# MEOE12 ASSIGNMENT – 3


## 111119055

## KRISHNA PRASAD R


**Problem 1)**

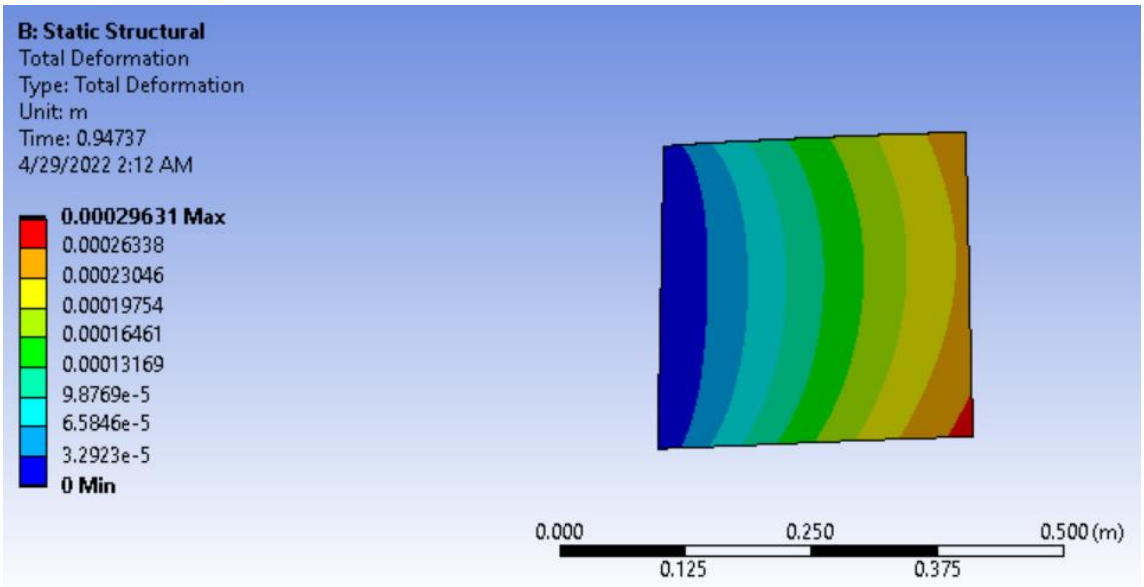
**Consider the laminate stacking sequence [0°/90°] is made up of Glass/epoxy material which is subjected to Nx = 20 N/mm and Ny = 20 N/mm. The geometry of laminate is 300 mm x 300 mm x 2 mm and thickness of each ply is 1 mm. Determine (i) total deformation of laminate (ii) maximum principal stress at each ply (iii) maximum shear stress at each ply (iv) Equivalent Von-mises stress at each ply. Check that whether the lamina fails if (i) Tsai-Hill theory (ii) Hoffman and (iii) Tsai-Wu theory is used.**

Ansys Workbench:

Considering the laminate containing 2 ply's made of Glass/epoxy material with stacking sequence of [0 degrees and 90 degrees] with each ply thickness = 1mm, making it to total geometry of laminate as 300 mm x 300 mm x 2 mm.

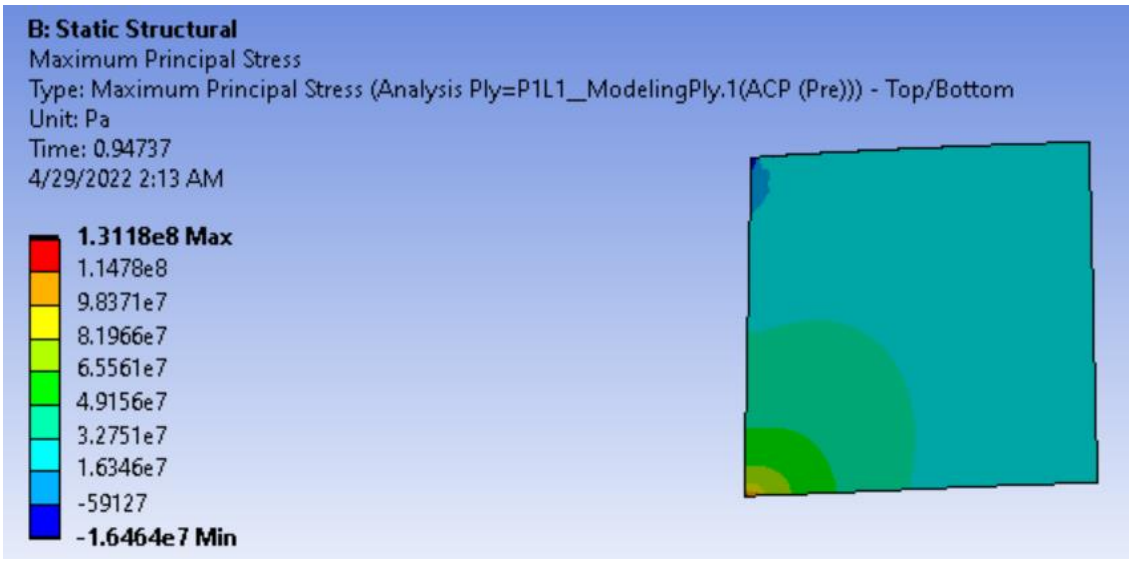
Ansys Results:

