iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 Issue: V Month of publication: May 2017

DOI:

Volume 5 Issue V, May 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Analytical Study by Varying the Parameters of Edge Stiffeners and Splice Plate used in Gusset Plate

Ahani R[1], Aswathy P[2], Vijitha N. K[3]
[1]*PG Student, Department of Civil Engineering, APJ Abdul Kalam Technological University*
[2]*Assistant Professor , Department of Civil Engineering , Thejus Engineering College*

Abstract: Gusset plates are used to connect diagonal members to a beam and a column, they are widely used in bridges to link the truss member at member conjunction. Gusset plates are subjected to either tensile or compressive load from diagonal members which depend upon the type of bracing system. The load from diagonal member will produce bending, shear and normal force in the gusset plate. During compressive loading , gusset plate buckling occur at the end of free edge and local buckling or crippling occur near the end of splice member. Emperical evidence from the past earthquakes and data from numerical simulations provide that secondary lateral force resisting capacity or reserve capacity plays an important role in seismic collapse behavior of low –ductility steel buildings .In 1994 Northridge earthquake, steel buildings did not collapse but there are many connections in lateral force resisting systems sustained undesirable damage because of non-ductile limits states. Hence studying of gusset plate connection plays a significant role in seismic behavior of low-ductiliy steel frame buildings. The project focus on compressive behavior and strength of gusset plate in concentric braced frames CBFs by finite element software (ANSYS 15). Also to increase the buckling strength of gusset plate connection and energy absorption behavior under cyclic loading , effect of adding edge stiffener and stiffener provided in splice plate at different thickness and width have been investigated.Also the effect of the length of splice plate is also investigated.
Keywords: Gusset plate; elastic buckling behaviour parametric study ; stiffeners

I. INTRODUCTION

Concentric braced frames are one of the most common lateral load-resisting systems for steel buildings. In a concentric braced frame the lateral loads applied to the structure are resisted by a network of inclined bracing members. Depending on the configuration of the braced frame, either tensile or compressive loads can be accommodated by the bracing members. These loads are commonly transferred to the beam and column members of the frame by gusset plate connections. Gusset plate receives the load from the diagonal bracing member and transfer it to the main framing members. The delivery of load into and out of the gusset plate will produce bending, shear, and normal force in the gusset plate.

Gusset plates are commonly used in building frames to connect the bracing members to the framing elements; they are also widely employed in bridges to link the truss members at member conjunctions. There are various types of gusset plate connections, including double gusset plate, dual gusset plate, gusset plate with double-sided splice member, and gusset plate with single-sided splice member.

Gusset plate with single sided splice plate member connection type is commonly considered in the situation that a tubular bracing member with a slotted-in splice plate is connected to the gusset plate, where the splice plate is normally shop welded into the slots of the tubular member and then field bolted to the gusset plate . A continuous tube-splice solution without slotted-in welding (also known as flattened end hollow section) is also commonly used. At present, these gusset plate connection types are still quite popular, especially in building frames and other lightly loaded structures, due to the ease of fabrication and construction

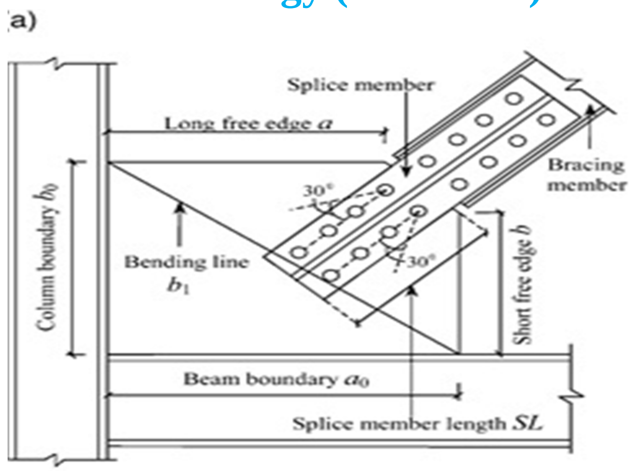


Fig 1 Gusset plate with single sided splice member

In particular when gusset plates are subjected to compressive loads; buckling of the gusset plate occurs at free edges and local buckling and/or crippling of the gusset plate occurs near the end of the splicing member. To increase the buckling strength of gusset plate and to improve the energy absorption behavior of the connections under cyclic loading, It is advantages to adding the stiffener along the splice member and/or adding free edge stiffeners are recommended.

