Rewarding Learning

AS LEVEL Section A

FACT FILES

Technology & Design

For first teaching from September 2011

For first award in Summer 2012

Material Choice and Selection Part 3

technology and design

FACT FILE

1.1 Material Choice and Selection Part 3

technology and design

Learning Outcomes

Students should be able to:

- Demonstrate knowledge and understanding of the following:
  - Mechanical properties – strength, elasticity, plasticity, toughness, hardness, durability and brittleness.

Course Content

Mechanical Properties:

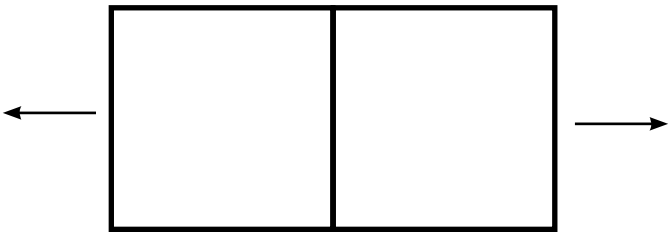
Mechanical properties of a material are related to how the material reacts to various forces that it might be subjected to.
If the force is significant the material will suffer from deformation.
There are two potential types of **deformation**:

1. Temporary (elastic)
2. Permanent (plastic)

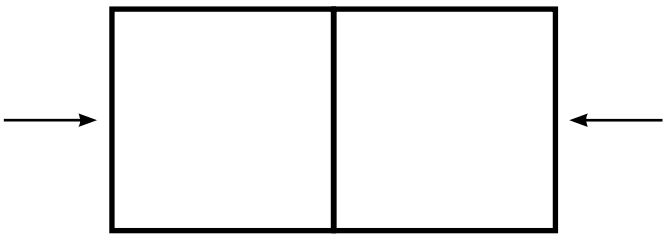
Strength

The strength of a material is directly related to the material's ability to withstand force without it breaking or permanently bending. Different types of strength resist different forces as demonstrated below:

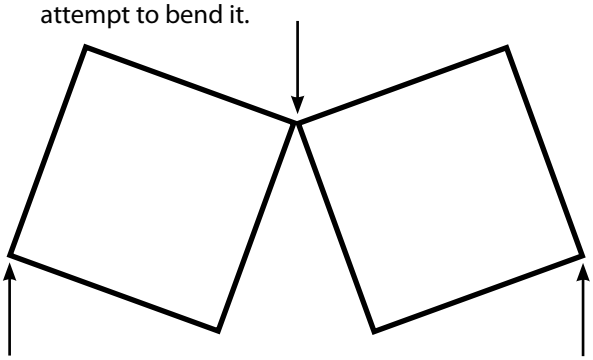
1. A material with high **tensile strength** properties has the ability resist pull forces and would be suitable for production of items such as chains, cables and ropes.



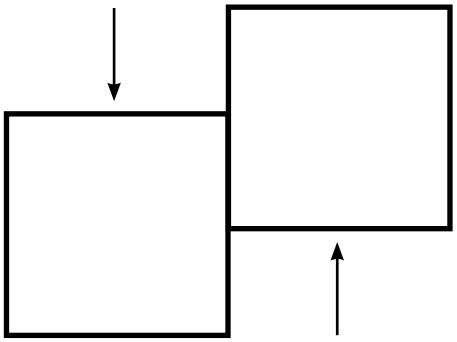
2. **Compressive strength** is related to a material's ability to withstand push forces that try to crush or shorten it.



3. **Bending strength** is the force applied to a material in an attempt to bend it.



4. **Shear force** is the force that subjects materials to a sliding action across their surfaces. This kind of force is present in hinges, rivets, scissors, secateurs for gardening, manual hedge clippers and other tools that involve two or more blades sliding across each other.



5. **Torsional force** is a force that is applied to a material to try to twist it. It is also known as **torque**.

Elasticity

Elasticity is the ability of a material to flex, bend and be deformed and return to its original shape once the forces are removed. An elastic band is a good example of a material with properties of elasticity.
All materials possess elastic properties of various degrees.

Plasticity

Plasticity does not only apply to plastics but it is the ability of an object or material to permanently change shape as a result of forces applied to it, without cracking or breaking. The plasticity of some materials increases when heat is applied.

