iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: CAAA-2018 **Issue:** Conference **Month of publication:** April 2018

DOI:

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

Fatigue Analysis of Lug Joint in the Nose Landing Gear

S. Balaji[1], R. K. S. Kishore[2], S. Sathish Kumar[3]
[1]*Assistant Professor,* [2]*UG scholar,* [3]*UG scholar, Department of Aeronautical Engineering, Nehru Institute of Engineering and Technology Coimbatore, Tamil Nadu*

Abstract: The objective of this project is to design a lug joint in the nose landing gear. During take-off and landing, static and dynamic loads are acting on the lug joint in the nose landing gear which leads to the structural failure of the component. The take-off and landing loads are calculated by using aerodynamic calculations. The dimensions of the lug in nose landing gear is obtained by strength of material approach for the aluminium alloy materials. Finite element analysis will be carried out in order to estimate the maximum local stress which will be required in the fatigue analysis of the lug joint. Fatigue life and maximum deformation of the lug joint in the nose landing gear at the region of high stress during the time of take-off and landing are estimated.

I. INTRODUCTION

An aircraft is a machine which is used for good air transport system. It is used to travel one place to another place (long or short distance) in a short period of time and it can able to carry high load i.e., in commercial aircraft passengers, cargo, flight crew, fuel tank, scientific instruments or equipment., in military aircraft warheads, bombs etc., Landing gear is the most important component of the aircraft. It can able to carry the whole weight of an aircraft at the time of takeoff, landing and taxing. Many types of landing gears are used. There are single, main, tricycles, quadricycle, tricycle, tail gear, multi bogey, releasable rail and skid. In most of the commercial aircraft, tricycle landing gear is used. It can be retractable or fixed. In modern aircraft to minimize the drag, retractable landing gear is used. Tri cycle landing gear has one nose landing gear and two main landing gears. In landing gear, lug joint is the most important structure. Lug is the structural member which can able to absorb high impact load at the time of takeoff and landing. And then the load is transvers through other components or members. So, the design of the lug joint is very much important. When design the lug joint of the main land gear, considered takeoff configuration. While takeoff, total weight of the aircraft is carried by the main landing gear

II. MATHEMATICAL APPROACH

A. *Load Calculation*

Distance between the aircraft center of gravity and the ground will be

$$H_{CG} = \Delta H_{clear} + D_{prop}$$

$$= 1.2 + \frac{3.95}{2}$$

$$H_{CG} = 3.175 \text{ m.}$$

Attach nose gear to the fuselage landing gear height will be,

$$H_{CG} = H_{CG} - \frac{D_{FUSE}}{2}$$

$$= 3.175 - \frac{2.5}{2}$$

$$H_{CG} = 1.925 \text{ m.}$$

Wing mean aerodynamic chord

$$B = \sqrt{\frac{S.AR}{2}}$$

$$= \sqrt{61 \times 12}$$

$$= \sqrt{732.05} m$$

$$= 27.05 \text{ m.}$$

$$\bar{C} = S \backslash b$$

$$= 61$$

27.05

$= 2.25$ m

$T_w = (t\backslash c)_{max}\ C = 0.12 \times 2.25$

$T\ w = 0.27$m.

B. Landing Gear Height

$H_{CG} = H_{CG} + t_w$

$= \frac{3.175 + 0.27}{2}$

$= 304$ m.

$X_{CWF} = X_{mg} - (\bar{X}_{ac} - \bar{X}_{cg\ fuel})\ C$

$= x_{mg} - (0.22 - 0.18) \times 2.25$

$= x_{mg} - 0.09$

$X_h = X_{ach} - X_{mg}$

$= L_h + (\bar{X}_{ac} + \bar{X}_{cg\ fuel})\ C - x_{mg}$

$= 13 + (0.22 \times 0.18) \times 2.25 - x_{mg}$

$= 13.09 - x_{mg}$

$H_D = H_{cg} = h_T = 3.175$

$K = \frac{1}{\pi \rho AR}$

$= \frac{1}{3.14 \times 0.9 \times 12}$

$= 0.029$

$C_{LC} = \frac{2\ W}{\rho V L^2 S}$

$= \frac{2 \times 23000 \times 9.81}{0.512 \times (127.8)^2 \times 61}$

$= 0.88$

$C_{CTo} = C_{LC} + \Delta C_{L\ FLAP}$

$= 0.88 + 0.9$

$CTo = 1.78$

$C_{DTo} = C_{DoTo} + KC^2_{CTo}$

$= 0.03 + 0.029 \times (1.78)^2$

$C_{DTo} = 0.12$

NOTE:

$V_R = 1.1 \times V_S = 1.1 \times 140 = 154$ Km\hr

$V_R = 42.7$ m\s

$D_{To} = 1\backslash 2 \rho v^2 R\ S C_{DTo}$

$= 1\backslash 2 \times 1.225 \times (42.7)^2 \times 61 \times 0.12$

$D_{To} = 8174.7$ N.

$L_{To} = 1\backslash 2 \times \rho v^2{}_R\ S_{REF}\ C_{LTo}$

$= 1\backslash 2 \times 1.225 \times (42.7)^2 \times 61 \times 1.78$

$L_{To} = 121258.3$ N.

$L_H = 1\backslash 2 \times \rho V_R^2\ S_h C_{Lh}$

$= 1\backslash 2 \times 1.225 \times (42.7)^2 \times 14 \times (-0.8)$

$L_H = -12507.7$N.

$M_{ACref} = 1\backslash 2 \times \rho v_R^2\ C_{Mac}\ ref\ S_{ref}\ C$

$= 1\backslash 2 \times 1.225 \times (42.7)^2 \times 61 \times (-0.03) \times 2.25$

$Mac_{ref} = -4598.2$N.

$L_{WF} = L_{To} - L_H$

©IJRASET (UGC Approved Journal): All Rights are Reserved

= 121258.3 – (-12507.7)

Lwf= 133766.05N.

Friction force :

$F_F = \mu (W – L_{To})$

= 0.04 (23000×9.81×- 121258.3)

Ff = 4174.8N.

$T = \frac{P\eta p}{V_R} = \frac{69854.7 – 4564.2 – 4174.8}{23000}$

A = 2.65 m\s^2

C. Contributing moment

$M_W = W (x_{mg} – x_{cg})$

$=23000×9.81(x_{mg})$

$M_D = D (Z_D - Z_{MG})$

= 4564.2×3.1

= 14149.02 Nm.

$M_T = T (Z_T – Z_{MG})$

= 69854.7 ×3.1

= 216549.5 Nm.

$M_{CWF} = L_{WF} (X_{MG} – X_{ac\ wf\ TO\ cg})$

$= 133766.05 (x_{mg} – 0.09)$

$M_{CH} = L_h (X_{ac\ h} - X_{mg})$

$= - 12507.7 (13.09 – X_{mg})$

$M_a = M_a - (Z_{cg} – Z_{mg})$

= 23000 ×2.65×3.1

$X_{mg} = \frac{I_{yy\ mg} \emptyset - (Z_D - Zmg) + (Z_T – Z_{MG}) – Mac_{wf} - ma (Zcg – Zmg) – Wx_{cg} + Lwf + Xac_{wf} + Lh_{ach}}{Lwf + Lh + W}$

= 23000×9\57.3 – 14149.02+ 216549.5 = (- 4598.2) – 188945 + 0 + 133766.05 + (12507.7 ×13.09)

133766.05 + (-12507.07) - 23000×9.81

$= \frac{130020.6}{104371.65} = 1.250$ m.

X_{mg} = 1.25m.

Check tip back requirement

$\Delta x_{cg} = Xcg – Xcg_{aft}$

=(0.30 – 0.18) C

= 0.12 ×2.25

= 0.27m

Distance between mg and aft

Xmg_{aft} Xmg aft = Xmg – Δxmg

= 1.25 – 0.27

= 0.98m.

Tip back angle

$\alpha tb = \tan^{-1} (Xmg\backslash Hcg)$

$= \tan^{-1} (0.98\backslash 3.175)$

α tb = 17.15deg .

This angle is greater than aircraft take off rotation angle (14 deg)

17.15>14

$Fn_{max} = \frac{B\ m_{max}}{} W$

$$0.15 = 1.25 \frac{W}{B}$$

$$B = \frac{1.25}{0.15}$$

B = 8.33 (Distance between mg and ng)

$Fn = Fn_{max} + Fn_{dynamic}$ (due to breaking)

$$= \frac{W\,B\,max}{B} + \frac{W \backslash ac \backslash H}{g\,B}$$

$$= \left((23000 \times 9.81) + \frac{1.25}{8.33} \right) + \left(\frac{(23000 \times 9.81 \times 3 \times 3.175)}{9.81 \times 8.33} \right)$$

$$= 33858.04 + 26299.5$$

Fn = 60157.5 N .

