

# Balancing preferences and performance by informed structural design: a case study

Lennert LOOS<sup>\*a</sup>, Georgia MARGARITI<sup>b</sup>, Kenny VERBEECK<sup>b</sup>, Lars DE LAET<sup>a</sup>

\*lennert.loos@vub.be

<sup>a</sup> Vrije Universiteit Brussel

<sup>b</sup> Bollinger + Grohmann Ingenieure

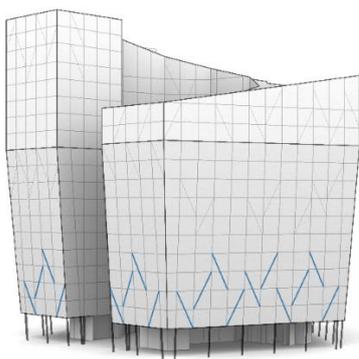
## Abstract

Modern computational and parametric design tools allow to generate quickly different design alternatives. To understand the structural design space comprehensively, it is important that the structural designer understands the behaviour of each alternative and that he/she can compare and relate these quickly. When using current methods (FEA representations, result tables), it is sometimes hard to make these comparisons [1], especially for complex structures. Recent research [2][4][5] showed already how real-time visual representations and graphs of structural data can help to quickly understand structural behaviour. In addition, it helps to compare different similar structures quickly.

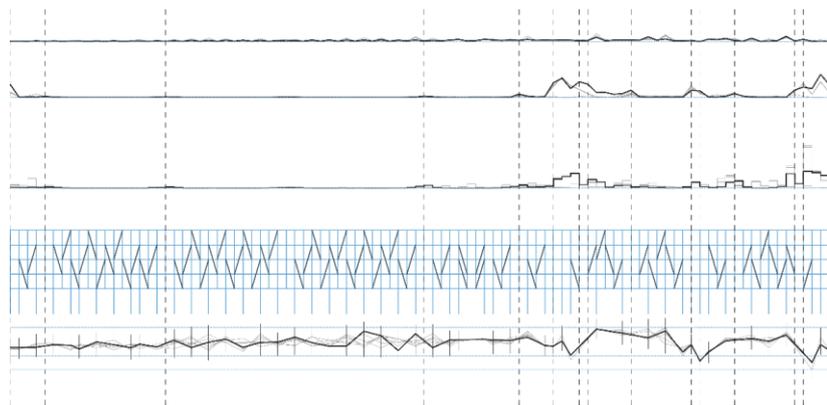
This paper presents a practical example in which these novel visual representations are used as an approach for informed decision-making. The case dealt with in this paper is the design of a large office building in Luxembourg. The architecture of this building challenges the structural design since the relation between geometry and structural behaviour is hard to predict. Specifically, the presented research investigates the configuration of diagonals in the façade. These diagonals try to reduce heavily the load on the beams that support the floating columns. Figure 1 makes the structural intention of the diagonal cables clear.

Different alternatives are generated by means of the gh-plugin Octopus and some are designed by hand (random and formalistic). Main aim of the investigation is to have a better understanding of the design space and to relate the different alternatives to each other. With the floor loads applied, the structural designers will compare the alternatives on their behaviour. Deformation energy, force path, and the distribution of column forces in the façade are the used parameters on which the comparisons are based. New designs can be generated (Octopus) or assembled (manually) with the help of the gained insights.

Whereas former research focussed on more theoretical/form-found typologies such as shells and bridges [4][5], this case helps to investigate the application of structural data representations for real building projects. A comparison between the traditional FEA software representations and the new interactive data visualisations (made with the developed gh-plugin inkbeagle [3]) is made critically and the process of informed decision-making is discussed. Based on the data visualisations (Figure 2) structural insights will help to proceed in the design process, without doing an algorithmic optimisation. Indeed, the aim is to serve the architectural concept and to look for a compromise between architecture and structure. This is only possible through a thorough understanding of the structural design space.



**Figure 1:** Cable configuration to reduce the bending action on the continuous beams at the first level.



**Figure 2:** An example of how different cable configurations and their structural impact on the overall behaviour can be compared visually. With an interactive link between the graphs and the structural models, the understanding of structural behaviour is facilitated.

- [1] Joyce, S.C., *Web Based Data Visualisation Applied to Creative Decision Making in Parametric Structural Design*. 2015
- [2] Loos, L. & De Laet, L., *Implementation of Real-Time Data Visualisations for Structural Design within a Parametric Workflow*. 2018
- [3] Loos, L. & De Laet, L., *Inkbeagle, informed structural parametric design*. <https://inkbeagle.io>, 2019
- [4] Loos, L. e.a., *Data visualization for gaining insight in the structural behaviour of bow-string bridges under various load cases*. 2017
- [5] Verbeeck, K., Loos, L., *How to re-open the black box in the structural design of complex geometries*. 2016