AN ULTRA-THIN, SINUOUS CONCRETE ROOF MADE WITH NEW DESIGN AND FABRICATION METHODS

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Concrete is the most used building material, but it has its drawbacks. For one, it is quite heavy (unless you're talking about ultra lightweight concrete) and needs to have a certain thickness to be strong. That is, unless you use state of the art design and fabrication methods, like a group of researchers from the ETH Zürich did. They designed an ultra-thin, sinuous concrete roof that is only 3 centimetres (1.2 inches) thick in some places!

The self-supporting, doubly curved shell roof is a 1-to-1 prototype of a rooftop apartment unit called HiLo that is planned to be built this year in Zürich, Switzerland. The aim of the project is to test the lightweight construction and combine it with intelligent and adaptive building systems.

The roof has a thickness of 3 to 12 cm (1.2 to 4.7 inches), with an average thickness of 5 cm (2 inches). It consists of multiple layers. Heating and cooling coils and the insulation are installed over the inner concrete layer. A second exterior layer of the concrete sandwich construction encloses the roof.

Instead of formwork using non-reusable custom-fabricated timber or milled foam, which would be needed to realise such sophisticated form, the researchers used a net of steel cables stretched into a reusable scaffolding structure. This cable net supported a polymer textile that together functioned as the formwork for the concrete. This not only enabled the researchers to save a great deal on material for construction, they were also able to provide a solution to efficiently realise completely new kinds of design. Another advantage of the flexible formwork solution is that during the concreting of the roof, the area underneath remains unobstructed and thus interior building work can take place at the same time.

The cable net was designed to take on the desired shape under the weight of the wet concrete, thanks to newly developed calculation method. The algorithms ensured that the forces were distributed correctly between the individual steel cables and that the roof assumed the intended shape precisely. The cable net weighed just 500 kg (1102 pounds) and the textile 300 kg (661 pounds); thus, with a total of only 800 kg (1763 pounds) of material the 20 tonnes (22 US ton) of wet concrete were supported.

The concrete was applied using a newly developed spraying method, so it had to be wet enough to be sprayable, but firm enough to stick to vertical surfaces.

Unfortunately, the prototype was already dismantled to make room for new experiments, so who wants to see the project in real life will have to wait for the actual apartment.

Photos: ETH Zürich / Michael Lyrenmann / Naida Iljazovic

COMMENTS