**Total Deformation**



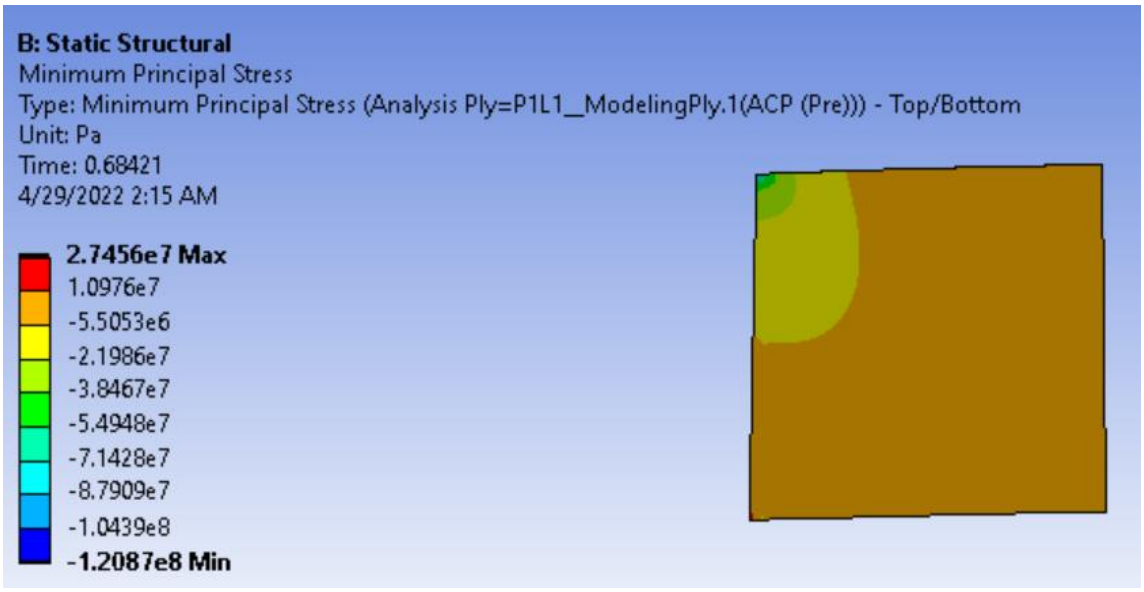

| | Time [s] | Minimum [m] | Maximum [m] | Average [m] |
|---|---|---|---|---|
| 1 | 1. | 0. | 2.9631e-004 | 1.3909e-004 |

**Maximum Principal Stress for both 0 degree and 90-degree ply,**




| | Time [s] | Minimum [Pa] | Maximum [Pa] | Average [Pa] |
|---|---|---|---|---|
| 1 | 1. | -1.6464e+007 | 1.3118e+008 | 2.9128e+007 |

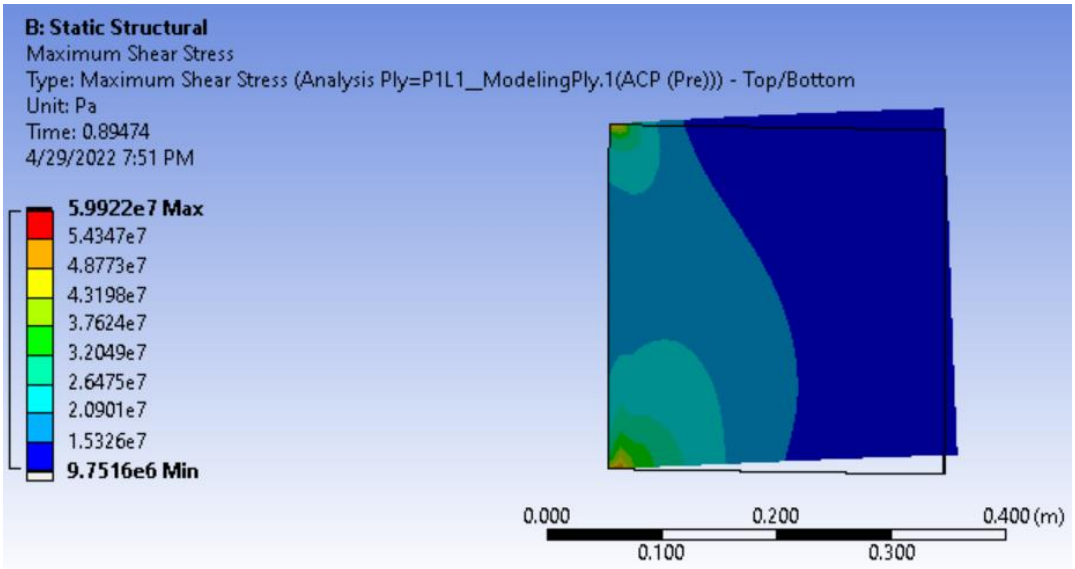
**Minimum Principal Stress for 0 degree and 90-degree ply,**




Tabular Data

| | Time [s] | Minimum [Pa] | Maximum [Pa] | Average [Pa] |
|---|---|---|---|---|
| 1 | 1. | -1.2087e+008 | 2.7456e+007 | -3.5018e+006 |

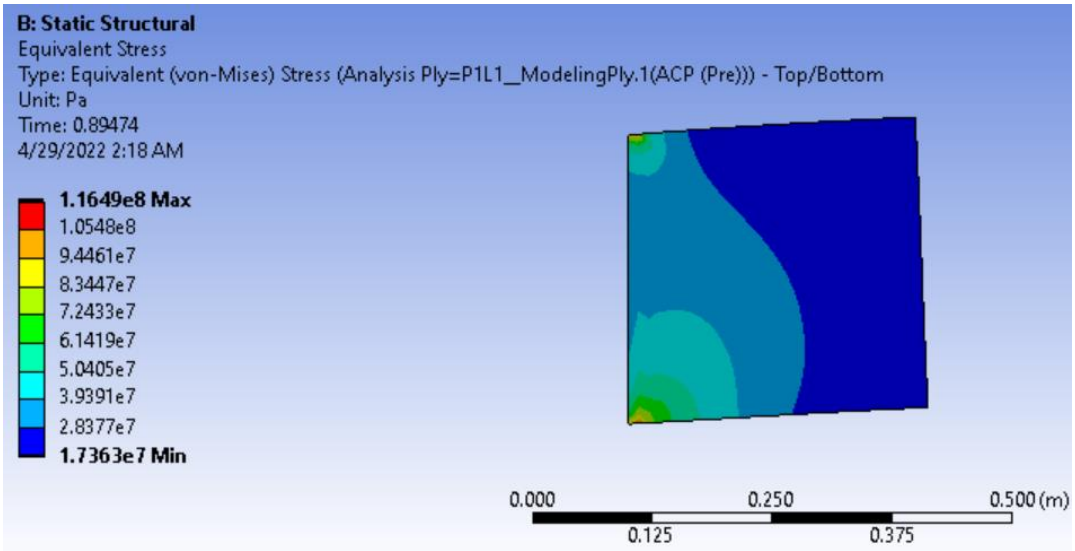
**Maximum Shear Stress at 0 degree and 90-degree ply,**




Tabular Data

| | Time [s] | Minimum [Pa] | Maximum [Pa] | Average [Pa] |
|---|---|---|---|---|
| 1 | 1. | -1.2087e+008 | 2.7456e+007 | -3.5018e+006 |

**Equivalent stress:**




Tabular Data

| | Time [s] | Minimum [Pa] | Maximum [Pa] | Average [Pa] |
|---|---|---|---|---|
| 1 | 1. | 1.7363e+007 | 1.1649e+008 | 3.0774e+007 |

