Construction materials in Australia

Introduction to construction materials in Australia

There is a wide range of possible building materials available for our use and the performance of these materials has an impact on the cost, aesthetics and function of the building. A well designed, economical building takes the following factors into account:

- the properties and behaviour of building materials
- the initial and long-term costs
- the effects on the environment
- how the materials interact with each other.

The following is a list of some of the more common building materials, and their applications:

<table>
<thead>
<tr>
<th>Material</th>
<th>Products and uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesives and joint fillers</td>
<td>For gluing, sealing and filling cracks and joints</td>
</tr>
<tr>
<td>Cement</td>
<td>For concrete slabs and other elements; concrete blocks; cement render on walls;</td>
</tr>
<tr>
<td></td>
<td>mortar for brickwork, blockwork and tiling; compressed cement sheets; Autoclaved</td>
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<tr>
<td></td>
<td>Aerated Concrete (AAC)</td>
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<tr>
<td>Clay</td>
<td>For bricks and tiles; mud bricks</td>
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<tr>
<td>Cloth</td>
<td>Canvas (for awnings, etc.)</td>
</tr>
<tr>
<td>Glass</td>
<td>For windows; skylights; doors; fibreglass insulation</td>
</tr>
<tr>
<td>Grasses</td>
<td>Straw (in mud bricks and rammed earth walls and in bales in straw bale constructions)</td>
</tr>
</tbody>
</table>
### Gypsum
For wet plaster on walls; grout between tiles; plasterboard

### Metals
- Timber fasteners (such as nails, screws, bolts, brackets, gang-nail plates)
- Steel (such as Zincalume® profile sheet steel, tanks, gutters, downpipes, wire and wire mesh)
- Structural steel (beams, columns, brackets and reinforcing)
- Copper (pipes and electrical wiring)
- Brass (taps, screws, door and window fittings)
- Aluminium (door and window frames, gutters, downpipes)

### Paper
Wallpaper, cellulose insulation

### Wool
Insulation

### Polyester
Insulation

### Plastics
For electrical fittings; paints; wastes, water and sewerage pipes; plastic sheets (such as moisture barriers)

### Soil
Rammed earth walls and floors

### Stone
Building blocks; slate roofs; aggregate in concrete; pebble finish on concrete; paving

### Timber
Floors; doors; window frames; weatherboards; roof, wall and floor framing; other structural components e.g. roof beams using LVL

Modern manufacturing processes have expanded the list of building materials. Building practitioners must be aware of many factors affecting the use of these materials.
Selection of building materials

Environmental factors
Many resources and raw materials such as rainforest timbers, fossil fuels, metals and stones are limited and non-renewable. It is important for building designers as specifiers and consumers to be aware of the implications of material selection for resource depletion and effects on the environment and our health. Where possible we should use renewable resources, such as timber from re-planting programs.

The 'energy content' or 'embodied energy' of building materials refers to the amount of energy used in extraction and production. Materials such as stone, timber or straw have a low energy content as they do not require a primary manufacturing process. Other materials require a lot of energy in their production, and therefore have a high energy content. These include for example; glass, bricks, plastics and metals. Selection of materials with a low energy content reduces the environmental impact of construction.

See the topic on energy efficiency for more information on environmental factors. You should have a good knowledge of the energy content of different building materials in order that you can make an assessment of a building’s compliance with sustainability and energy efficiency requirements.

Economic factors
The initial cost of building will depend almost entirely on the costs of materials and on the labour costs. The choice of materials should be based also on a consideration of the cost of repair, maintenance and replacement of short life-span products. Less durable materials may be cheap to buy, but maintenance, repair or replacement costs are usually high. The cost of maintenance such as painting should be considered.

Cheap materials usually lower the value of a building, whereas more durable materials, such as stone and brick, mellow with age and give the structure a more aesthetically pleasing appearance.

Physical factors
Materials have different characteristics, or properties. These properties are affected by physical, chemical and biological factors.

- **Density**—Different substances have different densities. For example, most timber floats in water because the timber is less dense than the water. Steel is obviously much denser than most timbers since it will definitely sink! More dense materials also have a higher thermal conductivity.
• **Strength** – A structure (e.g. a beam or a bridge) must be able to safely support its own weight plus the load it carries without distortion which will reduce the efficiency of the structure or make it break or look unattractive. A structure can be made much stronger without increasing its weight, by being made in a different shape. In the figure below, the steel beam A will be able to support more load than the steel beams B or C, even though they all contain the same amount of steel. Steel is strong under tension and will resist being stretched.

