Automated construction execution planning using BIM and simulation methods in early design phases

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Background
One key method to reduce the variability between different activities within the execution of a construction is Cycle Planning (CP), also denoted as Takt Time Planning (TTP). A construction section such as a floor consists of multiple work zones, which should have continuous flow and similar cycle times to coordinate needed resources efficiently.

Especially for concrete structures, it is often difficult to find suitable sizes of casting segments and their grouping to work zones. The number and size of casting segments have a significant impact on the success of CP (Kenley and Seppänen, 2010). Nowadays, scheduling experts usually use their practical experience to find an intuitive solution for CP, which might be sub-optimal.

Building Information Modeling (BIM) is suitable to get accurate quantity take-offs and provides the possibility to achieve forward displacement of planning processes (Borrmann et al., 2015). A building information model provides a very useful digital basis for creating the required breakdown structure to represent casting segments and work zones. This enables an immediate inclusion of the construction process in early design phases.

Research goal
The most important research goal is to generate optimal work zones for a cycle. The result should be a Cycle Planning layout, which considers the project parameters and delivers further information for formwork planning as well as for logistic aspects.

Whereas the term CP is commonly used for cast in-situ, TTP is a more general term, which is also used in the context of Lean Construction (Frandson, Berghede and Tommelein, 2013). The goal is aligning crews and creating flow on site for cast in-situ as well as for precast constructions.
Motivation
The result of a case study with three experts shows, that a Cycle Planning layout for the same construction section can look different (Fig. 1).

![Fig. 1: Visualization of the different layouts provided by experts](image)

Each number represents a casting segment. A group of identically colored casting segments forms a work zone. Every expert finds an own individual solution. All of them use similar rules, which are partly hard but rather soft constraint.

Research Method
A first approach is a smart algorithm to split existing objects like walls into smaller sections (Fig. 2).

![Fig. 2: Binary tree approach for a semiautomatic ruled based splitting of objects](image)

The goal is to get feasible sizes, which can be constructed or mounted on site. The algorithm is based on the binary tree data structure (Garnier and Taylor, 2010).

After splitting wall objects into small sections, an optimization algorithm aggregates wall sections to casting segments and casting segments to work zones. The objective function to find an optimal solution for the size of casting segments is currently a combination between construction time and number of joints. One goal is to find and analyze suitable optimization methods. There is a first approach by the use of simulated annealing (Kirkpatrick, Gelatt and Vecchi, 1983).

References


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