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Straw-inspiring: houses made of the humble bale

As a building material, the food byproduct is highly insulating, enduring and carbon-friendly

© Edward Caldwell / Watershed Straw Bale Residence, California

Architecture

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Paul Miles 7 HOURS AGO

Humanity has reached a milestone. There is now more weight of man-made stuff on the planet than the total mass of all living organisms, from plankton to whales, estimated by scientists at Israel's Weizmann Institute of Science to be 1.1tn tonnes. If we keep on at this rate, the weight of things such as infrastructure, houses, phones and plastic bottles will be triple the biomass on earth by 2040. Most of this manufactured mass is concrete.

The construction industry is responsible for nearly 40 per cent of global carbon emissions, according to the International Energy Agency. There has rightly been a lot of attention directed at reducing operational emissions of a building, by lowering the use of fossil fuels through rigorous ultra-low energy Passivhaus standards, for example.

Yet there has arguably been less attention paid to embodied carbon: the emissions produced in the mining, manufacture, transport and assembly of the likes of concrete, glass and steel. But there are many building materials that don't need mining; they grow naturally.

Governments worldwide are beginning to legislate on embodied carbon. The Netherlands has been a pioneer since 2013 with mandatory "lifecycle assessments" that address environmental impacts — including embodied carbon — of proposed developments over 100 square metres. In July this year, Colorado passed a bill intended to minimise embodied carbon in new public buildings and roads.

In the UK, an amendment to building regulations has been drafted by architects and members of the construction industry. "Part Z" would limit the embodied carbon of major building projects. The proposal has widespread industry support.

etail of the Watershed Straw Bale Residence, Sonoma County, California, by Arkin Tilt Architects © Edward Caldwell

One of the rooms at Watershed under construction

On a smaller, homely scale, what can we do? Instead of constructing houses with bricks — the manufacture of four pallets of which results in about one tonne of carbon emissions (even more if the bricks are imported long distances, for example to the UK from Asia, as an estimated 25m are

annually) — we could build with materials that pull carbon out of the air.

Plants are one of the oldest building materials in the world — straw, a byproduct of food production — has one of the lowest embodied carbon levels of any building material. While one cubic metre of concrete is responsible for 246kg of carbon dioxide emissions, the same volume of straw, suitable for use in construction, has locked up 129kg of the gas.

Straw is also long-lasting. A building that is believed to be the world's oldest surviving straw bale home was built in 1903 in the US. Today, the US has some of the largest contemporary straw bale homes in the world, making use of the byproduct of a variety of local crops.

"We have designed and built homes of rice straw in California, oat straw in Alaska, rye straw in Oregon and wheat straw in Colorado," says Anni Tilt of California-based Arkin Tilt Architects, which specialises in straw bale and rammed earth construction.

Over more than 20 years, the practice has built nearly 50 homes. Rather than quirky hobbit structures that many associate with straw bale construction, some of the sprawling properties designed by Arkin Tilt are sleek, expensive-looking homes.

"There's renewed interest in straw building due to the potential for carbon storing inherent in rapidly renewable bio-based building materials," says Tilt. "The building of structures can be part of the climate solution rather than part of the problem."

Rosenburg/Zuckerman residence, San Francisco (Arkin Tilt) © Edward Caldwell

There are three main types of construction with straw, says Barbara Jones, a veteran straw bale builder and director of the School of Natural Building.

Load-bearing straw bale, known as Nebraska style, began in the US in the 19th century. In this method, compacted straw bales, with a density of 120kg per cubic metre — one and a half times more dense than an average bale off the farm — are used as "bricks" laid one on the other, held in place solely by the weight of the roof. The walls are sometimes shaped and tidied with a chainsaw before being plastered or clad inside and out.

"Two and a half storeys is as high as has been achieved with load-bearing straw bale," says Jones. "Compacted straw bales are very stable." Research by Pete Walker at the University of Bath has shown that one metre of wall can bear at least one tonne of weight. "There's no reason why you

shouldn't be able to build higher [than 2.5 storeys] but it's not been tested," Jones says.

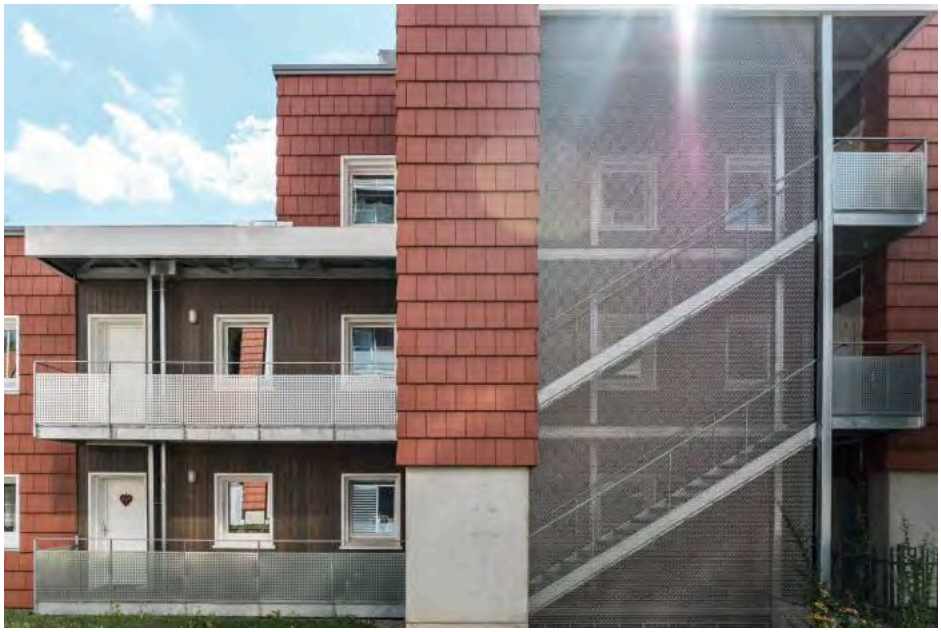
Europe's first two-storey load-bearing straw bale property — on the west coast of Ireland — was completed in 2003, using the labour of more than 100 volunteers, most of whom had no previous building experience.

