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Design and Analysis of Tensile Strength for Similar Plate with F.E.A. when Lap Welded Joint is Used

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A B S T R A C T

Welding is the simple process and excellent strength makes it useful in manufacturing of steel structures like ships, ocean structures, automobile, aircraft and bridges. The challenges associated with welding and welded joints are improved tensile strength of welding under variable environmental and working conditions. The parametric study has been carried out, overlap length and gap size are selected as parameters to be varied during experimentation. The range of parameters is decided by referring literature. Design and validation of fixture is carried out for testing purpose. Specimens are prepared with greater accuracy and tests were carried out using UTM. The results obtained from experimentation are compared with result obtained from simulation. It is recommended to keep overlap length 25 mm for 5 mm thick plate with minimum gap size. This will give maximum tensile strength.

Keywords: Overlap length, gap size, tensile strength

1. INTRODUCTION

Welding is the simple process and excellent strength makes it useful in manufacturing of steel structures like ships, ocean structures, automobile, aircraft and bridges. The challenges associated with welding and welded joints are improved tensile strength of welding under variable environmental and working conditions. The parametric study has been carried out, overlap length and gap size are selected as parameters to be varied during experimentation. The range of parameters is decided by referring literature.

1.1. Terms related to welding

- **Backing: -** It is the material support provided at the root side of a weld to aid in the control of penetration
- **Base metal: -** The metal to be joined or cut is termed the base metal.
- **Bead or Weld Bead: -** Bead is the metal added during a single pass of welding. The bead appears as a separate material from the base metal.
- **Crater: -** In arc welding, a crater is the depression in the weld metal pool at the point where the arc strikes the base metal plate.
- **Deposition Report: -** The rate at which the weld-metal is deposited per unit time is the deposition rate and is normally expressed as kg/h.
- **Fillet weld: -** The metal fused into the corner of a joint made of two pieces placed at approximately 90 degrees to each other is termed fillet weld.
- **Penetration: -** It is depth up to which the weld metal combines with the base metal as measured from the top surface of the joint.
- **Puddle: -** The portion of the weld joint that is melted by the heat of welding is called puddle.
- **Root: -** It is the point at which the two pieces to be joined by welding is nearest.
- **Tack weld: -** A small weld, generally used to temporarily hold the two pieces together during actual welding, is the tack weld.
- **Toe of weld: -** It is the junction between the weld face and the base metal.
- **Torch: -** In gas welding, the torch mixes the fuel and oxygen and controls its delivery to get the desired flame
- **Weld face: -** It is the exposed surface of the weld

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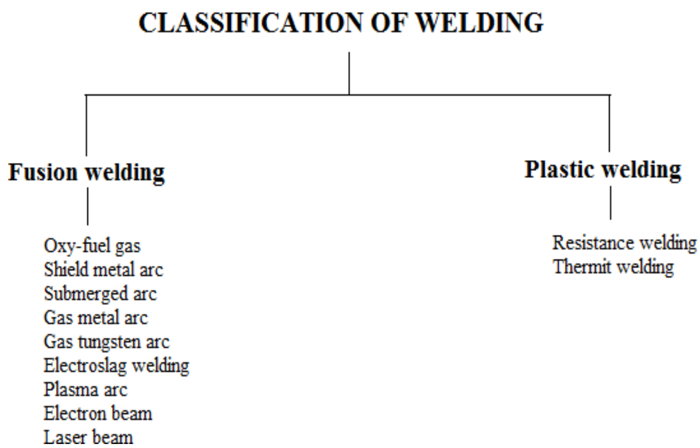
1.2. Classification of Welding



2. Literature Review

Peter A. Gustafson, Arnaud Bizard, Anthony M. [1] Waas in their paper studied the behavior of double lap joints under combination of thermal & mechanical loads. The first solution is similar to work carried volkersen & second solution is extension of work carried by Davies which captures peel stress as well as traction force on free boundary condition & the study dictates the shape of stress distribution.

