UNIVERSITY OF CAMBRIDGE
Department of Engineering

CONSTRUCTION ENGINEERING MASTERS DISSERTATION ABSTRACT

The Application of Complexity Theory to Address Safety Critical Design Errors in Precast Manufacturing Enterprises

Design error remains an innate and prevalent challenge for the construction industry, despite a plethora of related literature and technology aimed at addressing this problem. One explanation for this continued prevalence is that the increasing complexity of construction has negated benefit offered by research and technology.

Levels of complexity within the construction industry are increasing. Construction enterprises face complexity in procurement, and construction projects face complexity arising from inherent uncertainty, and the presence of system actors with non-aligned and conflicting objectives. Within such projects, the design phase is thought to be particularly complex. Construction designers face complexity of product, process, and that arising from the use of digital technologies. Designers within the off-site manufacturing sector face additional complexity due to requirements for suitable information at early project stages, the need for component standardisation, and a push for the take up of automated design technology, coupled with corresponding changes in designer skill-sets. In all scenarios, significant complexity arises from the presence of individuals as design can be conceptualised as a socio-technical activity that occurs within the complex social systems of construction projects. Design error can therefore be regarded as a complex social problem, and measures to counter complexity may offer value in addressing the prevalence of construction design error.

Consequently, the aim of this thesis is to investigate how measures aimed at addressing error and complexity may be of value in addressing this challenge. Approaches that directly address error, design error and complexity are reviewed. One approach that appears to offer significant value is that of the EMK Complexity Methodology. This methodology is specifically aimed at addressing complex social problems and asserts that two fundamentals are needed; namely the identification of the multi-dimensional problem space associated with complex problems, and the subsequent implementation of an enabling environment that facilitate co-evolution of measures to address this problem space via continual learning and local decision making. Accordingly, this thesis applies this methodology within a case study environment and investigates how this may be of value in addressing design error.

This thesis finds that the application of this approach offers benefits in identifying unknown and unforeseen aspects of design error, facilitating organisational change and creating emergent behaviours. The findings of the research are generalised to a high-level framework that may be applicable to addressing design error in any construction design environment. Recommendations for future research are also presented.

Scott Knight

June 2020