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# WHY WE WILL ALL BE LOOKING FOR A NEW JOB SOON, TRUE STORY BASED ON STUDY CASE OF ORKDAL FOOTBRIDGE

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**Summary**

The fourth industrial revolution, already present in the several industries, is now entering the field of civil engineering. Digital fabrication, mass customization, robot arms and drones are connected within the building information modeling (BIM) systems. All the work that is currently accomplished by nonprofessional or semi-professional workers can now be automated or delegated to robots. The main motivation behind this shift is economical: lowering the overall cost by increasing project time predictability and enhancing work security at the same time. The proper use of computers and machines helps avoiding random errors that are cumbersome to detect and thus slower the process of the project. For example: Using computer numerical control (CNC) sawing machines significantly increases the quality and accuracy of the timber elements that are sent to a construction side. Using pneumatic nail pistols or numerical welding machines speed up the joining process. Everything what happens since now was focused mostly on eliminating human factor from construction site. The most dramatic mistakes in civil engineering are prevalently made in the design phase of construction process. One can risk the thesis that knowledge available to the designer, i.e. the finite element method, scripting tools, Eurocodes, parametric modelling, and power computing machines could all be smartly merged together to eliminate the source of random errors from the design phase. In other words, we dare to propose an automated designing process concept with a limited interference of the designer. This is naturally followed by the new role of the designer, that to both qualitative and quantitative change.

**Keywords:** structural concepts; conceptual design; digital workflow; digital fabrication

## 1. Introduction – is engineering fixed?

The new design methodology proposal is based on the digital platform that is created by the participants of the designing process at the very beginning. In our case, the Grasshopper (Rhino plugin) software has been utilized and serves as the environment connecting all data about the project. The core of the platform is a parametric model linked to the finite element solver (Karamba plugin). The core can be supplemented with many components (small programs scripted in c# or python by the users) can be added. Adjustability of the software to individual needs creates possibilities and decreases the need of interference of the designer in the development of the project at further stages. This happens, because of the atomization of such

processes as element utilization checking, joint capacity validation or creation of the detailed drawings. To prove the statement above, two study cases are presented in the next chapters.

## 2. Orkdal bridge story

The platform made for the Berlin competition has his origins in the bridge project started in 2016. Orkdal municipality asked NTNU for help in designing two footbridges, which could be the new landmarks of the region. On the beginning the main task was to tight up the cooperation between manufacturer, architect and engineer as close as it can be. With the progress of the work some bottle necks of design process has been found. The biggest one in our opinion was the misunderstand of principles in data flow between participants. The todays BIM standard occurs not to cover all of the needs and possibilities of the participants digital tools. Yes, we exchange ‘’building’’ information’s, BIM works, we exchange even so much data, that the amount of it starts to be a problem in itself. Example: The model of the timber bridge made by architect is send to engineer. Engineer is creating his model of the structure, sometimes modelled based on the architects one, sometimes from the scratch. After discussion and changes the manufacturer gets drawings, sometimes 3D, more often 2D. Some of the details needs to be change, but generally the model have to be redone according to available CNC machine standards. Discussion, changes and finally the material can be send for machining.

Presented traditional model works fine, but since all of the presented steps in it are made in digital form, isn’t it rational to first establish this digital limits of the CNC tools, than, establish the structural limits of the numerical model which can not be crossed, then establish the architectural requirements, and then finally starts to design.

The visual programming software like grasshopper or dynamo, gives the opportunity to try the different, digital approach to design. By possibility to create your own codes in easy way, with small amount of programming skills big models can be discussed in conceptual stage not by intuitions and experiences of participants, but through the facts like capacity or deformation.

Parametrical model was connected with FEA and Eurocode checkers for the elements. As we have chosen the dowel system connection, we create component individually checking every node and adapting steel plates and dowel numbers to the forces in it. The manufacturing component were added. It can produce in several seconds, the code in .btl format, which can be send directly to CNC machine .

The Orkdal bridge will be build in June 2017, the traditional validation of the elements and joints made by the external construction office shows no bigger changes. The counted capacity of the elements were no bigger than 5% than calculated by our approach and only two dowels in 4 nodes had to be added. The average time of creating complex structure model with our approach is between 10 to 20 sec.

## 3. Discussion

The role of the engineer in proposed approach should be redefine. In the beginning of the process he will be responsible for creation of the specific components. In the second stage of design he will be responsible for really creative process of finding the best suited structure to the project requirements. The problem which is declared in the topic of this paper is coming from two predictions. First was mention already before, after creating several projects, the library of components will be so big that time spend on creating or adjusting them to temporary project will come to minimum. The engineer will not be needed than anymore at this stage. The second prediction is that one engineer operating on the one project occurs to be enough. We strongly believe that in future there is unfortunately place only for high educated professionals, with perfectly understanding of the mechanics principles and with advanced engineering knowledge, which could add positive value to design not just copy existing projects. Copying we left to machines.