EXPERIMENTAL STUDY ON FAILURE MODES OF STEEL TENSION MEMBERS DUE TO CHANGE IN CONNECTION ECCENTRICITY AND LENGTH

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***Abstract*: This paper presents a study of the examining the effects of connection eccentricity and connection length, on steel angle tension member fastened with bolted and welded connection. A total of twelve single angles with six of bolt connections and six of weld connections tested in tension on Universal Testing Machine. It is observed that specimens failed by partial section failure, net section failure, block shear failure, fracture of the cross section and failed in the weld and to calculate failure capacities and to plot the load versus deflection path.**

***Keywords*: Tension member, Connection eccentricity, Connection length.**

1. INTRODUCTION

The use of cold formed steel section is spreading significantly which is using shapes such as angles, channels and T sections. The connections of these sections are bolt, rivet and weld to the connector. The cold formed steel section is widely used as structural elements in agricultural equipment's, truss, bracing, and roof. It is easily transportation, time consuming manufacture, quick to construction, good aesthetical views all advantages are helpful to the designer, contractor and architect. The bolt and weld connections in angle section at only one of the leg due to this phenomenon the shear lag effects are induced in members. The line of activity of the load does not coincide with the centroid axis of a tension member due to that load eccentricity is generated. The stress concentration, effects of shear lag and effects of connection eccentricity reduces the efficiency of angle tension members. The difference between the centroid of the connection and the neutral axis of the member is the eccentricity of the connection. So the main aim of the experiment is to determine the effects of change in length and change in eccentricities on the performance of steel tension member.

1.2 OBJECTIVE

- To investigate the result of change in connection length and change in eccentricity on the ultimate capacity of welded and bolted steel tension members.
- To execute experiment to calculate and plot the entire load verses deflection path.
- To find out the failure modes noticed in the experiment analysis.

2. LITERATURE

A complete literature analysis was conducted, it was understand that connection eccentricity produce bending moments, and it has potential to decrease the failure load capacity of tension members. So the main aim is to determine the effects of change in length and eccentricity on steel tension members. In this experiment angle section of size ISA 50X50X5, ISA 65X65X5 in mm to obtain the result of change in eccentricity on the ultimate load capacity.

2.1 Review of Literature

M Prakt al (1975) studied the material of inappropriate combination, welding defects, fracture of failure. The main aim of this study is to get the effect of shear lag in welding joints.
J Barth al (2002) studied the performance of steel angle tension specimen subjected to unequal loading. In this experiment two methods were used to make the hole to specimen that is punch hole and drill hole with fastened with stiffer plate. It is observed usually to reduce the capacity and get the failure modes.
R Kulkarni (2010) Experimental study of light gauge rectangular section fastened with bolted connection, geo polymer concrete and normal concrete apply only at the joints. By applying no of grades of concrete at joints with single no of bolts, the strength of joints widely growing.
Vaghe (2013), "Experimental study on light gauge channel section by using stiffener plates at connection joints. The cold formed steel tension members are widely used in worldwide, usually it is more easily transport from steel mill to the fabricating plant. The strength of the joint is increased by using the thick plate.

3. METHODOLOGY

The results of tensile tests are used in choosing materials for engineering utiliasation. Tensile properties are frequently studied during development of new materials and processes, so that different materials and processes can be estimated. Finally, tensile properties are frequently used to project the performance of a material under different forms of loading. The strength of interest may be calculated in terms of either the stress necessary to reason appreciable plastic deformation or the maximum stress that the material can resist. The purpose of present test is to find out the effect of connection eccentricity on the failure capacities of bolted and welded angle tension members. In this work, connection eccentricity is varied, while keeping the pitch and end distance as constant.

Fig 1 ISA Specimen sizes

3.1 EXPERIMENTAL STUDIES

The literature overview showed studies that examined shear lag effects on the net section rupture capacities of tension members. However, the present study has particular focus put upon the effects of connection eccentricities with regards to produced bending moments. The experimental program consists of one set of ISA 50 X 50 X5, ISA 65 X 65X5 that are 605 mm in length and fastened at both ends with a single row of high strength friction grip bolts and weld through one of the leg.

