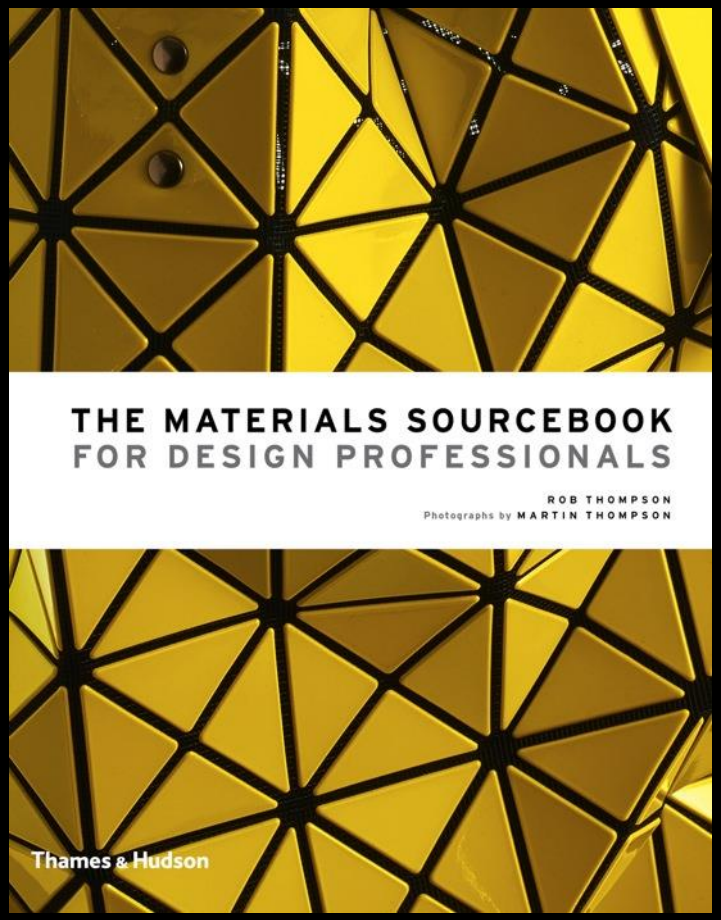
A one-stop resource for all design professionals, providing comprehensive information about basic materials with which they work daily plus exciting developments in
high-tech materials.

Final Cover

The Materials Sourcebook for Design Professionals

Rob Thompson and Martin Thompson



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Book

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Key Sales Points

- Written by Rob Thompson, author of the best-selling *Manufacturing Processes for Design Professionals*
- Covers nearly 100 material types across the six main ‘design’ material groups: Metal, Plastic, Wood, Plant, Animal and Mineral
- Includes comprehensive, accurate and accessible information about each material, describing its form, texture and most desirable properties, along with its uses within
  a variety of industries
- Complied in collaboration with materials suppliers and a mechanical engineer, to ensure the practicality and relevance of the contents
- Includes 450 illustrations within a clear layout, providing a one-stop sourcebook for both traditional and innovative high-tech materials

Target Market

- Designers and students of design
- Artists, sculptors and makers seeking information on a wide range of materials

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Rob Thompson and Martin Thomson

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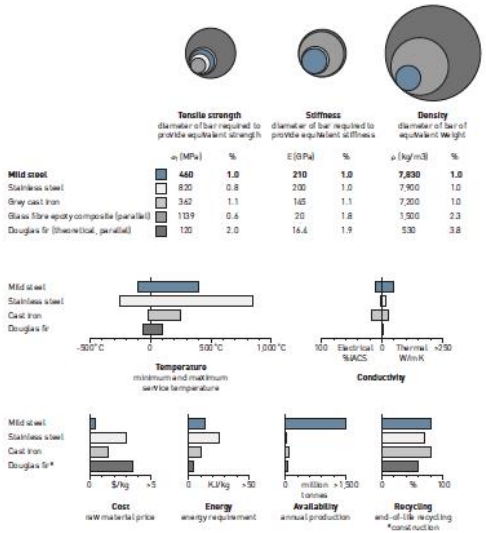
Contents

Steel

As the most commonly used metal it has had a very significant impact on design. Born out of the Industrial Revolution, steel rose to prominence following the development of an affordable mass-production technique. It has since been utilised at every conceivable scale, from micro medical components to packaging to skyscrapers and the longest suspension bridges.