**Failure theory:**

(iii) Tsai-Wu failure Criteria:

$$F_1\sigma_1 + F_2\sigma_2 + F_6\sigma_6 + f_{11}\sigma_1^2 + f_{22}\sigma_2^2 + f_{66}\sigma_6^2 + 2f_{12}\sigma_1\sigma_2 = 1.$$

↳ using some simplifications;

$$\Rightarrow F_1\sigma_1 + F_2\sigma_2 + f_{11}\sigma_1^2 + f_{22}\sigma_2^2 + f_{66}\sigma_6^2 = 1.$$

$$F_1 = \frac{1}{X_t} + \frac{1}{X_c}, \quad f_{11} = \frac{-1}{X_t X_c}, \quad f_6 = 0,$$

$$F_{66} = \frac{1}{S^2}, \quad f_2 = \frac{1}{Y_t} + \frac{1}{Y_c}, \quad f_{22} = \frac{-1}{Y_t Y_c}$$

→ By solving => 3.8431 > 1.

=.

(ii) Hoffman - failure criteria:

$$\frac{-\sigma_1^2}{X_c X_t} + \frac{\sigma_1\sigma_2}{X_c X_t} - \frac{\sigma_2^2}{Y_c Y_t} + \frac{X_c + X_t}{X_c X_t}\sigma_1 + \frac{Y_c + Y_t}{Y_c Y_t}\sigma_2 + \frac{\tau_{12}^2}{S_{12}^2} = 1.$$

→ $X_T$ = 1062 mpa, $X_C$ = 610 mpa,

$Y_T$ = 31 mpa, $Y_C$ = 118 mpa,

$S$ = 72 mpa.

=> → equal to = 3.8375.

→ 3.8375 > 1

⇒ The lamina fails in 2 direction.

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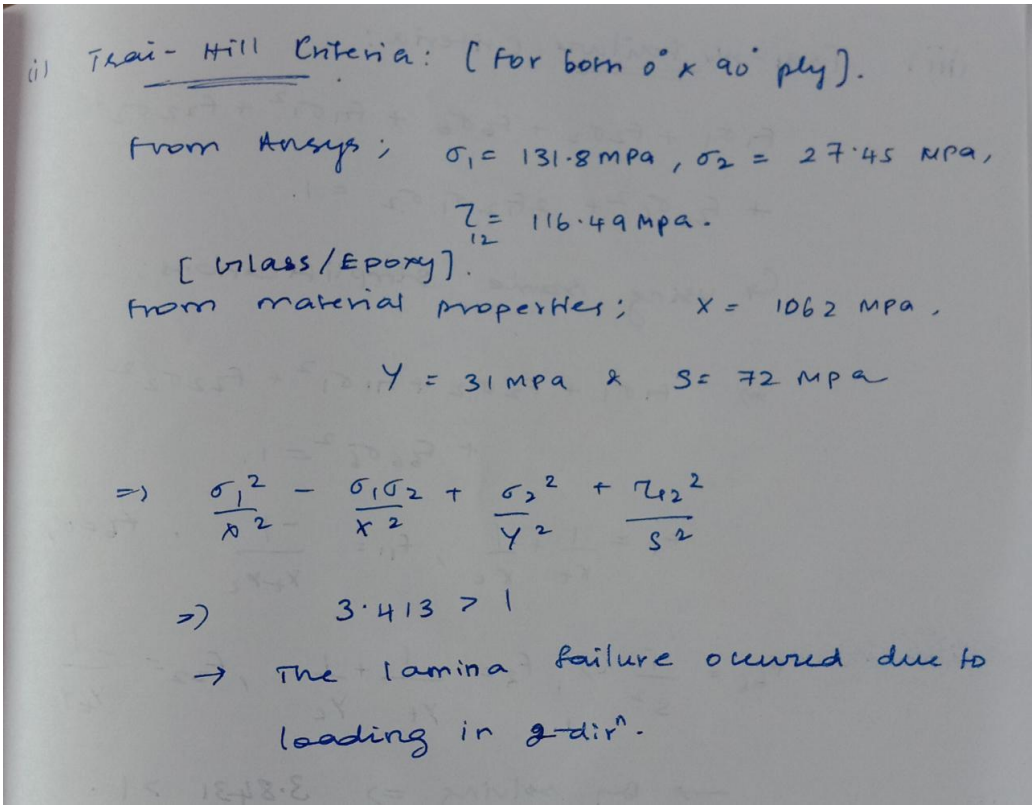



**Problem 2)**

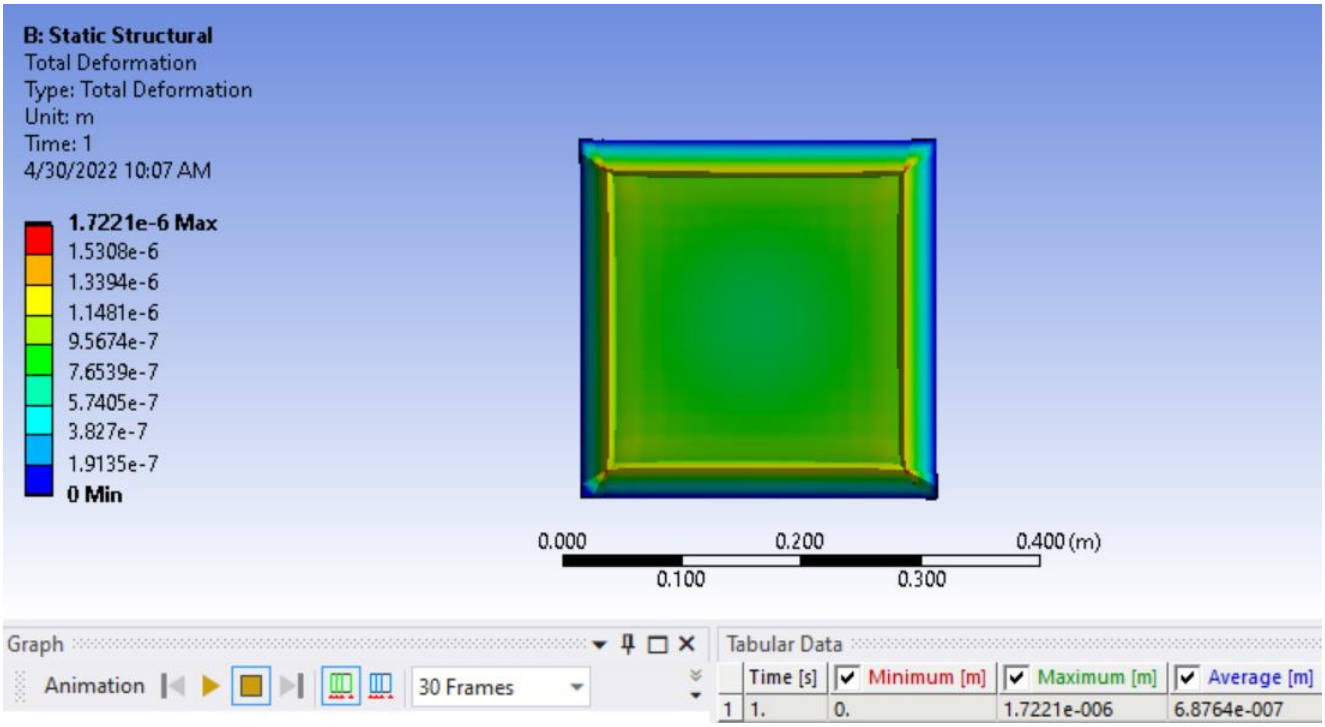
**Consider the laminate stacking sequence [0°/60°/-60°] is made up of Glass/epoxy material which is subjected to temperature change of 150°C. The geometry of laminate is 300 mm x 300 mm x 1.5 mm and thickness of each ply is 0.5 mm. The boundary conditions of the plate are fixed at all edges. Determine (i) total deformation of laminate (ii) maximum principal stress at each ply (iii) maximum shear stress at each ply (iv) Equivalent Von-mises stress at each ply. Check that whether the lamina fails if (i) Tsai-Hill theory (ii) Hoffman and (iii) Tsai-Wu theory is used.**

