iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 Issue: XII Month of publication: December 2017

DOI:

www.ijraset.com

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor :6.887
Volume 5 Issue XII December 2017- Available at www.ijraset.com

Experimental stress analysis & Finite element analysis of T-Joint under Tensile and Bending Loading

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Abstract: Welded joints are widely found in almost all applications like construction structures, automotive, industrial roofs and many more applications. Tensile, Bending , tortional and multi axial loads acts on various welded joints during operations' joints are used for various members coming together at same location joints behaviour at tensile and bending loading is investigated in this. Catia V5 software is used for modelling T joint of standard dimension. Discretiztion (Meshing) and finite element analysis is carried out using ANSYS package joints is welded with holding fixture for carrying out experimental analysis. Experimental Stress analysis is carried out using strain gauge for measuring strain values and UTM for applying gradual loads. Load of similar values were applied on T Joint in tensile and bending manner. Results were validated by comparative analysis using FEA and strain gauge values. Experimental and FEA correlation was in linear relation. It was concluded that T joints are stronger in tensile as compared to that of bending loading conditions.

Keywords: material, welding, specimen, fillet.

I. INTRODUCTION

Technological improvements in composite materials have been accompanied by an improvement in structural adhesives. As a result, the use of bonded joints has supplemented or replaced the use of traditional mechanical fasteners in composite and metallic structures.

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Welding is a manufacturing process of creating a permanent joint obtained by the fusion of the surface of the parts to be joined together, with or without the application of pressure and a filler material. The materials to be joined may be similar or dissimilar to each other. The heat required for the fusion of the material may be obtained by burning of gas or by an electric arc. The latter method is more extensively used because of greater welding speed. Welding is extensively used in fabrication as an alternative method for casting or forging and as a replacement for bolted and riveted joints. It is also used as a repair medium e.g. to reunite a metal at a crack or to build up a small part that has broken off such as a gear tooth or to repair a worn surface such as a bearing surface. Welding is the most commonly used process for permanent joining of machine parts and structures. Welding is a fabrication process which joins materials (metals) or thermoplastics, by causing union (A. Thirugnanam 2014). In the joining process of welding application uses heat and/or pressure, with or without the addition of filler material. Various auxiliary materials, e.g. shielding gases, flux or pastes, may be used to make the process possible or to make it easier. The energy required for welding is supplied from outside sources Welding, a metal joining process can be traced back in history to the ancient times. In the Bronze Age, nearly 2000 years ago, circular boxes made of gold were welded in lap joint arrangement by applying pressure. Later on in the Iron Age, Egyptians started welding pieces of iron together. But welding as we know nowadays came into existence only in the 19th century. Sir Humphrey Davy produced an electric arc using two carbon electrodes powered by a battery. This principle was subsequently applied to weld metals. Resistance welding finally developed in the year 1885by Elihu Thomson. Acetylene gas was discovered in 1836 by Edmund Davy, but it could not be used in welding application due to lack of a proper welding torch. When the require welding torch was invented in 1900, oxy-acetylene welding became one of the most popular type of welding mainly due to its relatively lower cost. However in the 20th century it lost its place to arc welding in most of the industrial applications. Advance welding techniques like Plasma Arc Welding, Laser Beam Welding, Electron Beam Welding, Electro-Magnetic Pulse Welding, Ultrasonic Welding, etc. are now being extensively used in electronic and high precision industrial applications.

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II. LITERATURE SURVEY

Peter A. Gustafson studied analytical and experimental methods for adhesively bonded joints subjected to high temperatures studied recent advances in material systems have expanded the temperature range over which adhesively bonded composite joints can be used. In this work, several tools are developed for use in modeling joints over a broad range of temperatures. First, a set of dimensionless parameters is established which can be used for analysis of joint performance for an orthotropic symmetric double lap joint. A critical dimensionless ratio of mechanical and thermal loads is identified. The ratio predicts characteristics of the resulting stress distribution. [1]

Sinjo Jose, M. James Selvakumar studied an Overview of Fillet Weld Joints Subjected to Tensile and Compressive Loads in which Mechanical assemblies and parts that are in service may be subject to high stresses and different types of loads such as fatigue loads, tension loads, compression loads. In this study, finite element analysis software, ANSYS, is used for a parametric study to research the effect of weld toe radius in fillet welded joint on compression strength and tensile strength. In metal constructions, machine assemblies, shipbuilding and other heavy industries, fillet joint is a widely used structural member. There are different types of loads acting on the fillet weld joints. There are various application of fillet weld joints .We can use fillet weld joints in steel bridge girder, building structures, machine assemblies etc. [2]

Lucas F.M. Silva, J.P.M. Gonc studied multiple-site damage in riveted lap-joints: experimental simulation and finite element prediction The multiple-site damage (MSD) phenomenon is discussed, and exemplified by the behaviour of riveted lap-joint specimens of aluminium alloy 2024-T3 alclad. The tests performed, on which the paper is based, are part of the contribution of IDMEC to a project on the fatigue behaviour of ageing aeronautical structures—the BRITE-EURAM project 'SMAAC', partially funded by the European Union. The study involves fatigue testing under constant amplitude loading of 1.6-mm-thick riveted lap-joints, and includes examination of the specimens during and subsequent to testing (post-mortem analysis of the fracture surface in a scanning electron Microscope) in order to determine the time of occurrence, location and extent of fatigue damage. Crack growth rates are determined from periodic crack length measurements with a travelling microscope. [3]