In 2007, the collapse of a large steel truss bridge in Minnesota, where thirteen people were killed, shocked the general public. The subsequent investigation deduced that the collapse was mainly attributed to overstressed and buckled gusset plates .The catastrophic event highlighted the importance of an appropriate design of gusset plate connections.

II. LITERATURE REVIEW

Various literatures reviewed on blast loading are carried out below

A. Whitmore (1952) has reported the results of a series of experiments on gusset plates. Based on his experiments, Whitmore has determined that the location of the maximum tensile stress is near the end of the tension diagonal and the maximum compressive stress is near the end of the compressive diagonal. Whitmore has also concluded that using beam formulas to determine the direct, bending and shearing stresses on a plane through the ends of the diagonals does not accurately reflect the stress condition in gusset plates. Based on his observations, whitemore has found that the maximum tensile and compressive stresses could be approximate effective length normal to the axis of the diagonal. This effective length is obtained by drawing 30º lines from the outside bolts of the first row, to intersect with a line perpendicular to the member through the bottom row of bolts. This concept compares quite well to test results and has since been used as one of the primary tools in gusset plate design. An estimate of the gusset plate yield load can be determined by multiplying the yield stress by the plate area at the effective width section. Tensile stress value based on Whitmore effective length is:

$$P_w = 0.6F_y\,(2L \tan 30 + S)t$$

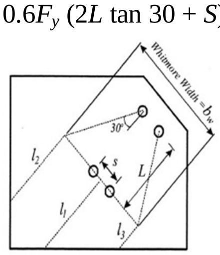


Fig 2 Gusset plate with Whitmore width

B. Thornton (1984) has proposed that buckling load of a gusset plate is considered as the compressive strength of a fixed-fixed column strip below the Whitmore effective width, b_W (Figure 1). The length of the column strip, L_C is the maximum of lengths

Volume 5 Issue V, May 2017
ISSN: 2321-9653

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

L1 , L 2and L3 and the effective column length factor, K, is 0.65. A column buckling equation together with the Whitmore section area b_W t is adopted to estimate the ultimate compressive load. The Thornton expression for the critical buckling load is given as follows:

$$Pcr = ((\pi^2 E / \left(\frac{KLc}{r}\right)\text{^2)bw t)}$$

Where t is the gusset plate thickness and r is the radius of gyration

C. Cheng Fang et al (2015) explained the compressive behavior of eccentrically loaded gusset plate connection .Three full scale tests were conducted , two specimen with unstiffened specimen and remaining one with stiffened splice specimen subjected to eccentric loading condition. Ultimate load of stiffened specimen is higher than unstiffened splice plate but its ultimate load was less when compared to concentrically loaded specimen .The influences of varying gusset plate and splice member geometric configurations were discussed. Three types of failure modes were noticed for the eccentrically loaded gusset plate connections, such as Gusset–Splice Interactive, Plastic Failure (G–SIPF), Splice Plastic Failure (SPF), and Gusset Plate Buckling (GPB). Based on the nature of each failure mode, a set design procedure was proposed.

D. Sheng et al. [2002], based on inelastic plate buckling equation, proposed a design method accompanied by some design charts for rectangular type gusset plate subject to compression. They also showed that neither Thornton nor modified Thornton method can estimate the ultimate load of large gusset plates under compression correctly. That's because the effects of plate action under buckling is not considered in Thornton's approach. In addition, they concluded that addition of free-edge stiffeners and centerline stiffeners considerably increases the ultimate capacity of the plate.

