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Engineering Materials

Module 5: Compression Test

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Module 5: Compression Test

Module Objectives

After the completion of this module, the student will be able to:

- Explain the difference between compressive and shear forces.
- Explain what the compressive test is and why do we perform it.
- Follow the correct procedure to perform compression tests on aluminum, brass, copper and steel specimens.
- Use the data obtained from a compression test to plot and analyse a stress-strain graph.
- Calculate the ultimate Compressive strength and modulus of elasticity for each tested material.

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Introduction

The compression test is the opposite of the tensile test. Notice in Fig. 5.1 the ends of the connecting rod are being pushed toward each other, “compressing” the part.

There are many situations in manufacturing where parts are subjected to compressive loads. An example of a common compressive load in manufacturing is a fastener (Bolt) which holds two parts together. This places a compressive force on the parts as shown in Fig. 5.2.

Compression tests result in mechanical properties that include the compressive yield stress, compressive ultimate stress, and compressive modulus of elasticity.

1. The difference between compressive and shear forces

A compressive force is a pushing force where the force is perpendicular to the surface of the material as shown in Fig. 5.2. While, the shear force is a cutting force where the force is parallel to the surface of the material as shown in Fig. 5.3. Accordingly, the direction of the force applied will decide the type of stress on the part.

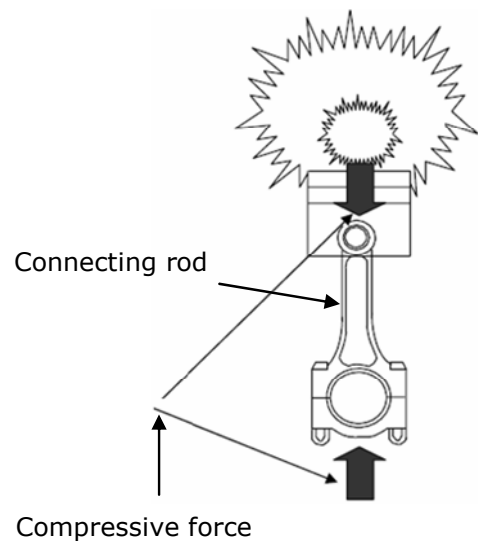


Fig.5.1: An engine connecting rod under compressive forces.

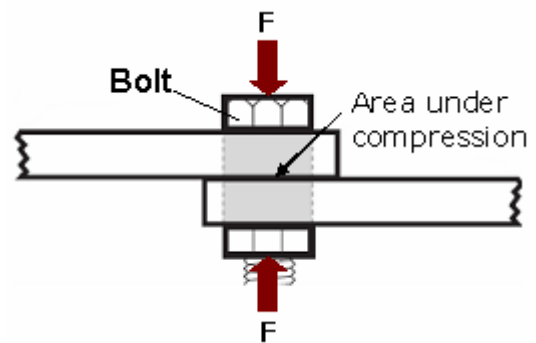


Fig.5.2: Fastener under compressive forces.

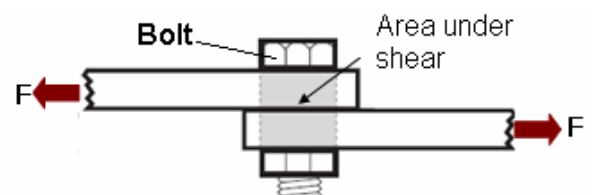


Fig.5.3: Fastener under shear forces.

Activity 1:

Write an illustrative report to explain the various forms of stress applied on engineering materials.

You can use the following links:

http://www.tpub.com/content/construction/14250/css/14250_14.htm

http://en.wikipedia.org/wiki/Stress_%28physics%29

http://www.ndt-ed.org/index_flash.htm

2. Compression test overview:

A compression test is performed on the universal testing machine. The compression space is situated at the lower end of the safety plastic box of the machine as shown in Fig 5.4.

Prior to the yield point tension and compression results are similar. For some ductile materials the specimen will compress until a flat slug is reached as shown in Fig 5.5.

However, brittle materials will fail immediately after their ultimate strength is exceeded. These brittle materials have much greater compression strength than tensile strength. That is why they are mostly tested under compression.

Concrete, wood and cast iron are examples of materials mostly tested under compression. For example the concrete compressive strength is the most important material property that engineers consider when designing and building a structure.

