CAN FORMAL MODELLING APPROACHES SUPPORT BUILDING PLANING AND PERFORMANCE MODELLING?

Ulrich Pont, Ardeshir Mahdavi

E259.3 –Department of Building Physics and Building Ecology

INTRODUCTION

Within building planning processes, regularly a multitude of domain specific aspects need to be considered. These aspects encompass, amongst others, building construction processes, building performance aspects (thermal performance, acoustical performance, ecology performance, etc.), structural stability, and material compatibility. Although the nature of the individual requirements and their normative proof-of-fulfilment procedures is not difficult to grasp, the consideration of all requirements together is non-trivial. Thus, even basic planning tasks require the reasoning capabilities of human experts. However, different stakeholders such as architects, building planners, engineers, or building physics consultants face major challenges while iteratively converging toward design decisions. Aside from being cumbersome and error-prone, "trial and error" processes often result in non-optimal solutions. Given the nature of certain routine working steps in the planning process, intelligent computational support could provide support. In this contribution, we explore the application potential of formal modelling approaches for the AEC (architecture-engineering-construction) domain. Using a case study approach, we outline the methodology and outcome of a number of recently conducted research projects connected with the idea of (partial) automation of routine building planning tasks. Moreover, we review the application potential of certain standard formal modelling approaches in building domain.

CASE STUDY-BASED PROBLEM STATEMENT & APPROACH

Figure 1 (left) illustrates various factors influencing building designs. Many of these aspects do not have an "optional" character, but come with minimum requirements. Regulations pertain to different levels of detail of the building, ranging from large-scale spatial planning over whole building requirements, to single zones, and to building construction assemblies. For instance, the minimum requirements for an exterior wall assembly encompass, amongst others, requirements regarding heat transmission, sound reduction index, vapour diffusion / condensation avoidance, and structural stability (Figure 1, right). The manual creation of assemblies can be understood as easy, if only one of these constraints is looked at. If a number of – partly contradictory - requirements need to be considered, a manual exploration of the design spaces may lead to a rather cumbersome trial-and-error process. Given the numerous possibilities in architectural engineering regarding building construction assemblies, this process can get very time-consuming. Moreover, while the result of this process probably will be a valid combination, it will highly probable be not one close to an optimum. Furthermore, it has to be considered that the generation of building component assemblies not only is performed multiple times for different constructions within an average building delivery process. Rather, today's planning practice shows the same components modelled repetively in different domain applications (drafting tools, energy certification applications, etc.).

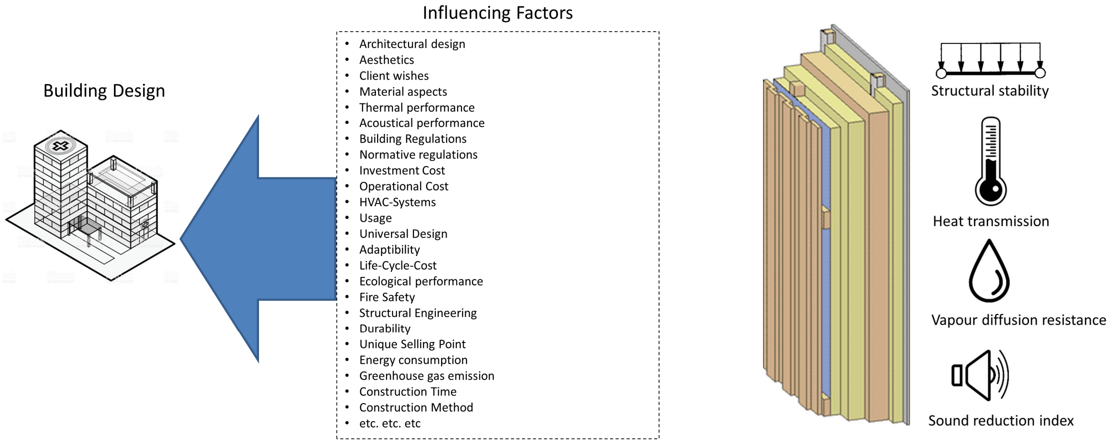

Figure 1: (left) Influencing parameters on building design;
(right) Important aspects that need to be considered in the design of an exterior wall

Formal modelling approaches are commonly used in ICT (information and communication technology) to model real-world situations in a machine-readable and understandable form. They can be deployed to partially automate specific processes, or to form tight rule-based frameworks (grammars) to identify valid solutions for a problem. There have relatively few efforts to adopt these principles (for instance deterministic and non-deterministic finite-state machines, regular languages, or context-free grammars) for the AEC-context. Given the effort regularly invested for routine tasks in the building delivery process (see, for instance [1], for the case of building performance assessment), the potential of such approaches can be considered as significant.

RECENT RESEARCH EFFORTS & NEXT STEPS

Recent projects that underlined the importance of the comprehensive exploration of the possibilities of formal modelling techniques for building-related purposes include the SEMERGY project [2], which targeted the utilization of semantic web technologies for early design evaluation of architectural projects, and – as a follow-up – the BAU_WEB-project [3], which focussed on the efficient provision of building product data in the WWW. In both projects the lack of automation for routine tasks turned out to be a crucial drawback for efficient utilization of time resources. As a response to this circumstance, an initial effort was made toward developing an alphabet and a grammar for building construction assemblies [3]. Further recent efforts include the definition of a set of common use cases. For these, the application of different formal modelling methods could identify the strengths and limitations of the different approaches.

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