Waste plastic in concrete could support sustainable construction in India

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The Bath-led research has shown how replacing 10 per cent of sand in concrete with waste plastic may help to reduce the vast amounts of plastic waste on India's streets, and deal with a national sand shortage. Credit: University of Bath

Research at the University of Bath has shown waste plastic to be a viable partial replacement for sand in structural concrete, providing one possible solution for future sustainable construction whilst addressing sand shortages in India.

The Bath-led research—in partnership with colleagues from Goa Engineering College, India – has shown how replacing 10 per cent of sand in concrete with waste plastic may help to reduce the vast amounts of plastic waste on India's streets, and deal with a national sand shortage.

Published in the journal Construction and Building Materials, the research demonstrates how the team investigated various different types of plastic to see if they could be crushed and used as a replacement for sand, which typically accounts for 30 percent of a concrete mixture.

The University of Bath-led project showed that replacing sand with similarly sized and shaped waste plastic particles from ground up plastic bottles, resulted in concrete which was almost as strong as conventional concrete mixtures. By replacing 10 per cent of sand in concrete, it is calculated this approach could save 820 million tonnes of sand a year, and help reduce levels of plastic waste.

The researchers investigated this approach by testing concrete cubes and cylinders. Five types of plastic particles, including those from recycled plastic bottles and recycled plastic bags, were trialled in the mixes in a variety of sizes. Recycled plastic bottles, ground and graded to match the sand being replaced, were found to perform best.

As one of the world's fastest growing economies, a booming construction sector and a rapidly growing urban population, the cost and demand for sand in India has sky-rocketed with 280 megatons of cement manufactured there in 2014 alone.

This has led to unregulated sand extraction from riverbeds; to the extent that such mining is now banned in many Indian states. Also, the high level of sand extraction can lead to other problems such as coastal erosion and an unstable fishing industry.

The country's rapid development has also meant waste plastic has become a significant problem in India with 15,000 tons of plastic dumped in the streets everyday due to a lack of suitable recycling facilities. Previous research has investigated the potential of partially replacing sand in concrete with crushed car tyres and other similar materials; this led to Dr. Orr and his team investigating the viability of using plastic waste as a possible alternative to sand.

This research, which today (Thursday 13 September 2018) has been selected by an international scientific committee to receive the Atlas Award in recognition of its potential societal impact around the world, provides the proof of concept for an approach which could significantly address India's waste and sand shortage problems as well offering a solution for future sustainable construction.

Principal investigator and Cambridge University Lecturer in Concrete Structures, Dr. John Orr – who completed the research whilst working at the University of Bath – commented:

Typically, when you put an inert, man-made material like plastic into concrete, you lose a bit of strength because the plastic material doesn't bond to the cement paste in the material in the same way that a sand particle would.

The key challenge here was to have a limit between a small reduction in strengths, which we achieved, and using an appropriate amount of plastic to make it worthwhile. It is really a viable material for use in some areas of construction that might help us to tackle issues of not being able to recycle the plastic and meeting a demand for sand.

Co-investigator and Reader in the University of Bath's Department of Architecture & Civil Engineering, Dr. Richard Ball, said:

Characteristics of the waste being added to the concrete, such as the type of plastic and the size and shape of the particles can all have an influence on the final concrete properties. Even when the reduction in performance prohibits structural applications lower tech uses such as paving slabs may be viable.

Globally, concrete plays an integral part in the construction industry accounting for around nine per cent of a new building's budget whilst being responsible for nearly half a building's CO2 emissions. Each year, 4.2 trillion kilograms of cement is manufactured, resulting in about 1.9 cubic metres of concrete for every person on the planet. It is predicted construction will continue to accelerate with a floor area equivalent to that of Paris expected to be built every week until 2040.

The paper, titled "Performance of structural concrete with recycled plastic waste as a partial replacement for sand," is published in *Construction and Building Materials*.

More information: J. Thorneycroft et al. Performance of structural concrete with recycled plastic waste as a partial replacement for sand, *Construction and Building Materials* (2017). DOI: 10.1016/j.conbuildmat.2017.11.127

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