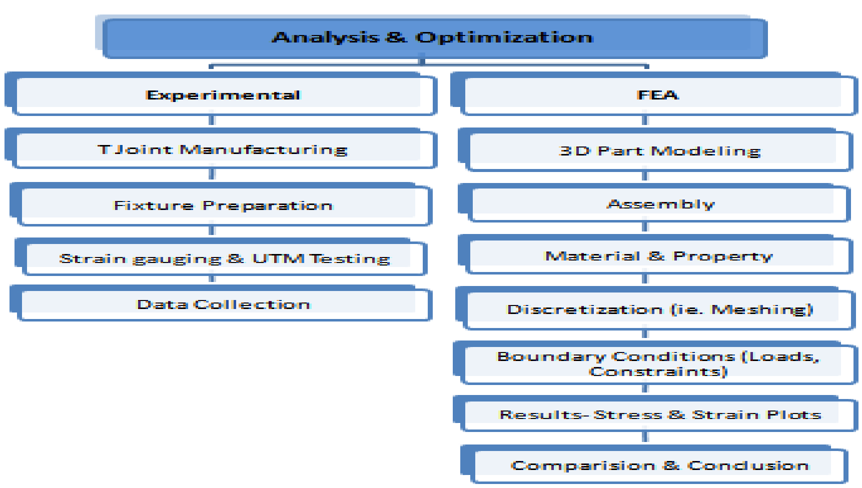
III. PROBLEM STATEMENT

Welded joints are widely found in almost all applications like construction structures, automotive, industrial roofs and many more applications. Tensile ,Bending ,tortional and multi axial loads acts on various welded joints during operations' joints are used for various members coming together at same location joints behavior at tensile and bending loading needs to be investigated

IV. OBJECTIVES

A. Catia V5 software is used for modeling T joint of standard Dimension.
B. Discretiztion (meshing) and finite element analysis is carried out using ANSYS package.
C. T joint is welded with holding fixture for carrying out experimental analysis.
D. Experimental stress analysis is carried out using strain gauge for measuring strain values and UTM for applying gradual loads.

V. METHODOLOGY



A. Solid Model- T Joint

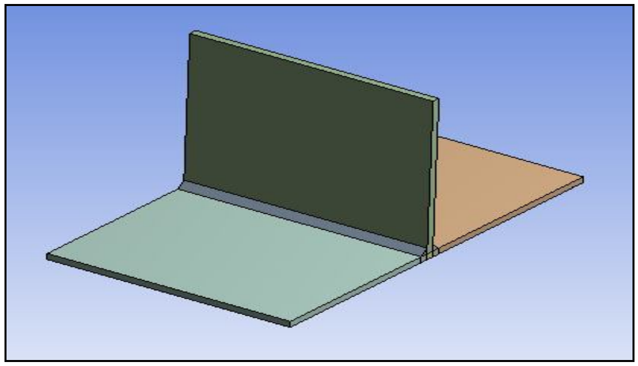


Fig. 1 Solid Model- T Joint

Properties of Outline Row 3: Structural Steel

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	7850	kg m^-3
4	Isotropic Secant Coefficient of Thermal Expansion		
6	Isotropic Elasticity		
7	Derive from	Young'...	
8	Young's Modulus	2E+11	Pa
9	Poisson's Ratio	0.3	
10	Bulk Modulus	1.6667E+11	Pa
11	Shear Modulus	7.6923E+10	Pa
12	Alternating Stress Mean Stress	Tabular	
16	Strain-Life Parameters		
24	Tensile Yield Strength	2.5E+08	Pa
25	Compressive Yield Strength	2.5E+08	Pa
26	Tensile Ultimate Strength	4.6E+08	Pa
27	Compressive Ultimate Strength	0	Pa

Fig. 2 material properties.

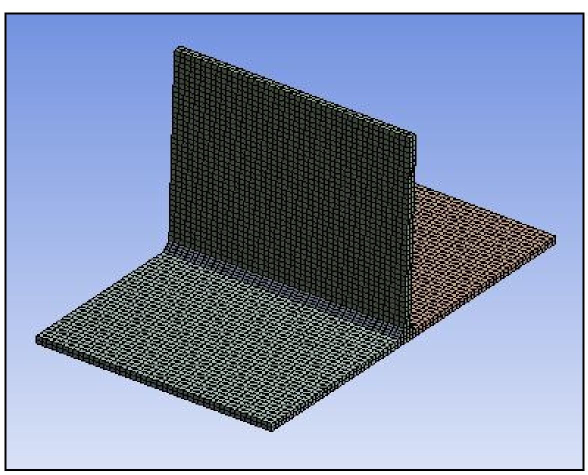


Fig. 3 Meshing

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B. Tensile loading.

