Recycled Haitian concrete can be safe, strong and less expensive, says Georgia Tech group

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Nearly one year after a 7.0-magnitude earthquake rocked the Republic of Haiti, engineering and concrete experts at Georgia Tech report that concrete and other debris in Port-au-Prince could be safely and inexpensively recycled into strong new construction material.

In a paper published today in the *Bulletin of the American Ceramic Society*, researchers Reginald DesRoches, Kimberly E. Kurtis and Joshua J. Gresham say that they have made new concrete, which meets or exceeds the minimum strength standards used in the United States, from recycled concrete fragments and other indigenous raw materials using simple techniques.

Most of the damaged areas of Haiti are still in ruins. The authors says their work points to a successful and sustainable strategy for managing an unprecedented amount of waste, estimated to be 20 million cubic yards.

"The commodious piles of concrete rubble and construction debris form huge impediments to reconstruction and are often contaminated," says DesRoches, professor and Associated Chair of Civil and Environmental Engineering at Georgia Tech. "There are political and economic dilemmas as well, but we have found we can turn one of the dilemmas — the rubble — into a solution via some fairly simple methods of recycling the rubble and debris into new concrete."

DesRoches, who was born in Haiti, traveled several times in 2010 to Port-

au-Prince to gather samples of typical concrete rubble and additionally collect samples of two readily available sand types used as fine aggregates in some concrete preparation.

He and Gresham also studied the methods, tools and raw materials used by local laborers to make concrete mixes. DesRoches recalls they encountered no mixing trucks. "Instead, all of the construction crews were manually batching smaller amounts of concrete. Unfortunately, they were mixing volumes of materials 'by eye,' an unreliable practice that probably caused much of the poor construction and building failure during the earthquake," he says.

Before leaving, DesRoches and Gresham manually cast an initial set of standard 3-inch by 6-inch concrete test cylinders using mixes currently in use at several different construction sites.

They returned to Georgia Tech with their cast blocks, sand samples and notes, where they were joined by Kurtis, also a professor and Chair of the American Concrete Institute's Materials Science of Concrete Committee.

They quickly discovered that the concrete test samples cast contemporary Haitian mix was of poor quality. "The Haitian-made concrete had an average compressive strength of 1,300 pounds per square inch," says Kurtis. "In comparison, concrete produced in the U.S. would be expected to have a minimum strength of 3,000 pounds per square inch."

They then manually crushed the samples with a hammer to provide coarse aggregate for a second round of tests. In this round, they made concrete samples from mixes that combined the coarse aggregate, obtained from the weak concrete, with one of the two types of sands they had collected in Haiti. However, instead of "eye-balling" the

amounts of materials, they carefully measured volumes using methods prescribed by the American Concrete Institute. The materials were still mixed by hand to replicate the conditions in Haiti.

Subsequent tests of samples made from each type of sand provided good news: The compressive strength of both of the types of new test blocks, still composed of Haitian materials, dramatically increased, showing an average over 3,000 pounds per square inch.

"Based upon these results, we now believe that Haitian concrete debris, even of inferior quality, can be effectively used as recycled coarse aggregate in new construction," says Kurtis. "It can work effectively, even if mixed by hand. The key is having a consistent mix of materials that can be easily measured and, when using recycled concrete, crushing the material to an appropriate size. We are confident these results can be achieved in large-scale reconstruction by proportioning the mix procedure and measuring quantities using common, inexpensive construction equipment."

DesRoches is pleased because recycling eliminates two hurdles to reconstruction. "First, removing the remaining debris is nearly impossible because there are few, if any, safe landfill sites near Port-au-Prince, and the nation lacks the trucks and infrastructure to haul it away. It is better to use it than to move it."

"Second," DesRoches says, "Finding fresh aggregate is more difficult than getting rid of the debris. It is costly to find, mine and truck in."

The trio notes recycled concrete aggregate has been used worldwide for roadbeds, drainage, etc., and that many European Union countries commonly use 20 percent recycled aggregates in structural concrete. Published research by others has also demonstrated that the use of local-sourced recycled aggregate concrete production can be more sustainable.

Because of the urgency of quick and safe reconstruction, the researchers urge that recycling the debris quickly move from proof-of-concept to large scale testing. "More work must be done to characterize the recycled materials, test additional performance parameters and gauge the safest ways to crush the rubble. Seismic behavior and building codes must be studied. But, these tests can and should be done dynamically, during reconstruction, because the benefits can be so immediate and significant," says DesRoches.

DesRoches, Kurtis and Gresham say they plan on sharing their research with Haitian government officials and nongovernmental organizations working on reconstruction projects. DesRoches is hopeful that a debris strategy and infrastructure will eventually emerge from the government once the disputed presidential elections in Haiti are resolved. "Some think that many rebuilding projects have been put on hold for the past few months because of distraction from the elections. The next round of elections is this month, so it soon may be possible to accelerate reconstruction," he says.

More information: The complete study, along with an interview with DesRoches, is available at: tinyurl.com/245plk2

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