Environmental impact analysis of temporary structures using genetic algorithm: case study of an ultra-lightweight pavilion

Carlotta MAZZOLA*, Salvatore VISCUSO [a], Carol MONTICELLI [a], Alessandra ZANELLI [a]

* Textile Architecture Network (TAN),
DABC, Politecnico di Milano; via G. Ponzio 31, Milano 20133, Italy,
carlotta.mazzola@polimi.it

[a] Textile Architecture Network (TAN),
DABC, Politecnico di Milano; via G. Ponzio 31, Milano 20133, Italy,

Abstract

Ultra-lightweight structures are often built and used for short duration during temporary events, making easy (de)mountability the strength of this kind of projects to speed up construction. Temporary structures are frequently marked by a lack of sustainability due to the production phase of components and transportation from the storage area. From an environmental point of view it is therefore essential to focus on the different cycles of use of a temporary structure to evaluate the environmental impact over time, considering not only the project short life-span but also re-use, end-of-life disassembly and recycling. Recently, some researches on the topic propose the integration of LCA analysis in parametric software in order to evaluate and optimize the environmental impact of a structure starting from the early design stage.

In order to deepen these growing approaches this contribution aims to present the developed methodology that integrates LCA database with a genetic algorithm - developed in Grasshopper ™ - able to assess the number of cycles of use necessary to make the impact of temporary structures sustainable, or/and to find the right balance between materials and the required durability. Through the evolutionary solver Galapagos, different parametric variables (i.e. geometry, material typology, quantities and cycle of use, etc.) can be linked alternatively to the fitness function of the genetic algorithm in order to optimize the remaining variables, the genotypes. In particular, this procedure is applied and verified in a case study: an ultra-lightweight membrane-based temporary pavilion that will be built for an ephemeral event lasting few days and re-built later for a longer stay. By setting the fitness input in search of the minimum environmental impact obtainable, the algorithm allowed to calculate the minimum number of reuse cycles necessary to reduce the impact of the structural materials used; otherwise, for some components such as the envelope, different technological and material options have been evaluated, in order to select the less impactful, more efficient and environmentally conscious solutions.

Keywords: lightweight structures, membrane-based structures, temporary architecture, environmental impacts, LCA, parametric model, genetic algorithm, optimization

References

[1] L. Fumeaux, E. Rey, "Toward the reduction of environmental impacts of temporary event structures" in *Procedia Engineering,* 85, 2014, pp. 166-174.

[2] A. Hollberg, J. Ruth, "LCA in architectural design—a parametric approach.", *The International Journal of Life Cycle Assessment, 21*(7), 2016, pp. 943-960.

[3] C. Monticelli, A. Zanelli, "Eco-efficiency and life cycle analysis of structural membranes in architecture", *IASS WORKING GROUPS 12 18 International Colloquium 2015 "Bio-Based and Bio-Inspired Environmentally Compatible Structures", 2015,* pp. 1-9.

[4] A. Zanelli, M.L. Spinelli, C. Monticelli, P. Pedrali. (eds.), *Lightweight Landscape. Enhancing Design through Minimal Mass Structures*, Polimi – SpringerBriefs, 2016.