![Figure 1: Different shapes of steel elements](image)

Materials such as concrete, stone and brick strongly resist being squashed; i.e. they have compressive strength. The behaviour of concrete under pressure is illustrated in Figures 2 and 3. Concrete cracks easily when stretched. It has low tensile strength. By using steel reinforcing in concrete, we combine the tensile strength of steel with the compressive strength of concrete, resulting in a product that is strong in tension as well as being strong in compression.

![Figure 2: A concrete beam in bending. The top is in compression, the bottom is in tension. Concrete is weak in tension and will crack.](image)
A piece of 25 mm wide galvanised steel strap, which is often used in bracing timber frames, is very difficult to stretch, but crumples easily when compressed lengthways. It has high tensile strength and low compressive strength.

- **Thermal capacity** (thermal mass) – is the ability of a substance to store heat. A brick or a stone wall, for example, will heat up slowly, hold the heat and lose it slowly as the outside temperature drops. A thin, light wall, on the other hand, heats and cools quickly and does not provide a buffer to the climate. The choice of materials of various thermal capacities will depend on the type of climate and the building’s use.

- **Moisture Absorption** – porous materials will absorb moisture more readily than others. However, most materials may take up moisture from the air, from the ground (e.g. through damaged dampcourses), from damaged roofs or gutters, or by condensation.

- **Acoustic properties** – insulation from noise can be achieved by the use of dense materials. Some porous materials are used for modifying the acoustics in a room but sound can only be prevented from travelling from one space to another by the use of dense materials or a vacuum.
Performance of building materials

Building materials undergo changes over time and the following factors affect their performance.

Movement

- **Movement caused by applied loads** may occur due to error in structural design or from overloading e.g. when a beam sags under a too heavy load.
- **Temperature changes** cause thermal movement - expansion when heated and contraction when cooled. Movement joints are placed at recommended intervals to allow for thermal movement. If movement is restricted, such as in a long wall butted up to buildings at each end, the wall may distort, causing cracks, bulges or failure at weak points, such as over archways or doorways.
- **Change in the moisture content** of most materials will result in deformation: swelling when wet and shrinking when dry. These moisture movements can result in warping, twisting, shrinking or cracking. Materials such as most timbers require surface treatment to prevent moisture absorption.

Durability

Durability will be dependent on exposure, but direct and indirect causes of deterioration include the following.

- **Sunlight** causes drying and cracking of timbers and fading of colours and pigments. Heating of dark coloured materials can greatly speed up their breakdown and ultraviolet radiation causes breakdown of clear finishes, stains, paints, rubber, some plastics, tars and bitumen, fabrics and canvas. Metals, bricks and stone are largely unaffected by sunlight.
- **Biological agents**—bacteria in the soil breaks down sulfur chemicals which cause corrosion of metals such as iron, steel and lead. Tree roots and vines growing in cracks exert a very strong and destructive force, expanding cracks in masonry, pipes, concrete or timber. Porous materials can also hold moisture, encouraging the growth of mould and fungi. Insects such as termites can be very destructive to timber, eating out the inside undetected.
- **Water and Frost**—selection of materials for use in damp areas requires careful consideration. Timber, particleboards, hardboards and other similar wood products lose some of their strength, and many flooring materials are less hardwearing when wet. Water can encourage fungal attack and certain destructive chemical reactions. Repeated wetting and drying causes surface crazing and cracking of timbers. Uneven drying of brickwork can cause uneven movements within the wall. Water also
often carries destructive acids, salts and other soluble chemicals. Water expands when frozen causing further problems.

- **Salt crystallisation**—Salts dissolved in water can come from the sea, the ground and from some building materials. As moisture evaporates from a surface, the salts are left behind in the form of powder or crystals, called efflorescence. Sometimes this is just an unattractive coating, usually white, but sometimes yellow, green or brown. However, it can be destructive if allowed to persist for a long time.

- **Chemical action**—Chemical reactions in materials can cause swelling, shrinking, weakness or damaged appearance due to chemical changes within the material itself, or changes brought on by attack from outside chemicals. Heat and moisture aid most reactions.

- **Abrasion and impact**—In situations of abnormal impact or abrasion, suitable materials and finishes need to be chosen. For example a concrete path or floor that will take heavy traffic requires correct concreting techniques to be followed so as to produce a hard, durable surface.

- **Vibration**—caused by proximity to machinery or heavy vehicular traffic can cause problems in light construction and with brittle materials.

