Building blocks for more affordable and sustainable homes

A Ugandan NGO and a UK research scientist are collaborating on a project to use waste material produced after harvesting rice, to reduce the financial and environmental costs of manufacturing building blocks for constructing homes. The potential for using rice husk ash in future cement manufacture will also be investigated.

This project is supported by the BRE Trust sponsored 2018 Royal Charter International Research Award for Young Constructors, awarded to Alastair Marsh of the University of Leeds.

The need for affordable, sustainable homes

The huge global need for affordable and sustainable housing can be particularly acute in developing nations where there is rapid population growth. In Uganda for example (the population of which is predicted to more than double by 2050), this has led to an increasing demand for fired-clay brick housing, which can offer a better quality of life than traditional mud and thatch homes, but at a far higher environmental and financial cost.

Meeting the huge global housing demand requires affordable and sustainable building materials.
(Image courtesy of HYT Uganda)

With the rapid deforestation that results from gathering firewood for fuelling brick kilns, and CO_2 emissions from the firing process, fired-clay bricks do not provide the sustainable building blocks needed to meet Uganda's urgent housing requirements.

An effective alternative

Cement-stabilised earth blocks are an increasingly popular alternative to fired bricks. These building blocks are made by mixing sub-soil with a small amount of Portland cement (typically 6 % by weight), which gives the blocks the durability they need, for example, to be resilient in wet conditions.

Compacted in a manual press and cured in atmospheric conditions, they have lower environmental and financial costs than fired-clay bricks and can be used for a variety of buildings including schools, water tanks and housing.

Cement-stabilised earth blocks have lower financial and environmental costs than fired clay bricks.
(Image courtesy of HYT Uganda)

Given the huge quantities of building blocks needed to meet housing demands in Uganda and countries around the world, further reducing costs and enhancing sustainability could bring enormous benefits. Although Portland cement is the minor component, it dominates the cost and environmental impact of cement-stabilised earth blocks (CSEB). Finding ways of reducing the cement content – whilst maintaining durability and quality – could further improve the affordability and environmental performance of CSEB.

Promising laboratory studies

Recent laboratory studies have explored the use of rice husk ash – left when the waste rice husks are burnt following the rice harvest – as a supplementary cementitious material. These have shown there is potential for rice husk ash to partly replace cement in CSEB – reducing its cost and environmental impact, and making valuable use of what is otherwise a waste material.

Cement-stabilised earth blocks are compacted in a manual press and cured in atmospheric conditions. (Image courtesy of HYT Uganda)

Rice is an increasingly important cash and food crop in a number of countries, including Uganda where the rice husks are either discarded or burnt in incinerators to generate heat – producing ash waste. Field research is now needed to transfer the laboratory findings into the manufacture of a more efficient CSEB product.

A field research opportunity

The charity organisation HYT Uganda, trains young Ugandans in the manufacture and use of cement-stabilised earth blocks. This gives them construction skills that improve their opportunities, while also providing a low-cost, carbon-saving alternative to the environmentally damaging fired brick. For this work, HYT Uganda won the International Ashden Award for Sustainable Buildings in 2017. Leeds University research scientist, Dr Alastair Marsh, an expert in the chemistry of earth construction, was approached by HYT Uganda for advice on how to reduce the quantities of cement in their CSEB products.

Alastair Marsh (right) being presented with the Royal Charter International Research Award for Young Constructors.

Recognising an opportunity to both field-test the use of rice husk ash and support HYT Uganda's important work, Alastair Marsh developed a research proposal and submitted it to the 2018 Royal Charter International Research Award for Young Constructors. He received the award – sponsored by the BRE Trust in collaboration with the Worshipful Company of Constructors – which provides £8,000 towards the cost of the winning project and publicity for the work.

The plan

The aim of this project is to develop a 'recipe' for using rice husk ash as a replacement for Portland cement in cement-stabilised earth blocks. Kicking off with a meeting at the BRE Trust in Watford, the preparatory work will be completed in 2019, with most of the testing work planned for spring 2020 to tie in with the rice harvest. This will be conducted partly in Uganda and partly at the University of Leeds, with input from the university and other partners.

Alastair Marsh will spend two months in Uganda, working with HYT Uganda to combine his understanding of the chemistry of supplementary cementitious materials in soil blocks, with the charity's practical knowledge of earth block manufacture and housing construction.

Alastair will use this time to fine tune the experiments to be undertaken and the CSEB mixtures to be tested, working with HYT Uganda so they can carry on with the testing after he returns to the UK. This will enable the field research to be continued in Uganda in his absence, so increasing testing capacity and learning opportunities.

Use of rice husk ash in future cements?

As part of his work at the University of Leeds, Alastair is investigating the potential for new and improved forms of cement. Alkali-activated cements (AACs), for example, are emerging binder materials that have the potential to provide performance that is equivalent to Portland cement, but with lower environmental impacts.

Fly ash and ground granulated blast furnace slag are two of the most established waste materials used as precursors for AACs, but in many parts of the world are not readily available. In Uganda, for example, there are no coal-fired power stations or blast furnaces to supply these materials. However, rice husk ash can be used to produce a sodium silicate activating solution, which can in turn be used to make AACs with other precursors, such as clay-rich soils.

It is not yet well understood whether rice husk ash would be best used as a partial Portland cement replacement, or as part of an alkaline activator for an AAC. The current project on using rice husk ash in earth building blocks in Uganda, will also give Alastair an opportunity to examine the potential for using this waste product in the manufacture of alternative cements in the future.