Department Of Aerospace Engineering,
Indian Institute Of Technology Madras

AS2070 - AEROSPACE STRUCTURAL MECHANICS

CRACK PROPAGATION IN DOUBLE CANTILEVER BEAM

Prathibha - AE23B001
G.Datta - AE23B009
L.Chandan Raj - AE23B015
M.Tanishq - AE23B017
R.Pavan - AE23B027

AIM:

→ The aim of the experiment is to observe the **Crack Growth in Double Cantilever Beam** with different initial crack lengths and compare with Theory.

APPARATUS:

→ The Apparatus used in the experiment are:

- Aluminium Metal Sheet
- Universal Testing Machine of Maximum Load 500N

→ The dimensions of the DCB is:

- Length = 240mm
- Breadth = 24mm
- Thickness = 1mm

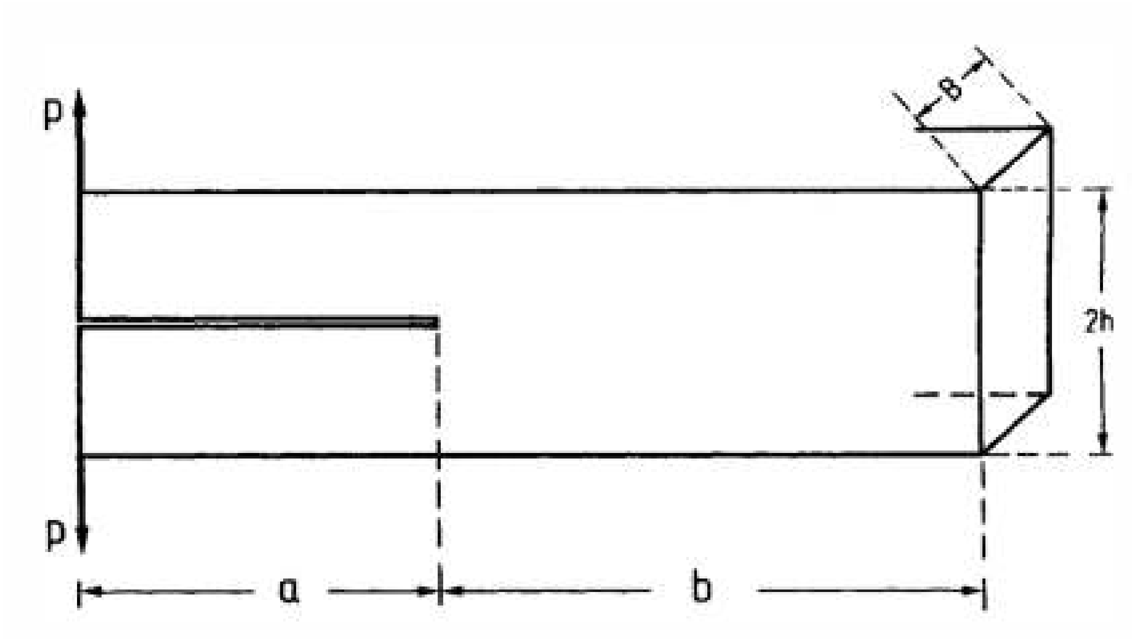
→ We cut that metal sheets into Double cantilever beam of specified dimensions.

Figure 1: Experimental setup

→ The non fixed ends are free to move.

THEORY:

→ Consider a specimen with initial crack length with dimensions as shown in below figure:



The Double Cantilever Beam (DCB) test is commonly used to evaluate the Mode I fracture toughness (G_c) of materials. In this method, a pre-cracked specimen is loaded in opening mode, and the energy release rate G is calculated.

Energy Release Rate

For a DCB with arms of thickness h, width b, and a crack of length a, the strain energy release rate G under linear elastic conditions is given by:

$$G = \frac{12P^2a^2}{B^2Eh^3}$$

where:

- P = applied load
- a = crack length
- E = Young's modulus

Critical Load for Crack Propagation

When the crack just begins to propagate, the energy release rate equals the critical value G_c:

$$G_c = \frac{P_{cr}^2 a_0^2}{12B^2Eh^3}$$

Solving for P_{cr}:

$$P_{cr} = \sqrt{\frac{12B^2Eh^3G_c}{a_o^2}}$$

Inverse Relationship

This gives a linear relationship between the critical load and inverse crack length:

$$P_{cr} \propto \frac{1}{a_0}$$

Thus, plotting P_{cr} vs $1/a_0$ should yield a straight line, allowing experimental determination of G_c from multiple tests with different initial crack lengths.