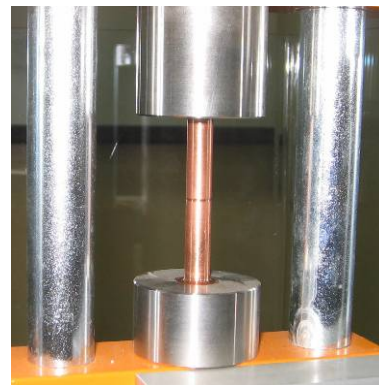


Fig. 5.4: Compression test portion on the universal testing machine.



Fig.5.5: A ductile material after the compression test.

2.1. The ultimate compressive strength:

The ultimate compressive strength is the maximum compressive load divided by the original cross sectional area of the specimen.

Ultimate Compressive Strength

$$= \frac{\text{Maximum Load (N)}}{\text{Original Area (mm}^2\text{)}}$$

The piece of material to be tested is placed in the provided place of the machine for compression testing and pushed until it bends. The test piece first deforms elastically, then plastically. See Fig.5.4.

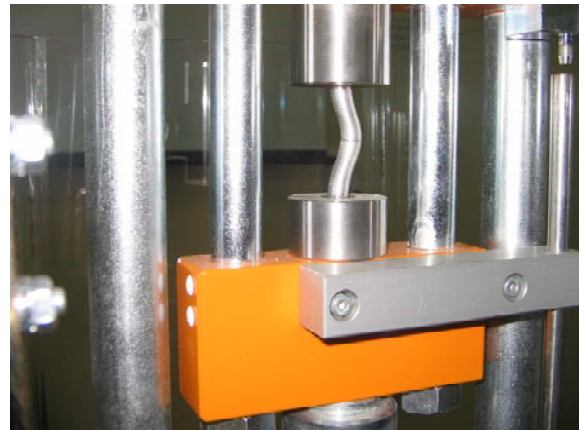


Fig.5.4: A test piece is pushed until it bends.

2.2 Yield Point

The yield point during the compression test is reached at the exact moment when the stress on a material exceeds the material's elastic range as explained earlier in module 4 (see Fig. 5.5).

2.3 Modulus of elasticity

The compressive modulus of elasticity is usually higher than the tensile modulus of elasticity and is greatly considered when designing parts that will be subjected to compressive forces.

As you can see in the stress/strain diagram shown in Fig. 5.5, the stress and strain are proportional within the elastic range.

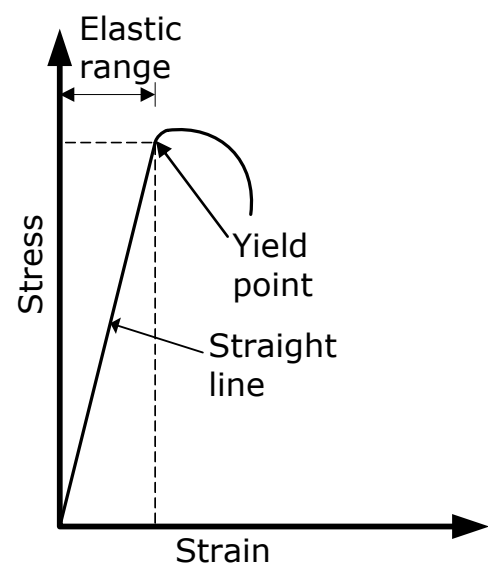


Fig.5.5: Stress-strain diagram for a material under compression.

The modulus of elasticity (Young's modulus) can be calculated using the following formula.

$$E = \frac{\sigma}{\epsilon}$$

Where E= modulus of elasticity in Kpa.

σ = Stress at the yield point in Kpa.

ϵ = Strain at the yield point.

3. Compression test procedures

1. Use the Vernier caliper to measure the diameter of the specimen as shown in Fig. 5.6 and record it.

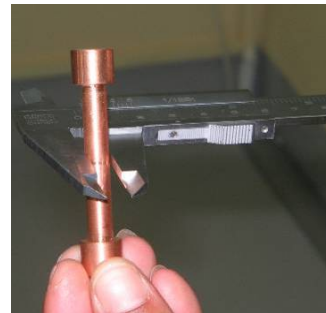


Fig. 5.6: Measuring the diameter.

2. Switch on the machine as shown in Fig. 5.7.



Fig. 5.7: The machine ON/OFF switch.

3. Place the specimen in the compression test piece holders. Make sure that the specimen is centered as shown in Fig. 5.8.

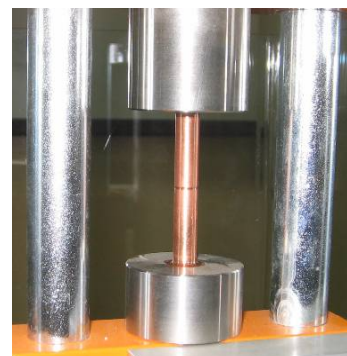


Fig. 5.8: The specimen is fixed on the holder.

