5 Material types

A Metals and non-metals

Engineering materials can be divided into:

- **metals** – examples of **metallic** materials are iron (Fe) and copper (Cu)
- **non-metals** – examples of **non-metallic** materials are carbon (C) and silicon (Si).

As iron is such a widely used material, metals can be divided into:

- **ferrous metals** – those that contain iron
- **non-ferrous metals** – those that do not contain iron.

B Elements, compounds and mixtures

With regard to the **chemical composition** of materials – the chemicals they contain, and how those chemicals are combined – three main categories can be used:

- **Elements** are pure materials in their most basic form. They cannot be broken down into different **constituents** ('ingredients'). Examples of elements widely used in engineering materials are iron, carbon and aluminium (Al).
- **Compounds** consist of two or more elements that are **chemically bound** – that is, combined by a chemical reaction. An everyday example is water, which is **a compound of** hydrogen (H) and oxygen (O).
- **Mixtures** consist of two or more elements or compounds which are mixed together, but which are not chemically bound. In engineering, common examples are **alloys** – that is, metals which have other metals and/or non-metals mixed with them. A common example is steel, which is an **iron–carbon alloy**, and can include other **alloying metals** – metals which are added to alloys, in small quantities relative to the main metal. Examples of widely used alloying metals are chromium (Cr), manganese (Mn) and tungsten (W).

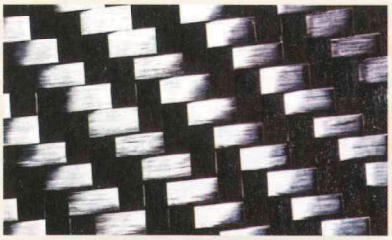
BrE: aluminium /ˌæl.jʊˈmɪn.i.əm/; AmE: aluminum /əˈluː.mɪ.nəm/

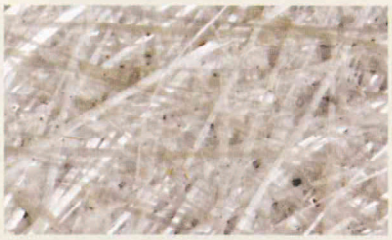
Note: For a list of chemical elements and their symbols, see Appendix IV on page 104.

C Composite materials

The article below is from an engineering journal.

Materials under the microscope: composites





When you think of examples of hi-tech materials, **composite materials** come to mind – such as carbon-fibre, used in aerospace and Formula 1 cars. But although we think of **composites** as hi-tech and highly expensive, that's not always true. The earliest examples of composite materials were bricks made from mud and straw. Or, to use the correct composite terms, from straw **reinforcement** – the structural network that reinforces the material inside, and a mud **matrix** – the material surrounding the reinforcement. These terms explain what a composite material is: a matrix with a **reinforcing material** inside it. A modern, everyday example is fibreglass – correctly called **glass-reinforced plastic (GRP)** – which has a plastic matrix **reinforced with** glass fibres.

5.1 Complete the sentences using the words in the box. Look at A opposite and Appendix IV on page 104 to help you.

metal	non-metal	metallic	non-metallic	ferrous	non-ferrous

1 Carbon (C) is a ..... .
2 Copper (Cu) is a ..... metal.
3 Aluminium (Al) is a common ..... .
4 Steel (Fe + C) is a widely used ..... metal.
5 Although it is used in steel, carbon is ..... .
6 Aluminium is relatively lightweight for a ..... material.

5.2 Decide whether the sentences below are true or false, and correct the false sentences. Look at B opposite to help you.

1 The elements that make up a compound are chemically bound.
2 Alloys are chemical compounds that are frequently used in engineering.
3 Alloys can contain both metallic and non-metallic constituents.
4 In an alloy, an alloying metal is the biggest constituent, by percentage.
5 Steel is a metallic element.

5.3 Complete the extract about concrete and steel, using suitable forms of the word *reinforce* from C opposite. Sometimes there is more than one possible answer.

(1) ..... concrete is one of the most widely used construction materials, and one we take for granted. However, using steel bars to (2) ..... concrete structures located outdoors is only possible thanks to a fortunate coincidence: concrete and steel have practically the same coefficient of thermal expansion – in other words, as atmospheric temperature varies, the concrete and the steel (3) ..... expand and contract at the same rate, allowing uniform movement. Using a (4) ..... material with a different coefficient of expansion would not be feasible. For example, (5) aluminium-.....concrete would quickly disintegrate.

5.4 Read the text below and find two elements, two compounds, an alloy and a composite. Look at A, B and C opposite to help you.

Generally, the steel used in reinforced concrete will have previously been exposed to water and to the oxygen in the air. As a result, it will usually be partly corroded, being covered with a layer of iron oxide (rust). However, once the steel is inside the hardened concrete, it will be protected from air and water, which prevents further rusting. Additionally, the cement in concrete does not react aggressively with the iron in steel.

Element	Compound	Alloy	Composite