There are 2 key terms that are associated with plasticity:

- Malleability
- Ductility

Malleability is the degree of which materials can be permanently deformed in all directions as a compression forces caused by impact such as hammering, pressing, rolling, without cracking or breaking.

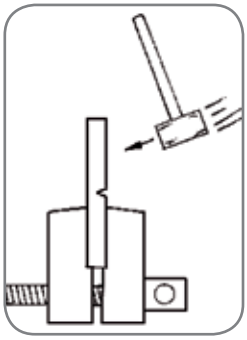
Ductility is the ability of a material to be drawn to be longer and thinner, e.g. into wire. The forces applied to enable the material to undergo cold plastic deformation include bending, twisting and stretching.

The table below shows the order of ductility and malleability of certain metals. All ductile materials are malleable; however, not all malleable materials are ductile.

Order	Malleability	Ductility
1	Silver	Silver
2	Copper	Iron
3	Aluminium	Nickel
4	Tin	Copper
5	Lead	Aluminium
6	Zinc	Zinc
7	Iron	Tin
8	Nickel	Lead

Toughness

Toughness is the ability to withstand sudden shocks or blows. The IZOD impact test is a common test used to calculate the toughness of materials. A large pendulum swings to hit a piece of material (with a 45° notch cut in the centre). The tougher the material, the more capable it is of absorbing the energy of the impact force. Also, when the material breaks, the pendulum will swing past the holding vice for a shorter distance for tougher materials.



The amount of energy that can be absorbed during fracture also depends on the size of the piece of material, therefore in the IZOD test, the different materials must be the same size.

Hardness

Hardness of a material describes the ability to resist indentation. Materials that possess a high degree of hardness have the ability to resist indentation as a result of impact as well as being scratch resistant.

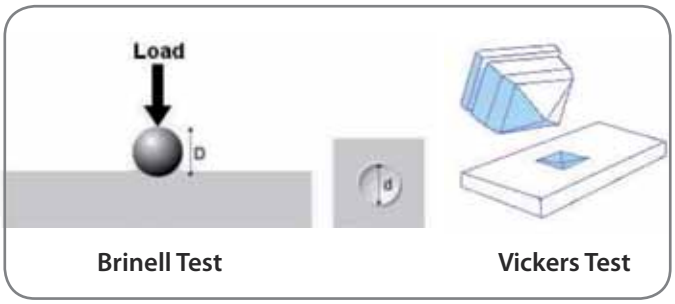
Scratch tests

Minerologists adopt a scale used to rank the scratch resistance ability of materials. The scale is called the Moh's scale and each material will scratch the one coming before it. A diamond has a hardness rating of 10 in Moh's scale.

Indentation tests

There are many different types of indentation test; however, all involve a similar process of forcing a hard object into the surface of a material. The hardness value in these tests are based on the surface area of the indentation or the depth of the indentation. The three main tests include:

- Brinell test (using a hard steel ball)
- Vickers test (using a small pyramid-shaped diamond tool)
- Rockwell test (using either a steel ball or diamond cone)



Durability

The more durable a material is, the more capable it is of withstanding wear and tear and deterioration as a result of weathering. Weathering may cause the material to weaken (mechanically) as well as altering the appearance. Metals are prone to corrosion. This is a chemical breakdown of the surface. Plastics are less prone to decay, which has led to their everyday use of outdoor products; however, this makes them difficult to dispose of if they are not recyclable.

Brittleness

If a material is brittle it tends to have poor plasticity properties. Brittleness is the opposite of plasticity. Materials that are brittle tend to break or shatter before they deform. Examples of brittle materials include cast iron and glass. In general, brittle materials possess high compressive strength but low tensile strength. E.g. Cast iron is not used in bridge building.

Revision questions

1. The tensile, compressive, shear or torsional strength of a material can influence its selection. Briefly explain each of these four elements of strength.

2. Explain what is meant by the following properties:
   a. Durability
   b. Brittleness.
   c. Toughness.

3. The mechanical properties of a material can greatly influence selection.
   a. Briefly explain what is meant by the term mechanical properties.
   b. Briefly explain what is meant by the term toughness and hardness.

4. Give examples of workshop tools that have brittle parts? Why is it important to store them correctly?

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