4. Reset the DL-indicator to zero as shown in Fig. 5.9.



Fig. 5.9: Reset the DL-indicator.

5. Close the safety plastic door as shown in Fig. 5.10.

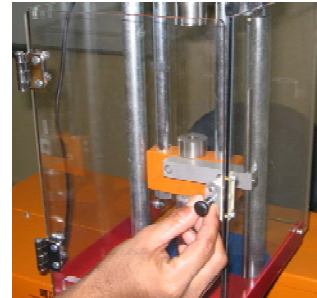


Fig. 5.10: Secure the plastic door.

6. Adjust the cylinder speed by turning the speed adjustment valve 1/16 of a turn anticlockwise from the closed position as shown in Fig. 5.11.



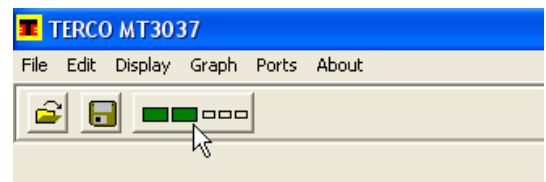
Fig. 5.11: Adjusting the speed valve.

7. Switch on the instrument panel and make sure that the middle button is set to PC as shown in Fig. 5.12.



Fig. 5.12: the instrument panel

8. Click the measuring display button as shown in Fig. 5.13a, then click the start button to start the test as shown in Fig. 5.13b.



(a)



(b)

Fig. 5.13: (a) Measuring display button. (b) Measuring display box.

9. The machine starts and the cylinder moves slowly upwards while four measurements of load and extension per seconds are being stored in a table as shown in Fig. 5.15.

Important tips:

1) You need to **STOP** the compression test manually.

2) **Do not compress** more than shown in Fig 5.14.



5.14: The maximum compression limits for the test.

10. Record the maximum load that the specimen resisted.

11. Save the table and the graph as shown in Fig. 5.15.

12. Calculate the original area of the specimen and use it with the maximum load recorded to calculate the ultimate compressive strength.

