Materials – characteristics and properties

Classifying & Testing Materials (Nelson Ch 6)

Classifying Materials

Non- resistant	**Resistant**
Material that are flexible, and easily moved, bent & shaped	*Materials that are generally solid in form*
Fibre, Yarns & fabrics	Wood
Plastic Film	Metal
Rubber & Leather	Glass
	Ceramics
	Solid plastics

Material	**Major Classification subgrouping**
Wood	Softwoods
	Hardwoods
	Manufactured boards

Material Testing all material

Thorough Testing will help you choose the best & most appropriate materials. You must also ensure that you collect & record your results accurately, and of course, follow all safety procedures

Elements of successful testing

Consistency	Your testing procedure needs to be consistent & controlled so that it can be repeated for each for each comparative test
Planning	Plan your test carefully. If possible, trial a number of set-ups for your test
Repeatability	You need to be able to repeat your test a number of times for each material
Accurate measuring	It is important to devise tests that give you objective results that can be measured & quantified (using numbers)
Record Results	Make sure you collect & record you results in a methodical way. This will help you see the difference between your results
Safety	Make sure that your test procedure is safe & that you don't put yourself or other at risk

Materials – characteristics and properties

Resistant Materials

RESISTANT MATERIALS

Forces and effects

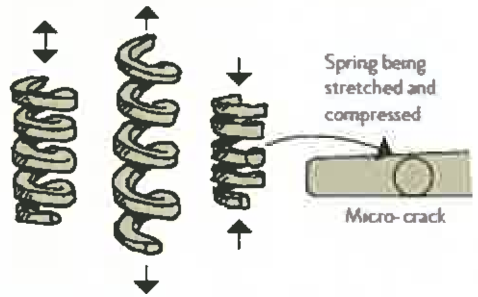
To make effective use of materials, a designer must understand how materials respond to the application of external forces, such as tension, compression, bending, torsion and shear, all of which are discussed below.

Types of forces/effects

Depending on the size of the force applied, solid materials will display one or more of the following reactions/effects under load:

- **elastic deformation** – where the material stretches/moves when a force is applied, and then returns to its original shape on release of the load
- **plastic deformation** – where the shape of the material is changed through the application of force
- **rupture** – where the material fails to take the load and breaks.

Other types of failure, including fatigue and creep, involve the application of force over extended periods of time.



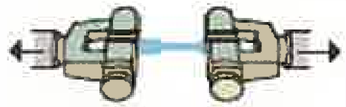
Fatigue in a spring

Fatigue can be defined as a progressive fracture in the material. It occurs when mechanical parts are subjected to **cyclic loading**, bending or vibration repeatedly. No deformation is apparent, but small, localised cracks develop and work their way through the material, weakening it.

Creep is a slowly progressing form of permanent deformation, often induced by gravity or rotational forces. Turbine blades, long-span cables and engine components can all suffer deformation from creep. Materials subjected to high operating temperatures are the most susceptible.

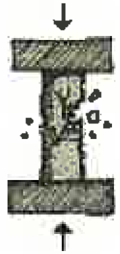
Types of force

Tension is a pulling force (called tensile force) that acts in one direction (usually along the object's axis) and stretches the material until it changes, breaks or tears. Testing of this nature is usually performed on a tensiometer, which records the stress versus strain and produces a stress/strain curve to visually represent the material's reaction under load.

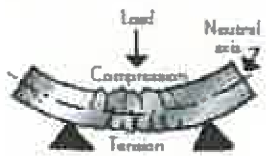


Tensile elongation

Compression is a pushing force that tends to shorten the object. Brittle materials such as glass or concrete will crush or fracture, while flexible ones such as rubber will shorten and increase their diameter.



Bending is unique, in that the application of a bending force will create both tension and compression forces within the one object. If a piece of aluminium is bent to form a curve, material on the outside of the curve will be in tension while material on the inside will be in compression.

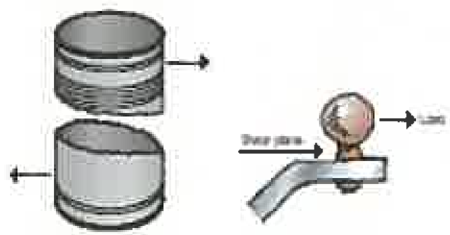


Bending force

Bent aluminium tubing, subject to compression and tension

Torsion is a twisting force, such as is experienced in propeller shafts on a boat, or in a car axle.

Shear forces act at right angles to the material's longitudinal axis, and may be imagined as trying to cut across the material along a **shear plane**, like scissors cutting paper. The bolts securing a car tow bar and the crankshaft of a combustion engine experience these types of load, as they can be cut or 'sheared' by the force.