Ansys Workbench:

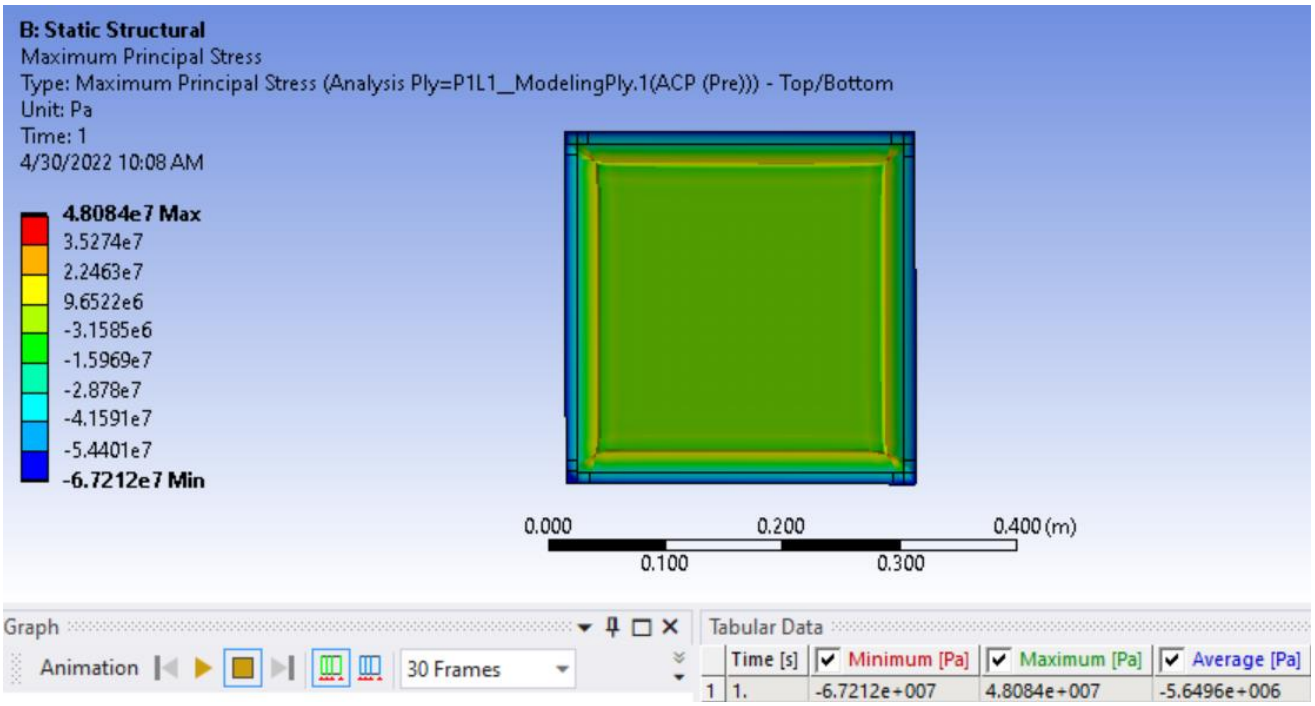
Considering the laminate containing 3 ply's made of Glass/epoxy material with stacking sequence of $[00^0, 60^0, -60^0]$ with each ply thickness = 0.5mm, making it to total geometry of laminate as 300 mm x 300 mm x 1.5 mm.

Ansys Results:

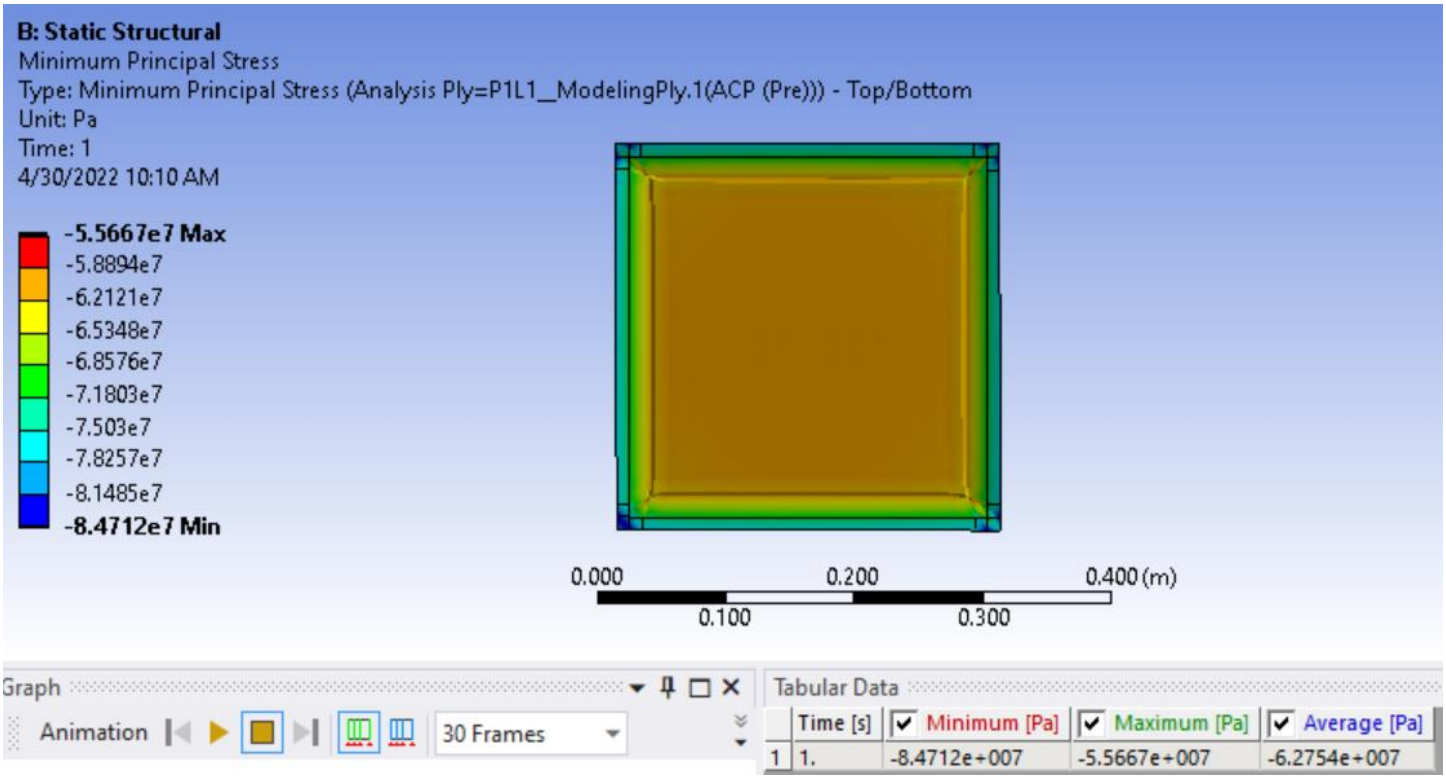
**Total Deformation**



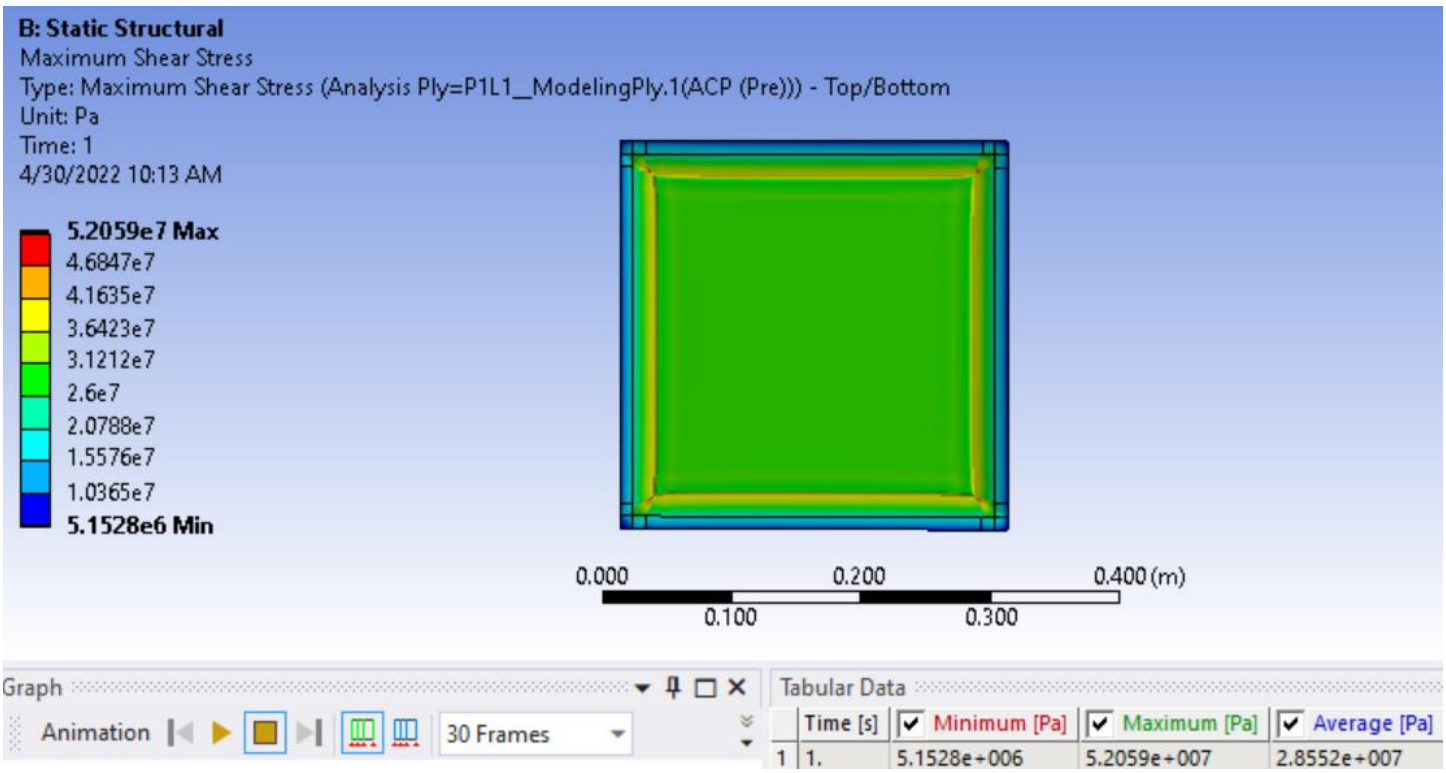

**Maximum Principal stress for 