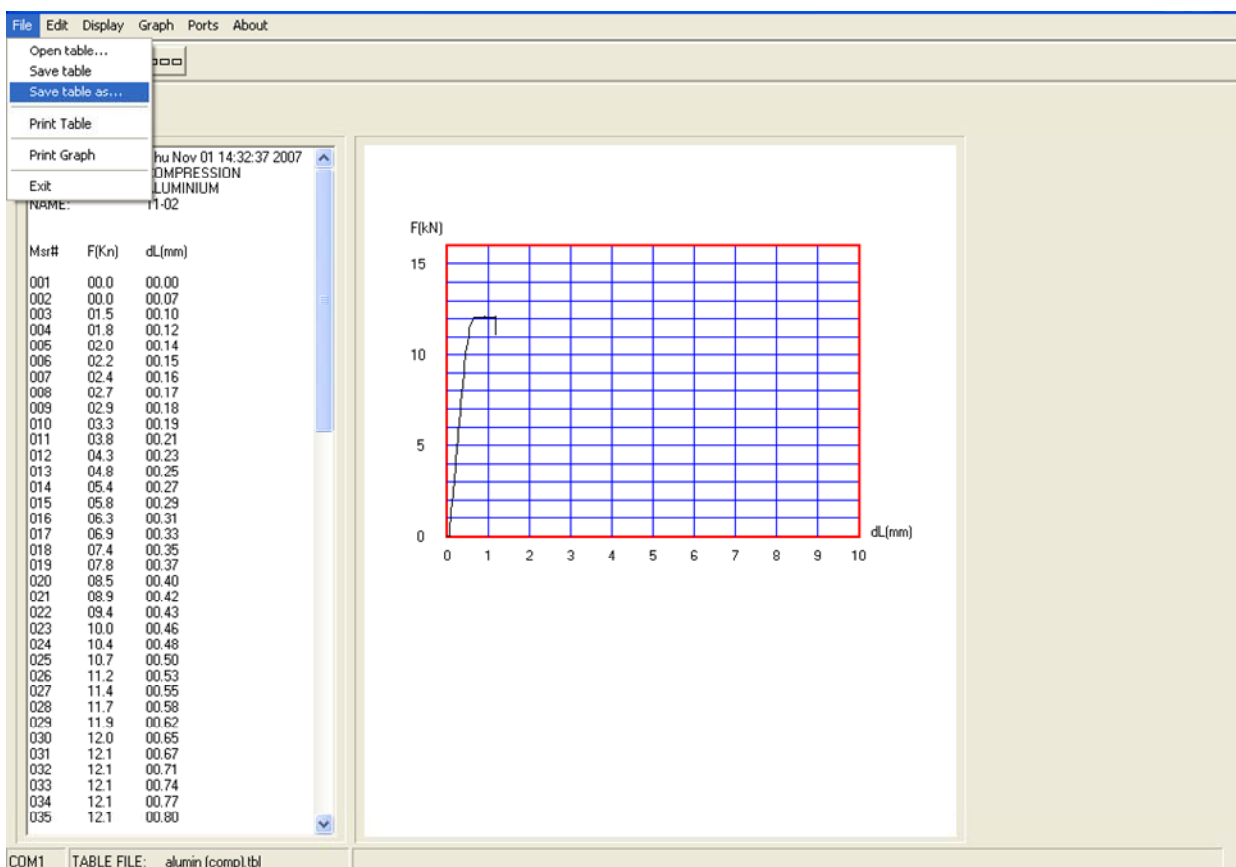


Fig. 5.15: Final test results.

4. Compression test results analysis

4.1 The compression test results for an aluminum test piece.

Type of material	Aluminum
Original Diameter, mm	_____
Maximum Force (Load) in KN	_____
Original Area, mm ²	_____ _____
Ultimate compressive Strength(σ_u), (N/mm ²)	_____ _____
Modulus of elasticity	_____ _____
Yield stress	_____

Activity 2

Plot the stress-strain diagram for the aluminium specimen using the sets of data result from the test. The data will be given as force applied on the part and extension of the part.

After plotting the curve, identify the following:

- 1- Elastic range.
- 2- Yield point.
- 3- Plastic range.
- 4- Ultimate compressive strength.

Note: you can use the spread sheet or any other similar application to calculate the data and draw the stress-strain curve.

4.2 The tensile test results for a brass test piece.

Type of material	Brass
Original Diameter, mm	_____
Maximum Force (Load) in KN	_____
Original Area, mm ²	_____ _____
Ultimate compressive Strength(σ_u), (N/mm ²)	_____ _____
Modulus of elasticity	_____ _____ _____
Yield stress	_____

Activity 3

Plot the stress-strain diagram for the brass specimen using the sets of data result from the test. The data will be given as force applied on the part and extension of the part.

After plotting the curve, identify the following:

- a. Elastic range.
- b. Yield point.
- c. Plastic range.
- d. Ultimate compressive strength.

4.3 The tensile test results for a copper test piece.

Type of material	Copper
Original Diameter, mm	_____
Maximum Force (Load) in KN	_____
Original Area, mm ²	_____ _____
Ultimate compressive Strength(σ_u), (N/mm ²)	_____ _____
Modulus of elasticity	_____ _____ _____
Yield stress	_____

Activity 4

Plot the stress-strain diagram for the copper specimen using the sets of data result from the test. The data will be given as force applied on the part and extension of the part.

After plotting the curve, identify the following:

- a. Elastic range.
- b. Yield point.
- c. Plastic range.
- d. Ultimate compressive strength.

4.4 The tensile test results for a steel test piece.

Type of material	Steel
Original Diameter, mm	_____
Maximum Force (Load) in KN	_____
Original Area, mm ²	_____ _____
Ultimate compressive Strength(σ_u), (N/mm ²)	_____ _____
Modulus of elasticity	_____ _____ _____
Yield stress	_____

Activity 5

Plot the stress-strain diagram for the steel specimen using the sets of data result from the test. The data will be given as force applied on the part and extension of the part.

After plotting the curve, identify the following:

- a. Elastic range.
- b. Yield point.
- c. Plastic range.
- d. Ultimate compressive strength.

Activity 6

Analyze the stress -strain curves of the four tested material specimens created earlier to find the following:

1. Which material has the highest compressive strength?

2. Which material has the highest yield strength?

5. References

1. MT3037 Universal Testing machine manual.MT3037-312 July 2007.
2. Modern engineering materials edition 1.
3. Engineering materials 1. "An introduction to Properties, Applications, and Design".
4. Modern Materials and Manufacturing Processes, R. G. Bruce, M. M. Tomovic, J. E. Neeley, and R. R. Kibbe, Prentice Hall, 2nd Ed., 1987, pp 55-60.
5. Different internet sites.

Student's notes

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