"Load-bearing straw bale building is quite labour-intensive and often involves volunteer labour from friends and family," says Jones. As for longevity, "we build to a design standard of 200 years, anything less is unsustainable," she says. "The most important thing [to ensure a house endures] is that the straw is very dry [to prevent it decaying] and also very dense," says Jones. "If later in the home's life, you want to put in a new window or door, you simply cut out a hole with a chainsaw," she says.

A newer method of straw construction is to build a wooden frame and infill it with straw bales. In the UK, one example is Leyburn in Yorkshire by architects Halliday Clark. Completed in 2017, this handsome home clad in reclaimed limestone was the world's first straw bale building to achieve the Passivhaus Plus standard (Passivhaus standard with additional on-site renewable energy, usually solar panels), thanks in part to the highly insulating properties of thick straw walls.

In France, a seven-storey block of flats has been constructed in a similar way, the straw bales squeezed into individual timber *caissons* before being installed in an engineered timber frame. The 26-apartment block Jules Ferry residence in Saint-Dié-des-Vosges was completed in 2013 at a cost of about €1,800 per sq m after tax, about 15 per cent more than a conventional build.

According to architect Antoine Pagnoux of ASP Architecture, this premium is soon offset by small energy bills. A similar 10-storey straw bale and timber tower block is presently under construction.



Seven-storey straw bale Jules Ferry apartment block, Saint-Diédes-Vosges, France (ASP Architecture) © Arthur Janin

"France is at least 10 years ahead of the UK in straw bale building," says Jones. "They have the land, the straw, the farming co-ops and the political framework. People see what straw buildings are like and want to live in them. If we're to build affordable, high-quality straw houses for ordinary people here in the UK, the way forward is the newest method of construction: prefabricated panels filled with compressed straw."

EcoCocon began production of its prefab panels in 2008 in Lithuania. The structural panels have wood fibre board on the exterior and an interior of compressed straw that can be plastered.

“A two-storey house can be erected in two days,” says chief executive Bjorn Kierulf. So far 32,000 sq m of walling — equating to some 260 homes — has been constructed using EcoCocon panels, mostly in Europe. One sq m panel contains 48kg of straw and has sequestered 97kg of CO2, says Kierulf.

“Even taking into account the transport emissions to deliver the panels, an EcoCocon home will be significantly carbon negative,” he says. The highest building so far is three storeys “but five or six is possible”.

The panels meet stringent EU fire regulations, resisting burning for 120 minutes at temperatures of over 1,000C. “Compacted straw just chars on the outside,” says Kierulf. “There isn’t enough air for a fire to take hold.”

Old Holloway Passivhaus, (George Mikurcik), Herefordshire, UK, using prefab straw panels by EcoCocon

The fear of fire, even if unfounded, is a hurdle in the UK. “After the Grenfell tragedy, insurers are jumpy about anything that is different,” says Jones. There are estimated to be just 10 homes built of EcoCocon panels in the UK.

The company is now expanding, opening a second production unit in Slovakia. There are plans for at least 10 more across Europe in the next decade. “The main problem for scaling up is storage of straw,” says Kierulf. “There’s plenty of material — in Europe 48m tonnes of straw annually could be used without degrading the soil — but we need lots of storage to keep it dry.”

Another company producing straw-filled panels is UK-based Modcell. These panels differ from EcoCocon in that they are manufactured from whole straw bales in a temporary production unit near the building site.

Fifteen one- and two-bedroom homes constructed of the straw, timber and strawboard structural panels will be placed atop the office block of homeless charity Emmaus in Bristol. They are expected to be completed next year.

Straw and timber unit built by Agile Homes using Modcell panels

In 2016, the world's first straw homes to sell on the open market went on sale near Bristol. The seven homes of Modcell straw bale and timber panels clad with bricks (to satisfy council planning requirements) have solar panels and air-source heat pumps.

"They attracted lots of attention and all sold on day one," says Modcell founder, Craig White.

Research continues on the potential of new straw crops. The Institute of Biological, Environmental and Rural Sciences (IBERS) at the University of Aberystwyth has studied elephant grass (miscanthus) which grows prolifically even on poor-quality land. Unlike cereal crops, miscanthus doesn't need to be sown annually, thus minimising carbon emissions from ploughing and soil degradation. IBERS helped with the construction of the world's first miscanthus bale house in 2017.

"After COP26, with everyone talking about decarbonising, building with straw is the way to go," says White. "[Building with plants] is 'carbon capture and storage' in the built environment. The best thing you can do with carbon is to build with it."

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