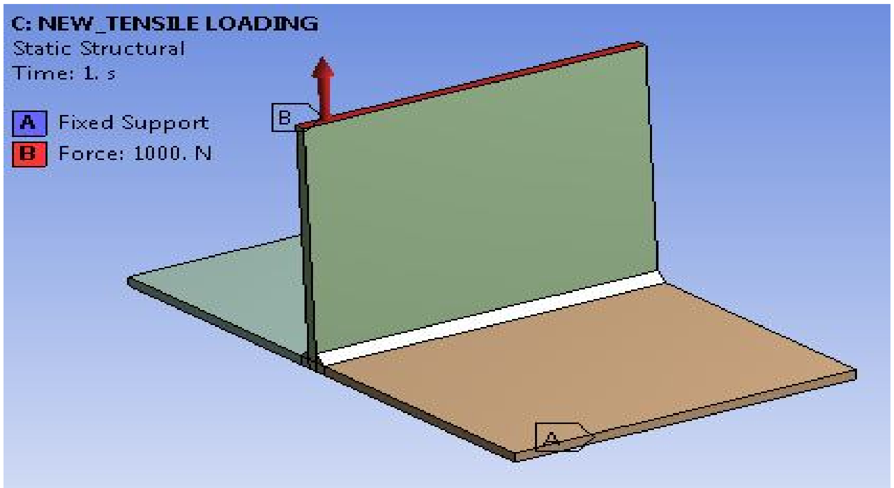

Fig. 4 Tensile Loading
(Boundary condition- Force=1000N)

