275
9.8	210200	500	305
13.3	207600	501	295

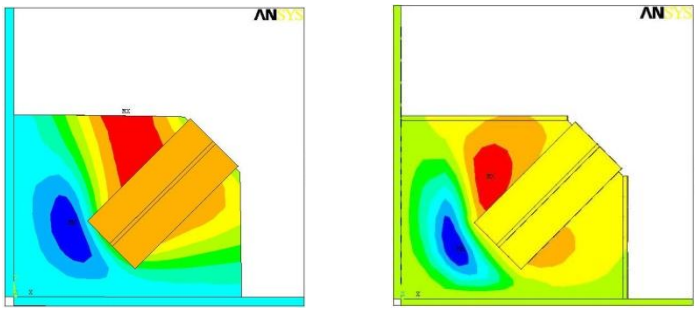
Table.2 .properties of material

4. Results

4.1. Comparing of simple and stiffened Gusset plate with Middle stiffener

The simple Gusset plate is the verifying model and stiffened Gusset plate with edge stiffeners width of 50mm and thickness of 10 mm demonstrated in fig.2 and fig.5. All condition for two models are similar and differentiation of these model are in stiffened and unstiffened with edge stiffeners mentionable. According to fig.6, with comparing of buckling mode after loading and analysis of models demonstrated that simple Gusset plate bucked in edge of Gusset plate and stiffened with edge stiffener eliminated the edge buckling and the buckling formed in end of bonding member. This different shown that

existing of edge stiffeners changed the failure mode from edge buckling state to local buckling and according to Astaneh-Asl defining, this different improved the malleable of model.



(a) (b)

Fig. 6. Comparing of (a) simple and (b) stiffened gusset plate

Load-displacement curves of fig.7 shown that the edge stiffener increased the ultimate bearing and ductility of Gusset plate and whereas the energy dissipation was defining as bottom area of load-displacement curve, therefore the edge stiffeners increased the energy dissipation and these improved the performance of Gusset plate totally.

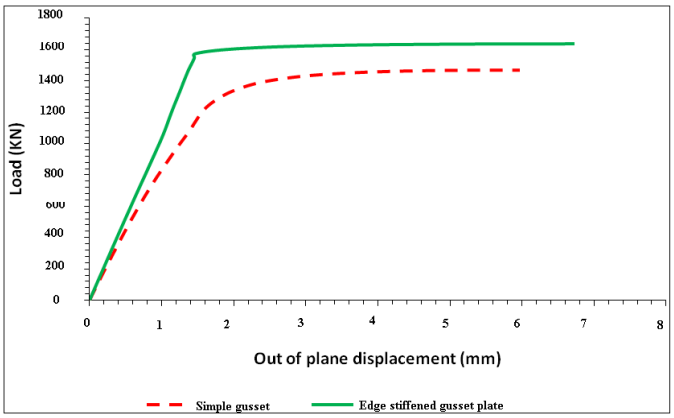


Fig.7. load- displacement curve of simple and stiffened gusset plate

4.2. The study of Gusset plate thickness on edge stiffeners effect

In this section, thickness of Gusset plate role investigated on variable width and thickness of edge stiffeners. Therefore, three Gusset plate thicknesses consist of 6.5, 9.8 and 13.3 mm with edge stiffener widths consist of 20, 30, 40, 50 and 60 mm and three thickness of Gusset plate consist of 6.5, 9.8 and 13.3 mm with edges stiffeners thicknesses consist of 10, 12, 14, 16, 18 and 20 modeled and analyzed. The result had shown that, according to fig. 8 with increasing the thickness of Gusset plate width of edge stiffeners increased the ultimate bearing noticeably.

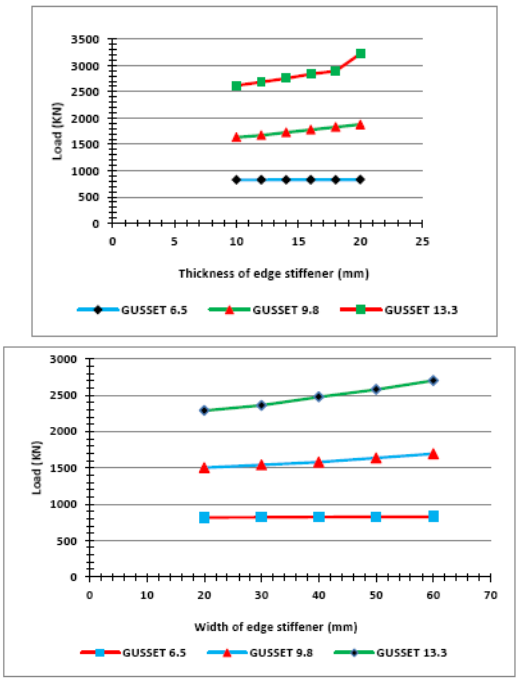


Fig.8. The width and thickness of edge stiffener effect

5. Conclusions

The investigation of different type gusset plate with edge stiffeners and simple demonstrated that:

1. The edge stiffener varied the buckling mode and increased the malleable behavior and compressive capacity of model.
2. The edge stiffeners increased the energy dissipation and improved the compressive behavior of Gusset plate.
3. Increasing the Gusset plate thickness increased the edge stiffeners effect on compressive behavior of Gusset plate.

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