Genetic algorithms in super light concrete design

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Super light concrete

Concrete is the worlds most used building material, and it is estimated that the production of concrete is responsible for over 5% of the global CO_2-emission. Recently, Kristian Dahl Hertz, professor at the Technical University of Denmark, invented a new concrete design technology, which has already been applied to several building projects. The technology won the 'Cleantech Open Global Ideas Competition'. The 'super light concrete' design allows, not only impressive price reductions, but also more than 50% reduction in CO_2-emission compared to similar conventional concrete structures. The focus of this project is to optimize the technology even further using computational genetic algorithms.

Genetic algorithms

Nature has been adapting itself to changing environments since life began to form. Through reproduction, mutation and natural selection the next generation of species will be better suited for a specific environment than the previous. Computational genetic algorithms (GA) use this exact approach to find solutions to complex man-made problems. GA's have been used in many fields, but within structural building design many optimization problems are solved by hand, using intuition and experience. Even though this method normally generates good results, it only includes a handful of possibilities. GA's are able to generate and optimize an unlimited amount and the algorithm will simply return what it considers the best possible solution.

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This project focuses on optimization of cross section properties of 'super light concrete' decks. The cross section design is geometrically more complex than conventional concrete cross sections; hence it is more difficult to optimize.

With use of GA's it is possible to create thousands of different randomly generated cross sections; what can analogically be described as a first generation. The section properties, dimensions and constrains is the DNA of the cross section. The resulting environmental impact along with the mechanical properties and material usage determines the individual cross sections ability to reproduce. The next generation of cross sections is generated through reproduction of the previous generation. Weighted randomized mixing and mutation of the DNA pool is the core of the reproduction process. Each generation will be stronger than the previous.

This approach makes it possible to find an, with the given DNA structure, optimal solution for any structural load case. A maximal reduction of CO_2 –emission and a minimal material usage can be approached.

The use of genetic algorithms in construction design is applicable in many design situations, and this is one example of many. The project will be conducted in the 3-week period of June 2015, and presented at the Green Challenge Conference.