D. Dimension calculation of the nose landing gear joint

Vertical load is applied on the wheel is ,

$F_{vn} = FOS \times F$

$= 1.5 \times 60157.5$

$= 90236.25$ N

Material used : AL 7075

Yield stress :

$$\sigma yt = \frac{P}{(2\pi d^2 \backslash 4)}$$

$$503 = \frac{90236.25}{\frac{2 \times 3.14 \times d^2}{4}}$$

$$503 \times 1.57 = \frac{90236.25}{d^2}$$

$d^2 = 114.2$

Bearing stress:

$$\sigma\ bearing = \frac{P}{D \times t}$$

σ bearing = 0.5 × ultimate stress

= 0.5 ×572

σb = 286 Mpa .

$$\sigma\ bearing = \frac{90236.25}{11 \times t}$$

$$3146 = \frac{90236.25}{t}$$

$$t = \frac{90236.25}{3146}$$

t = 28.68 mm. or 29 mm.

h = 2d ; b = t

h=2×11 ; b = 28.68

h =22mm ; b = 29mm

Material used : AL 7050

σ_{yt} = 470 Mpa

$$\sigma_{yt} = \frac{P}{(2\pi d^2 \backslash 4)}$$

$$470 = \frac{90236.25}{}$$

©IJRASET (UGC Approved Journal): All Rights are Reserved

$2\pi d^2\backslash 4$

$d^2 = 122.28$

$d = 11mm.$

$\sigma_b = 0.5 \times 470$

$\sigma_b = 235$ Mpa

$\sigma bearing = \frac{P}{D \times t}$

$235 = \frac{90236.25}{11 \times t}$

$2585 = \frac{90236.25}{t}$

t = 3.5 mm,

h = 22mm,

b = 35mm.

Material used : AL 7178

$\sigma yt = 538$ Mpa

$\sigma yt = \frac{P}{(2\pi d^2\backslash 4)}$

$1.57 \times 538 = \frac{90236.25}{d^2}$

$d^2 = 106.83$

d = 10.33

d = 11mm.

$\sigma_b = 0.5 \times 538$

$\sigma_b = 269$ Mpa

$\sigma_b = \frac{P}{D \times t}$

$269 = \frac{90236.25}{11 \times t}$

$2959 = \frac{90236.25}{t}$

t = 30.49 , t = 31mm.

E. Final Values

t = 30mm,

b = 30mm,

d = 10mm,

h = 25mm.

III. MATERIAL SELECTION

The material of lug joint must be carefully selected. So that it can able to withstand for high applied load. Thus there are Several materials can be used for manufacturing the lug joint. Considered the strength and weight is very much important. The strength must be high and weight must be less to reduce dead weight of the aircraft during fly . Here Aluminium Alloy is considered to design the Lug joint. Selection of material depends upon

1) Stiffness
2) Strength
3) Durability
4) damage tolerance

©IJRASET (UGC Approved Journal): All Rights are Reserved

5) Corrosion.

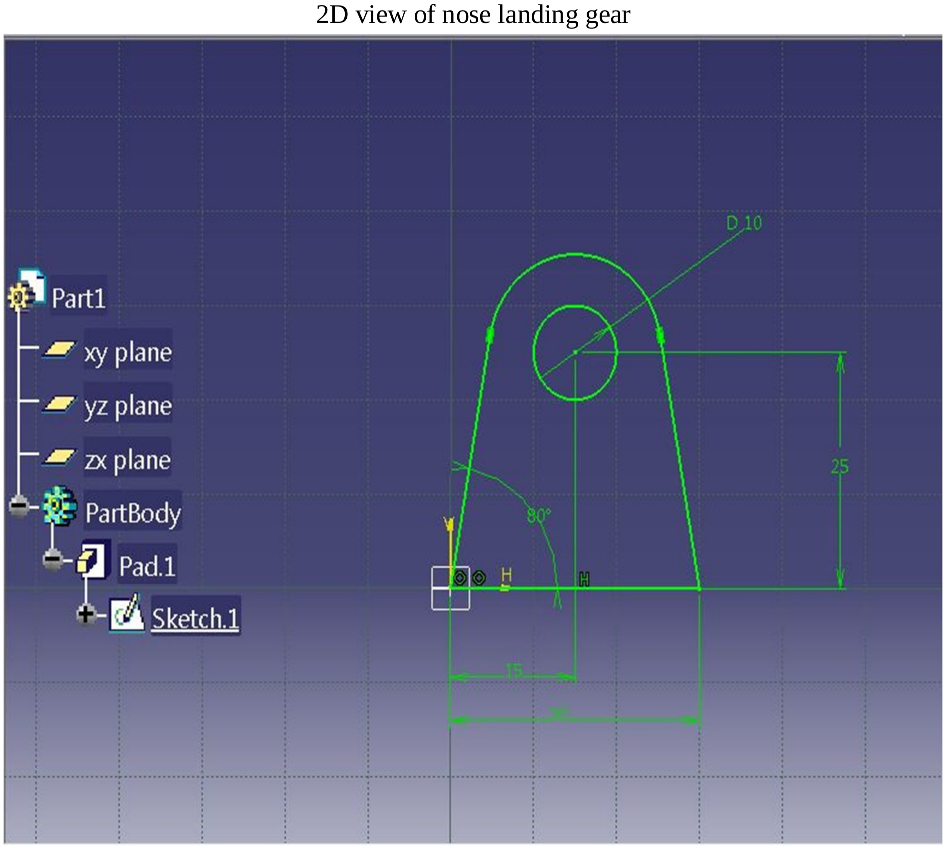
Al 7075-T6 has high strength, lower fracture toughness.
Used for tension application where fatigue is not critical. It
also has low short transverse properties and low stress corrosion resistance.

IV. MATERIAL PROPERTIES

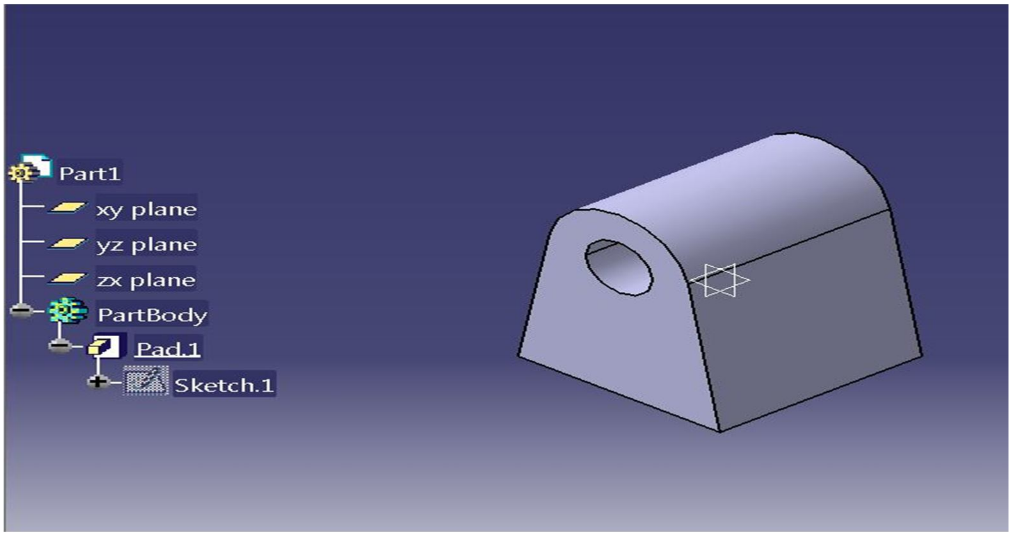
ALUMINIUM ALLOYS	Al - 7050	Al - 7178	Al - 7175	Al - 7075
Density, ρ	2830 Mpa	2830 Mpa	2800 Mpa	________
Elastic modulus, E	71.7 Gpa	72 Gpa	________	________
Ultimate tensile stress , σ_t	525 Mpa	607 Mpa	552 Mpa	572 Mpa
Yield stress, σ_y	470 Mpa	538 Mpa	503 Mpa	503 Mpa
Fatigue strength	200 Mpa	150 Mpa	160 Mpa	159 Mpa
Poisson's Ratio ν	0.33	0.33	0.33	0.33