E. D.G. Lutz et al (2005) aimed at investigating the behavior of thin steel gusset plates in compression. Key parameters that were considered in the experimental study were the thickness of the gusset plate, the width and length of the gusset plates, the fastener location, and the fastener pattern. Both a plate model and a column model were investigated for computing the strength of a thin plate in compression. Based on the findings of this study, design recommendations were proposed

F. Chung-Che Chou et al (2009) explained an analytical study of the compressive behavior for brace restrained buckling frames of central gusset plate connections by finite element software ABAQUS. A parametric study of various gusset plate dimension and free edge stiffener is conducted for the compressive strength of BRBF central gusset plate connections. To predict ultimate load, an inelastic plate buckling equation together with coefficient charts is proposed. To increase the yield load and post –yield strength, adding free edge stiffener to gusset plate. To investigate the effect of the gap and the influence of various parameters on the fatigue behavior of knife plate connection a test program was conducted. Ultimate fracture of the specimen is mainly due to stress concentration cracks which developed in the hollow section steel walls at the forward edge of the inserted knife plate

G. Christopher D. Stoakes et al(2012) focused on the limit states of failure of fillet weld between the gusset plate and beam, low-cycle fatigue fracture of steel angles joining the beam and gusset plate to the column, and bolt .The models were utilized to evaluate the flexural stiffness, strength, and ductility of braced frame connections with primary attention on the effects of beam depth, angle thickness, and a supplemental seat angle. The finite element analysis signify that increasing beam depth and angle thickness and adding a supplemental seat angle are increased the stiffness and strength of the connection while maintaining deformation capacity. A procedure to estimate the flexural behavior of beam-column connections with gusset plates was proposed based on the results of the numerical simulations

III. ANALYTICAL STUDY

In thesis parametric study of edge stiffeners and splice plate used in gusset plate is done .For parametric study varying the thickness and width of stiffener used in gusset plate and varying the length of splice plate . The gusset plate with single splice member is modelled in FEA software ANSYS WORKBENCH 15 for various cases

A. Edge stiffener

Volume 5 Issue V, May 2017
ISSN: 2321-9653

In this section varying the thickness of edge stiffener used in gusset plate is done.For varying the thickness of stiffener selected some ratio which depend up on thickness of stiffener and thickness of gusset plate. The thickness of gusset plate is taken as 13mm.ts represent the thickness of stiffener and tg represent the thickness of gusset plate Table show thickness used in different cases

Table 1 Thickenss Used In Different Cases

Cases	ts/tg	Thickness of stiffener(mm)
1	.25	6.5
2	.5	9.75
3	.75	13

For varying the width of edge stiffener used in gusset plate selected the ratio which depend upon the width of stiffener and width of gusset pla

Table 2 width of stiffener used in different case

Cases	Ws/Wg	Width of stiffener (mm)
1	.125	50
2	.1875	75
3	.25	100
4	.3125	125
5	.375	150

A. Splice Plate

For parametric study of splice plate varying the length of splice plate. Table 3 show the length of splice used in different case

Table 3 length of splice plate used in various case

LENGTH	Peak Load(KN)
L1=224mm	276.26
L2=242mm	287.61
L3=260mm	305
L4=274mm	315
L5=296mm	332

Volume 5 Issue V, May 2017
ISSN: 2321-9653

B. Material Properties

Table 4 show the material properties used in various cases

Table 4 material properties

Material	Yield strength(MPa)	modulus of elasticity(MPa)	Poisson's ratio
Gusset plate	295	207,600	.3
Splice plate	435	201,500	.3
stiffener	284	197,800	.3

C. Element Used

Suitable elements are selected from ANSYS library. Solid 185 element is used for modelling gusset plate with edge stiffener. Solid 185 element is defined by eight nodes having three degrees of freedom at each node: translations in the nodal x, y, and z directions. The element is capable of plasticity, stress stiffening, large deflection, and large strain capabilities.