Jaesong Kima, Kyungmin Leea, Boyoung Leeb [2] in their paper, Steel structures such as ships, ocean structures, automobile, aircraft and bridges should be designed and manufactured to be able to endure under various environmental conditions such as static load, impact, fatigue and torsion etc. Especially, many researches about improvement of fatigue strength have been performed in relation to welding to be used for connection of steel structures. In case that welded structures were applied cyclic fatigue load, the factors such as profile of weld bead, direction and size of applied load, welding residual stress and undercut have affected fatigue life.

Michele Carbonia, Fabrizio Moronib [3] in their paper, the fatigue behavior of hybrid lap-joints (obtained by USMW plus adhesive bonding) made of light alloys thin sheets. Fatigue tests were carried out at different stress ratios, finding that a different failure mechanism takes place with higher applied mean stresses.

L. Reisa, V. Infantea, M. de Freitasa, F.F. Duarteb, P.M.G. Moreirac, P.M.S.T. de Castro [4] in their paper, the experimental results obtained in tensile and fatigue tests of welded lap joints. The specimen types include the loading condition applied to the specimen in a transverse or longitudinal direction to the weld bead. The fatigue tests were carried out under constant amplitude loading with a stress ratio for a wide range of applied stress.

3. DESIGN & PREPARATION OF SPECIMEN

3.1. Factor affecting tensile strength of welded joint

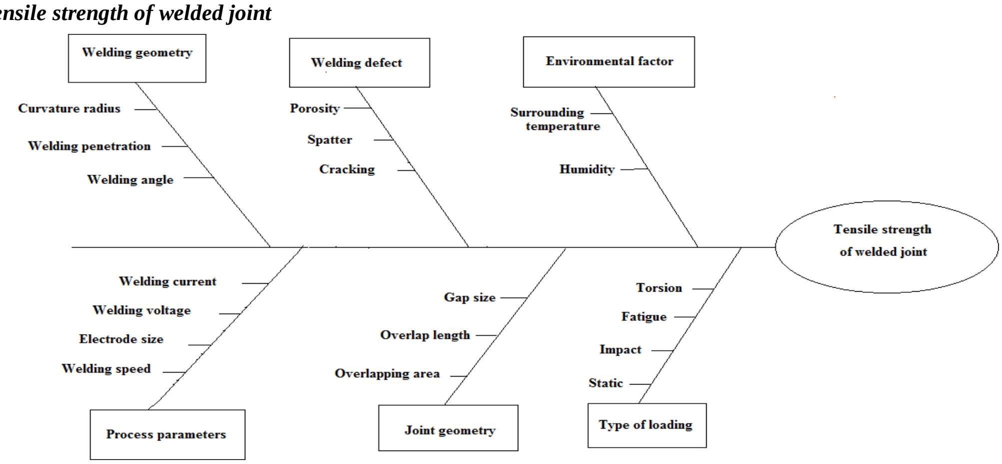


Fig 3.1 Cause and effect diagram of leaf spring

3.2. Selection of welding length

The double transverse fillet weld (Lap joint) specimen will be used testing purpose. The specimen will be as shown in figure.

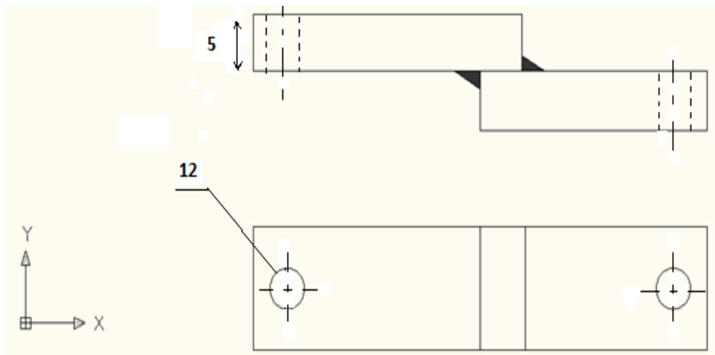


Fig.3.2 Specimen of lap welded joint

For this 10mm welding is assumed.It is well known that increasing the welding length increases joint strength and it can be proved analytically.