Fig 2 Measurement of specimen

The main aim of the experimental program has been on the effects of connection eccentricity on the failure capacities as found by the net section rupture and blocks shear failure modes. In the experimental specimens, the connection eccentricity is varied. Pitch and end distances are held constant in all specimens as 40mm and 30mm respectively. As per IS 800, the minimum edge distance to be provided for 12 mm diameter bolt is 18mm.

In ISA 65 x 65 x 5 eccentricity can be changed by 8mm. i.e. Bolts are provided at 30mm, 38 mm and 46 mm in specimen 1, 2 and 3 respectively. In ISA 50 x 50 x 5 eccentricity can be varied by 5 mm. i.e. Bolts are provided at 25 mm, 30 mm and 35 mm in specimen 1, 2 and 3 respectively. All specimens are fixed with a pair of bar-stock grips, which simulates gusset plate effects. They are used to transfer the load from 1000 KN capacity universal testing machine (UTM) to the specimen. They are fabricated from 40 mm by 5 mm plate and have 12 mm diameter holes drilled at the appropriate pitch for ISA 50 X 50 X 5 and for ISA 65X 65 X 5 the plates are fabricated from 40 mm by 5 mm plate and have 14 mm diameter holes drilled at the appropriate pitch.

Fig 3 Bolting of specimen

To prevent bending of the grip ends and, thus, enabling the UTM wedge-grips to have a perfect contact surface with the bar stock grips, spacer plates of the same thickness as a specimen thickness are to be placed between the ends of the grips. Also, specimens of ISA 50 X 50 X 5 were fixed with 12mm diameter bolts, tightened to the snug-tight condition, in standard holes located in the one leg. Snug tight condition is defined as the tightness that exists when all plies in a joint are in firm contact. Once bolted, the specimen-grip assembly is to be secured in a 1000-kN capacity universal testing machine with wedge grips same procedure done with weld connection instead of bolting. Each specimen is to be then loaded pseudo statically to failure.

3.2 TESTING PROCEDURE

After the appropriate grips were fastened to ISA section the specimen-grip assembly is to be then placed and cantered in the UTM and then secured fast with the wedge-grips in the UTM crossheads. Each specimen is to be examined to failure at which point the load applied by the UTM would drop off considerably by steadily increasing the applied load. Shows a typical ISA specimen held in UTM.

Each specimen was tasted to failure by steadily increasing the applied load. With all instrumentation zeroed, the tensile load was then applied in control with strain rate 1.8 mm per minute.

Fig 4 ISA Specimens with varying eccentricity

Fig 5 Specimen Clamped in UTM

4. Results and Discussion

From the experimental analysis it is clear that as the eccentricity increases there is a decrease in the load carrying capacity of the sections. This is because of the generated bending moments due to the eccentricity in connection.
It is seen that eccentricity is directly effect on the net section efficiency.
The modes of failure were seen among the tests that is partial rupture of the net section, full rupture of the net section and fails in weld.

Table no 4.1 Specimen dimension and failure load of bolted connection

SR NO	ISA SP –B	Length of SP	No of bolts	Diameter of bolt	Gauge dis	SP fail	Failure load	Specimen Connection
1	50x50x5	605	3	12	25	BS	80	SP50-B25
2	50x50x5	605	3	12	30	BS	74	SP50-B30
3	50x50x5	605	3	12	35	PNS	65	SP50-B35
4	65x65x5	605	3	12	30	PNS	115	SP65-B30
5	65x65x5	605	3	12	38	FNS	105	SP65-B38
6	65x65x5	605	3	12	46	PNS	98	SP65-B46

