Technology for architects keen on low-energy design

Rammed earth is going mainstream as a result of its insulation and sustainability properties.

There's no shortage of smart technology for architects keen on low-energy design. Glass-covered Trombe walls, brises soleils and innumerable permutations of highly insulated curtain wall are today's mainstream technology. But how much of this innovation is just a solution looking for a problem? Are complex multi-layered building envelopes really more effective at temperature and energy control than a basic mud hut?

Proponents of rammed wall construction would argue the toss. They would point out that earth is free, earth is plentiful, and when compressed it has excellent thermal and acoustic insulation properties. All one has to do is excavate the soil, add a chemical stabiliser such as lime or sugar paste, compact the earth between wooden formers, and hey presto, you have a durable, strong and highly insulated wall.

The build process is simplicity itself. The selected soil is mixed to the right consistency, then compacted in layers using hand tools. Formers are used to act as a mould for the wall. Other materials can be added to improve compaction, such as ground glass, shredded rubber tyres or natural fibres. Once the wall has been constructed, the formers can be removed. The wall is immediately ready to take structural loads.

Rammed earth walls used as internal partitioning can also suppress noise transfer between rooms very effectively.

At the Eden Centre in Cornwall, the walls of the visitors' centre were built from earth excavated on site. The soil was compacted by hand to form 40 panels, each 2.5m high and weighing around 10 tonnes. The walls were strong enough to support themselves without reinforcement on the day they were built, and to support the roof loads of the centre.

But while it's not surprising to find rammed earth walls at beacons of sustainability such as the Eden Project, the technology is also turning mainstream. Newcastle based architect Jane Darbyshire & David Kendall (JDDK) has designed Europe's largest internal rammed earth wall for the Rivergreen Business Centre at Aykley Heads in Durham.

Interestingly, the decision to create a rammed earth wall in the Aykley Heads project was driven by the client, Rivergreen Developments. The company had seen an earth wall at the Autonomous Environmental Information Centre (AtEIC) project at the Centre for Alternative Technology in Powys, and was keen to try the technique as part of its commitment to sustainable construction.

"We visited the AtEIC project with the client and were very impressed with the thermal and aesthetic qualities of the rammed earth wall," said JDDK's project architect Ruth Walters. "Although we didn't have any experience with the technology, the client was willing to take the risk. We also worked with consultants experienced in designing and building rammed earth walls."

The 6m-high, 600mm-thick rammed earth wall brings environmental benefits, because it uses natural materials readily available on site; and performance benefits because it offers a relatively cheap and simple method of creating a high thermal mass within the building

to even out swings in temperature. It is also believed to help control moisture in the building.

The wall has been constructed in six separate panels inside the atrium of the 3,700sq m, two-storey, timber-framed building. Being south-facing and subject to direct solar gain, the wall absorbs the sun's energy during the day and releases it at night and early morning to preheat the adjacent offices prior to occupation.

The rammed earth wall is the most innovative of the building's sustainable features, which include space heating provided by a biomass boiler fed with wood pellets, and collecting rainwater for toilet flushing and irrigating the building's sedum roof. These helped it achieve an "excellent" Breeam rating.

Approximately 80% of the material used in the wall's construction is fine sand obtained from the basement excavation. The remainder consists of gravels and clay from local quarries. The success of the method depends upon the proportions of the mix and the overall moisture content, which will be unique to every wall.

Since there is no firing process and no toxic emissions, the amount of CO2 emitted depends solely on the transport requirements for additional materials, such as clay and chemical stabilisers. The Aykley Heads wall used 60% site material, with the remaining 40% transported in.

For the project, JDDK commissioned Bath University's Department of Architecture & Civil Engineering to develop the optimum blend of clay, sand and gravel and advise on improvements to the soil to improve compaction and cohesion. The team constructed sample panels to check stress resistance. JDDK's Walters feels this was a crucial step. "We would stress the importance of getting sample panels made and testing them for their aesthetics as well as their durability," she says.

Following its success at the Aykley Heads centre, JDDK Architects has since specified an external rammed earth wall for the £4.1 million Wild Bird Discovery Centre on Teesside.

"The main risk is to do with controlling the shrinkage of the wall," says Walters. "At Aykley Heads we were able to build in a controlled environment - it's much easier to build internally. But we still made the wall in six separate panels, with expansion joints between them."

Other downsides of rammed earth construction include a lack of national guidelines for design and construction, higher labour costs for the compacting process, and limited data on the materials' physical characteristics. There is no shortage of guidelines for hot countries such as Australia, but very few in the UK.

The most recent guidance is a BRE book Rammed Earth: Design and Construction Guidelines published last year. It gives practical advice on the material selection, construction, design, detailing, maintenance and repair of rammed earth walls.

JDDK relied heavily on Simmonds Mills, a Hereford-based firm which acted as the rammed earth consultant for the AtEIC project and led the team that constructed the walls. At Aykley Heads, it advised JDDK on soil types, shuttering and construction methods, and trained the construction operatives in earth-ramming techniques.

In common with many construction materials, the thermal performance of a rammed earth wall depends on its density, porosity and water content. Rammed earth walls between 1,400 and 1,800 kg/cu m can have thermal conductivity U-values of 0·7 to 0·9W/sqmK. As a comparison, the CIBSE Guide quotes thermal conductivity of 0·51W/sqmK at 1,400 kg and 0·87W/sqmK at 1,800 kg for homogenous masonry.

Allowing for normal internal and external surface resistances, and assuming the wall will be rendered and plastered, a nominal wall thickness of 2m may be needed to achieve a U-value of 0·35W/sqmK. Additional insulation is likely to be needed where rammed earth walls are used externally. Insulation would be best placed on the external elevation, leaving the internal spaces to take advantage of the wall's thermal mass.

Essentially, any finish that can be applied to brick or concrete can be applied to a rammed earth wall, such as tiling, rendering, lime washes, pebbly finishes or a clear coating of silicon emulsion to seal the earth. Environmentally friendly surface treatments include boiled vegetable extracts.

Undoubtedly rammed walls are a worthy contribution to sustainable architecture, but their use will not outweigh the energy used by conventional gas-fired heating or electrically powered ventilation. Architects seeking to reduce carbon dioxide emissions need to approach rammed earth walls as part of a wider strategy to reduce CO2 emissions. One thing they must not become is lipstick on the gorilla.

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