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# Using "Choosing by Advantages" and 4D Models to Select the Best Construction-Flow Option in a Residential Building

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**Abstract**

In Peru, construction planners use 2D drawings and do quantity take-off by hand when scheduling structural work. However, selecting the best construction-flow option is usually point-based and does not follow a comprehensive method. This paper describes a teaching strategy that was used to choose the best construction-flow option for a residential building by means of the Choosing by Advantages (CBA) and 4D models in two Construction Management courses at the School of Civil Engineering at the Pontifical Catholic University of Peru. First, a workshop was held to assess the improvement in understanding of the construction flow when 4D models are used with undergraduate students. A survey, including student perceptions before and after the deployment of 4D models, was conducted. Using a paired T-Test, it was concluded that there is significant improvement in visualization and process-clash detection when 4D models are used. Second, Master's students designed four different construction-flow options during structural work using *Takt-time* schedules and 4D models. These tools allowed students to visualize the construction flow, identify process clashes, and retrieve information from the BIM model. The workshop simulated a CBA decision-making meeting to choose the most advantageous alternative. The success of the workshop was reflected in the improved collaboration and the transparency of the decision-making process.



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*Keywords:* BIM; CBA; decision-making; *Takt*-time schedule; teaching.

## 1. Introduction

During the construction of residential buildings, a reinforced-concrete structural system is erected, dividing each story into a number of zones. In each zone, several tasks are performed (e.g., vertical and horizontal formworks,

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rebar, concrete pouring). Such tasks are usually scheduled according to production-physics principles in a linear fashion. The visual tools used to make such schedules are based on 2D drawings and spreadsheets in collaborative sessions. As a result, *Takt*-time schedules [1] or flowlines [2] are produced. However, in Peru, the researchers have observed that scheduling structural work in residential buildings typically is marked by limited visualization of the construction sequence, very few construction alternatives, late identification of process clashes, and a lack of any comprehensive method to select the best construction-flow option. In this context, BIM models, such as 4D, appear to be a means of improving visualization and comprehension early in the construction planning stage [3]. A 4D model allows planners to visualize the construction process, identify construction constraints, retrieve quantity take-off information, and make iterations as needed. Furthermore, Choosing by Advantages (CBA) offers an additional comprehensive method for selecting the best alternative via a comparison process, thus creating transparency and collaborative environments for decision-making [4]. CBA turns out to be the best multi-criteria decision-making (MCDM) method, when compared to the Analytical Hierarchy Process (AHP) method [5], Weighting Rating Calculating (WRC) [6], and Best Value Selection (BVS) [6].

The aim of this research is to describe a teaching strategy utilized in the School of Civil and Building Engineering at the Pontifical Catholic University of Peru that incorporated CBA and 4D Models in two construction-management courses. The research had two stages. First, in an undergraduate course entitled "Construction Planning," the impact of 4D models when scheduling and detecting process clashes was analyzed, comparing it to traditional tools such as 2D and spreadsheets. The workshop strategy and survey results are presented. Second, a CBA workshop was developed in a graduate course called "Lean Construction and BIM Synergies." Students were responsible for the design and modelling of four different construction options in a mock-up project. Then a pull-planning meeting was developed, using CBA as a tool to choose the best construction-flow alternative. An outline of the workshop, results, and lessons learned is presented.

**Nomenclature**

| | |
|---|---|
| BIM | Building Information Modeling |
| CBA | Choosing by Advantages |
| MDCM | Multi-Criteria Decision Making |

## 2. Pull Planning and *Takt*-Time Scheduling

"Pull" refers to a linear manufacturing process in which all stations perform a task. In a pull system, downstream stations demand quantities of work from upstream stations in a steady rate of production at a *Takt*-time. The challenge is to create a pull system with a steady rhythm (*Takt*-time) and design workstations to deliver on demand at a specific rate [1]. The system fails if a workstation does not deliver on time to its successor, as the next workstation will have to wait for work. Similarly, if a workstation overproduces, the next station will only be able to process the results according to its capabilities [1]. As a result, the product will get hung up between stations, and the flow will become irregular. According to the Last Planner System®, "pull planning" is a technique to develop a production plan at any level of detail, such as during the structure phase in a residential building [7]. Pull planning is used to plan work, sequence activities, and collaboratively produce pull schedules [8]. Pull planning meetings should call upon stakeholders who are able to make decisions or provide adequate information about constraints to the production team [7]. In a residential building, each story is divided in a number of zones (workstations) in which construction activities should flow at a steady rate. The quantities in the zones must be roughly the same, in order to maintain similar resource levels in every *Takt*. The *Takt*-time can be a week, a day, or an hour, and workstation resources are planned accordingly. Each trade spends a certain amount of time (*Takt*-time) in a zone in order to complete its work [9]. This allows the pull system to run smoothly.

## 3. Choosing by Advantages

Choosing by Advantages (CBA) is a multi-criteria decision making (MCDM) method for choosing alternatives based on the advantages of selected options. Key terms in CBA include "alternative," "factor," "criterion,"