C. EQVI – Von Misses Stress

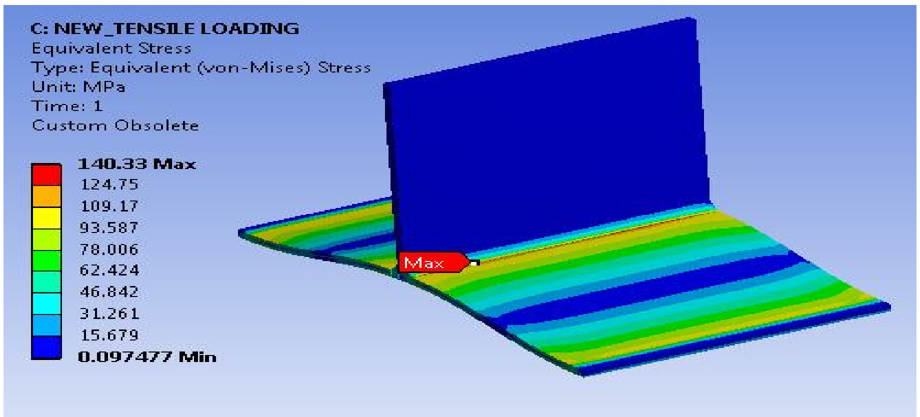

Fig.5 Tensile Loading

D. Maximum Shear Stress

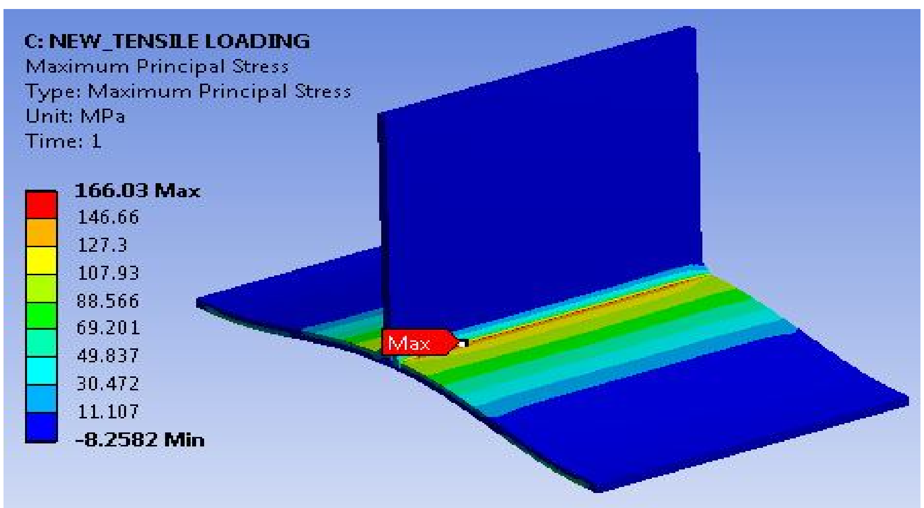

Fig. 6 Tensile Loading Shear Stress

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E. Deformation

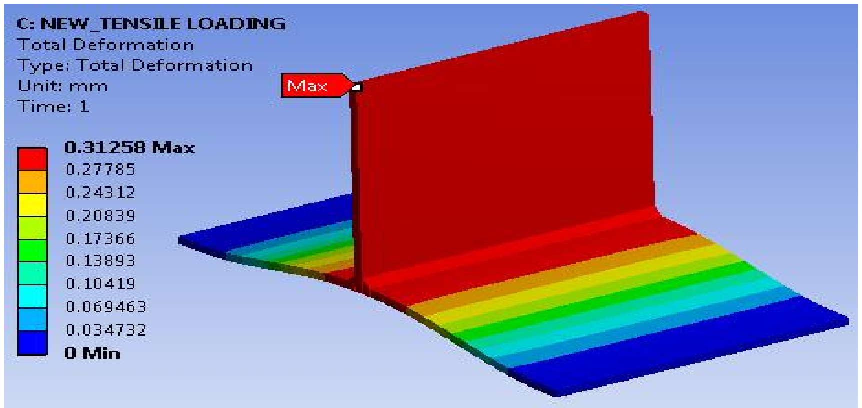

Fig. 7 Tensile Loading

F. Max principal strain

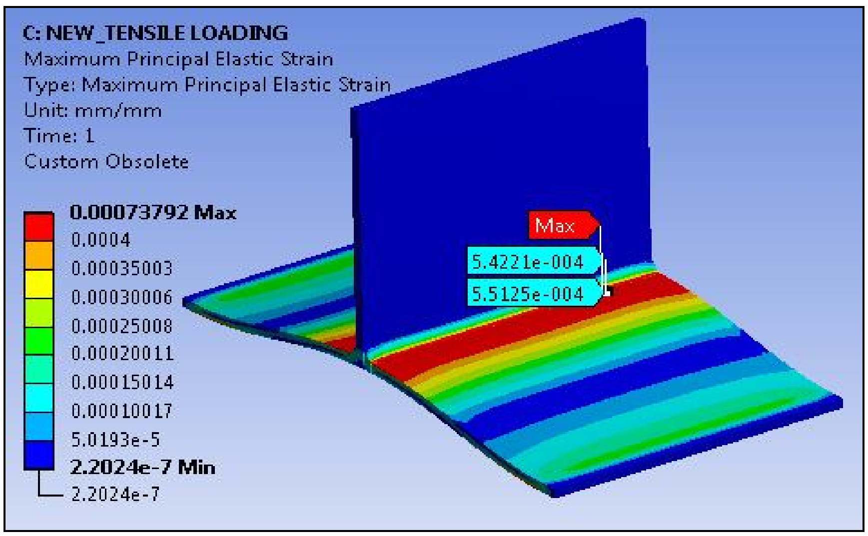

Fig.8 Tensile Loading

G. Strain gauge will be placed in nearby feasible location during fatigue life curve.

Table of Properties Row 12: Alternating Stress Mean Stress

	A
1	Mean Stress (Pa)
2	0
*	

	B	C
1	Cycles	Alternating Stress (MPa)
2	10	3999
3	20	2827
4	50	1896
5	100	1413
6	200	1069
7	2000	441
8	10000	262
9	20000	214
10	1E+05	138
11	2E+05	114
12	1E+06	86.2