Table 4.2: Deflection of specimen under loading with bolted connection

Load KN	SP50-B25	SP50-B30	SP50-B35	SP65-B30	SP65-B38	SP65-B46
0	0	0	0	0	0	0
10	0	0	0	0	0	0
20	2.4	1	0.5	1.6	0	0.9
30	6.5	6.8	1.9	3.5	0.8	4.9
40	8.5	8	3.5	6.7	2.7	6.8
50	10.4	9	4.8	8.5	3.9	8.4
60	12.3	10.5	7.5	11.4	5.5	10.9
70	15.7	11.5	-	-	6.5	13.5
80	0	15.3	-	-	9	-
90	0	0	-	-	-	-
100	0	0	-	-	-	-
110	-	-	-	-	-	-

Table 4.3 : Specimen dimension and failure Load of welded connection

SR. NO	ISA SP-W	Length of SP	Length of weld	Thick of weld	Gauge dis	SP fail	Failure load	Specimen Connection
7	50x50x5	605	110	3	25	N	101	SP50-W25
8	50x50x5	605	110	3	30	M	92	SP50-W30
9	50x50x5	605	110	3	35	M	80	SP50-W35
10	65x65x5	605	110	3	30	N	125	SP65-W30
11	65x65x5	605	110	3	38	N	111	SP65-W38
12	65x65x5	605	110	3	46	M	90	SP65-W46

Table 4.4 : Deflection of specimen under loading with welded connection

Load KN	SP50-W25	SP50-W30	SP50-35	SP65-W30	SP65-W38	SP65-W46
0	0	0	0	0	0	0
10	0	0	0	0	0	0
20	0	0	0	0	0	0
30	3.1	0	2.5	0	1	1
40	4.3	0	3.7	1	1.7	2
50	5.1	0	4	1.5	2.5	2.5
60	6.1	1	5	1.9	2.7	3
70	6.3	2	5.6	2	4	4.1
80	10	3	7.9	7.1	4.6	4.5
90	15.3	7	10	12.7	9	5.3
100	-	11.9	22	23.3	12.3	9.1
110	-	24	-	-	18	24

All loads are in KN, All dimensions are in mm
SP –specimen, BS-block shear
PNS-partial rupture of net section
FNS-full rupture of net section
N-nominal, M-measured

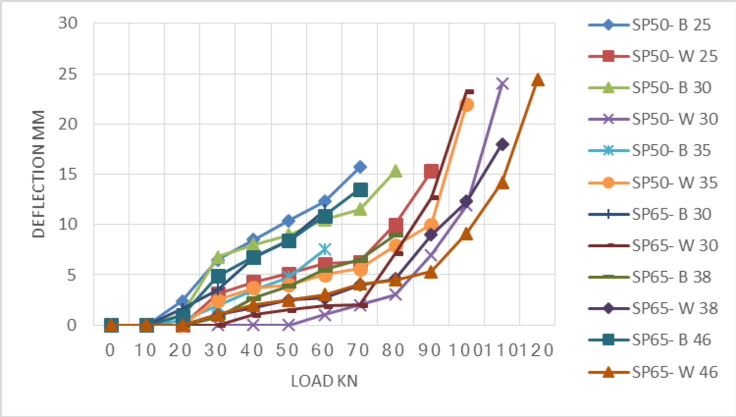

Fig. 4.5 Graph between load versus deflection

5. CONCLUSION

1. The present work was focused on examining the effects of connection eccentricity on bolted angle tension member capacities. Here the connection eccentricity is varied while keeping the pitch and end distance as constant and the failure load was obtained from the test for each experimental specimen.
2. All the three modes of failure were observed during the test; Partial net section failure, full net section failure and Block shear failure.
3. Stress and Strain contours at failure as well as the yield point were obtained from finite element analysis.
4. Eccentricity is readily observed to have a direct impact on a connection's net section efficiency. From the experimental study it is clear that as the eccentricity increases there is a reduction in the load carrying capacity of the members. This is because of the induced bending moments due to the eccentricity in connection.

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