V. MODELING OF LUG

2D view of nose landing gear

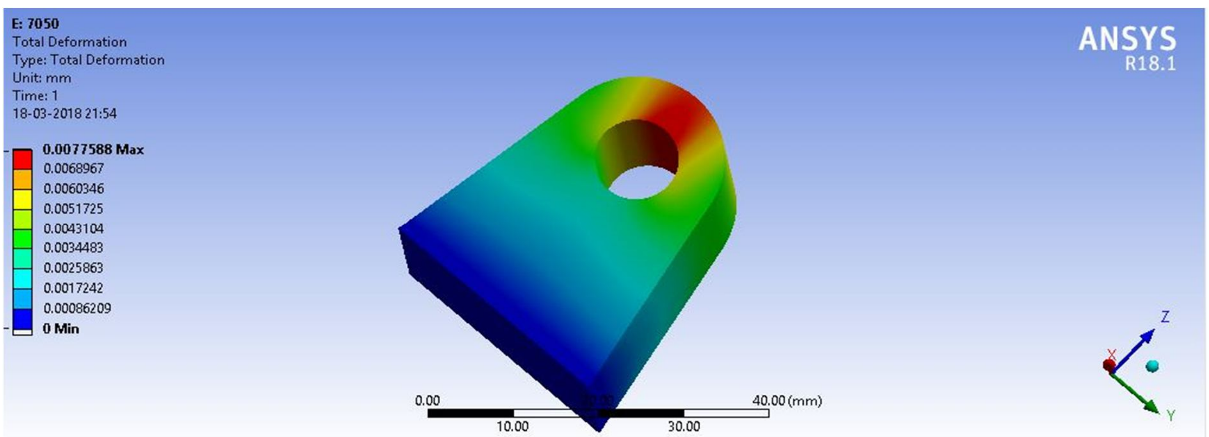


3D view of nose landing gear

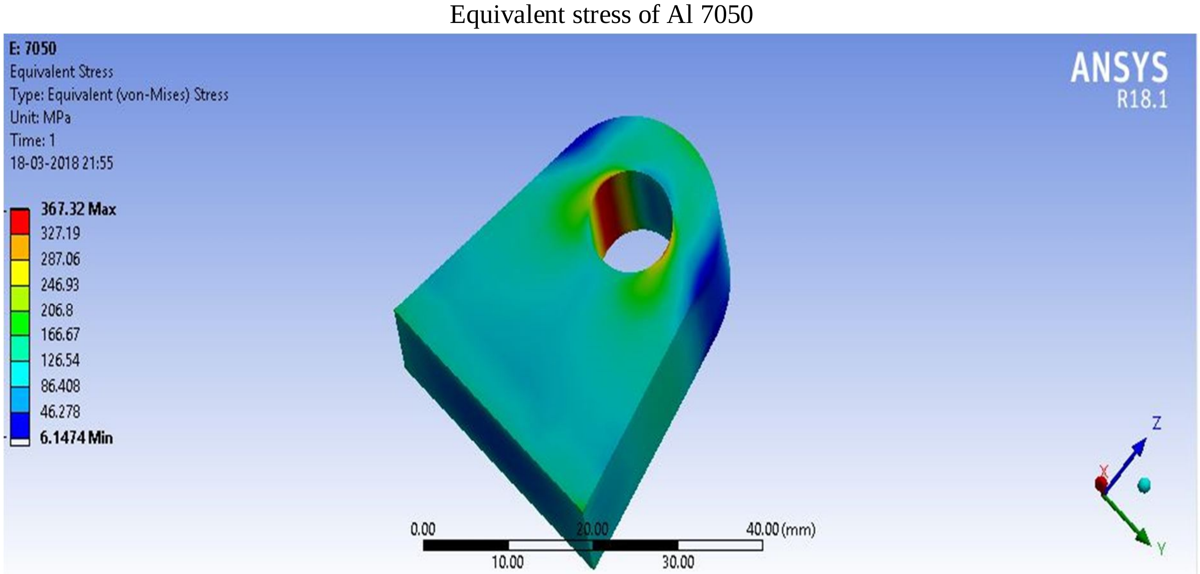


A. Fatigue Analysis Of Al 7050

Total deformation of Al 7050

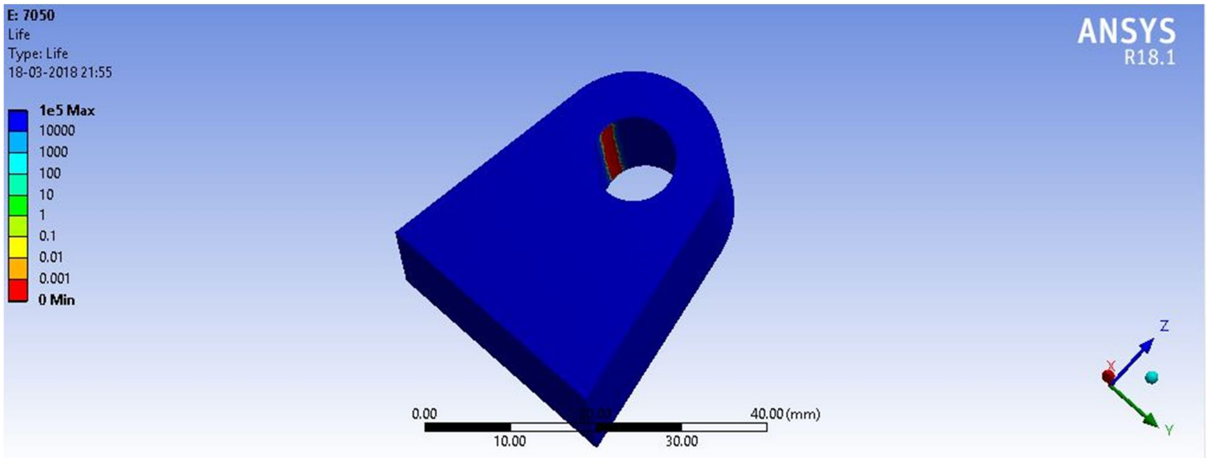


Equivalent stress of Al 7050

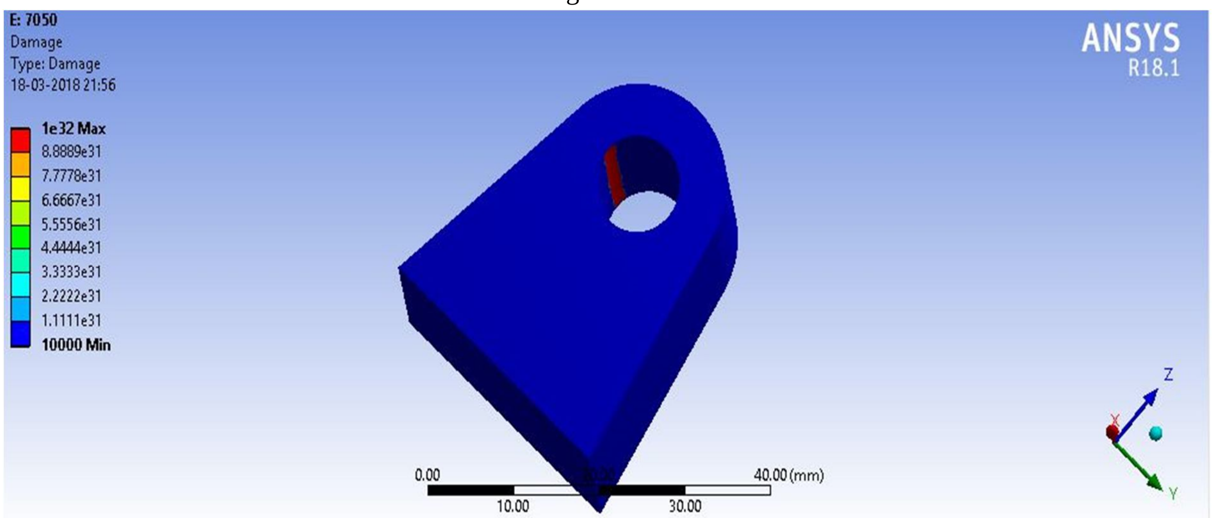


