# Trondheim HolzBau Pier – The Elegance of Efficiency

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## Summary

An elegant timber pier, erected recently in the city of Trondheim in Norway, is the result of close interdisciplinary co-operation throughout its design process from the initial sketches, via modelling and analyses, to its fabrication and construction. Parametric tools, an iterative design process, and computational techniques are among the methodologies applied. The main result of this project is the development of an innovative synergy design process based on a common generative parametric geometry tailored for use by both the architects and structural engineer. Moreover, the parametrically generated geometry is applied automatically as a basis for the CNC manufacture of all structural components. This paper is expected to promote further construction of original (and elegant) structures in that it explores new means of co-operation throughout all stages of design and construction.

**Keywords:** timber pier; Finite Element Analysis; computational geometry; digital architecture.


*Fig. 1: The HolzBau Pier – a) elegance in terms of architecture, b) and c) in terms of details directly derived from the engineering method.*

There is general agreement that the introduction of digital tools to the construction industry is resulting in safer, more reliable, and (potentially) cheaper structures over their service lifetimes as a result of the optimisation of cost-effectiveness and quality. However, it is not obvious that the development of software products will improve and simplify communication between the different parties involved in building design and construction, no matter how effective future digital tools may prove to be.

In response to this situation, this paper intends to unify architectural intention and structural design by means of a unique process showcased using the case study of a timber pier (the HolzBau pier), designed and built in Trondheim in Norway during the summer of 2014. The paper elaborates on the design process and points out some particular features of the construction project.

The pier would provide a new and complementary perspective on one of Trondheim's main attractions – the river and the warehouses – rather than being the main attraction itself. With this in mind the architects envisaged a simple lightweight construction design which would not disturb existing views of the warehouses. The architectural intention was thus to visualise the forces acting within the construction, and to use an optimised structural pattern to minimise the dominance of the object within the unspoiled space between the warehouses on both sides of the river (Fig. 1a). The load-bearing superstructure of the HolzBau pier is composed of a double truss made up of parallel diagonal elements (Fig. 1b). In accordance with the architectural intention, the width of each diagonal truss element is determined in accordance with its structural requirements, see Fig. 1c).

The approach used assumes sharing a common basis in the form of a parametric generative geometry. In other words, the pier geometry obeys simple generation rules which can be expressed relatively easily in any programming language. The rules are based on a finite set of parameters, such as the total length of the pier, the centre-to-centre distance between diagonal elements, and the angle of the diagonal elements. This set of parameters can be simply expressed in a text file, and constitutes the basis for the architectural work (used to check the design intention) and engineering work (used to check the structural design).

The first step in the process is generated by the architects, who formulate the architectural intention and determine a concept for further design. This concept is then translated into objectives to be completed as part of the structural design process (Fig. 2).

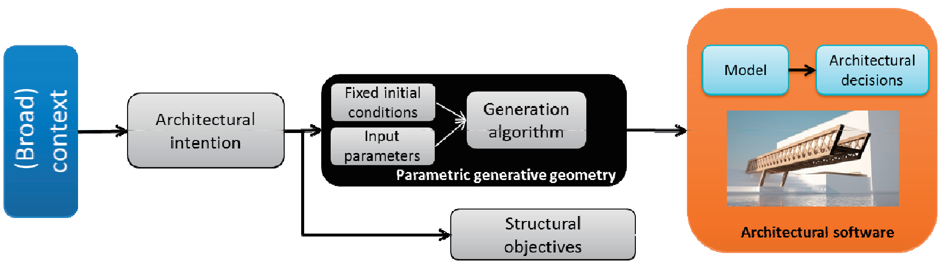


*Fig. 2: The generative parametric geometry used as a basis for the architects.*

In addition to realising the architectural intention, the architects also make suggestions for the values of most parameters, referred to as "fixed initial conditions" in Fig. 2. This is done based on context and their personal experience, as well as legislative and other stakeholder requirements. They must also define a subset of those parameters, referred to as "input parameters" in Fig. 2. These are parameters that will be modified by the engineers in order to meet the architectural intention.

The distinctive design of this innovative wooden construction also demonstrates "elegance" in the form of the end-result of a structural design process governed by architectural intention. It is anticipated that this paper will foster innovative synergistic design processes between architects and structural engineers and promote the construction of more original (and elegant) structures by means of new collaborative approaches.