Shear forces are exerted on the vertical 'bolt' of a car's tow bar when a trailer is attached

The twisting effect of torsion

Classifying & Testing Materials

Characteristics & Properties

Mechanical properties

- **Strength** is one of the most important properties since it determines a material's ability to hold loads without failure. Strength can vary greatly depending on how the forces of a load act on the material. Cast iron, for example, is strong in compression strength but comparatively weak in tensile strength.
- **Hardness** is the ability of a material to resist scratching, abrasion or indenting, and is closely related to strength. Sunglass lenses, for example, need to be scratch-resistant.
- **Elasticity** is the ability of a material to return to its original shape and dimensions when a **deforming load** is released. Bungee jumpers, for example, depend on the elasticity of the cords to absorb shock when they jump, and to return to their original shape for use by the next jumper.
- **Stiffness** or **rigidity** is the ability of a material to resist **deflection** under load. It is important in design, e.g. in shelving or sailboard fins.
- **Plasticity** is the ability of a material to be permanently deformed without breaking. It is important when shaping processes are being considered, as the material may have to be heated or worked in a special manner.
- **Malleability** is a material's ability to manage all types of **plastic deformation** without damage. Gold, silver and other precious metals are well known for being malleable. They can be readily hammered into thin sheets or drawn into fine wire.
- **Toughness** is the ability of a material to absorb energy when being deformed, and therefore to resist **deformation** and failure. Steel, for instance, would be considered tougher than window glass, particularly where suddenly applied impact loads are a concern.
- **Ductility** is the malleable ability of a material to be drawn out (stretched longitudinally) with a tensile force, yet remain intact, e.g. copper and gold can be pulled into thin 'wires' without breaking.

Shutterstock.com/donatas1205

Bookshelves should not deflect or bow under a heavy load of books

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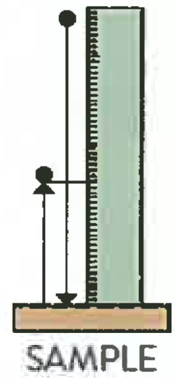
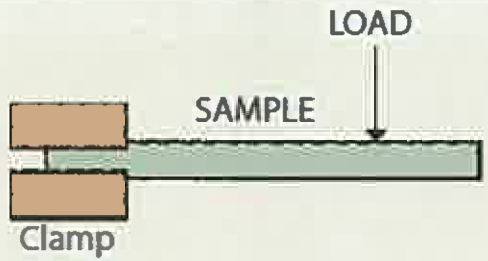
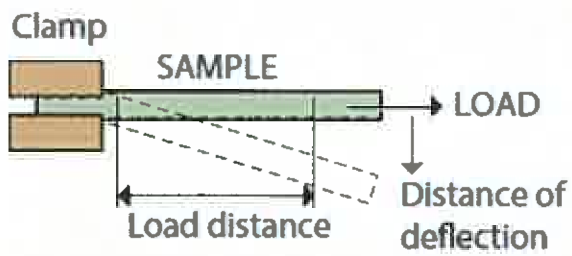
Materials – characteristics and properties

Tests for resistant materials

Property	Description of test	Diagram
Hardness	Drop a 12 mm ball bearing from a specified height (e.g. 300 mm), and compare the size of indentation and measure the height the ball rebounds. Harder surfaces will rebound further and not mark from the impact. Or do a scratch test. Gather a series of material samples. Scratch one against each of the others. The material that marks the other sample is harder than it. Rank the samples from softest to hardest.	
Strength and durability	Hang a load from the material sample, increasing the load until failure occurs. Measure the weight required to break the sample.	
Elasticity	Subject the material sample to loading until it bends. Release the load and check to see if the sample returns to its original position, or measure the distance from its original position (you will need a reference point to measure from).	

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VCE Product Design & Technology Resistant Material Testing Group Circle 1 2 3 4

Date _____/_____/______ Group Circle 1 2 3 4

Students names

Test 1 Elasticity

Sample the material sample to loading until it bends. Release the load & check to see if the sample returns to its original position or measure the distance from its original position (you will need a reference point to measure from)

Temperature			Humidity			
Timber	Classification	Force	Angle	Force	Angle	Spring back return
Pine		5 Kg		8 Kg		
Jarrah		5 Kg		10 Kg		
Vic Ash		5 Kg		10 Kg		

Sample	Size in mm	Conclusions
Length	500	
Width	10	
Thickness	19	

Test 2 Strength & Durability

Hang a load from the material sample, increasing the load until failure occurs. Measure the weight required to break the sample

Temperature		Humidity		27 May 18	
Timber	Classification	Angle	Weight	MAX Weight	Time
Pine				7. 40 KG	
Jarrah				11.00 KG	
Vic Ash				15.00 KG	