Fig.9 SN – curve for fatigue life calculation

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H. Fatigue life

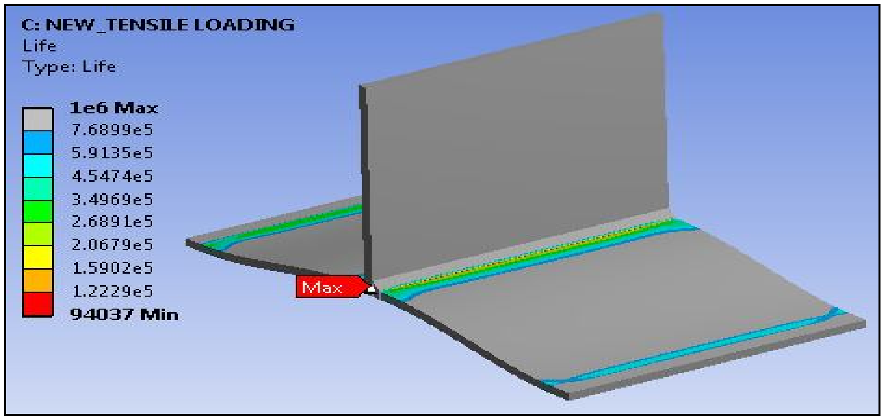

Fig. 10 Tensile Loading

I. Factor of safety

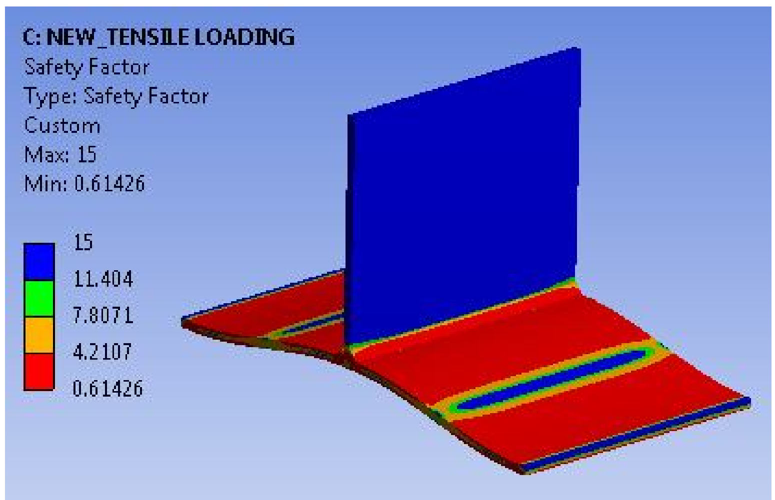

Fig. 11 Tensile Loading

J. Bending loading

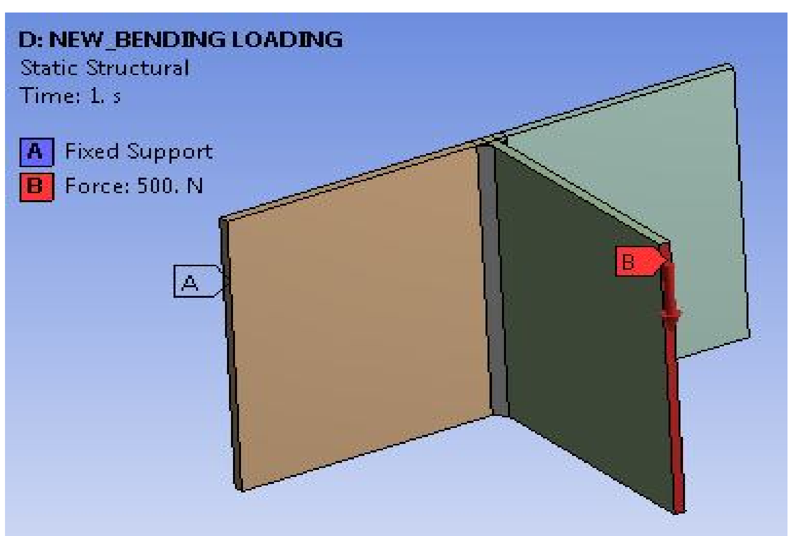

Fig. 12 Bending Loading.