©IJRASET (UGC Approved Journal): All Rights are Reserved

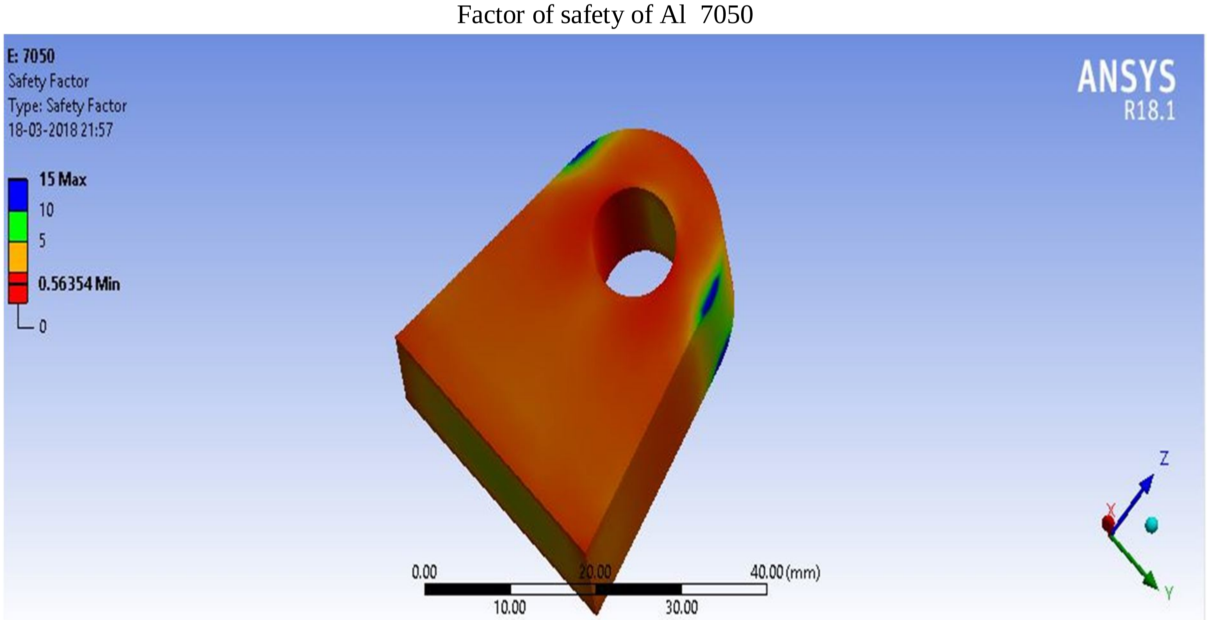
Fatigue life of Al 7050



Damage of Al 7050



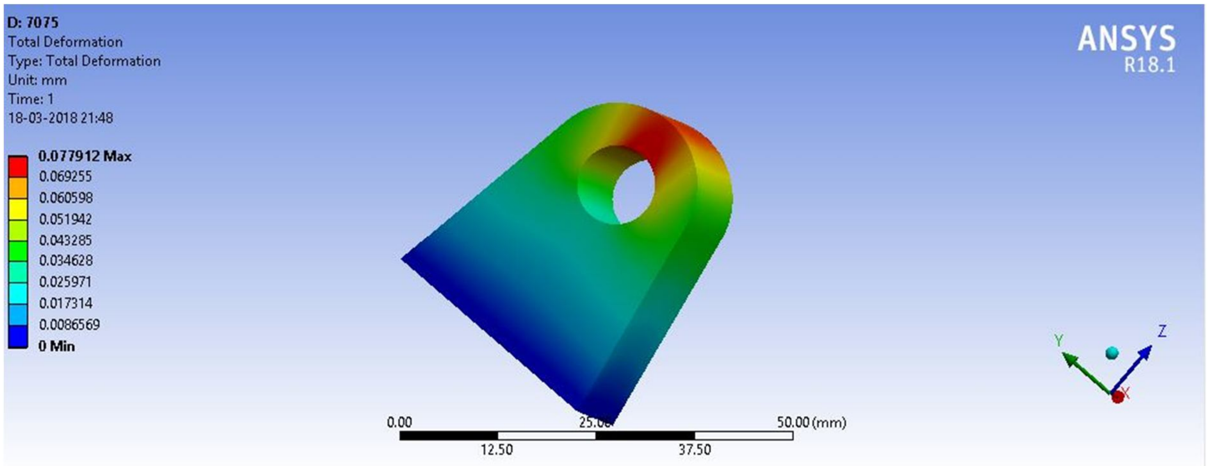
Factor of safety of Al 7050



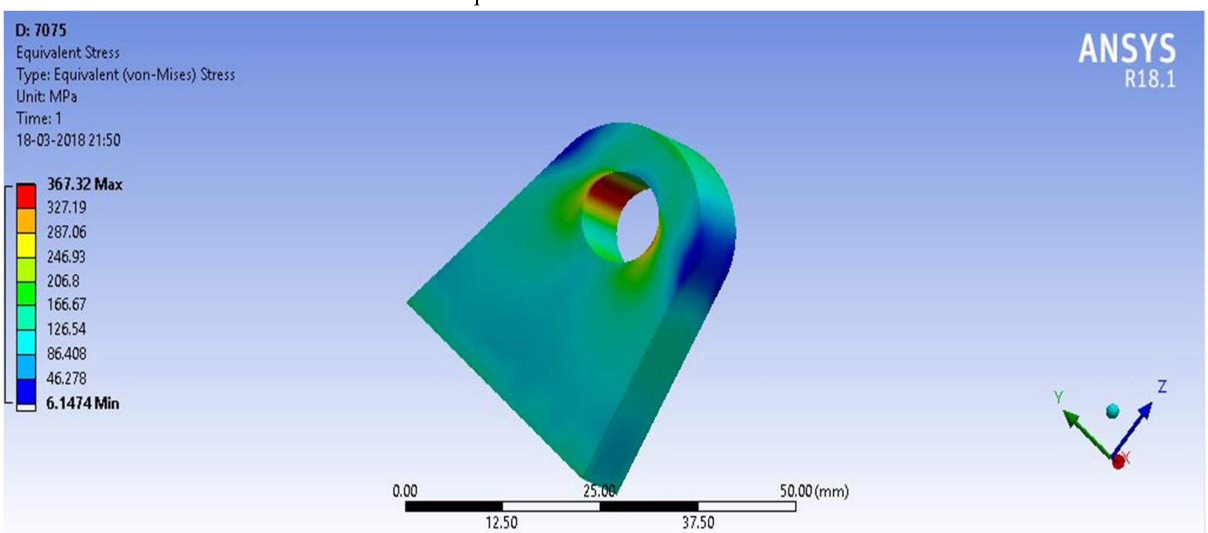
©IJRASET (UGC Approved Journal): All Rights are Reserved