Hence the parameter welding length will be kept const. throughout experimentation. The probable load carrying capacity of above joint is calculated as follows.

Strength equation for double transverse fillet weld is,

P= 1.414 * h * 1 * σt ………….. (1)

Where,

H= 5 mm …….. (Equal to thickness)

1 = 10 mm ……… (Assumed)

σ_t = 110 N/mm^2 …(Mild steel)

So, substituting above values in equation (1)

P = 1.414 × 5 ×10 × 110

P = 7.777 KN … (Say 10 KN)

The joint can sustain max 10 KN force.

3.3. Design of Fixture

Fig.3.3 shows probable fixture to be used for tensile testing. It is made up with available resources, to limit the cost of project. It consist of circular mild steel bar of diameter 12 mm welded to two mild steel plates of 5 mm thickness having holes for specimen mounting as shown in figure. As the fixture has to be made by welding process, it should have higher tensile strength than tensile strength of joint to be tested. For this reason design of fixture is included.The factor of safety for design of fixture is considered as 2 [20]. As the joint is design for 10 KN. So, fixture will be design for maximum load of 20 KN.

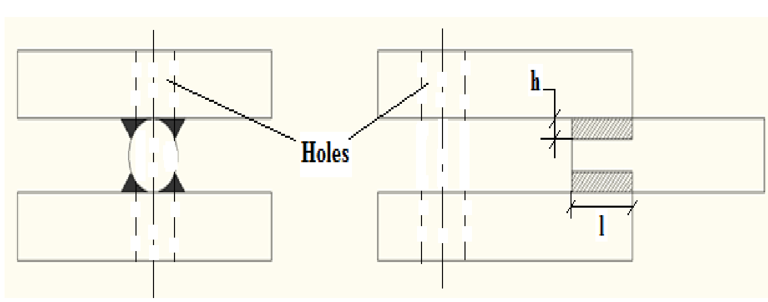


Fig.3.3. Fixture for holding specimen

Strength equation of double parallel fillet weld is,

P = 1.414× h× l×ʈ

Here a pair of double parallel fillet is used; hence equation is to be modified, P = 1.414× h× l ×ʈ×2

Where,

h= 5mm ……… (Equal to thickness of plate)

$\tau = 95 N/mm^2$ …….. (Mild Steel)

$20000 = 1.414 \times 5 \times l \times 95 \times 2$

$20000 = 1343.3 \times l$

$l = 14.88$ m ...…. (Say 15 mm)

The rods are shown in fig. are used to hold the assembly in the cross head of UTM. The washers are used to avoid specimen rotation and eccentric loading. The bolt shown in fig is subjected to shear failure. So shear strength of bolt must be calculated.

3.4. Design of Bolt subjected to subjected to shear stress

Fig 3.2 Photos of Bolt

The bolt used is of plain carbon steel 30C8 with yield point stress 400 N/mm^2.

S_{yt} = 400 N/mm2

Fs = 5 …… (Assumed)

Now, permissible shear stress $S_{sy} = 0.5\ S_{yt}$

$S_{sy} = 0.5 \times 400 = 200\ N/mm^2$

$\tau = S_{sy} / Fs = 200/5$

$= 40\ N/mm^2$

Shear area of 2 bolts = $2 \times (\pi/4 \times d^2) \times \tau$

As the bolts are subjected to double shear;

$P = 2 \times (\pi/4 \times d^2) \times \tau \times 4$

Load carried by the bolt $P = A \times \tau$

$P = 2 \times (\pi/4 \times 12^2) \times \underline{40} \times 4$ …… (Double shear)

P = 36.12 KN

From above equation we can say that, the bolts can sustain 36.12 KN and which is greater than load carrying capacity of fixture i.e. 20KN.