0 degree and -60 degree ply,**



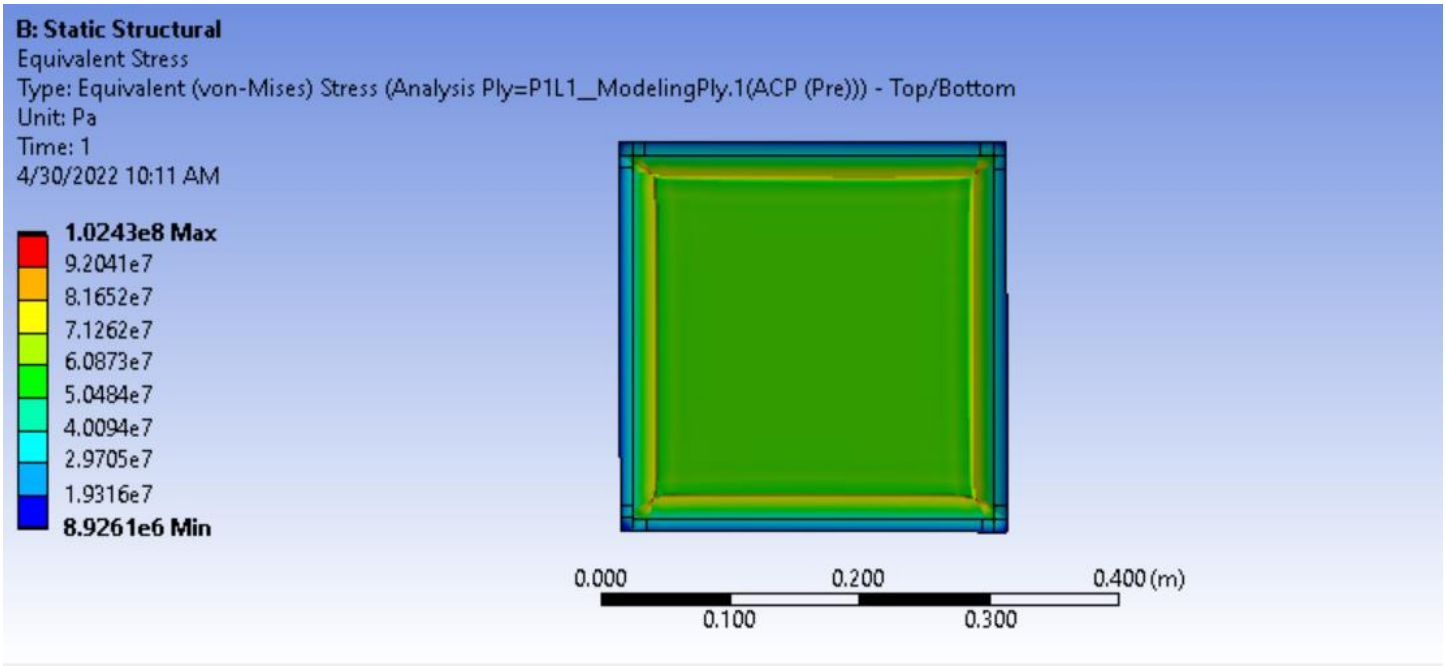
**Minimum Principal Stress for 0-degree and -60 degree ply,**