B. Fatigue analysis of al a 7075

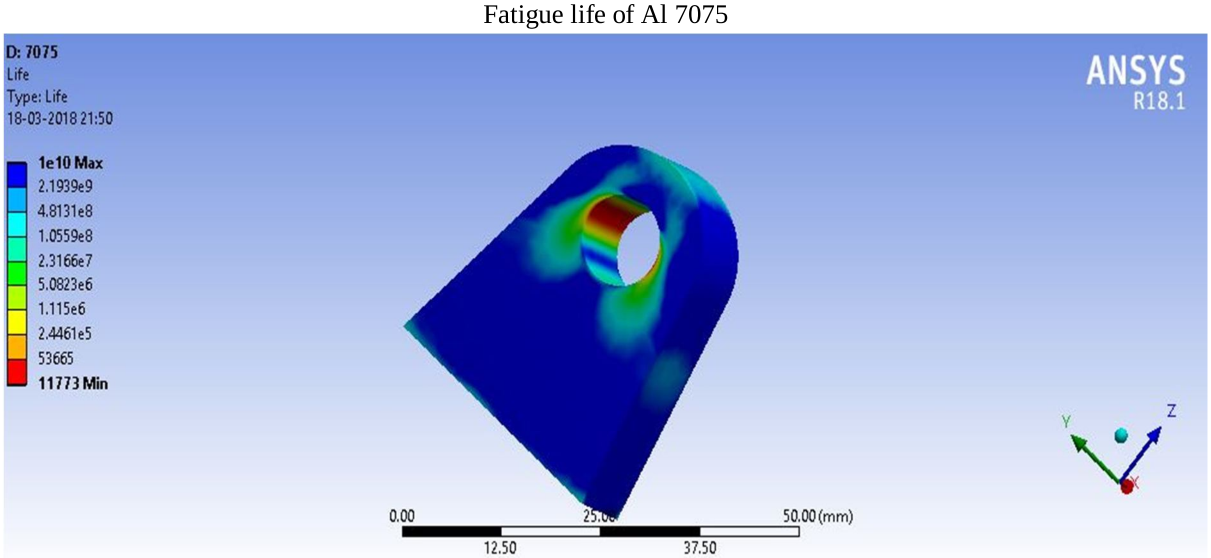
Total deformation of Al 7075



Equivalent stress of Al 7075

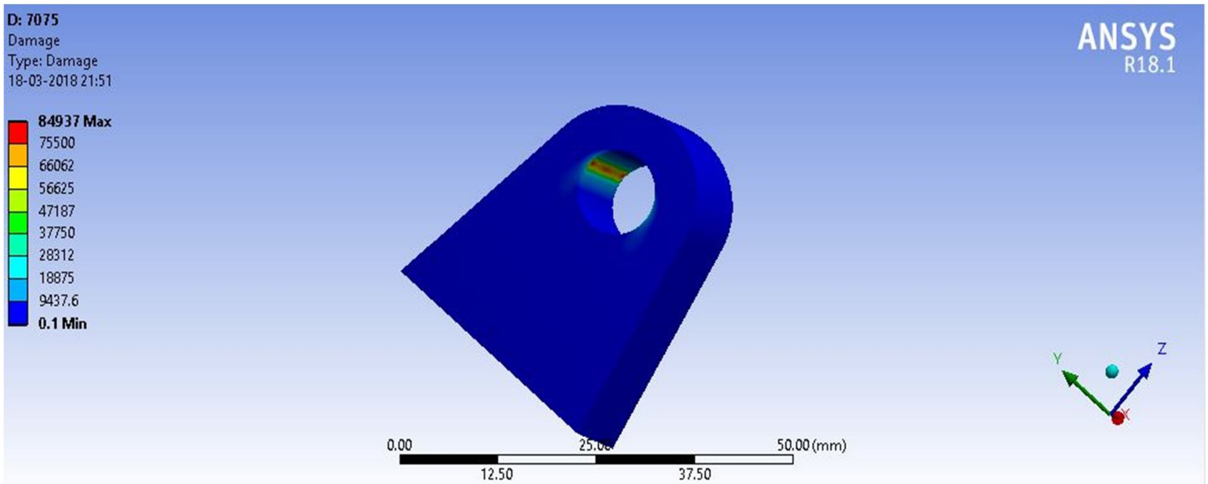


Fatigue life of Al 7075

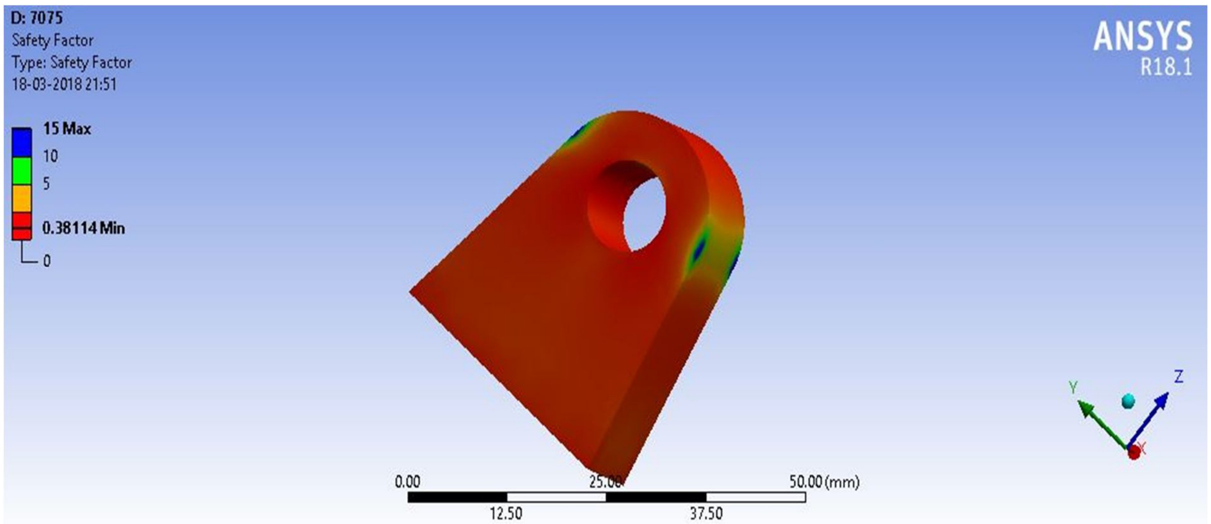


©IJRASET (UGC Approved Journal): All Rights are Reserved

Damage of Al 7075

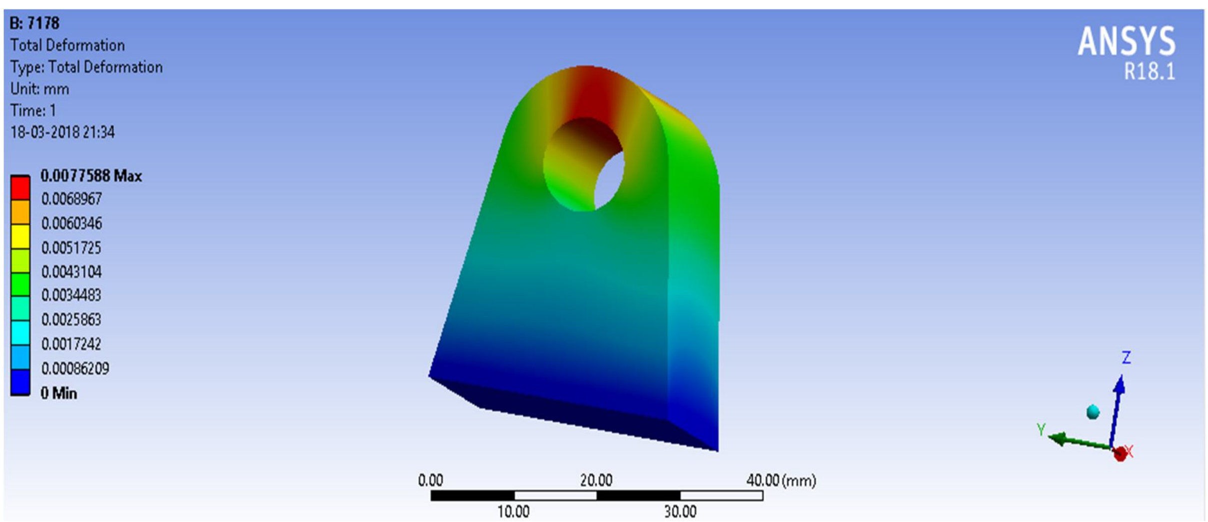


Factor of safety of Al 7075

