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## Lean Building Design Model

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### Abstract

Improper design in building projects leads to changes in orders, rework, budget overruns, schedule delays, and low constructability, making it a major cause of waste. The objective of this study is to develop a Lean Building Design Model (LBDM) using lean ideas to improve design quality. To improve the design quality, concurrent engineering is used to develop a learning environment that integrates design needs between project stakeholders. Feasibility of the proposed LBDM is validated using system dynamics. The analysis shows that the LBDM could improve the design quality, thus enhancing project performances.

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### 1. Introduction

Designers face difficulties while conducting a comprehensive design that involves various professional sectors. As building projects are increasing in complexity, rare designers could claim comprehensive expertise [1]. As a result, completed design works may hide problems that might break out in the construction phase [2]. Minor design errors could be resolved on the construction sites, whereas serious problems incur change orders that may increase both project duration and costs [3, 4].

Low quality design is arguably one major waste in the construction industry [5]. When defective design is found in the construction phase, it has to be reported to the designer for amendment. The corrective procedure causes additional time and efforts [6, 7]. Indeed, conception and designing phases have the greatest impact on the project performances [8]. Faulty design can result in mandatory change orders. More than 40% of design changes could be

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attributed to low quality design [9]. How to improve design quality has always been a measure to mitigate waste, thus enhancing project delivery and minimizing cost overruns [10–12].

Lean production, originated from the Toyota Production System (TPS), has been regarded as a systematic way to reduce waste and enhance customer value. Researchers have reported successful projects that conducted with lean ideas in engineering and design. Ko and Kuo [13] applied lean ideas in formwork engineering to remove unnecessary waste. Formwork productivity is thus enhanced due to waste reduction. Lean principles have also been used to pull the submittal review process. Ko and Li [14] validated that preparing submittals for review using pull mechanism could protect the contractor from the impact of change order, thus enhancing project delivery. Although previous studies have proved that lean production could be used to enhance productivity and duration, rare research could be found in improving design quality through lean. The objective of this study is to apply lean production principles to enhance design quality. Background information about lean production is introduced. A Lean Building Design Model is then developed based on lean concepts. Finally, system dynamics is used to validate feasibility of the proposed method. Conclusions are addressed in the final section.

## 2. Lean production system

The Toyota Production System, also known as lean production system, consists of 14 principles that can be categorized into 4Ps. Each category begins with the first capital character P, i.e. Philosophy, Process, People/Partners, and Problem solving [15]. In Fig. 1, the Philosophy is a foundation for the production system. Leaders of the TPS treat their company as a media to create values for their customers, society, community, and colleagues. The second P, Process, emphasizes that positive results can be retrieved from the correct process. For People/Partners, TPS adopts a strategy to let their employees and suppliers grow by challenging them to create values for the company. In lean production system, tools are used to reveal hidden problems, providing employees and suppliers an environment to think and grow. The top of the pyramid, Problem solving, drives the organization to learn. Lean production system endeavours on finding root causes for problem solving. As a result, enterprise can be improved and thus values can be created. To improve design quality, Problem solving for organizational learning is adapted to improve design quality.

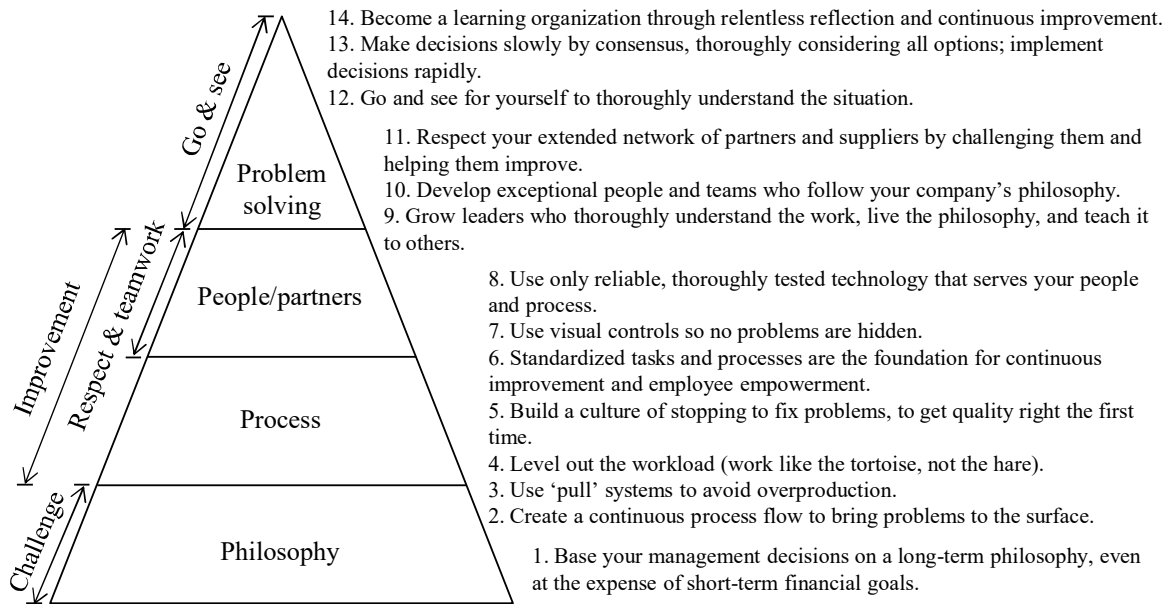


Fig. 1. The Toyota Way.  
 Source: [15].

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