K. EQVI – Von Misses Stress

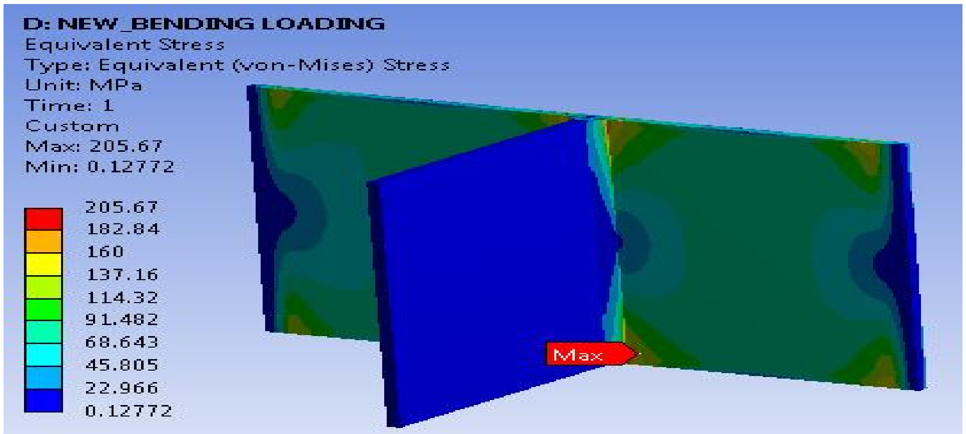

Fig. 13 Bending Loading

L. Maximum Shear Stress

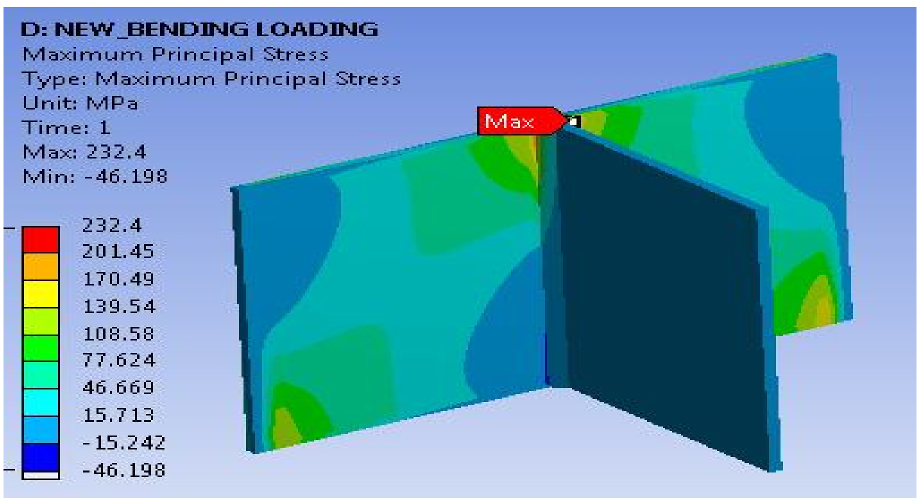

Fig. 14 Bending Loading

M. Deformation

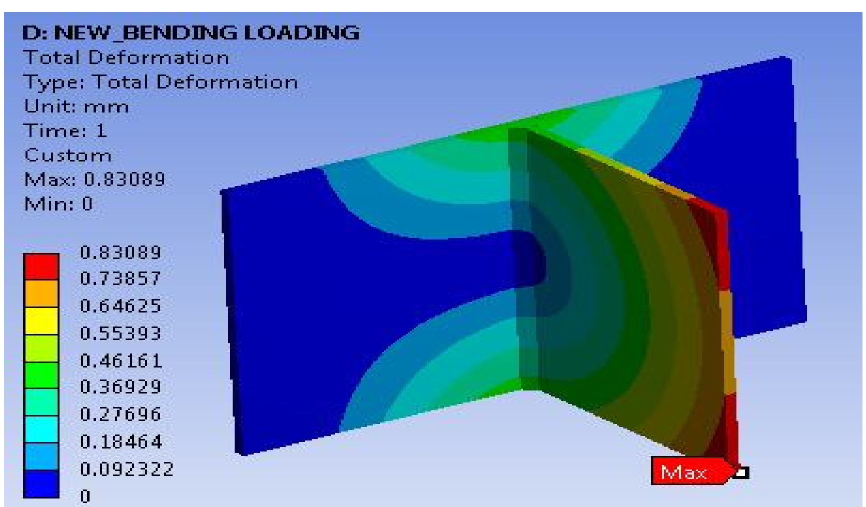

Fig. 15 Bending Loading

N. Max principal strain

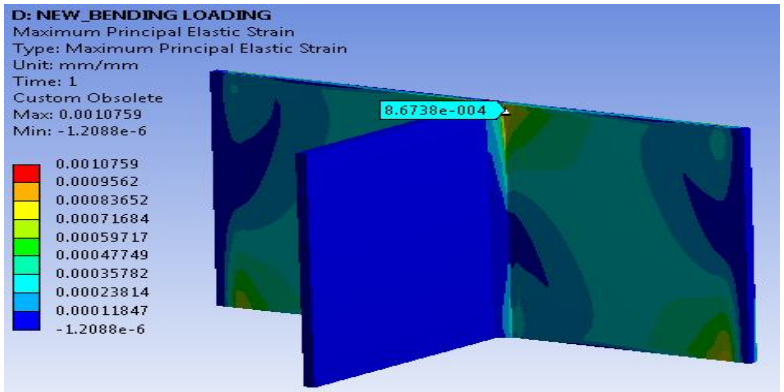

Fig. 16 Bending Loading

O. Fatigue life curve

Table of Properties Row 12: Alternating Stress Mean Stress

	A
1	Mean Stress (Pa)
2	0
*	

	B	C
1	Cycles	Alternating Stress (MPa)
2	10	3999
3	20	2827
4	50	1896
5	100	1413
6	200	1069
7	2000	441
8	10000	262
9	20000	214
10	1E+05	138
11	2E+05	114
12	1E+06	86.2

Fig. 17 SN – curve for fatigue life calculation

P. Fatigue life

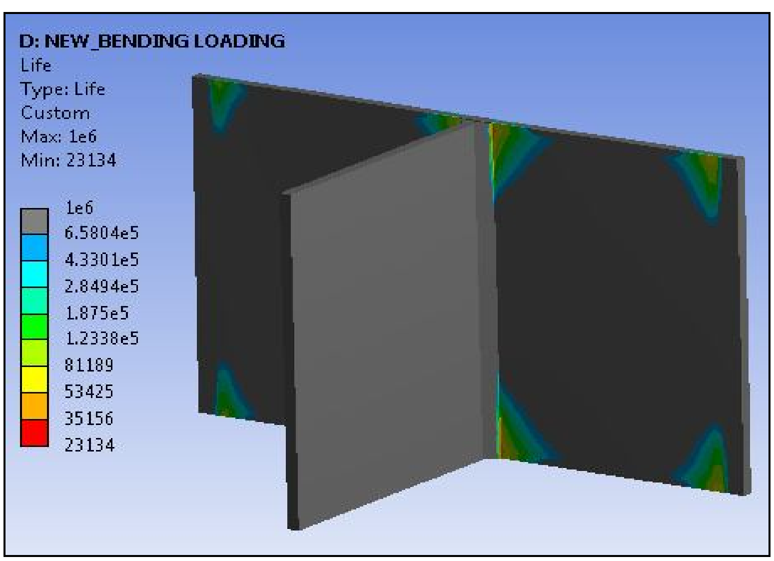

Fig. 18 Bending Loading

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Q. Factor of safety

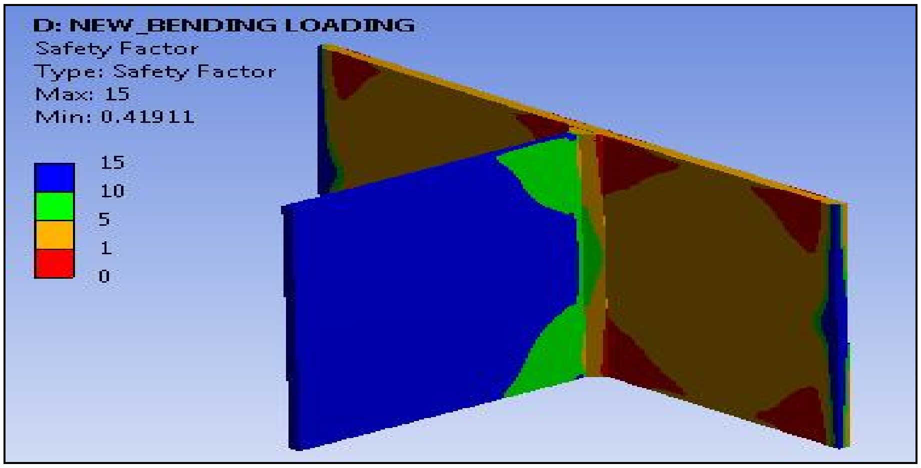

Fig. 19 Bending Loading.

VI. EXPERIMENTAL STRESS ANALYSIS

There are various types of experimental methods to analyze strains and stresses at a point. Strain gauge methods use either electrical or mechanical means to measure strains. In these types of strain gauges, electrical resistance strain gauges are the most accurate and widely used ones. This experiment consists of three parts, all utilizing electric resistance strain gauges. You will perform three experiments.