**Maximum Shear Stress for 0 degree and -60 degree ply,**

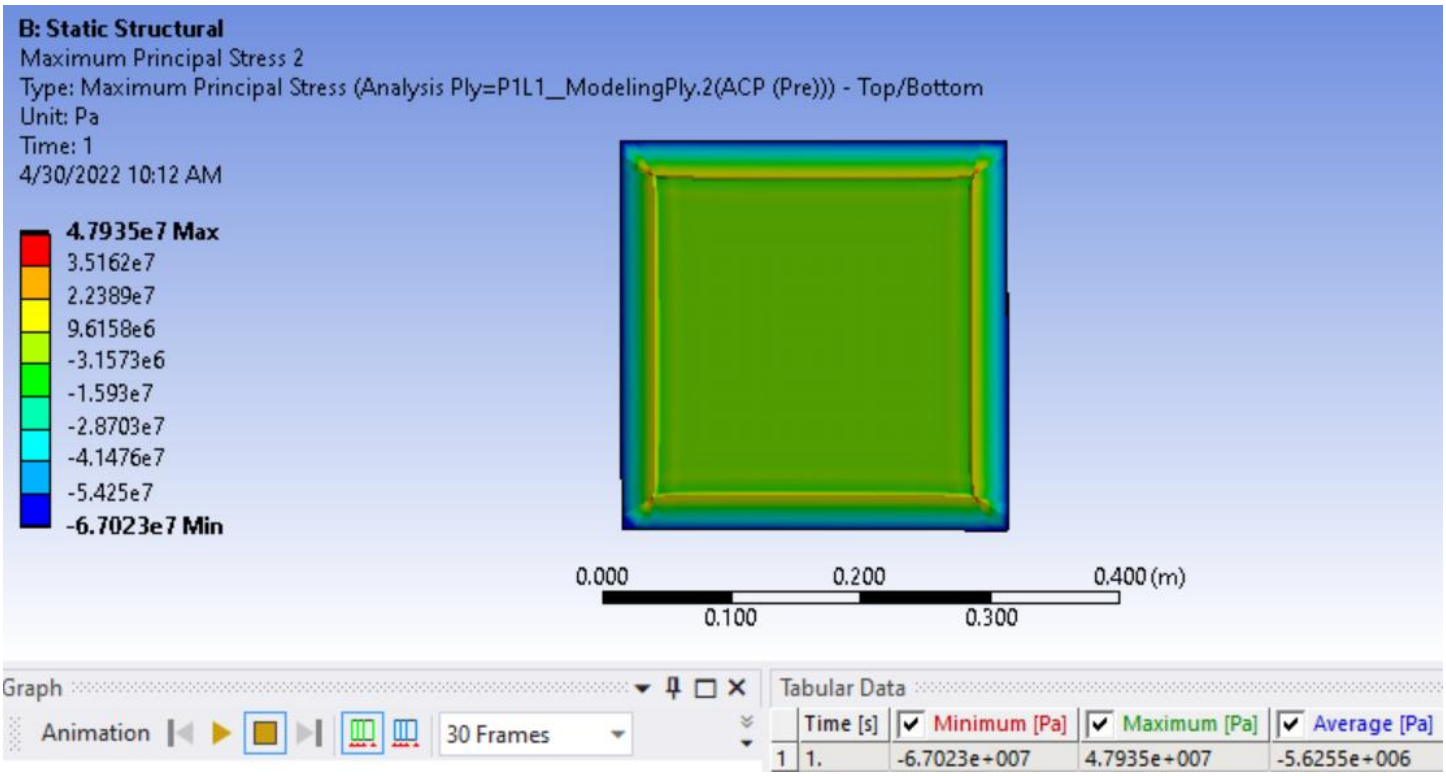


**Equilivalent Von-Mises Stress for 0-degree and -60 degree ply,**

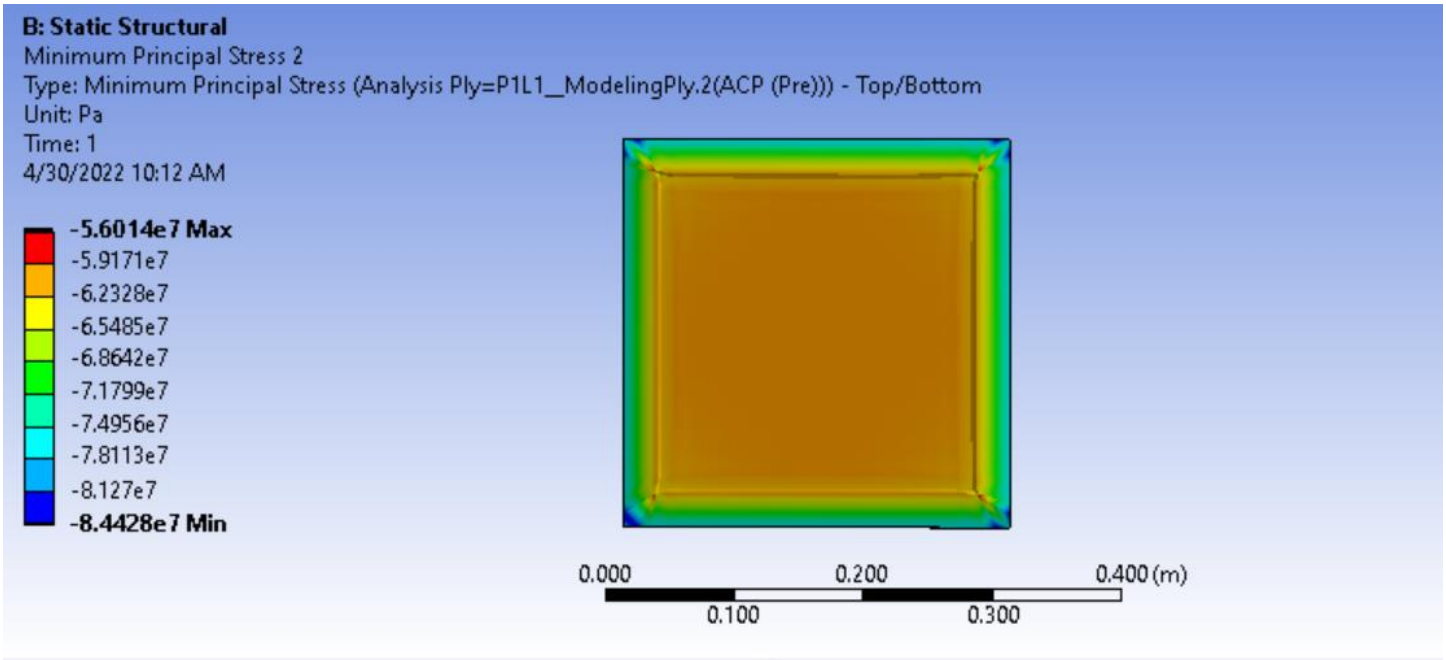



## For 60-degree ply,

**Maximum Principal Stress,**

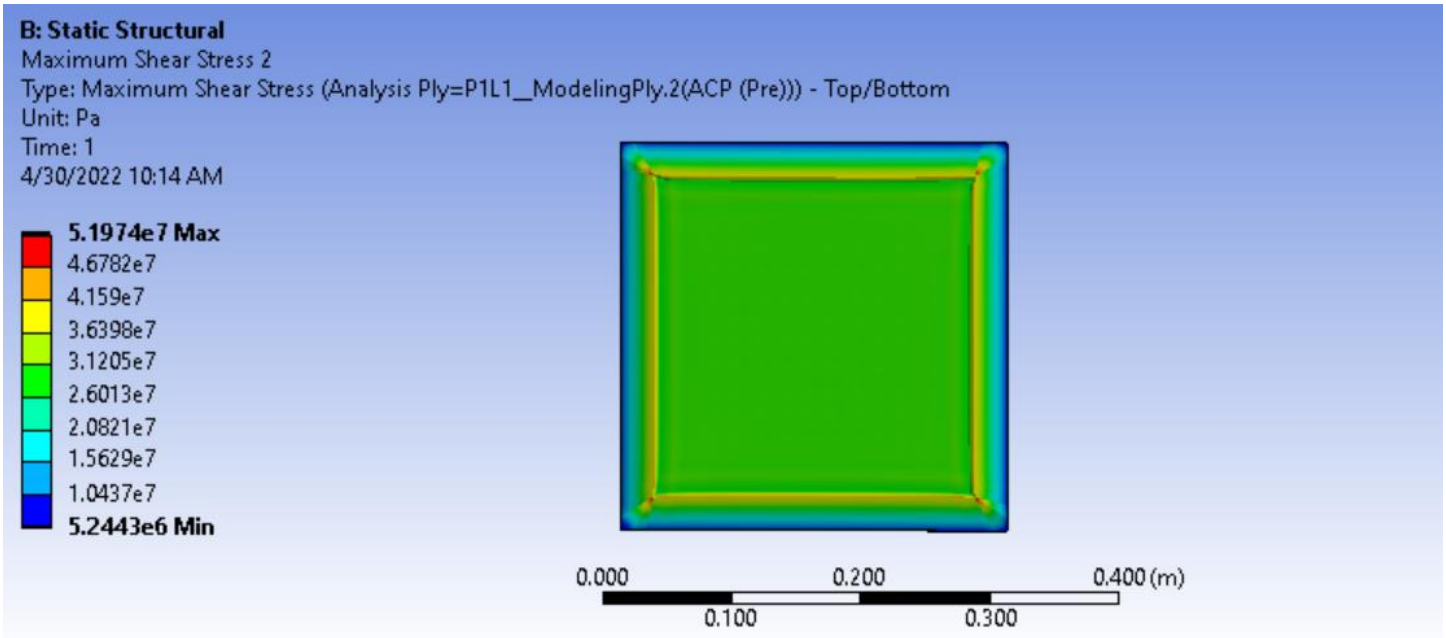


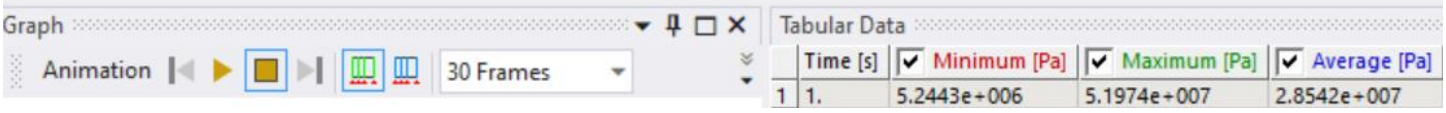
**Minimum Principal Stress,**



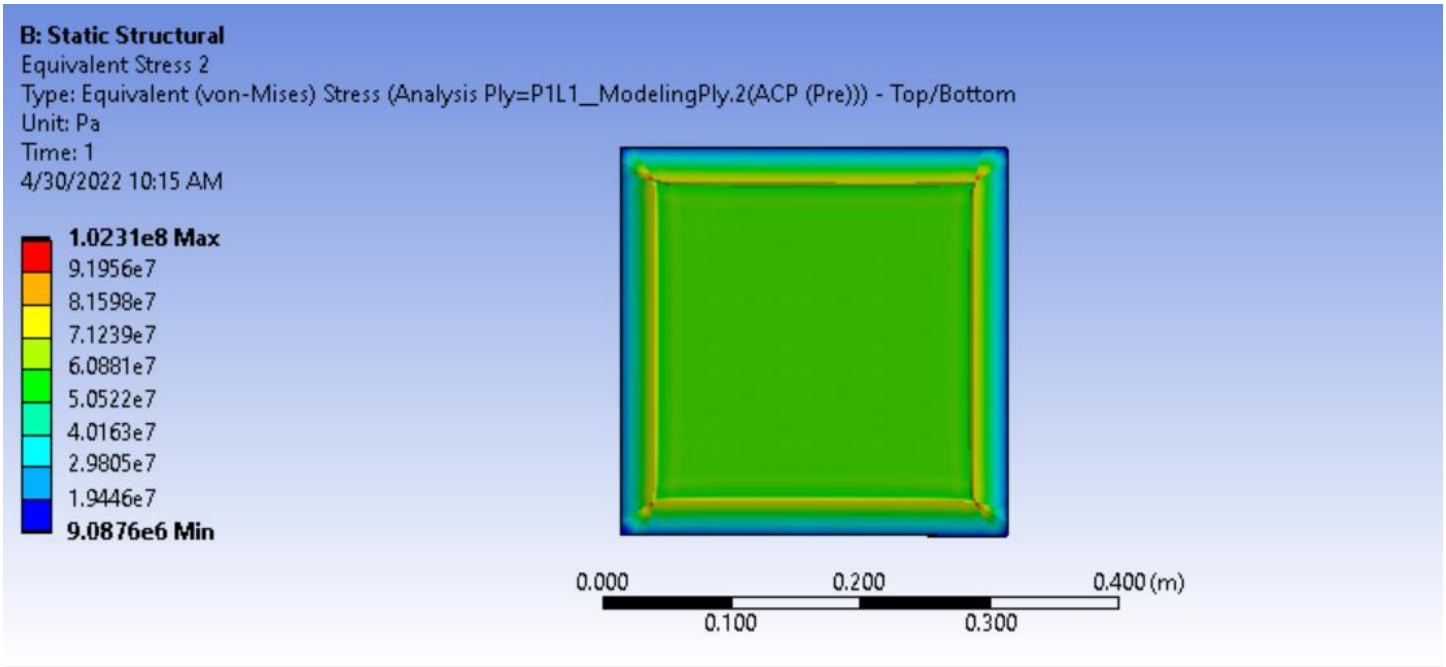


**Maximum Shear Stress,**



**Equivalent Von-Mises Stress,**




## Failure Theory,

### 1) Tsai -hill, hoffman, and tsai-wu failure criteria for 0 degree and -60 degree ply,

```
sigma_1=48.084;
sigma_2=-55.667;
tau_12= 52.059;

Xt=1062;
Xc=610;
Yt=31;
Yc=118;
S=72;

f1= (1/Xc)+(1/Xt);
f11= -(1/(Xc*Xt));
f6=0;
f66=1/S^2;
f2= (1/Yc)+(1/Yt);
f22= -(1/(Yt*Yc));

tsai_hill = (sigma_1^2/Xt^2)-((sigma_1*sigma_2)/Xt^2) + (sigma_2^2/Yt^2) + tau_12^2/S^2
hoffman_failure = -(sigma_1^2/(Xt*Xc))-((sigma_1*sigma_2)/(Xt*Xc))...
        -(sigma_2^2/(Yt*Yc))+ ((Xc+Xt)/(Xc*Xt))*sigma_1 +((Yc+Yt)/(Yc*Yt))*sigma_2  + (tau_12^2/S^2)
