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REAL TIME ENGINEERING ANALYSIS BASED ON A GENERATIVE COMPONENTS IMPLEMENTATION

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1. Introduction

Building design on one hand contains a lot of thoughts on structural, functional and cost-demands, while on the other hand it sometimes also has to fulfil aesthetical demands from the architect or designer. Building design can be viewed as an integrated process between engineers and architects where the engineers and architects have various digital analysis tools and design tools, respectively. With these relatively new digital tools, new possibilities have appeared in both engineering and architecture – both in virtual reality and in the build reality [1]. Development today in CAD programmes goes towards also doing the design, modelling and analysis inside so-called Building Information Modelling (BIM) tools [2]. A drawback of those tools is that they follow a bottom-up approach for the configuration of the structural system with limited room for higher level concepts such as structural subsystems and assemblies. In addition, such tools do not consider the interdependency between functional spaces and the structural system and do not provide capabilities for inspecting the architectural model from a structural standpoint.

Recently, several conceptual structural design tools [3-9] have been proposed where focus has been on the integrated design process between architects and engineers. These tools have primarily been developed simply by and for engineers. The designer/architect tends to be neglected in this respect and to be forced to rely unduly on the know-how of the engineer. A digital design tool for conceptual design should provide the possibility for the architect to work with both the aesthetic as well as the technical aspects of architecture without jumping from aesthetics to technical and back, but to work with both simultaneously and real time.

The present paper outlines the idea of a conceptual design tool with real time engineering analysis which can be used in the early conceptual design phase. The tool is based on a parametric and associative design system approach using Generative Components with embedded structural analysis. Each of these components uses the geometry, material properties and fixed point characteristics to calculate the dimensions and subsequent feasibility of any architectural design. The proposed conceptual design tool provides the possibility for the architect to work with both the aesthetic as well as the structural aspects of architecture without jumping from aesthetics to structural digital design tools and back, but to work with both simultaneously and real time. The engineering level of knowledge is incorporated at a conceptual thinking level, i.e. qualitative information is used in stead of using quantitative information. An example with a static determinate roof structure modelled by beam components is given. The example outlines the idea of the tool for conceptual design in early phase of a multidisciplinary design process between architecture and structural engineering.

2. Conceptual Design Tool

Generative Components (GC) is a parametric and associative design system developed by Bentley and Robert Aish [3]. me time addressing key issues in the efficient management of conventional design and documentation processes. GC uses an advanced parametric engine to unify all aspect of design which allows designers to build geometric models based on components and inter-component relationships. A ‘component’ can be as simple as a line (a geometric primitive) or as complex as double curves adaptive glazing panel arrayed over a complex building façade. A ‘component’ can also be a numeric value (a single parameter) or a complex expression linking a number of parameters to the ‘driving’ properties of geometric components. This enables the GC to make explicit, not just geometry, but design intent as well. Editing both the geometry and the inter-component relationships allows such models to be used to conveniently explore alternative design scenarios. Changes to the key geometry and parameters automatically ‘ripple-through’ the rest of the

design models. This enables the designer to explore alternatives without having to manually re-build the detail design model. The basic idea of the conceptual design tool is the possibility at early stages in the design process to perform an investigation of the effects that the shape and the structural systems of buildings have on the distribution of forces and on deformations. The tool is implemented into GC which makes it possible for designers and engineers to explore various design proposals of an architectural design by either manipulating the geometry of it or switching 'components' , which makes it easier and faster to test various designs compared to doing the same in an ordinary CAD programme.
It is this facility which is used for an embedded structural analysis implementation. In stead of only letting geometry adapt to changing conditions also dimensions of structural components should adapt due to the effects that a changed shape have on the distribution of forces and on deformations. Therefore the idea is to make a library of structural components which use the geometry, material properties and fixed point characteristics to calculate the dimensions and subsequent feasibility of any architectural design.

3. Conclusions

Recently several proposals for digital conceptual design tools have been given primarily developed simply by and for engineers. The designer/architect tends to be neglected in this respect and to be forced to rely unduly on the know-how of the engineer. The design process becomes divided up into a designer/architect and an engineering part instead of a collaborative process being established. The presented paper proposes a digital conceptual design tool which should be able to use by a designer with a basic level of knowledge about structural calculations. The engineering level of knowledge is incorporated at a conceptual thinking level, i.e. qualitative information is used in stead of using quantitative information. The present tool should be available to be used by architects/designers, i.e. the results should not come out as quantification of stresses and deformation but as a proposal for overall dimensions of structural components such as beams, columns, trusses etc. due to an embedded structural analysis. The aim of the tool is to deliver indicative in stead of detailed and accurate results. The present tool can only handle static determinate structures modelled by beams. Future developments of the tools are described concerning architecture with more complex geometry and improvements of the method used for the embedded structural analysis.

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