Sample	Size in mm	Conclusions
Length	500	
Width	10	
Thickness	19	

Test 3 Hardness

Drop a punch from a specified height and compare the size of indentation and measure the height the punch rebounds. Harder surfaces will rebound further and not mark from impact (Punch weight 200 grams)

Temperature		Humidity			
Timber	Classification	Height	Dent Dia / Depth	Height	Dent Dia / Depth
Pine		250mm		500mm	
Jarrah		250mm		500mm	
Vic Ash		250mm		500mm	

Sample	Size in mm	Conclusions
Length		
Width		
Thickness		

Test 4 Moisture

Research has shown that in-service moisture contents will vary seasonally and may differ from the target manufacturing range. In addition, other factors relating to house design, heating and cooling systems, and the micro-climate of the particular locality can have a significant influence on in-service moisture contents. Installation and finishing practices need to accommodate both the adjustment to climatic conditions associated with the in-service environment and the seasonal movement that will occur in that climate.

Relative humidity is the major influence determining whether seasoned products will absorb moisture from the air and swell or lose moisture to air and shrink. If the moisture content of timber products is close to the average in-service moisture content, seasonal changes in humidity will result in small dimensional changes. The average equilibrium moisture content (EMC) of timber used indoors is often 1% to 3% below that of timber articles, components and assemblies used in outdoor applications.

https://qtimber.daf.qld.gov.au/guides/seasoning-and-timber-moisture-content

Test moisture of timber
Remove cap
Turn meter on
Insert probes into timber
Record moisture Percentage

Temperature		Humidity	
Timber	Classification	Raw / machined	Percentage
Snow Gum			
Plum tree			
Pine tree			

Sample	Size in mm	Conclusions
Length		
Width		
Thickness		

Conclusions

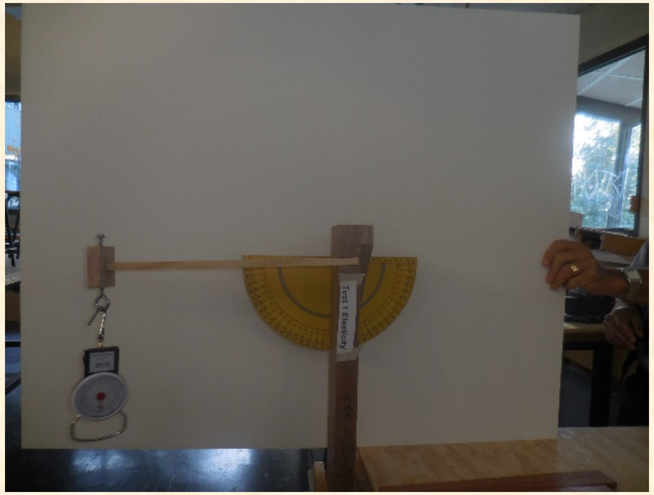
Compare test result with other groups

Group	**Test 1 Elasticity**	**Test 2 Strength & Durability**	**Test 3 Hardness**	**Test 4 Moisture**
1				
2				
3				
4				

How could you apply the Data gathered to improve or enhance your product?
Test 1 Elasticity **Test 2 Strength & Durability** **Test 3 Hardness** **Test 4 Moisture**