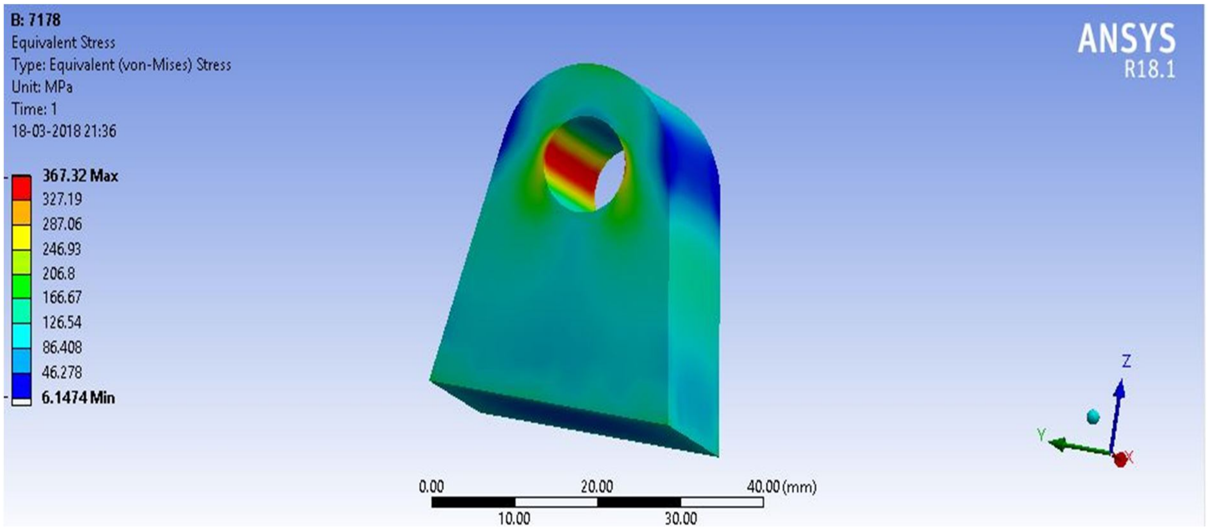


C. Fatigue Analysis Of Al 7178

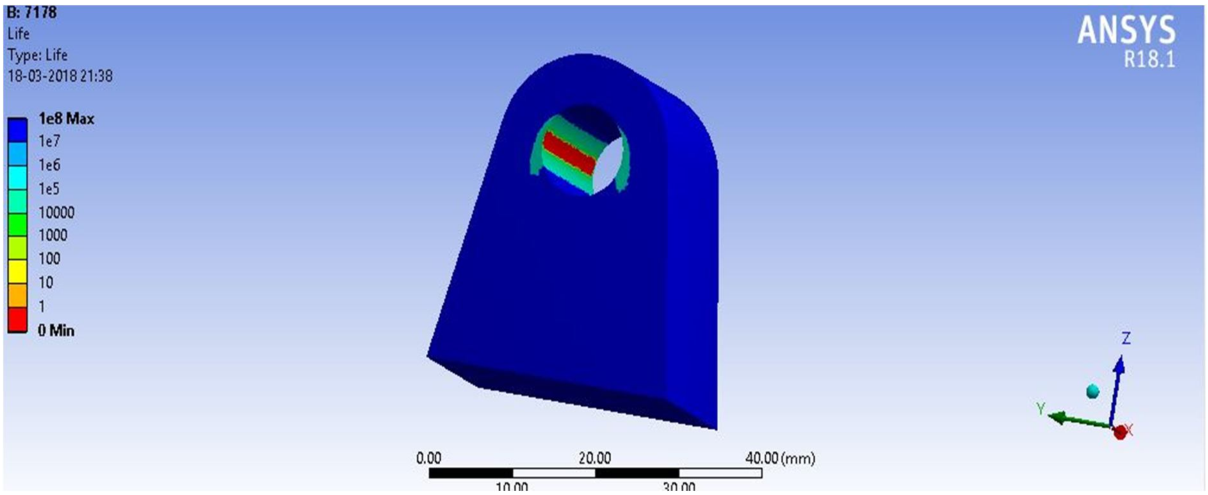
Total deformation of Al 7178



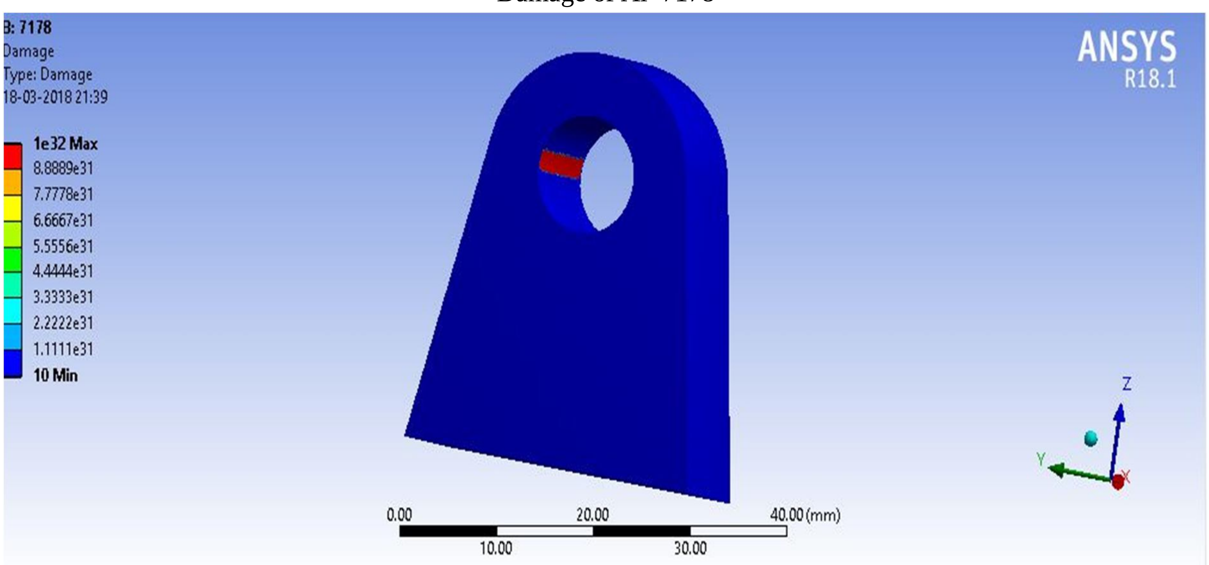
Equivalent stress of Al 7178



Fatigue life of Al 7178

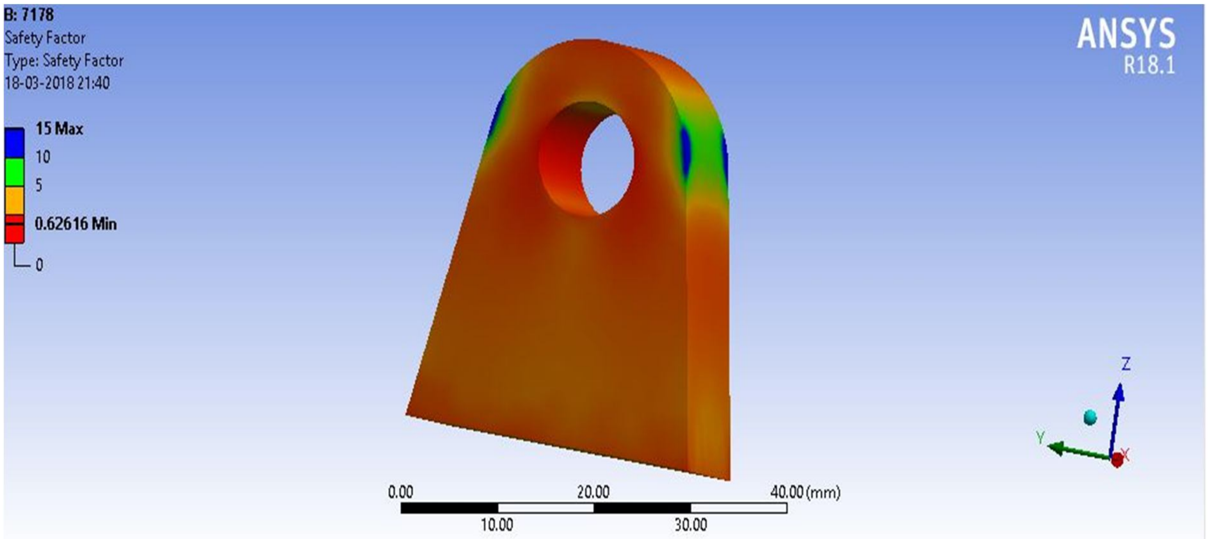


Damage of Al 7178



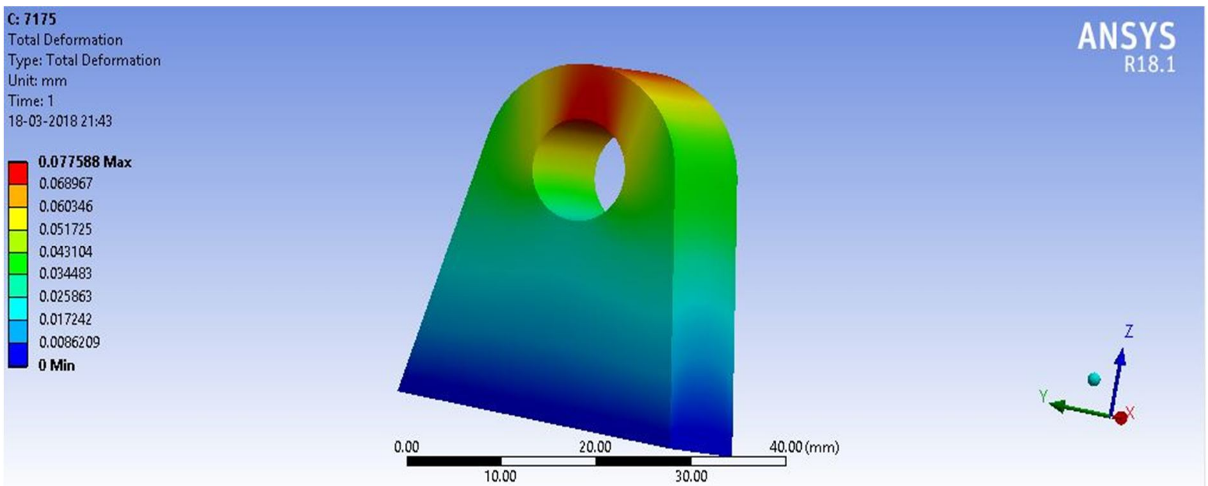
©IJRASET (UGC Approved Journal): All Rights are Reserved

