Experiment : Determination of Tensile Strength and Modulus of Elasticity Of Fibre Reinforced Composite Specimen

Objectives

1. Understand basic construction and operation of Universal Testing Machine (UTM).
2. Find the Tensile Strength and Modulus of Elasticity of the given FRP specimen.
3. Understand the ASTM D638-03 Standard for Tensile test.

Significance of the Test

Testing of mechanical properties plays an important role in evaluating mechanical behavior of engineering materials as well as in developing new materials and in controlling the quality of materials for use in design and construction. If a material is to be used as part of an engineering structure it will be subjected to various loads. It is important to know whether the material is strong enough and rigid enough to withstand loads; and what kind of deflections it will produce during manufacturing, handling and in service.

As a result several experimental tests have been developed for mechanical testing of engineering materials subjected to different types of loads e.g. tension, compression, bending and torsion and shear loads.

Tension test is widely used to provide basic design information about the strength of a given material and is an acceptance test for the specification of materials. The relevant standard developed by American Society for Testing Materials for testing the Tensile Strength and Modulus of Elasticity of FRP materials and products is: **ASTM D638-03** which is a widely accepted standard in the world.

Equipment used for the Test

1. Universal Testing Machine (UTM)
   Make: LLYOD, Model: EZ 50, Load Capacity : 50 KN
2. Micrometer Screw Gauge
3. Vernier Calliper
4. Ruler 30cm
5. Ink Marker

6. Strain Gage

The Universal Testing Machine (UTM) is a very sophisticated machine designed for determining/testing several mechanical properties (both static and dynamic) of the materials/products. It can be used to perform different tests such as **tension, compression, flexure, shear, buckling and cyclic load test** on components and finished products of a variety of materials like metals, plastics and composites, packings, adhesives. Hence, it is commonly called **Universal Testing Machine (UTM)**. The measurements of loads and the associated deflections such as those encountered in **tensile, compressive or flexural modes** (static) are easily done on this machine.

For the present experiment, we shall be using **LLOYD-EZ 50** machine which has the following description:

Features of EZ 50 UTM:

Loading Capacity:

1. Max. Force **50 kN** (both in compression and tension)
2. Force Range using interchangeable load cells: **0.1 N** to **50 kN**
3. Force measuring accuracy > **0.5%**.

Displacement:

1. Max cross head displacement **1055mm**. (excluding grips)

Speed:

Crosshead Speed range **0.01** to **254 mm/min**.

Slow Speed:

Recommended speed for **slow movements** of Cross Head : 1 mm/min

Note: Slow speed is used during the test when loading is increased gradually so that load is distributed uniformly in the specimen and the specimen does not break in the grips.

Fast Speed:

Recommended speed for **quick movements** of Cross Head : 100 mm/min

Note: Fast speed is used during change of grips, mounting the specimen

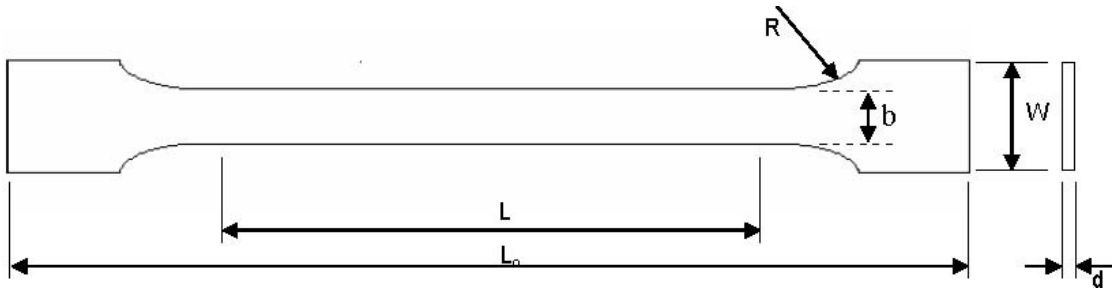
Crosshead Speed Accuracy: ± 0.2% @ 100 mm/min

Max Working width: **400 mm** between columns.