D. Structural Modeling

Geometry of gusset plate with edge stiffener is shown in figure below

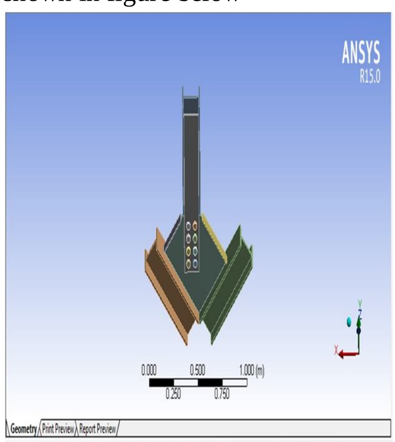


Fig 3 Geometry used in ANSYS

Geometry of gusset plate with single splice plate is shown in figure

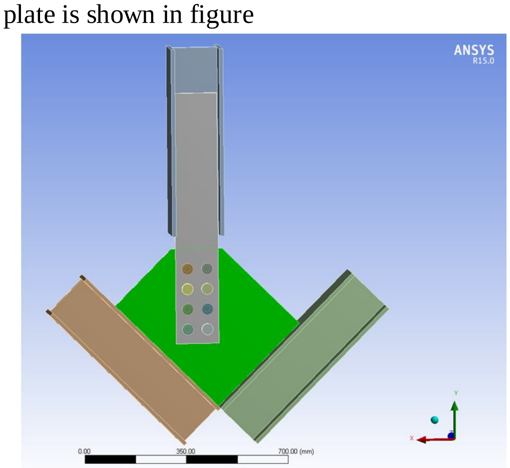


Fig 4 Geometry used in ANSYS

Volume 5 Issue V, May 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

E. Boundary Condition and Loading Condition

Vertical displacement in x and z direction are restrained. Fixed support is provided in the lower end of beam and column. Displacement Control analysis with push over loading was used in ANSYS software. Displacement is increasing with 0.5mm per sec with maximum amplitude of 6mm is provided.

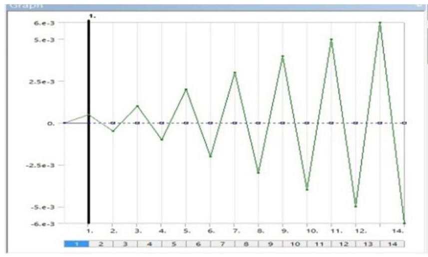


Fig 3 Load In ANSYS

IV. RESULT AND DISCUSSION

A. Edge Stiffener

By varying the width of stiffener provided in gusset plate there is no significant increasing in the ultimate load carrying capacity and post buckling strength. Table 5 show the result for varying the width of stiffener.

Table 5 Result Of Stiffener Provided In The Free Edge Of Gusset Plate By Varying The Width Of Stiffener

Case	Peak load (KN)	% increase in load carrying capacity	Post buckling load	%increase in post buckling load capacity
with out stiffener	305		252.713	
Bs/Bg=.125	328.68	7.76	269.455	7.14
Bs/Bg=.1875	337.467	10.6	284.186	14.23
Bs/Bg=.25	348.465	14.25	292.13	20.48
Bs/Bg=.3125	362.231	18.76	293.56	23.85
Bs/Bg=.3745	362.295	18.78	293.56	24.45

By varying the thickness of edge stiffener provided in gusset plate the ultimate load carrying capacity of stiffener and post buckling strength is increased effectively up to the ratio of ts/tg=.75

Table 6 Result Of Stiffener Provided In The Free Edge Of Gusset Plate By Varying The Thickness Of Stiffene

Case	Peak load	% increase in load carrying capacity	Post buckling load	%increase in post buckling load capacity
with out stiffener	305		235.87	
ts/tg=.25	328.682	7.76	252.713	6.66
ts/tg=.5	364.077	19.36	298.462	26.53
ts/tg=.75	372.462	22.11	303.846	28.8

Volume 5 Issue V, May 2017
ISSN: 2321-9653

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

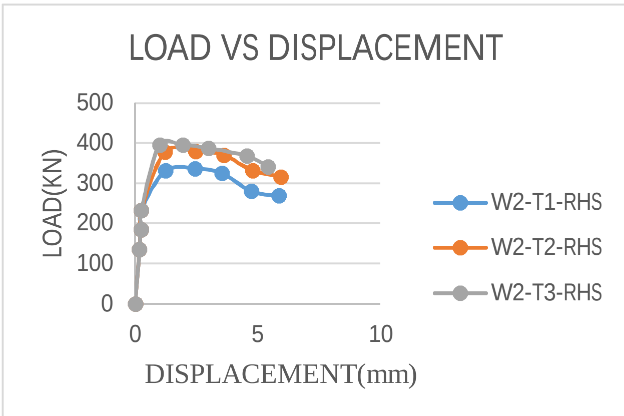
The ultimate load carrying capacity is increased with increasing the length of splice plate. Maximum ultimate load carrying capacity is obtained when the length of spice plate near to the beam column boundary.