Types	Typical Applications	Sustainability
• Carbon steel • Alloy steel • Stainless steel	• Automotive • Construction • Packaging	• Additional energy input is required to convert iron into steel and more still to produce stainless steel • Highly recycled
Properties	**Competing Materials**	**Costs**
• High tensile strength • Work hardening • Carbon steels are prone to corrosion (rust)	• Aluminium alloy • Fibre-reinforced composites • Timber	• Relatively low material cost • High manufacturing costs for complex parts



INTRODUCTION

The potential of steel was well understood centuries before a cost-effective method of high volume production was developed. The first major step towards affordable steel occurred around mid-19th century. A process patented by Henry Bessemer in UK – there is evidence of steelmaking using similar techniques in Asia much earlier, but not on an industrial scale – overcame the high cost of steelmaking by reducing the time taken and materials required. The invention uses pressurised air, which is blown through molten iron, to burn off the impurities and accelerate heating through the introduction of oxygen.

Bessemer's process revolutionised steelmaking and dominated production until the development of the basic oxygen technique in mid-20th century. With this process, air is replaced with oxygen, which greatly increases efficiency. Fluxes (lime or dolomite) are mixed into the molten iron to absorb impurities and alloying

Laminated steel Japanese Santoku knife
Thin sheets of stainless steel – one with more carbon and other with less, to make it softer – are folded together in alternating layers to create a flexible and very hard blade. The highest quality modern kitchen knife blades consist of 60 or so layers. The pakka wood handle is injected or coated with silicone (page XXX) to make it easier to maintain.

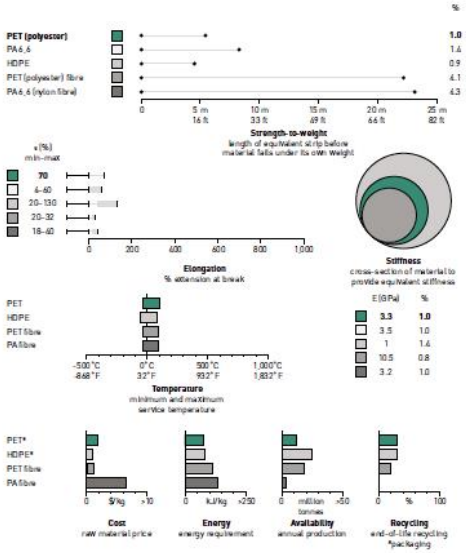
The folding technique was made famous two millennia ago by the blacksmiths of Damascus, ancient Syria, who created impressively strong and sharp swords that became the envy of the world. Over time, the secret was passed on, eventually reaching Japan where the technique was developed and turned to samurai swords. Highly regarded, each sword may have consisted of up to two million layers. Its characteristic curve and the outstanding performance are the result of the combination of layering with a painstaking heat treatment process, which took several weeks to complete.

Polyethylene Terephthalate (PET), Polyester

Also known as
Acronyms and abbreviations: PES, PEL, PETE, BOPET, poly
Trademark names: Mylar, Melinex, Hostaphan, Dacron, Terylene, Trevira, Corterra, Sorona, Radyarn, Ultradur, Crastin, Rynite

These high-strength engineering plastics have an enviable balance of thermal, mechanical and chemical properties. They are extremely versatile and are available in virtually all formats. Applications range from low-cost commodity items through metal replacement. As a result of its widespread use in disposable packaging, PET is one of the most commonly recycled plastics.