Historically, the development of strain gauges has followed many pathsand various methods have been developed based on mechanical, optical, electrical, acoustic and pneumatic principles. In spite of the very wide variations in the strain gauge designs, they all have four basic common characteristics. These are gauge length, gauge sensitivity, measuring range, and, accuracy and reproducibility. Gauge Length: Strains cannot be measured at a point with any type of gauge, and as a consequence non-linear strain fields and local high strainsare measured with some degree of error being introduced. In these cases, the error will definitely depend on the gauge length Lo. In selecting a gauge for a given application, gauge length is one of the most important considerations. Gate Sensitivity: Sensitivity is the smallest value of strain which can be read on the scale associated with the strain gauge. Range: It represents the maximum strain which can be recorded without resetting or replacing the strain gauge. Accuracy: Accuracy is the closeness to an accepted standard value or set of values, and is numerically equal to the referred error value. Reproducibility: Reproducibility is the closeness or agreement between two or more measurements of the same quantity taken at different times. There are different types of commercial strain gauges; these are:

A. Unbounded wire gauges
B. Bonded wire gauges
C. Bonded foil gauges
D. Piezo-resistive gauges
E. Semi-conductive gauges

The first three of these types are very similar and they are based on Lord Kelvin's findings. The major differences between them are based on the design concepts rather than principles. The last two are entirely new concepts and are based on the use of a semiconductor as the strain sensing element.

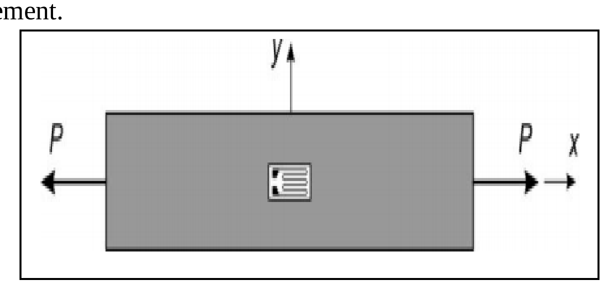

Fig. 20 Bonded foil strain gauges

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Bonded foil gauges is the very common gauge type. This strain gauge is one of the important electrical measurement technique applied to the measurement of mechanical quantities. As their name indicates they are used for the measurement of strain. The strain of a body is always caused by an external influence or internal effect such as force, pressure, moment, heat, structural change of the material etc. The strain gauge must be mounted on the surface of specimen on which the stress shall be determined. This is normally done with the aid of special bonding agents or glues. The two dimensional state of stress existing on the surface of the specimen can be expressed in terms of three Cartesian strain components through Hooke's law. In general, it is necessary to measure three strains at point to completely define the strain field. In certain special cases, the state of strain may be established with a single strain gauge.