Table 7 Peak Load Of Different Splice Length

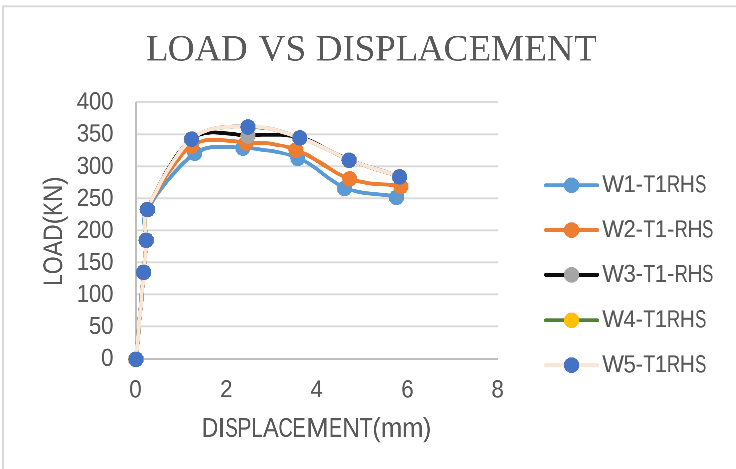
Cases	Peak Load(kN)
L1=224mm	276.26
L2=242mm	287.61
L3=260mm	305
L4=274mm	315
L5=296mm	332

V. CONCLUSIONS

From the load –displacement graph it can be concluded that the ultimate load carrying capacity of gusset plate and post buckling load carrying capacity is increasing with thickness up to the ratio of ts/tg=0.75

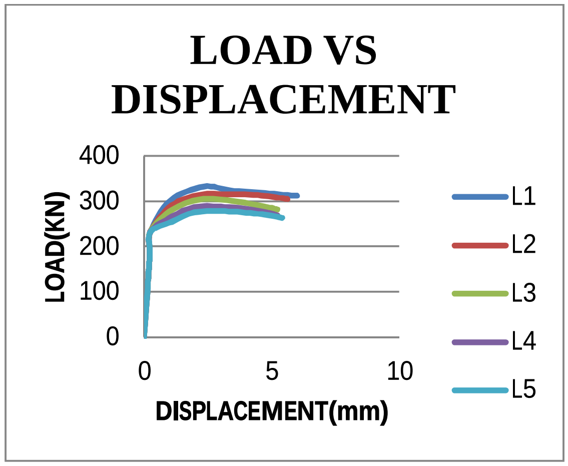


From the graph it can be concluded that ultimate load carrying capacity of gusset plate and post buckling load carrying capacity has no significance with increasing with width of edge stiffener.



Volume 5 Issue V, May 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

From the graph it can be concluded that ultimate load carrying capacity is increased with increasing the length of splice plate.



REFERENCES

[1] Christopher D. Stoakes and Larry A. Fahnestock"Cyclic flexural analysis and behavior of beam-column connections with gusset plates"journalof constructionalsteel researchcenter vol 72 ,2012

[2] Dawn E. Lehman; Charles w. Roeder;David Herman; Shawn Johnson; and Brandon Kotulka" Improved SeismicPerformance of Gusset Plate Connections" june 2008

[3] Cheng Fang , Michael C.H. Yam , J.J. Roger Chengand Yanyang Zhang , " Compressive strength andbehavior of gusset plate connections withsingle-sided splice members", journal of constructional steel research center, vol 106 ,2015

[4] A.A. Khalaf, and M.P. Saka," Evolutionary structural optimization of steel gusset plates" ,journal of constructional steel research center, march

[5] Chung-Che Chou, Gin-Show and Liou, Jiun-Chi Yu ," Compressive behavior of dual-gusset-plate connections for buckling-restrained braced frames", Vol 76, September 201

[6] N. Sheng , C.H. Yam , V.P. Iu" Analytical investigation and the design of the compressive strength of steel gusset plate connections"Vol 58,Januvary 2002