New age of building materials

With a global impetus to reduce carbon emissions, scientists and manufacturers are working to develop more environmentally friendly building materials. Some are already in production, others still in the lab.

BY DAEI CLIMO, BUILD DEPUTY EDITOR

A NEW GENERATION of building materials is complementing and sometimes replacing the traditional choices of brick, concrete, timber, steel and glass. Some materials are being re-engineered to make them stronger, self-sustaining, more versatile and easier on the environment.

Environmental concerns a driver

Simultaneously, new materials are under development that will allow engineers and architects to take buildings places that were previously aesthetically and structurally unachievable.

Buildings are responsible for a hefty slice of carbon emissions when the whole life cycle of a building, including the materials used in construction, is considered.

New climate-friendly materials are needed to help achieve the net-zero emissions of greenhouse gases by 2050 that 77 countries, including New Zealand, signed up to in the Paris Agreement in 2016. In November 2019, New Zealand also passed the Zero Carbon Bill to reduce greenhouse gas emissions to a near-neutral level by 2050.

Greener, stronger concrete

The most popular manufactured building material is concrete, which forms the backbone of most modern commercial buildings.

While strong, durable, fire-resistant and good at storing heat, during production, it emits significant quantities of greenhouse gases.

New forms of concrete that are kinder to the environment are being developed that reduce and even eliminate the use of cement, as well as new concrete types that combat common problems such as cracking.

Alternative to Portland cement

Concrete that absorbs carbon dioxide as it hardens has been developed by Novacem in the UK and Solidia Technologies in the US using an alternative to ordinary Portland cement (OPC).
Instead of the industry standard OPC, magnesium silicates are used, forming bonds between particles that are stronger than those in OPC and resulting in 30% less carbon emissions.

Self-healing concrete
A common problem with concrete is its vulnerability to cracking. This accelerates a structure’s degradation, increases maintenance costs and, in severe cases, can lead to structural failure. Scientists and manufacturers around the world are working to find a solution to this.

At the University of Waikato, a new process to allow materials to heal themselves, using concrete as a medium, has been developed. A kind of bio-concrete has been developed by introducing microorganisms and nutrients into the initial mix to create calcium carbonate when cracking occurs. Calcium carbonate crystallises to produce elements such as chalk, shell and rock. In this process, it fills the cracks as they appear.

In Holland, Dutch biotech company Green Basilik has developed a process to embed special limestone-producing bacteria into concrete. The bacterial spores are able to endure heat, drought and cold for years inside the concrete. When a crack occurs, moisture entering the crack activates the spores, causing microorganisms to grow. Chemicals in the concrete such as calcium and nitrate and the activated bacteria turn these into limestone that seals the crack.

Self-healing concrete cuts maintenance costs and has a positive environmental effect by reducing the amount of concrete work required.

Graphene-enhanced concrete
Graphene, a material composed of a one-atom-thick sheet of linked carbon atoms, has been used in a new type of concrete that is much stronger, water-resistant and more environmentally friendly.

Graphene-enhanced concrete has a 146% increase in compressive strength compared to regular concrete, a 79.5% increase in flexural strength and a decrease in water permeability of almost 400%. This meets British and European construction standards.

The increased strength and water resistance should allow structures made with the concrete to last much longer. Building elements will not need repairing and replacing so frequently, reducing a building’s carbon footprint.

Engineered timber
Recent developments in engineered wood products such as cross-laminated timber (CLT), laminated veneer lumber (LVL) and glued laminated timber (glulam) are the big story in timber building materials due to their strength and versatility.

Tools such as the free BRANZ CO2NSTRUCT provide values for embodied greenhouse gas and energy for construction materials in New Zealand. Construction company Naylor Love has also developed a calculator that quantifies the amount of carbon in building structures using different materials. It has found that engineered timber reduces carbon emissions by up to 90%.

The low environmental impact of engineered wood has seen a surge in the number of timber high-rise builds globally. The tallest,
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the recently completed 85.4 m high Mjøstårnet building, is in Brumunddal, Norway. Built entirely of timber, the building has lift shafts made from CLT and columns made from glulam. CLT and glulam are strong enough to support large loads, and using timber means the carbon absorbed from the atmosphere by the trees is locked into the structure permanently.

New look for glass
Glass windows and walls are another area where scientists have been developing new products that address the perennial problem of heat loss through windows. A pane of glass, for example, can lose or gain up to 10 times the amount of heat of the same sized wall area.

Smart windows
US company View has developed so-called smart glass that promises energy savings. Its windows use electrochromic technology to control light levels, eliminating the need for blinds and curtains.
Over the lifetime of the windows, it is estimated energy use is reduced by 20% while worker productivity is said to increase by around 2%. View’s windows have been installed in over 200 commercial buildings in the US.

Bendable glass
In Germany, researchers at the Fraunhofer Institute have developed glass that can be bent to form angular corners as an integral part of a single sheet of glass without affecting the optical properties of the glass.

Glass made from wood
Researchers from KTH Royal Institute of Technology in Sweden have developed a window material made of wood that regulates how much heat is let in and out. While still at the development stage, the see-through wood technology answers the need for functional loadbearing materials that can cut energy consumption by storing and releasing large amounts of thermal energy.
In winter, the material provides better thermal insulation to reduce heat loss. In warm weather, the transparent wood can be tuned to allow a set amount of heat to pass through, maintaining a comfortable indoor temperature.
The material is opaque, similar to a frosted window, but becomes clearer as it stores more heat.

Paints, plastics and more
Exciting developments, some employing high-tech materials, are also being seen in a raft of other products. While many may never make it out of the lab, others are already on the market:
- Paint that senses cracks in a structure - conductive paint is layered over the top of electrodes placed around the skin of a building. A current is run through the electrodes in different combinations to work out if, and where, the electrical potential has changed.
- Hydro-ceramic bricks - these have a clay or concrete shell to give the appearance of a brick but are filled with hydrogel that absorbs and sheds water up to 500 times its own weight. This water cools the interior of the building through evaporation. Tests at the Institute of Advanced Architecture of Catalonia where the bricks are being developed show hydro-ceramic bricks can lower interior temperatures by up to 6°C.
- Strand Rod - carbon fibre is used in a reinforcement material called Cabkoma that is five times lighter than metal, is aesthetically appealing and protects buildings during earthquakes. Carbon fibre has a very high tensile strength, and unlike rigid rods that require drilling for installation, the Strand Rod is a flexible, thin band secured using screws and an adhesive. It works in the same way as the traditional brace and bolt, but instead of anchoring the building’s walls to its foundation, it tethers the roof of the structure to the ground. When an earthquake strikes, the entire building moves together. Japanese company Komatsu Seiten Fabric Laboratory developed the material, and it is used on the exterior of its head office.