RE:CRETE – A FOOTBRIDGE MADE OF REUSED CONCRETE BLOCKS

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Summary

Concrete is the most widely used construction material worldwide. Strong, versatile, durable, and vector of economic development, this exceptional material is also the principal cause of CO_2 emissions, material depletion and waste generation by the construction industry. Today, demolished concrete is at best crushed to be used as gravel for road sub-base or to serve as aggregate in so called recycled concrete mixes. These mixes require similar amounts of cement as standard mixes, meaning that the process is still CO_2 intensive. Instead, the direct reuse of entire concrete elements, extracted from pre-existing obsolete building structures, into new structural applications has large potential to significantly reduce the environmental impact of construction. This strategy is still rarely implemented and never for a bridge structure.

To demonstrate the potential of reusing concrete elements for bridge construction, this paper shows the construction of the Re:Crete arch prototype shown in Figure 1. It is a segmental arch with a span of 10 m and a rise of 1.20 m. It is composed of 25 reclaimed concrete blocks used as voussoirs and post-tensioned to ensure stability under asymmetrical loads as well as a fully compressed concrete section under live loads. The structural behavior of the arch is verified using a Finite Element Analysis (FEA) model.

Figure 1. The Re:Crete footbridge prototype installed in Wallis, Switzerland.

The blocks are extracted from 20-cm thick basement walls of a building undergoing major transformations. Blocks are cut from the wall with a diamond saw, directly into the required dimensions of 120 x 40.5 x 20 cm. After extraction, the holes for the post-tensioning cables are drilled into each block. The arch is assembled on a temporary timber centring and the joints grouted with mortar to ensure a good contact. After hardening of the mortar, the cables are post-tensioned and the centring removed.

Schmidt rebound hammer measurements carried out on the concrete blocks validated the assumptions made on the mechanical properties of the concrete during the design process. Ground Penetrating Radar (GPR) is employed to measure the concrete cover thickness and the rebar spacing. Although the rebars are not necessary to ensure structural safety of the arch system, results provide information on the durability of the concrete blocks with regards to corrosion risk. Finally, the structural response of the bridge, calculated with the FEA model, is validated through load testing.

A Life-Cycle Assessment compares the global warming potential (GWP) of the Re:Crete arch to similar designs made of other materials. The results show that the construction of the Re:Crete prototype has a 71% lower GWP than the same design in recycled concrete. This validates the potential to reduce the GWP of structures through the reuse of concrete structural elements. Furthermore, reuse avoids waste, reduces the demand for raw material and delays the downcycling of concrete. As the Re:Crete prototype demonstrated, it is possible to build reliable concrete structures without pouring any new concrete.

Keywords: reuse; concrete; post-tensioning; existing structures; structural design; circular economy.

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