Factor of Safety of Al 7178

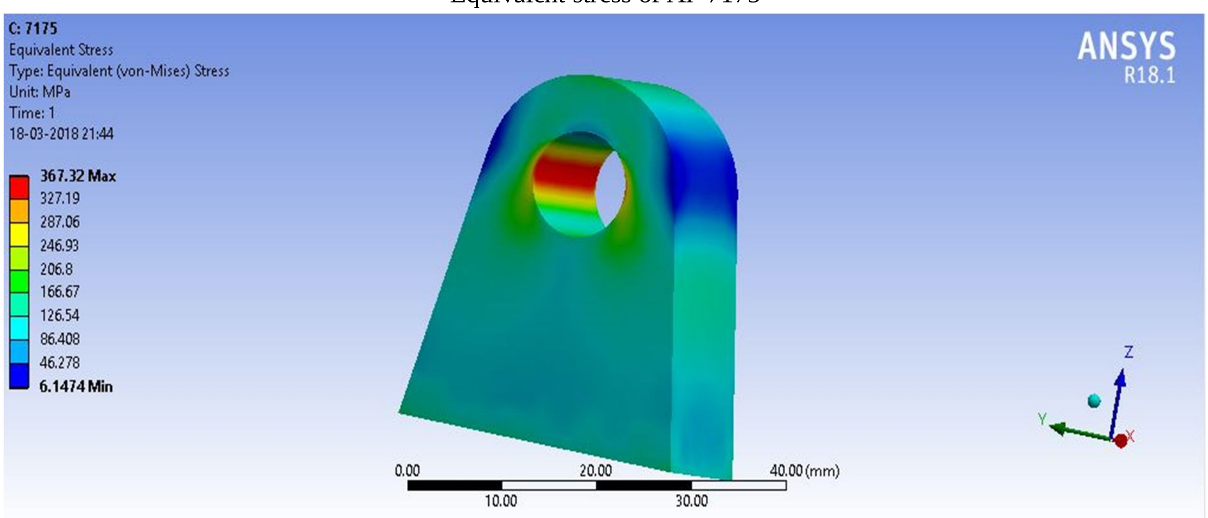


D. Fatigue Analysis Of Al A 7175

Total deformation of Al 7175

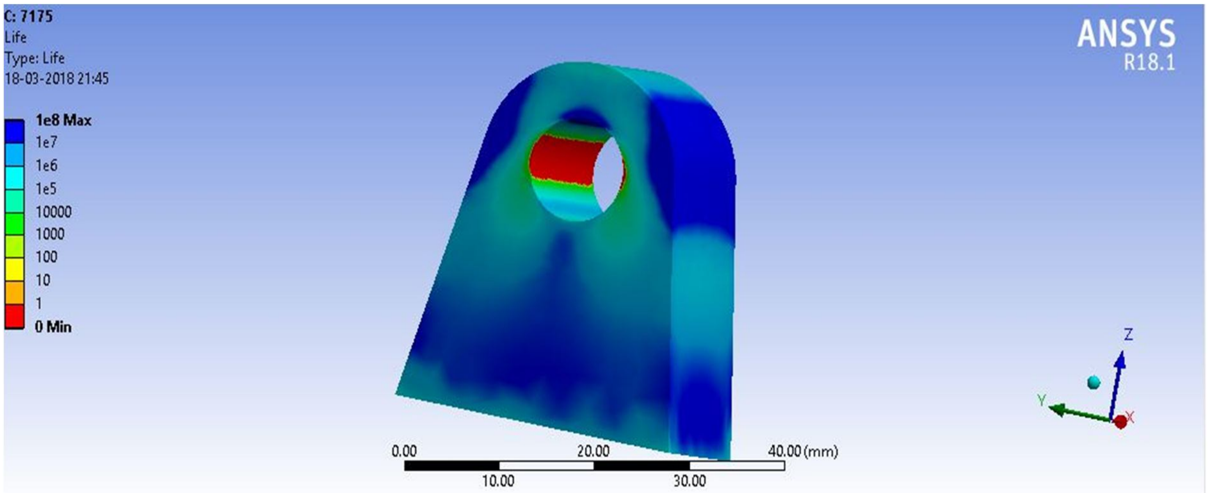


Equivalent stress of Al 7175

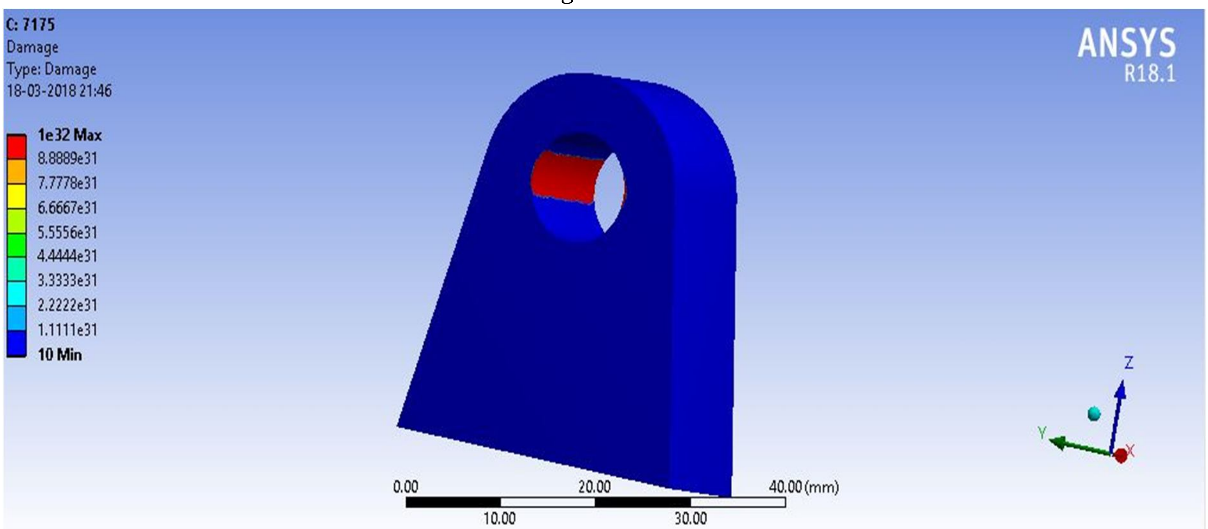


©IJRASET (UGC Approved Journal): All Rights are Reserved

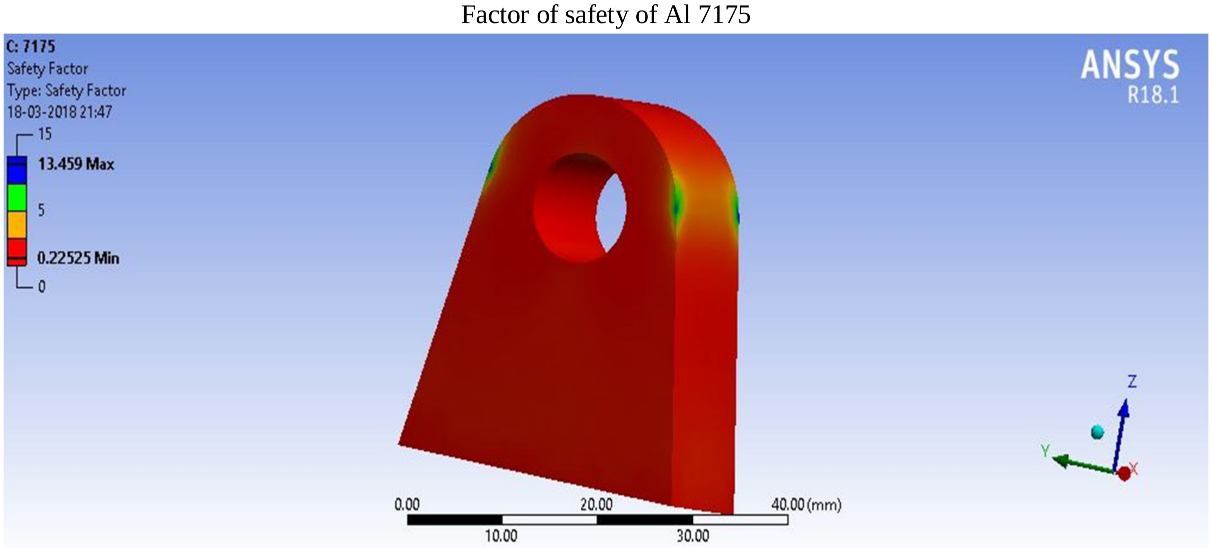
Fatigue life of Al 7175



Damage of Al 7175

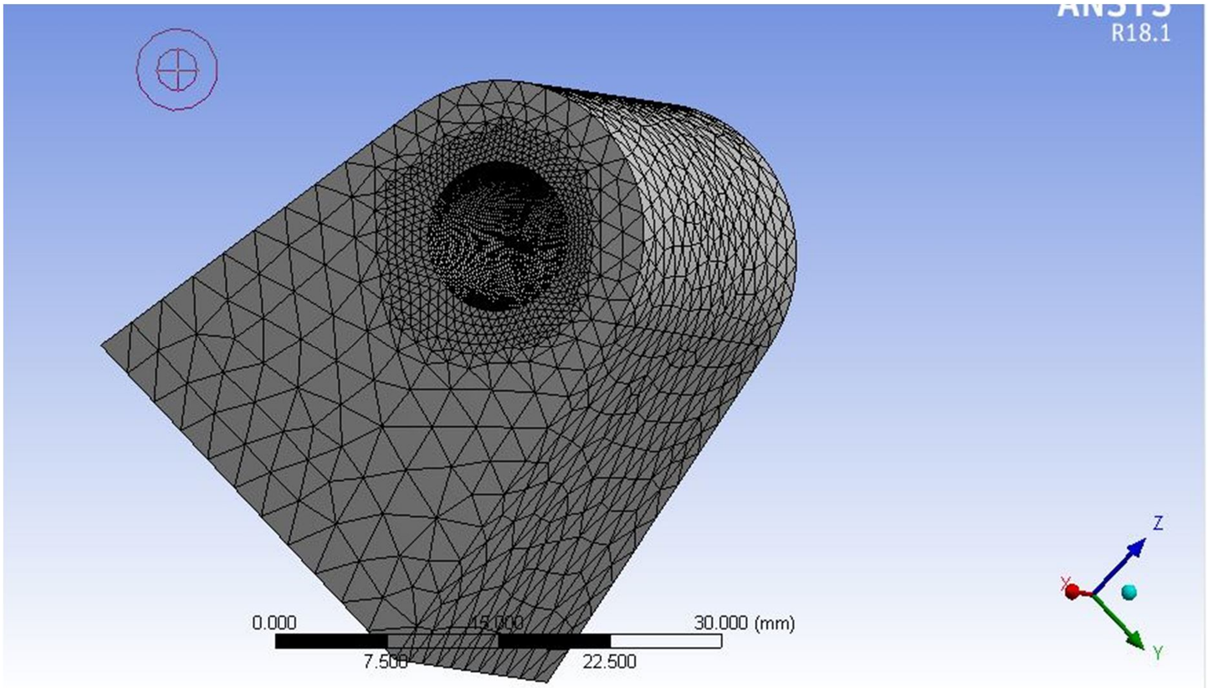


Factor of safety of Al 7175



©IJRASET (UGC Approved Journal): All Rights are Reserved

Meshed nose landing gear



VI. CONCLUSION

This project work present a computational model for the fatigue analysis of the lug joint in the nose landing gear. The dimensions of the proposed model are obtained by the strength of material approach and the stress analysis and the fatigue life is estimated. For this estimation finite element analysis tool is used. Stress analysis of the lug is carried out and maximum stress is identified around the hole of lug which is found out to be lower than yield strength of material. So, the lug design is safe. For this design, life of the lug in the nose landing gear is $1*10^{10}$ cycles for Al T6 7075 which is greater than other aluminium alloys like Al 7050, Al 7178, Al 7175 through comparison of fatigue analysis.

REFERENCES

[1] Prasad Kabade, "Design and Analysis of Landing Gear Lugattachment in an Airframe", International Journal of Innovative Research in Science, Engineering and Technology, Vol.2, Issue10, October 2013, pp.5358-5370

[2] P.Mohanraj, "Fatigue Analysis In Aircraft Landing Gear Axle Shaft To Develop The Life Cycles", International Journal of Engineering Research & Technology (IJERT), Vol. 2, Issue 6, June 2013, pp.2265-2272

[3] R.Ravi Kumar, "Design and Analysis of Main Landing Gear structure of a Transport Aircraft and Fatigue Life estimation for the Critical Lug", International Journal of Mechanical and Production Engineering, Vol.1, Issue 4, Oct 2013, pp.22-26