### Fire Resistance

Fire is usually the fastest, most destructive and dangerous way in which a building can be damaged or destroyed. It is a very important consideration for building design.

The Building Code of Australia and Australian Standards provide legislative requirements and guidance for minimising fire hazards in public or private buildings. Fire resistance ratings of materials are determined by laboratory tests. The ratings indicate the time before a material fails in a fire.

In a fire, materials may melt, burn, weaken, expand, shrink, crack or give off toxic fumes. Flame and building collapse cause injury and death, however, smoke and gases are equally dangerous (even when flames are not present), causing confusion, unconsciousness, panic, loss of vision and asphyxiation. Solids can smoulder in a confined space for a long time on only one-third of their normal oxygen supply and then, on the sudden entry of air (a door being opened for example), burst explosively into flame.

### Combustibility

Materials that ignite, give off flammable gasses or show considerable self-heating when exposed to a heat source in a furnace, are combustible.

Non-combustible materials, do not feed a fire, and flame does not spread over them. Non-combustibility does not mean fire resistance. Non-combustible materials (such as steel) may expand and disturb attached structures, or lose strength and collapse, or others may spall
(flake) and shrink or crack (such as concrete). On the other hand, some combustible materials (such as timber) can often provide a useful degree of fire resistance by charring on the outside only.

Fire resistance is expressed as the time in hours and minutes a component survives a fire test of set temperature before it can no longer perform its function. It is considered to fail the test when any of the following occur:

- It collapses
- It forms holes or cracks through which flame can pass
- It gets hot enough to ignite other combustible materials it is in contact with and which the fire hasn’t yet reached.

Fire Performance of Materials

**Timber**

Timber easily ignites at about 221 - 298 °C. However, some timber (particularly large cross sections, at least 100 x 75 mm) is resistant to the fire once the surface has been charred. Many Australian hardwoods have this characteristic and have proved to be more fire resistant in buildings than steel. However, all timbers do burn readily if temperatures stay high enough; therefore timber buildings are not classified as fire resistant. Timber has good thermal insulation, preventing materials not in contact with the fire from heating up to extreme temperatures. When hot, timber does not expand in length (unlike steel) and neither does it markedly lose strength. Laminated timber structures glued with synthetic resins have similar fire resistance to solid timber, although resistance will vary according to the type of timbers and glues.

**Stone**

Stone blocks and slabs are usually satisfactory in fires, but overhanging features and lintels are liable to fail. Free quartz (e.g. in granites) explodes suddenly at 575 °C and should not be present in any stone that is required to be fire resistant. Sandstones behave better than granite, but in drying they may shrink and crack, with 30-50% loss of strength.

**Plastics**

Although many plastics are made in fire-retardant grades, all are combustible and some give off large quantities of toxic smoke. PVC melts at fairly low temperatures, and most thermoplastics (plastics that can be heated and shaped) char above 400 °C and burn at 700-900 °C.
**Clay Products**

Most clay products perform well in fires, having been made at kiln temperatures higher than most fires reach. Brickwork failure is often caused by expansion of enclosed or adjoining steel work.

**Concrete**

Ordinary Portland cement concrete disintegrates at 400-500 °C. However, concrete performance depends greatly on the presence of reinforcement and the type of aggregate it contains.

**Metals**

Metals used in building are non-combustible, but they lose strength when heated. Aluminium, lead and zinc melt in building fire temperatures. The expansion of hot metals can cause problems, and also the high thermal conductivity of metals means that the temperature of surfaces remote from a source of heat will approach the temperatures near the fire, causing fires to spread.

**Steel**

Mild steel behaves in an interesting way when heated. Up to 250 °C, it gains strength then gradually returns to normal strength by 400 °C. After that, it rapidly weakens so that, at 550 °C (referred to as the critical temperature), it begins to fail. Generally structural steelwork must be protected with fire-resistant encasements such as concrete or brickwork.

**Glass**

Although glass is non-combustible, it readily transmits heat and often shatters unpredictably at an early stage in a fire. Toughened glass is not fire-resistant.

**Glass fibre and Rockwool**

Resin-bonded glass fibres are combustible. Glass fibres themselves melt at about 600 °C.

**Fibrous Cement**

This material tends to shatter when heated, sometimes explosively. It does not contribute to making a fire-resistant structure.