tsai_wu = f1*sigma_1 + f2*sigma_2 + f11*(sigma_1)^2 + f22*(sigma_2)^2 + f66*(tau_12)^2
```

**Results:**

```
>> untitled

tsai_hill =

    3.7518


hoffman_failure =

   -2.4671


tsai_wu =

   -2.4713
```

## 2) Tsai -hill, Hoffman, and tsai-wu failure criteria for 60-degree ply,

```
sigma_1=47.935;
sigma_2=-56.014;
tau_12= 51.974;

Xt=1062;
Xc=610;
Yt=31;
Yc=118;
S=72;

f1= (1/Xc)+(1/Xt);
f11= -(1/(Xc*Xt));
f6=0;
f66=1/S^2;
f2= (1/Yc)+(1/Yt);
f22= -(1/(Yt*Yc));

tsai_hill = (sigma_1^2/Xt^2)-((sigma_1*sigma_2)/Xt^2) + (sigma_2^2/Yt^2) + tau_12^2/S^2
hoffman_failure = -(sigma_1^2/(Xt*Xc))-((sigma_1*sigma_2)/(Xt*Xc))...
        -(sigma_2^2/(Yt*Yc))+ ((Xc+Xt)/(Xc*Xt))*sigma_1 +((Yc+Yt)/(Yc*Yt))*sigma_2  + (tau_12^2/S^2)
tsai_wu = f1*sigma_1 + f2*sigma_2 + f11*(sigma_1)^2 + f22*(sigma_2)^2 + f66*(tau_12)^2
```

**Results:**

```
>> untitled

tsai_hill =

    3.7904


hoffman_failure =

   -2.4939


tsai_wu =

   -2.4981
```

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