[4] Sriranga B.K, "Stress Analysis And Fatigue Life Prediction Of Wing- Fuselage Lug Joint Attachment Bracket Of A Transport Aircraft", International Journal Of Research In Engineering And Technology (IJRET), Vol.03, Special Issue.03, May-2014, pp.818-822

[5] Amardeep Singh, Jashandeep Singh, Paviterpuneet Singh, " Lug Attachment of Wing-Fuselage", International Journal of Aerospace and Mechanical Engineering, Vol.1, September 2014, pp.12-14

[6] K. Mookaiya," Crack Growth Analysis In Aircraft Wing Lug Section And Fatigue Life Estimation", International Journal of Engineering Research & Technology (IJERT), Vol. 2, Issue 6, June – 2013, pp.2018-2023

[7] A.Ramesh Kumar, "Design Of An Aircraft Wing Structure For Static Analysis And Fatigue Life Prediction", International Journal of Engineering Research & Technology (IJERT), Vol. 2, Issue 5, May 2013, pp.1154-1158

[8] Sadraey M,"CHAPTER 3: Drag Force and Drag Coefficient", Aircraft Performance Analysis, VDM Verlag Dr. Müller, 2009, pp.1-57

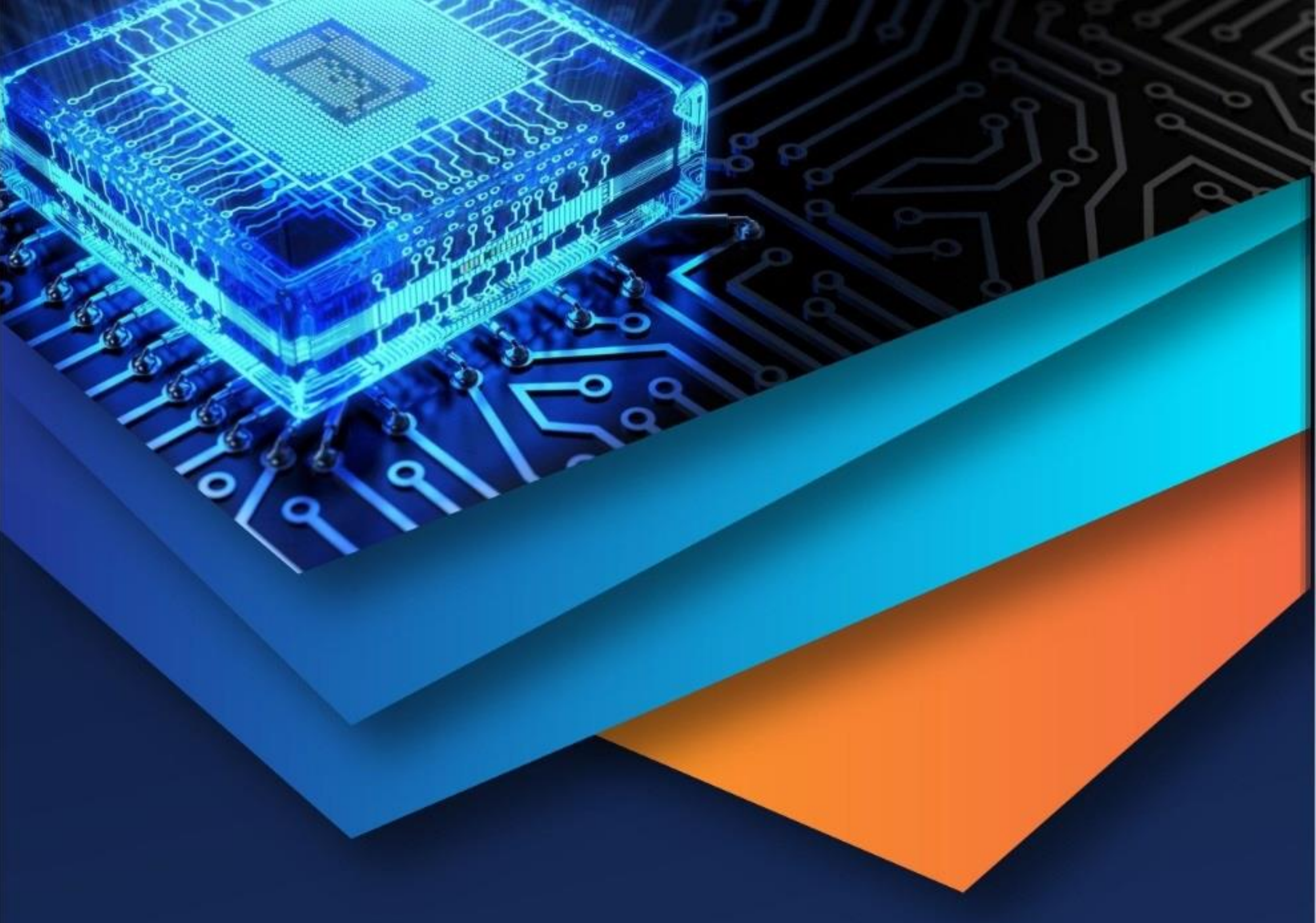
[9] Prof.E.G.Tulapurkara, "Flight dynamics-I, Chapter 3, Lecture 10, Drag polar 5", Dept. of Aerospace Engg., Indian Institute of Technology, Madras, pp.1-23

[10] W. H. Wentz, Jr., "Wind Tunnel Tests Of The Ga (W)-2 Airfoil With 20% Aileron, 25% Slotted Flap, 30% Fowler Flap, And 10% Slot-Lip Spoiler", U.S. Department of Commerce National Technical Information Service, AUG 76, pp.1-73

[11] Mohammad Sadraey,"Chapter 9 Landing Gear Design", Daniel Webster College, pp.808-581

[12] W.H. Mason," 6.Subsonic Aerodynamics of Airfoils and Wings", Configuration Aerodynamics, 3/9/06, pp.1-57

[13] Paul Jackson, "Jane's All the Worlds Aircraft", Issue 95, 2004- 2005, pp.1-400 Vol. 5 Issue 05, May-2016 International Journal of Engineering Research & Technology (IJERT) http://www.ijert.org ISSN: 2278-0181



10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)