**Paints**

Generally paint films are combustible, emit toxic smoke, and may help spread flame over surfaces. However, as they are thin, they only contribute a small amount to the fire load. When applied to combustible materials, certain paints can reduce the spread of flames. They delay but never prevent the spread of flame.
Compatibility of materials

The large range of new materials on the market today, many of which are chemically based, plus widespread pollution, has led to new chemical and physical problems with materials. A material may break down many times faster than normal in the presence of another particular substance. Problems do not always show up until a product has been on the market for a number of years. Incompatibility of building materials can be grouped roughly under the following headings:

- corrosion of metals
- stains and discolouring effects
- problems with surface finishes
- chemical reaction between materials.

Corrosion of metals

Galvanic reactions: These occur between metals that have different levels of electronegativity. This is often seen as corrosion of one metal or a deposition of metal scale on the other metal. Offcuts or filings of metals left around in moisture can cause rapid destruction of nearby metal building components. Some common galvanic reactions are listed below.

- Lead used with zinc or aluminium promotes corrosion. Therefore, metal roof-flashings need to be carefully chosen.
- Steel screws or nails should not be used with aluminium or zinc roofing, unless they are zinc or cadmium coated.
- Copper should not touch or drain onto zinc, aluminium, Zincalume® or galvanised materials.
- Lead-based or graphite paints should not be used on aluminium.

Water–metal corrosion: Most iron or steel rusts on contact with air and moisture. Protection is provided by galvanising or coating with zinc, aluminium or PVC plastic.

Galvanised pipes: For water supplies these are reasonably durable where water is hard or not acidic. But if water is low to moderately hard, corrosion occurs quite rapidly at joints with brass or other copper alloys. This can be reduced with effective diameter pipes, and eliminated with plastic connectors.

As heat speeds up corrosion, different metals should not be mixed in hot water systems.

Copper and brass are permanently resistant to water.

Aluminium: This becomes encrusted in coastal atmospheres. Mortar, cement or concrete pit the surface of aluminium if splashed on it.
Industrial atmospheres: These are usually acidic and corrode all metals.

Stains and discolouring effects

Copper: Water dripping off copper causes green stains.

Rust: Water running off exposed iron or steel will stain surrounding surfaces.

Eucalypt timbers: When wet, many eucalypt timbers produce brown stains on masonry.

Efflorescent salts: When these move through porous brick, stone, mortar or concrete, they cause surface crusts called efflorescence.

Problems with surface finishes

When finishes won't stick to the surface they are applied to, it is usually due to the two being unsuitable for each other. The surface may either be too smooth or it may be powdery or flaky; or there might be a chemical incompatibility between the surface and the finish. This will be dealt with in more detail in the unit on paints but a few special points are:

- Many silicone sealants will not accept paint.
- Acid-resisting grouts (for floor-tiles) cannot be satisfactorily cleaned from the tile surface.
- Primers, undercoats, finish paints, lacquers, varnishes and stains should all be used according to manufacturers' instructions as many are incompatible with certain materials.

Chemical reactions between materials

Salt: This is highly corrosive to iron and steel. Porous masonry and ceramics (such as some stone, brick, terracotta and concrete) can be severely affected by salt penetration.

Milk: Milk contains lactic acid, which is very destructive to concrete in dairies and special surface treatment is needed.

Ammonia: Ammonia, present in some adhesives, can damage copper and brass.

Lead and galvanised steel: These metals will corrode in wet conditions when in contact with cement mortar or concrete.
Testing of materials

The testing of materials is carried out by the manufacturer or supplier before delivery (e.g. stress testing of timber). Upon delivery, an inspection should be carried out with respect to the quality and suitability for the construction situation intended.

Concrete is one material which is tested on site (the slump test), and later laboratory tested for compressive strength at 28 days. Materials such as paints, adhesives, glass and the like have been developed and trialed under strict laboratory controls and conform to Australian Standards.

You as the building designer need to be informed of all the information relating to products specified.

Tolerances

All building work in Australia is covered by the Building Code of Australia and many Australian Standards. These standards have been developed for most building materials and detail tolerances, application, testing (if applicable) and method of installation. These tolerances should be followed and best industry practice adhered to.

Handling and Storage of Materials

Storage and handling of materials on site is important as many materials are easily damaged if due care is not taken in handling, and some can deteriorate if exposed to moisture and direct sunlight.

Materials should be stored in accordance with manufacturers' instructions; for example, stacked flat, off the ground, in a dry area or in a secure area for flammable or toxic materials. When handling materials on site, safe working practices must be followed and all WHS regulations implemented.