Internal extensometer resolution: 5 micron.

Test Specimen Details

Tensile specimens are machined from the material/product/component to be tested in the desired orientation. The specimen used for the present test is a **flat** specimen made up of FRP prepared as per **ASTM D638-03.** The cross section of the specimen is usually round, square or rectangular. For metals, a round specimen is commonly used as it can be easily machined. For sheet and plate stock, a flat specimen is usually employed. For composites, a flat specimen as shown in the figure below is used.



Tensile Test Specimen

Material :

E-glass/epoxy woven fabric composites of fibre volume fraction $\mathbf{V_f}$ =

or

Unidirectional E glass/epoxy composite of fibre volume fraction $\mathbf{V_f}$ =

or

Carbon/epoxy composites of fibre volume fraction $\mathbf{V_f}$ =

Layer stacking sequence and their orientation:

Specimen Dimensions:

In this test, a specimen is prepared as per **ASTM D 638-03 Type I. Failure of the specimen should occurs within the gage length portion of the specimen; if this does not happen or failure occurs at the grips then thet test is repeatd with IV specimen.**

Choose suitable grips and spacers for the jaws of the testing machine. The choice depends upon the cross section geometry and thickness of the specimen.

The specimen used should be uniform over a gage length (the length over which two arms of extensometer/gage extend and elongation measurements are done)

Method of Conducting the Test:

Using appropriate grips, the specimen is mounted in the UTM. Speed and other setting of the UTM are set by the operator. A tensile load is applied to the specimen until it fractures. During the test, the load applied and corresponding elongation is displayed on the screen and recorded and from this data the tensile behaviour of the material can be obtained.

The following formula is used in calculating elastic modulus of the material,(E)

$$\mathbf{E=\frac{mL}{bd}}$$

Where, **m**: Slope of load vs. elongation curve

L: Length of the specimen in m

b: Width of the specimen in m

d: Thickness of the specimen in m

Procedure

1. Measure and compare the dimensions of the specimen with those specified in **ASTM D 638-03.** Use appropriate measuring devices with respective accuracies in dimensions at 5 locations in the direction of measurement and take the average.
2. Place the specimen in the UTM in position and make sure that it is aligned properly and load the grips.
3. Check the setting of the UTM.
4. Conduct the test by applying the tensile load on the specimen gradually so that strain rate is very slow or quasi static. The specimen should fail within ½ to 5 minutes.
5. During the test, the load applied and corresponding elongation is recorded at uniform intervals of elongation until the specimen completely fails/breaks in tension.
6. The readings are tabulated and a plot is drawn for load vs. elongation to determine the modulus of elasticity of the material.
7. Repeat the procedure for remaining specimen. Discard the results of the specimen, if any obvious defects are observed.

Observations

1. Report the dimensions in a tabular form (report 3 values of each dimension taken at different locations along the length and average).
2. Report the readings of load and corresponding elongation taken at least at 5 points in the range in a tabular form for all the specimens.
3. Plot the load vs. elongation curve and obtain the modulus of elasticity and tensile strength of the specimen.
4. Give error analysis of your observations.

Exercise

1. What is the significance of the shape of the specimen?
2. What is the significance of gauge length from stress point of view?
3. What is proportional limit, 0.2% proof stress? How will you calculate the yield stress for Aluminium?
4. What is secant modulus?
5. What is the effect of high strain rate on the properties of your specimen?
6. What other devices are commonly used to measure extension?
7. How can fatigue test be conducted using UTM?

Reference

1. ASTM D 638-03 Standard Test Method for Tensile Properties of Plastics.
2. Engineering Mechanics of Composite Materials by Daniel, Ishai.
3. LLOYD instruments Ltd., User manual for EZ50 (UTM) part No.01/2839 2.0 Ver.