Types	Typical Applications	Sustainability
• PET and PET modified with glycol (PETG) • Polytrimethylene terephthalate (PTT) and polybutylene terephthalate (PBT) • Biaxial-oriented polyester (BOPET) film	• Automotive • Textiles • Furniture • Packaging	• Recyclable and identifies by code #1 or 'PET' • PET is one of the most widely recycled plastics
Properties	**Competing Materials**	**Costs**
• Good chemical resistance and thermal properties • Whereas PET has higher tensile strength, PTT and PBT have higher elastic recovery	• PP, PE, PA and synthetic fibres • Natural fibres and animal fibres • Glass • Aluminium alloy	• PET is low-cost • Other types are more expensive

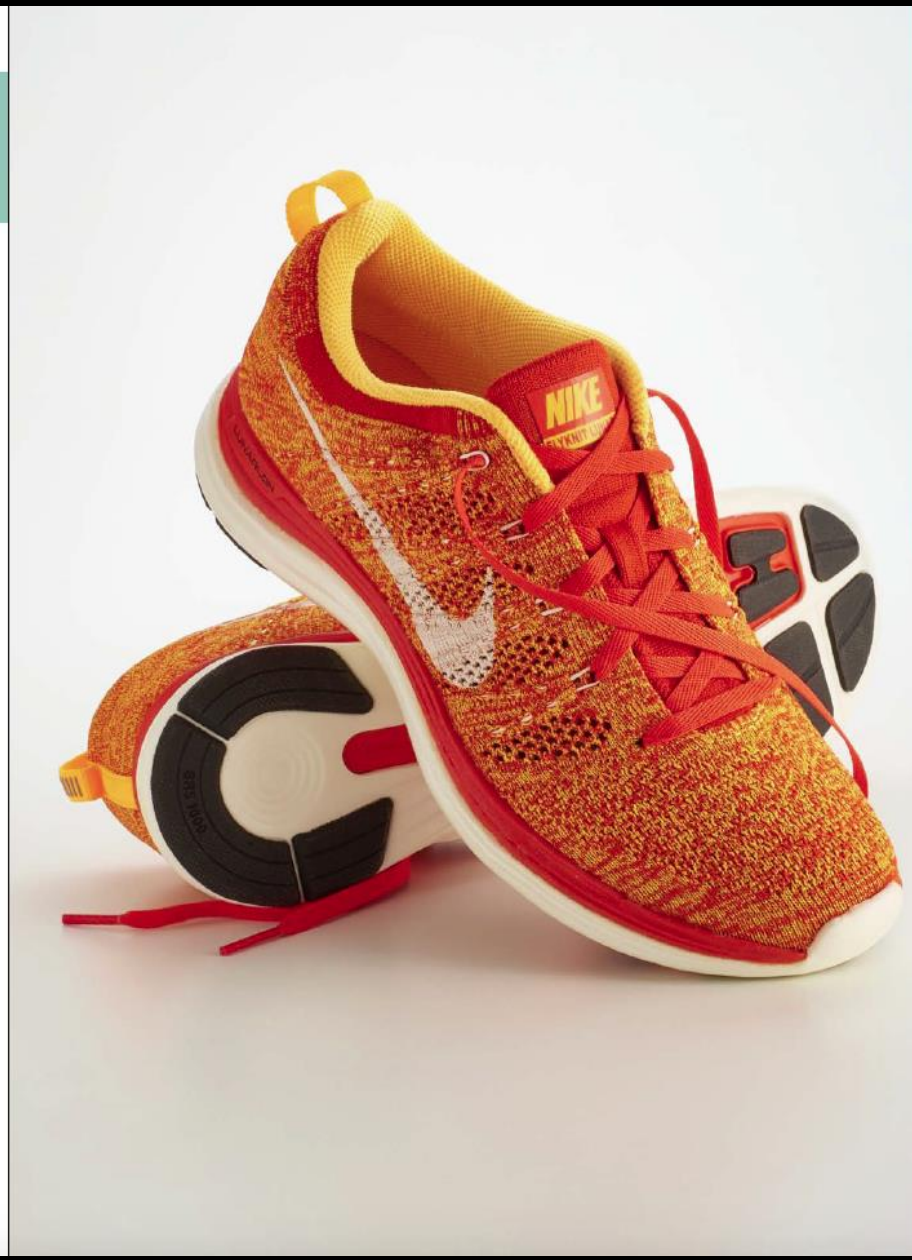


INTRODUCTION

There are two types of polyester: saturated and unsaturated (page 228). These saturated polyesters are thermoplastic – they do not form cross-links between the polymer chains and so can be molded and reprocessed through melting. Biobased thermoplastic polyesters include polylactic acid (PLA) (page 262), and polyhydroxyalkanoates (PHA and PHB) (see PLA).

