HELMETS

Helmets have existed since early times to protect people in battle. Before the introduction of steel and aluminium, they were made of iron and beaten into shape. These days helmets are not only used by the police and army, but have also seen widespread use in more peaceful areas like building, cycling, horse riding, snowboarding, boxing etc. Modern helmets are mainly of polymer construction, but their design varies depending on the application.

Impact resistance

The most important design consideration for helmets is their ability to survive impacts. These impacts can vary from falling objects to head-on collisions. The helmet lessens the impact by absorbing energy – but it turns out that the best way of doing this, and the best materials, depends on the type of impact.

Hard Hats

Workers on a building site or in dangerous factories must wear a hard hat. This is to prevent injury caused by impacts from small falling objects such as tools or small stones dropped by those working overhead – no helmet will protect from a falling girder! The key requirement here is that the helmet must not break under the impact. The materials used must have good toughness so they do not fracture (crack), and enough strength to take the maximum load without deforming.

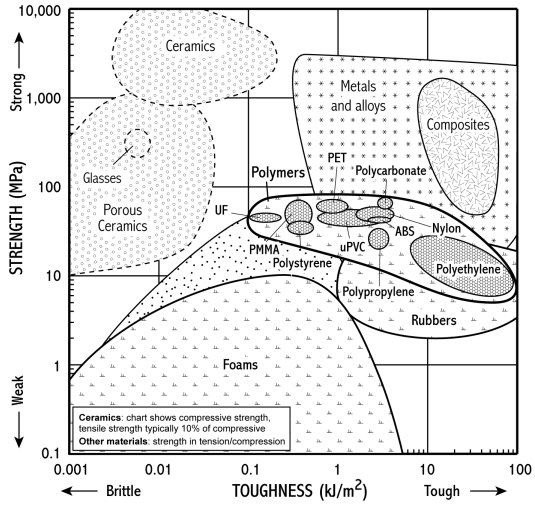
The selection chart helps identify materials that have high toughness and sufficient strength. Composites, most metals, and many polymers look good. Another requirement for hard hats is that they should be inexpensive and low weight. Polymers best meet all these needs and are also easy to manufacture. In fact hard hats are mainly made from **polycarbonate** or **ABS** and fitted via adjustable polyethylene straps inside the shell.

Climbing Helmets

The requirements for a climbing helmet are similar to those of a hard hat (although a climber must be able to rely on their helmet even after it has suffered an impact). The first designs for climbing helmets were, therefore, not much different from a hard hat. Since then, considerable effort has been put into making climbing helmets more comfortable and lighter in weight. The shell is often still made of **polycarbonate**, but as cost is less of an issue new materials like **glass fibre** or **carbon fibre reinforced polymer (GFRP/CFRP)** composites are now being used to reduce weight. Helmets can be made more comfortable by producing a wider range of shapes and including a liner (usually made of a nylon fabric).

Cycling Helmets

As well as protecting from small knocks, a cycle helmet must protect against the large impact on the head received during a crash. In this case it doesn't matter if the helmet is permanently damaged (all manufacturers recommend replacement after an accident), but it must absorb *lots* of energy. The best materials for this are foams – they absorb lots of energy when they are crushed. The main impact absorbing material in a cycling helmet is, therefore, a moulded block of **polystyrene foam**, usually with a **polycarbonate** covering. These materials are easily shaped – cycling helmets often have striking shapes to improve their aerodynamic performance.



Try it yourself 1

Devise a test to compare the impact resistance of different polymers like polystyrene foam, PMMA (also known as Perspex) and polyethylene. Investigate how easy they are to break if damaged with a small cut.

Try it yourself

Manufacturing

All helmets are made from a number of components: an outer shell, an inner liner (for good fit and comfort), fitting straps, and perhaps a decorative covering.

Helmet shells are made by blow moulding, vacuum moulding or injection moulding. In many cases the relatively thin section of the outer shell lends itself to sheet process technologies.

Question 1

Aesthetics

Compare and describe the aesthetics (colour, texture, pattern) of many different types of helmets, and discuss how the market influences the style and appearance of each design.

Question