From 3D-CAD Models to Structural Analysis: An Automated Approach with Wireframe Builder

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In recent years, the digital construction industry has experienced significant growth, largely fuelled by the rapid advancement of computer technology and the increasing reliance on various software tools. One area of particular interest is the use of 3D modelling and simulation for structural analysis, which can improve the accuracy and efficiency of the design and construction process and becomes a compulsory step of the design process in most building projects nowadays.

This thesis addresses this challenge by developing a tool, called „Wireframe Builder“, for simplifying 3D geometry and preparing it for use in structural analysis software. The tool uses on automation possibilities offered by the CAD environment Rhino 8 and scripting (Python) and exploits graph theory to represent and analyse the spatial relationship between elements in the 3D model. The tool utilizes graph theory to represent the topology by analysing the connectivity and spatial relationships between elements. This graph-based representation of the structure‘s topology, together with the computed centroid axes of the solids, form the basis allowing to generate a connected wireframe model.

The literature survey offers a review of the current state of research in digital construction and structural analysis, highlighting gaps and limitations, tools and approaches that already exist, as well as the state of the art in the industry. It also mentions a solution that exist in the market. The findings from the literature survey guided the conceptualization and design of the Wireframe Builder tool, enabling it to tackle some recognized challenges while aligning with the state of the art in the industry.

The methodology lays the foundation for creating wireframe, including the tools used, complex processes, and the approach used to develop the “Wireframe builder” tool. It introduces a design philosophy that prioritizes modularity and user-friendliness, and the object-oriented approach for code organization, promoting modularity and code reusability.

The results of this research through a few case studies that the “Wireframe Builder” tool show that it successfully tackled the challenge of adapting 3D geometry for structural analysis. By simplifying complex models into connected wireframes, the tool streamlines workflow, improves efficiency, and is a step closer to using a 3D model in structural analyses. However, it is important to recognize that while the tool represents significant progress, it has limitations and offers opportunities for further development and refinement. It lays a solid foundation for automated, data-driven structural analysis workflows in the digital construction industry.

The thesis includes a practical testing phase where the “Wireframe Builder” tool is applied to actual projects provided by HESS Timber within the Rhino 8 WIP environment. Subsequently, the wireframe representations generated by the tool are seamlessly imported into the RFEM 6 software. It is important to note that the primary objective of this validation is to confirm the accurate connectivity of the wireframe model rather than conducting a full structural analysis.

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