- Surface Energy per unit area (γ)= 2030 mN/m (max)
- $G_e = 2\gamma$
- Young's Modulus = 70 GPa

→ P_{cr} for the crack length of 36mm is ,

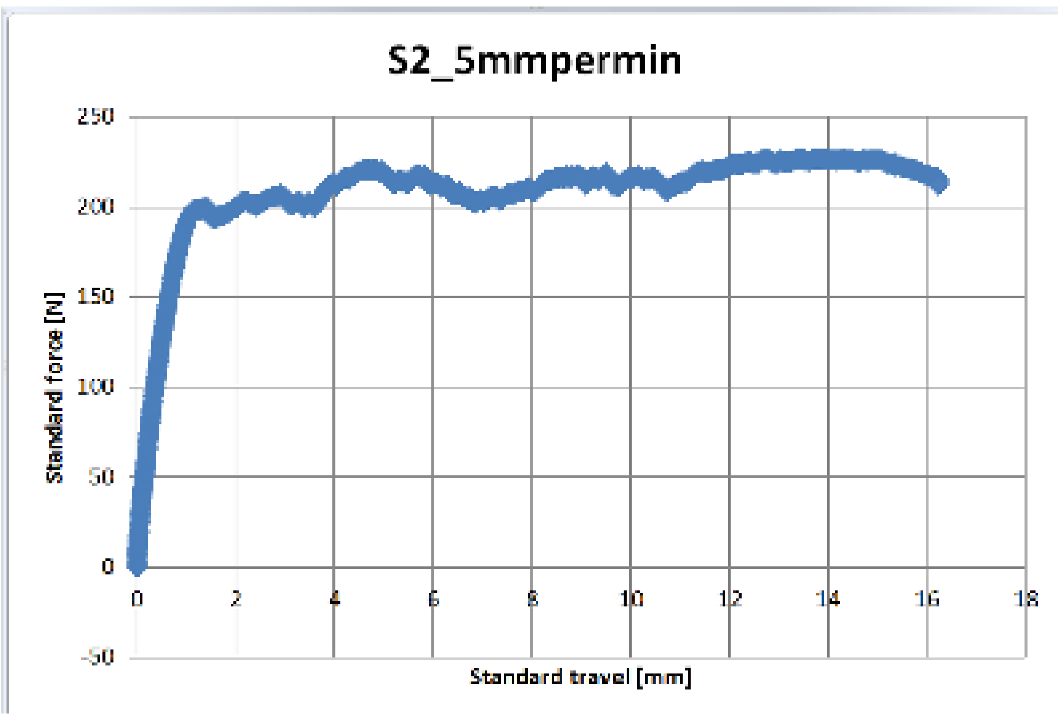
$$P_{cr} = 190.73N$$

→ It is less than 500N due to which we used UTM of maximum load 500N.

PROCEDURE:

- First , Prepare the specimens of different crack length.
- The reason for making different crack lengths is to plot the P_{cr} v/s a_o initial crack length.
- Then test it on the UTM and get the Force v/s Displacement graph.

OBSERVATIONS:



→ We got the graph similar for other pieces.

- We were not able to observe the crack-propagation because of the significant twisting moment.
- As the beam starts bending, there will be a component of force along the length of DCB.
- The Force distribution along the thickness of the support is non uniform, then it causes the Twisting moment.
- The moment is of order 1 and generally it is a small moment but the Flexural rigidity EI is very small which causes significant deflection.
- Once, the twisting motion is initiated ,that causes a component of force in out of plane direction from which the moment increases due to which deflection also increases.
- This Twisting moment is observed while doing the experiment and may be the possible explanation for the phenomena.

CONCLUSION:

- Therefore , observing crack propagation in UTM is not preferred.
- Other alternative to conduct this experiment is using Three point bending apparatus.
- In three point bending apparatus, if there is any twisting moment generated at the corners the support gives opposite moment to neutralize the effect of twisting.
- Therefore, we cannot conduct this experiment for crack propagation on UTM.

ACKNOWLEDGEMENTS:

→ In the process of completing experiments, there are people who helped us.
→ Special Thanks to :

- Prof. David sir (for usage of UTM)
- Staff at workshop in department.
- Ashok sir (for helping)
- Aakash sir(for guiding in usage of UTM)
- TA:Priyanka Samal(For guiding throughout the process.)