4. Experimentation Procedure

4.1. Introduction of UTM (Universal Testing Machine)

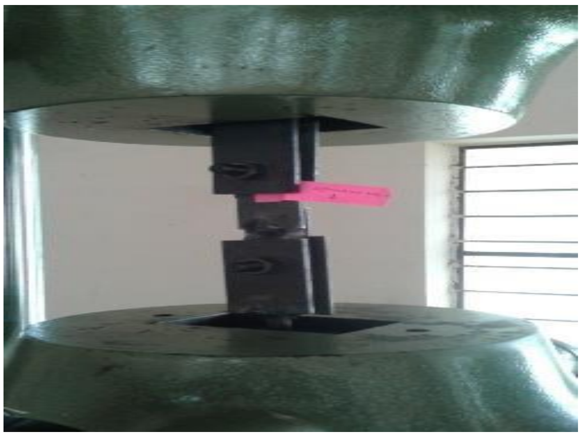
Fig.4.1 Universal Testing Machine

Parameter	Values
Maximum Capacity	400KN
Measuring Range	0-400 KN
Connected load Weight (Approx)	2500 Kg

Table 4.1 Specification of UTM

The tensile test on the specimen has carried out using UTM as shown in fig.4.1 & Table 4.1 show's actual specification of UTM

4.2. Experimental Set-up



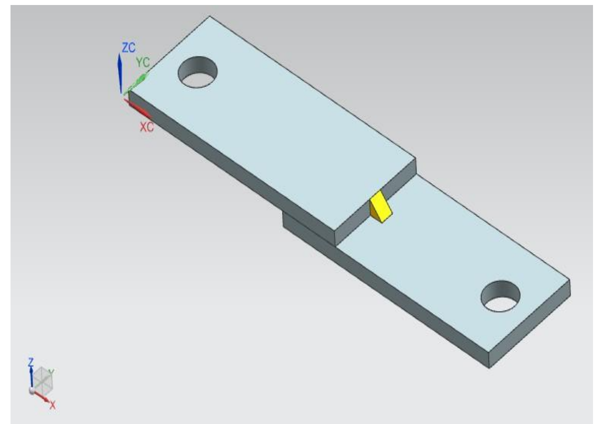


Fig.4.2 experimental set up

Fig4.3 Cad model of overlap length specimen

Fig.4.2 shows experimental set up. It consists of two jaws held by cross head of UTM. Between two jaws the specimen is held with help of bolts washers. The fixture is designed so that it will not be eccentrically loaded and the rotation of Specimen while conducting the test is avoided.

To consider overlap length and gap size of specimen as parameter to be varied for experimentation. The overlap length is marked on specimen and precise welding is done by holding the specimen in C clamp so that accurate overlap length can be obtained. Specimen held in C clamp and measurement of length is shown in following fig.4.3.

Fig.4.4 Procedure for overlap length specimen preparation

4.3. Specimen Detail (Overlap Length)

Specimen number	Overlap length	Specimen number	Gap size
1	21 mm	6	0.2 mm
2	23 mm	7	0.4 mm
3	25 mm	8	0.6 mm
4	27 mm	9	0.8 mm
5	29 mm	10	1 mm

Table.4.2. Specimen details (Overlap length)

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4.4. Gap Size

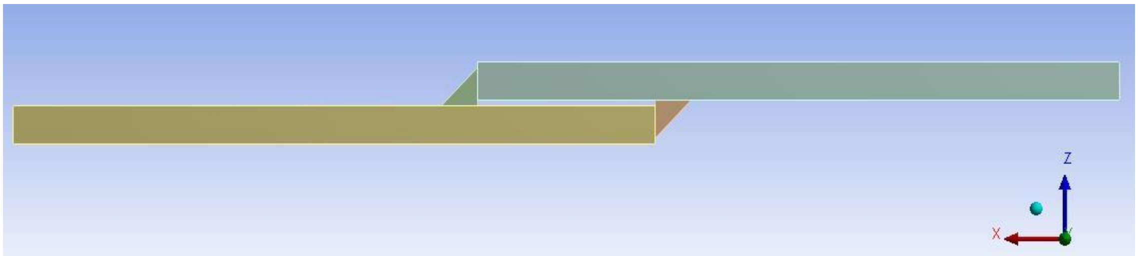

Fig.4.5 Cad model of gap size specimen

The gap size is maintained by filler gauge. One metal placed over other by sandwiching the filler gauge between plates and plates with filler gauge is held by clamp and welding is done then filler gauge is removed. This maintains gap between the plates equal to filler gauge failures.