Patented in 1941, polyethylene terephthalate (PET) has become one of the most widely used thermoplastics and dominant in consumer and industrial products alike. It is the most important thermoplastic polyester and the benchmark against which the others are compared. Its success is due to a combination of performance, adaptability and, most importantly, cost. PET is resistant to most chemicals and has high tensile strength and good thermal properties. Its low cost has led to widespread use, which has been accompanied by high rates of recycling (although comparatively low compared to metals), in particular bottles used for drinks, household products and cosmetics.

Knitted running shoes
Nike revolutionized trainers with the development of Flyknit. Before its launch in 2012, uppers were manufactured from leather, mesh, weave or laminate. This lightweight alternative utilizes high-strength polyester fibre. The yarns are knitted with an openwork structure to eliminate material (and weight) where it is not needed. Purported to have taken four years of intensive development, the knitted shoe upper is engineered to provide optimum support, flexibility and breathability. Compared to the company's previous leading running shoe (Zoom Streak 3), the Flyknit is 19% lighter overall. In addition to the technical benefits, the Flyknit unlocked the fashion potential of knitting in shoe construction, including the opportunities of shape, pattern and colour.



CONSTRUCTION

Lightweight
It is low-density: almost one-third lighter than Douglas-fir and half the weight of oak. This means that while it is not particularly strong, it has very good strength-to-weight and so is very practical as cladding.

Softness
It is relatively straightforward to cut and work to a fine finish. Its low density contributes to its relatively high insulation value.

Sustainable
Several species are available from PEFC- and FSC-certified forests. Grown throughout the world, the timber is likely to be available from local sources.

Durability
The heartwood has superior resistance to decay and the oil in certain species repels insects. It provides a long-term solution – there are many examples of ancient buildings that prove its endurance. Where necessary, sapwood is treated with preservative.

CYPRESS FAMILY IN ARCHITECTURE AND CONSTRUCTION

While these timbers are used in a variety of applications, their long-established and varied role in construction warrants further discussion. It competes with several other species of softwood, including varieties of larch (page 310) and pine. It competes with hardwoods too, in particular oak (page 336) and iroko (page 366).

Planks are cut into profiles – there are countless standard shapes, or bespoke designs are made – for window frames, louvres, decking, fencing and cladding (overlapping slats are used in strip boat construction also). It is much less stiff than other timbers used for similar applications, but has superior resistance to decay. Therefore, it is mainly reserved for outward-facing surfaces. The timber is graded according to its visual quality.

Throughout the world it is used as roofing and siding material. Known as shingles, small neat tapered tiles are overlapped to provide protection from sun, rain and snow. They are known as shakes when produced from split timber. Being susceptible to fire and relatively expensive, they are not as common today as they have been in the past.

The ability of certain species to resist warping and cracking with changes in humidity is very important during production, as well as in use, especially because they are often manufactured in one climate and shipped to another. Planks are often shipped green (not dried) when used for outdoor applications. They are dried (naturally or using a kiln) to reduce their moisture content and improve stability where necessary.

Western red-cedar shiplap The curved profile of the London Olympic Velodrome, designed by Hopkins Architects and completed in 2011, is fabricated from overlapping strips of western red-cedar. The prefabricated panels span approximately 8 m (26 ft) between the steel (page 28) trusses. A smooth curve is maintained by dividing each panel into four parts. Strips of aluminium (page 42) conceal the end grain and provide a visually clean division between each facet. Louvre panels, fabricated from a different profile, provide ventilation. A coating of oil helps to preserve the colour of the wood and enhance its natural durability. Photo courtesy of Hopkins Architects.

Western red-cedar interior The National Assembly for Wales (also known as the Senedd) building was designed by Richard Rodgers Partnership and completed in 2005. The main funnel (known as the Oriel) and ceiling are clad with western red-cedar. Employing a bespoke assembly system, each panel consists of several strips held in place by concealed fixings. To accommodate the varying radius of the shape, each panel has a trapezoidal profile. The gently undulating tones of wood contribute to the interior's warm ambience.