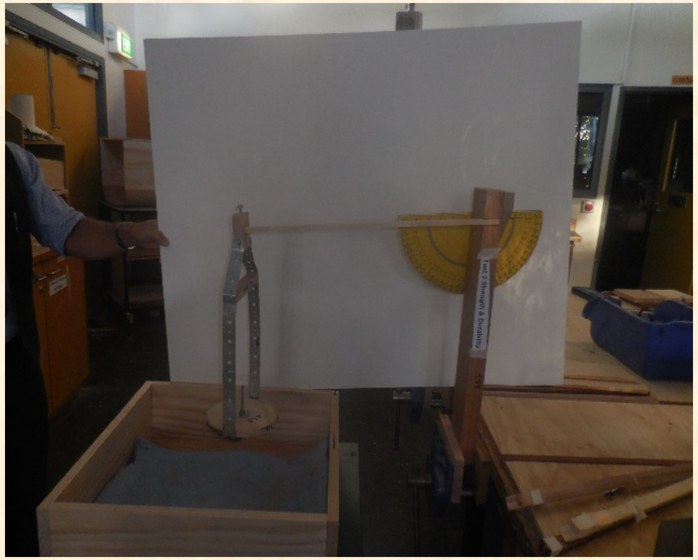
Year 12 PDTW Material Testing Photos

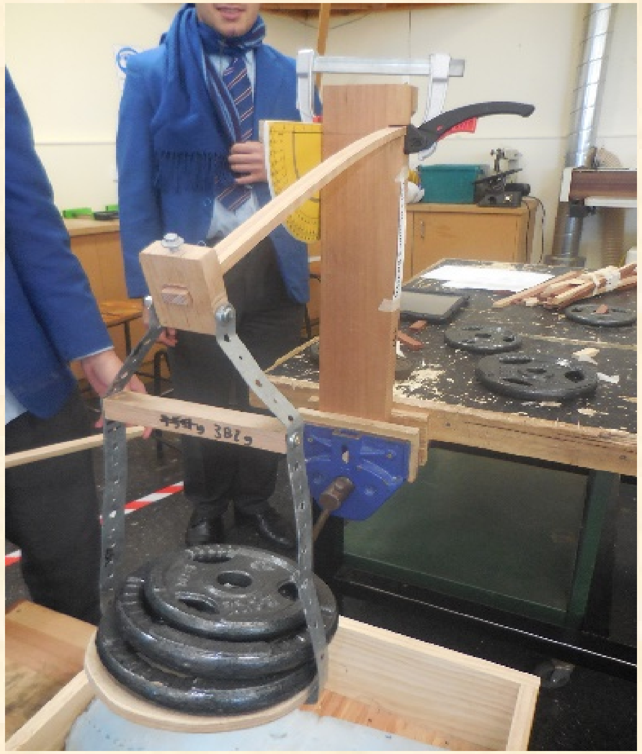
Test 1 Elasticity

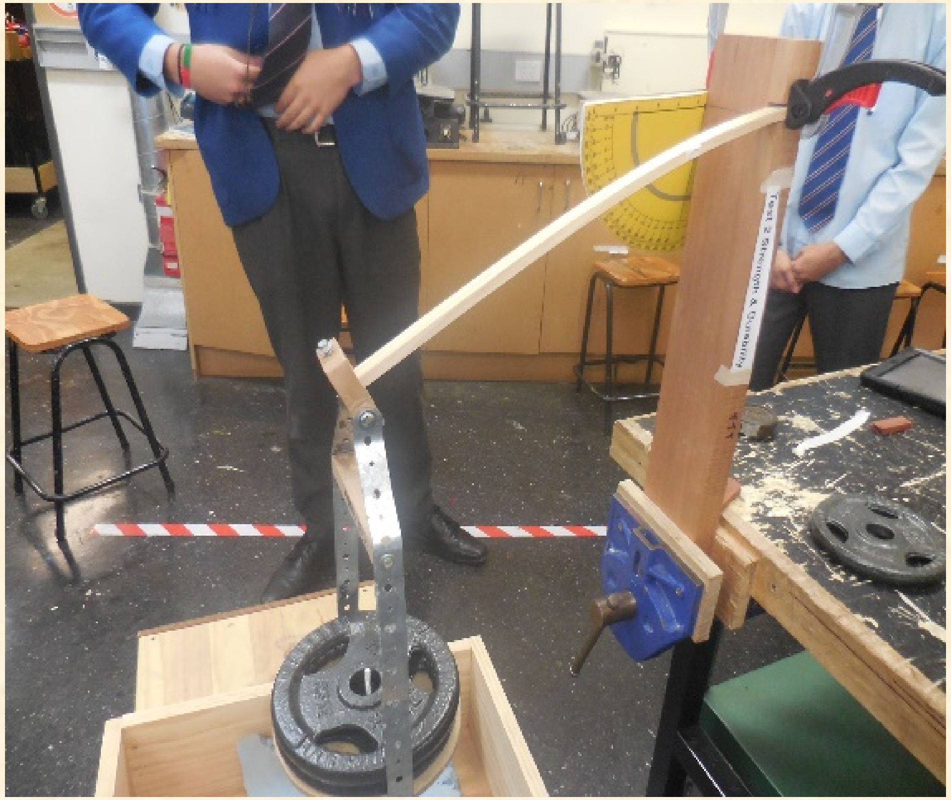


Year 12 PDTW Material Testing Photos

Test 2 Strength & Durability







Year 12 PDTW Material Testing Photos

Test 3 Hardness

Year 12 PDTW Material Testing Photos

Test 4 Moisture

12PDTW3a Timber Weight

TIMBER WEIGHT 300mm SAMPLE

WED - 19 JUNE 19 | TEMP 22.1°C | HUMIDITY 51%

ALL SAMPLES 300 mm

PLYWOOD 5 PLY -	140 x 12mm -	300g
PINE RADIATA	140 x 19m -	401g
	140 x 12mm -	251g
VICTORIAN ASH	135 x 19 -	495g
	135 x 34 -	861

12PDTW3a Timber Weight

12PDTW3a Timber Weight