Fig.4.6 Procedure for gap size specimen preparation

The above mentioned procedure is followed for preparing all the specimens.

4.5. Experimentation by varying overlap length

To see what happens if overlap length varied? Ten specimens are prepared as per table and testing was carried out that are discussed below.

- **Testing of specimen 1**

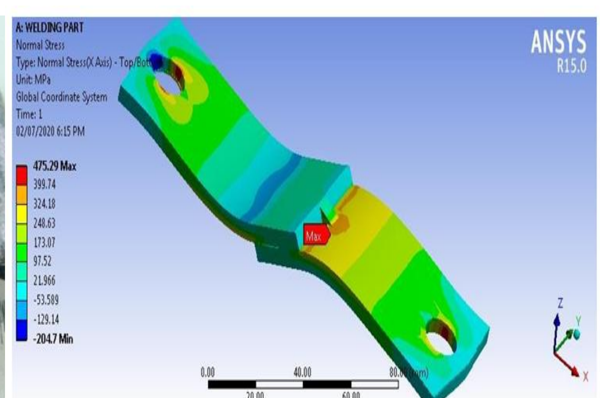

Fig.4.7 Photo of specimen 1

Fig.4.8 Simulation of specimen 1

- **Testing of Specimen 2**

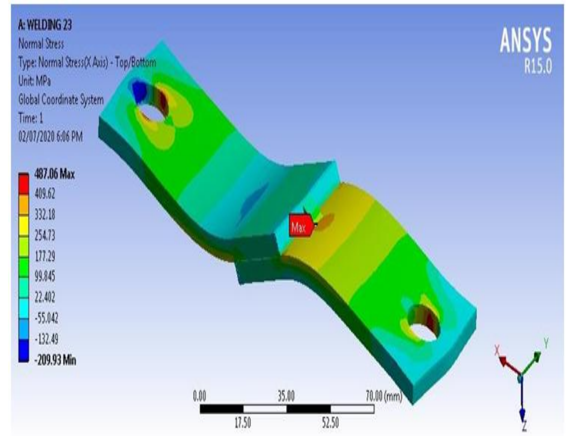

Fig.4.9 Photo of specimen 2

Fig.4.10 Simulation of specimen 2

The above mentioned procedure is followed for preparing all the specimens. (Upto 10 Specimen)

4.6. Obtained Values

Sr. No	Tensile strength (KN)		Percentage deviation
	Value calculated experimentally	Value calculated by simulation	
1	34.5	32.41	6.05
2	35	33.21	5.11
3	36	35.03	2.69
4	34.1	32.54	4.57
5	35.3	33.44	4.72
6	18.214	15.956	12.39
7	9.104	6.27	31.12
8	7.253	5.819	19.77
9	4.467	2.755	38.325
10	2.631	1.994	24.21

5. Conclusion

Various design parameters are considered and effect of this parameter on tensile strength of lap welded joint is discussed. Analytical design procedure was adopted for designing fixture to hold the specimen. The specimen dimensions were finalized and specimens were prepared by varying overlap length and gap size. The values of stress obtained from experimentation and values obtained by simulation are compared for validation of experimentation.

1. The tensile strength obtained by variation of overlap length shows maximum tensile strength of 36 KN with 25 mm overlaps length. This implies that while using 5 mm plates for welded joint 25 mm overlap is recommended.
2. Increasing the overlap length above 25 mm results in poor tensile strength and decreasing overlap length below 25 mm will also reduce tensile strength.
3. Variation in gap size shows maximum tensile strength of 18.214 KN with 0.2 mm gap size. Increasing ahead the gap size decreases the tensile strength. So it is recommended that keep the gap size as minimum as possible.
4. With minimum gap size the chance of work piece rotation is also reduced. Because of reduction in gap size reduces eccentricity in loading.

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