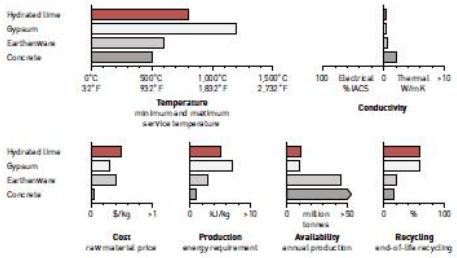
Plaster

Also known as
Also referred to as: plaster of Paris, render, mortar

Plaster enhances the durability and cleanliness of buildings, as well as providing a means of artistic expression. Based on clay or calcium minerals, it transforms from a wet and pliable material to stone-like when dry. It is an ancient medium – synonymous with sculpture, stucco and fresco – that has found modern application in the form of precision 3D printing.

Types	Typical Applications	Sustainability
• Clay • Lime • Gypsum	• Interior and exterior walls, and ceilings • Sculpture, model making and mold making • Medical casts	• Clay has the lowest impact; gypsum and lime have higher embodied energy • Widely available from local sources • Non-renewable
Properties	**Competing Materials**	**Costs**
• Gypsum is fast-setting and does not shrink or crack • Lime is strong with very good resistance to weathering	• Concrete and stone • Lining materials, such as paper and PVC	• Inexpensive raw materials • Straightforward to process

	σ_c (MPa)	%	E (GPa)	%	ρ (kg/m³)	%
Hydrated lime	5	1.0	3	1.0	480	1.0
Gypsum	9	0.8	5	0.9	1,130	0.7
EarthenWare clay (brick)	100	0.2	40	0.5	2,400	0.5
Concrete (12% cement)	30	0.4	20	0.6	2,450	0.4
Stone_marble	140	0.1	54	0.5	2,770	0.6



INTRODUCTION

Plaster is traditionally used to coat the walls and ceilings of buildings. As well as providing a smooth, clean surface, it enhances the durability of masonry (see Clay, page 480) and provides passive fire protection. It has been utilized in this way for thousands of years; pyramids built by the Egyptians more than 4,000 years ago feature plastered walls that remain intact to this day. The gypsum formulation used then is almost identical to modern plaster. The ancient Greeks continued the use of plaster and covered the inside and outside walls and ceilings of temples. They used plaster casting in the reproduction of sculpture and objects.

As well as providing a smooth covering for walls, plaster is molded and modelled into relief profiles. Known as stuccowork, it is used to decorate buildings as well as for free-standing sculpture. This practice has a long history in the Mediterranean and was employed extensively by the Greeks and Romans. It became popular in 18th-century Europe, as can be seen in many elaborately stuccoed monuments and terraced houses of major cities.

The original method of three-dimensional printing technology

Hand-modelled stucco
This stucco by architectural sculptor Geoffrey Preston is located in the dining hall of a new Palladian-style villa in Wiltshire, England, designed by George Saumarez Smith of Adam Architecture. They are a work of art, reflecting the Italian character of the house with long curling leaf forms reminiscent of Baroque and Rococo plasterwork. The four panels, each measuring 2.3 x 1.2 m (7.5 x 4 ft), took several months to complete. The stucco consists of a combination of lime, gypsum, aggregate and binder. This gives a putty-like consistency with just the right setting time for hand modelling. To achieve the deep profile each section was built up in layers: a core is laid down followed by a fine finishing coat. Photo by Nick Carter, courtesy of Geoffrey Preston.

