Ray Oliver

The London 2012 velodrome

Olympic alloys

The development of new alloys is allowing Olympic athletes to improve their performances. When the 2012 Games finish, the winners will take away their own pieces of alloy – gold, silver and bronze medals.

Alloys are mixtures of metals or of a metal with a non-metal, as with steel. Steel is an alloy of iron and carbon. There is no upper limit to the number of possible new alloys with novel and useful properties. Alloys are generally harder, stronger and resist corrosion better than pure metals.

The ArcelorMittal Orbit Tower

The Olympic Park in Stratford contains the largest alloy steel sculpture in Britain. The 115 metre high Orbit Tower was designed by Anish Kapoor with the engineer Cecil Balmond. The name 'Orbit' refers to the electron clouds moving in orbits inside atoms. In metals, positively charged metal ions are held together by a cloud of shared electrons.

63 per cent of the Orbit Tower is made of recycled steel. Steel is a malleable and strong alloy that can be rolled and bent into all the complex shapes needed for the sculpture. It will be the tallest sculpture in the UK.

2000 tonnes of steel and 19 000 litres of paint have been used to build the ArcelorMittal Orbit tower

On two wheels

Designers must consider the properties of the materials used to make both sports equipment and buildings. These include strength, density, toughness, ductility and resistance to fatigue – will it break too easily?

The London Velodrome has been made of thousands of steel alloy sections that support a distinctive-shaped roof. The architect used an unusual cable-net roof in a double-curve to reflect the geometry of the cycling track itself. The whole building uses strong steel alloys to give a lightweight design intended to reflect the advanced designs of the bicycles.

The bikes used at the Olympic Velodrome look very different to ordinary mountain or racing bikes used in road races or off-road. A range of alloys and composite materials can be used. Composites are made from two or more different materials combined to maximise the best properties of each. Examples include carbon fibre and plastics reinforced with fibre glass.

Materials chosen for Olympic cycle construction

Material used	Reason for using this material
Titanium	Very strong but low density
Aluminium alloys	Rigid structures hold their shape well
Magnesium alloys	Very tough
Carbon-fibre composites	Low density and strong

For the Velodrome cyclists, the ordinary tubular metal frame of bikes is replaced by a composite monocoque, a single piece. Other high-performance bikes can use a wide variety of alloys to help athletes achieve top performances: Chromoly, an alloy steel containing chromium and molybdenum, lightweight aluminium alloys or even titanium alloys first used in the aerospace industry.

Trying out the BMX track in front of the velodrome

Throwing alloys through the air

Olympic javelin throwers have seen record performances improve as new materials have been developed. A javelin needs to be aerodynamic and must have low vibration in flight so that it travels further. At the Olympics, the javelins are likely to be made of aluminium alloys or aluminium combined with carbon fibre. These materials combine low density with a rigid structure that does not flex in flight, something that can slow down the javelin.

Leryn Franco, Paraguayan javelin thrower

An 800 g javelin

Some of the strongest and largest athletes at the Games are the shot-putters. The sport has a long history, there are reports of British soldiers holding cannon-ball throwing competitions hundreds of years ago. The design of a modern shot-put can vary. They can use the copper-zinc alloy familiar as brass, or be solid iron or even have an outer metallic shell filled with lead. The heavy metal ball weighs 7.26 kg for the men's event and 4.0 kg for the women's.

See the next page for the alloys used in the Olympic torch and medals.

Alloys in the water

Aquatic sports and those on ice in the Winter Olympics play an important role in the Games. Both sailing and rowing rely upon advanced alloys and composites. These have replaced traditional materials used in boat construction such as wood and canvas. Olympic rowers now mostly use carbon-fibreglass composite oars. The high strength and versatility of such composites have allowed oar-blade design to change, giving extra speed in the water. The smooth surface of the material improves its hydrodynamics – how easily it enters and leaves the water, reducing drag.

Sailing boats need a strong and flexible mast to support the sails. Most masts are made of aluminium alloys. Smaller masts can be constructed in a single piece using extrusion, like squeezing toothpaste from a tube. Extrusion is possible since metals like aluminium are both ductile and malleable. A recently developed alloy called Alustar is one-fifth stronger than previous alloys. Designers can save weight and increase sailing speeds by using thinner and lighter metal masts. Aluminium alloys also show good corrosion resistance, essential when sailing in salt water. The presence of an electrolyte such as sodium chloride, common salt, accelerates metallic corrosion.

Alustar is aluminium alloyed with magnesium, manganese, zinc and zirconium.

Ray Oliver is a science teacher and author of many textbooks and industry-related teaching resources.

The beginning and the end

Olympic torch

The London Olympic torch is made of a special aluminium alloy originally produced for the car and aerospace industries. This alloy has good heat resistance, so the flame will not melt it. It is also strong and lightweight, making it easier to carry. The torch has 8000 circles representing each of the Torchbearers.

Ben Slocombe, David Smith and Nicole Easy from Hayes School Bromley show off the Olympic torch.

Olympic medals

The London 2012 medals have been designed by David Watkins. He also did the special effects for the film 2001: A Space Odyssey in 1968. The medals are manufactured at the Royal Mint in Llantrisant, S Wales.

medal	composition	comment
gold	1.34% gold 92.5% silver 6.16% copper	plated with a minimum of 6g of gold
silver	92.5% silver 7.5% copper	pure silver (or gold) would be soft and easily damaged
bronze	97.0% copper 2.5% zinc 0.5% tin	harder than copper but easier to melt and mould into shape

At the Sydney Olympics, the bronze for the medals came from old melted-down one and two-cent coins – sustainable medals. The bronze used to make a medal for the London 2012 games is worth about £2.