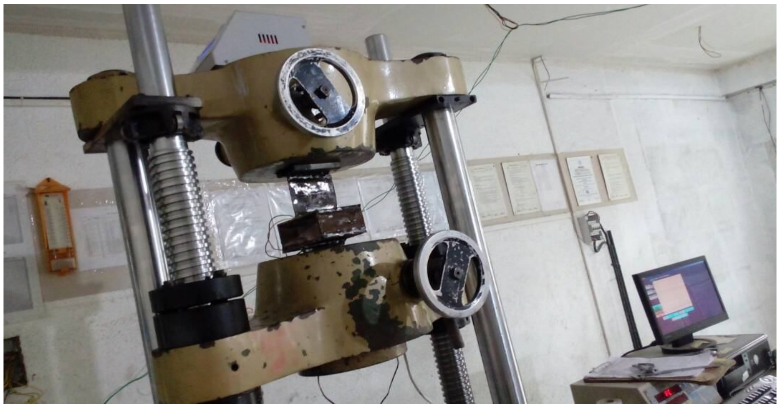

Fig. 21 Tensile Loading on T-Joint

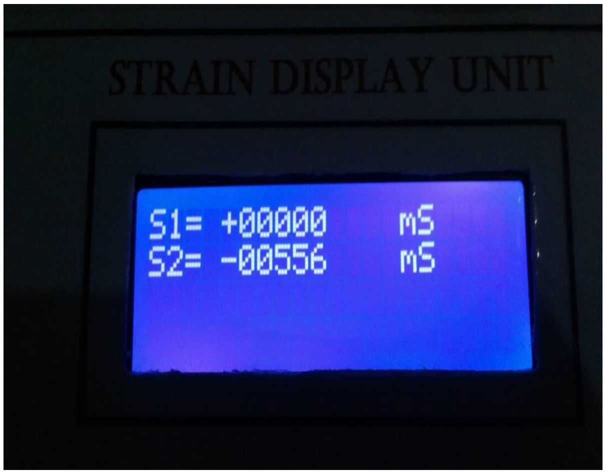

Fig. 22 Strain gage output 556 micro strains

Fig. 23 Bending Loading on T-Joint

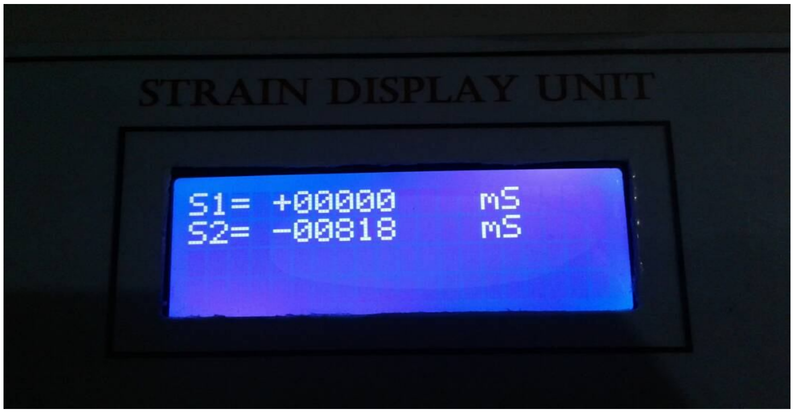

Fig. 24 Strain gage output 818 micro strains

VII.RESULT TABLE

FEA and Experimental strains are in good correlation with each other which validates thesis work.

LOADING	EXPERIMENTAL STRAIN	FEA STRAIN
BENDING	818 ms	867 ms
TENSILE	556 ms	551 ms

VIII. CONCLUSION

T Joints are stronger in tensile loadings as compared to bending loadings.

IX. ACKNOWLEDGMENT

It is of immense pleasure to me in expressing sincere and deep appreciation towards my guide Prof. R.L. Mankar., for priceless execution of steering this contribution all the way through this work with soft suggestions, embedded supervision and invariable advocacy. Special thanks to the principal and teaching staff of JCOE Kuran, for needful support and encouragement throughout the course.

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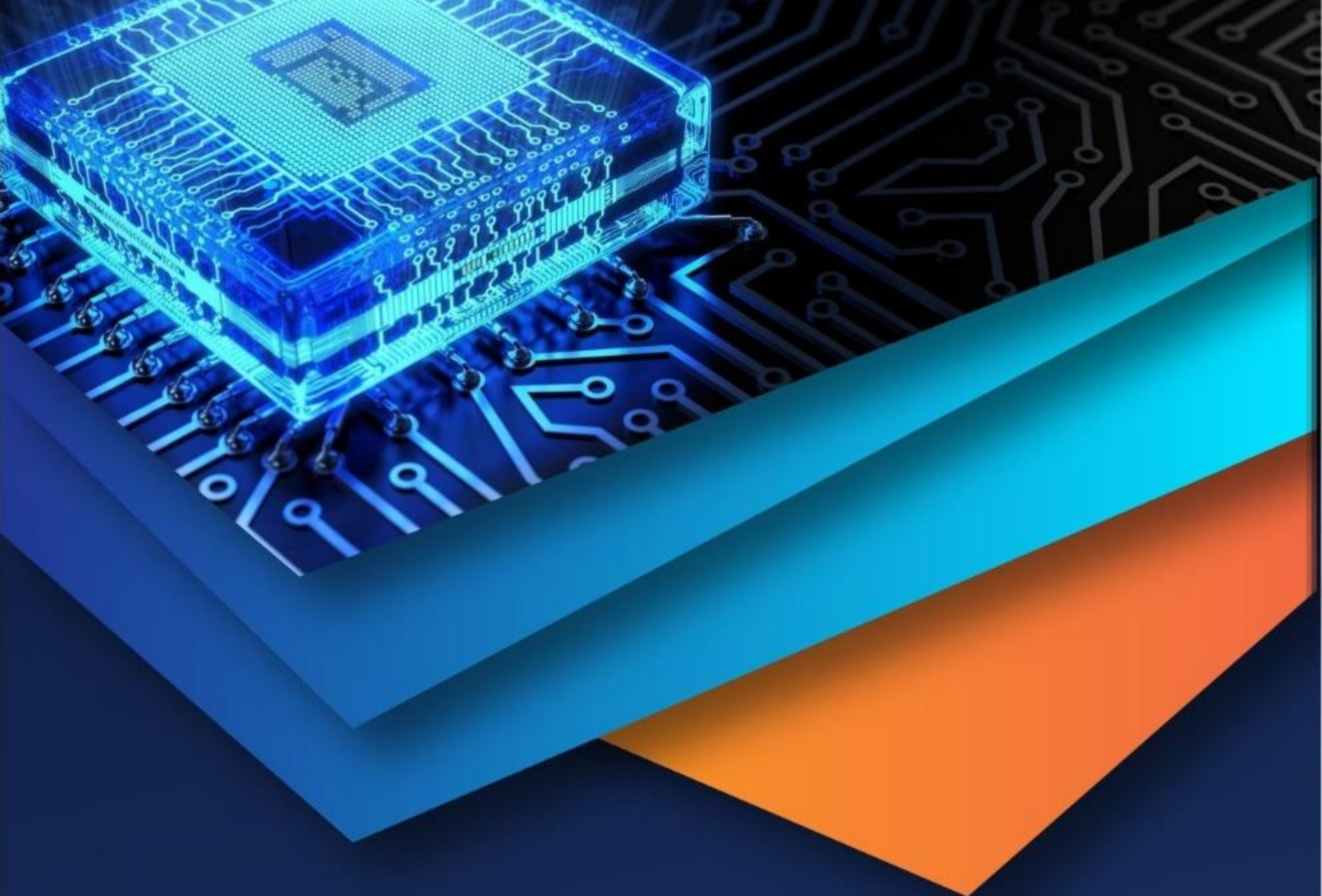

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