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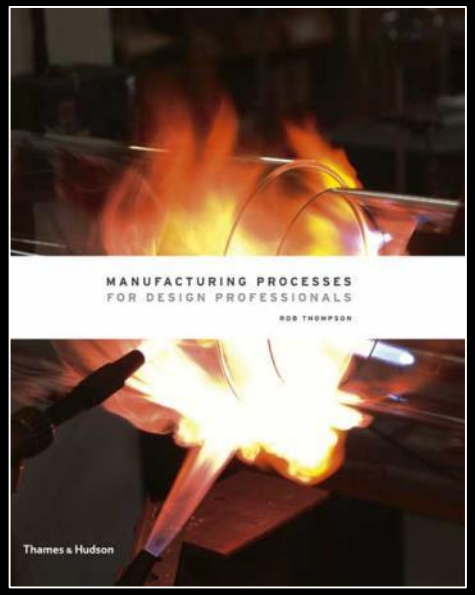

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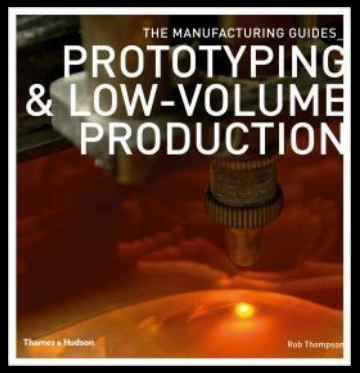

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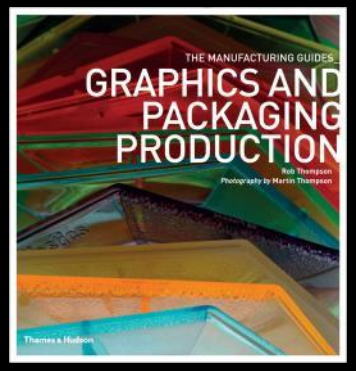

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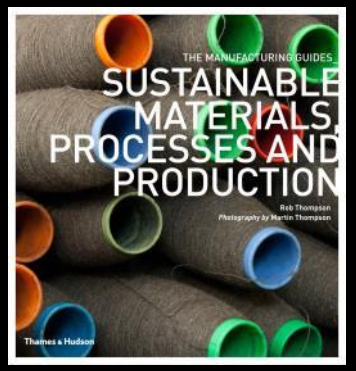

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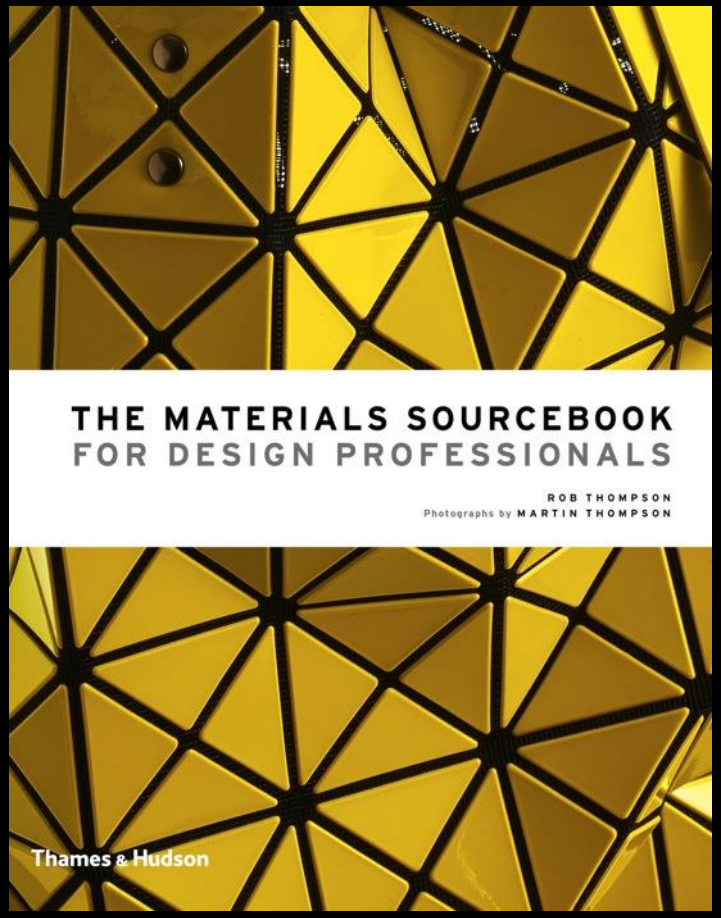

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