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قسم

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AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Department of Structural Engineering Department

Integration of Building Information Modeling with Value Engineering Analysis to Develop Sustainable Construction Projects in Egypt

A Thesis submitted in partial fulfillment for the requirements of the degree of Doctor of Philosophy in Structural Engineering

(Construction Engineering and Management)

by

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Cairo - (2021)

Abstract

The recent accelerated development of the information management process has contributed to further technical developments in the construction industry. This affects the development of building design in the implementation of buildings with a high level of environmental performance, the application and assessment of sustainable construction requirements. Egypt is one of the countries facing the challenge of not adopting technology among stakeholders. As a result, the construction industry is not in line with the rapid development of the process of information management for the sustainable construction industry in developed countries. Sustainability has also not yet been identified as an important factor in the performance of the project and therefore the value of the project. Hence, there is a need for better tools and increased use of technology to improve sustainable building efficiency. It is important to examine the design of sustainable construction projects and to consider all possible alternatives, especially at the design stage, in order to achieve the best sustainable design. This problem may become very difficult when the choice of alternative depends on the assessment of a number of alternatives related to a number of criteria.

The use of Building Information Modeling and Value Engineering has helped to provide further improvements in sustainable design and technical development in the construction industry. BIM coupled with VE can generate innovative alternatives, evaluate and compare different alternatives using AHP model. Many researchers are interested in the AHP because of its mathematical properties and the fact that the necessary input data are relatively simple to obtain. AHP is a basic approach to decision making. It is designed to choose the best alternative from a number of alternatives with multi-criteria.

The objective of this thesis is to presents a framework for the integration of BIM with VE to improve and evaluate sustainable design at the early design stage of a project, which include: 1) Provides a questionnaire to study the expected benefits of integrating BIM with VE. The opinions of construction industry participants were taken to assess the impact of the BIM application with VE. 2) Developing a 5D BIM model that integrate BIM with VE. This integration based a number of alternatives created to visualization capabilities of specifications, schedules and costs using the Navisworks simulation. 3) Study the energy efficiency of buildings by analyzing weather and virtual environment data with the DesignBuilder tool. 4) Assess the relative environmental impacts

of building materials used in the alternative design through environmental emission analysis using SimaPro. 5) Life Cycle Assessment is considered through the LEED rating system according to ISO 14040 standards. 6) Develop a multi attributed decision environment to choose an optimal sustainable design alternative. A model using a computational programming platform in C# is proposed by Visual Basic Studio for AHP to evaluate the data.

This research has shown the importance of integrating BIM with VE in construction industry as a powerful tool that contributes to the improve sustainable design. The questionnaire focused on achieving an overview of the importance of BIM use and VE in the Egyptian construction industry. The majority of responses agree that the integration of BIM with VE offers several benefits that can improve project success. The model was applied to case study to verify its use and capabilities by creating three different alternatives. The results demonstrated the importance of the model in evaluating and selecting the most appropriate design alternative. Also, the model has been validated by engineers that have a good experience in the field of construction industry. The model with its components, the nature of its use, and access to outputs are applicable and effective, where performance is estimated at 84%.

Key words: Construction Industry, sustainable construction, BIM, VE, AHP, Energy Efficiency, Environmental Impacts, Life Cycle Assessment and LEED.

AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
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Summary of the PhD. Thesis Submitted by

Eng. Ayman Hussein Hussein Taher

Title of the thesis:

Integration of Building Information Modeling with Value Engineering Analysis to Develop Sustainable Construction Projects in Egypt

The methodology of this thesis is based on the creation of a questionnaire survey administered to a group of qualified construction industry professionals in Egypt to take their opinions on the intended usefulness of BIM integration with the VE. Study the impact of integrating BIM with VE to improve building sustainability and introduce sustainability analysis by developing a 5D BIM model, studying the energy efficiency of building design. Also, assess the relative environmental impacts of building materials. Use Life Cycle Assessment tool through the LEED rating system accordance with ISO 14040 standards. Finally, developing a model using the Analytical Hierarchy Process (AHP) to choose appropriate alternatives for sustainable design.

The thesis is divided into seven chapters as follow:

Chapter 1: Introduction

This chapter provides an overview of the research that includes introduction, problem statement and objectives of the study. Also, it presents a summary of the research methodology as well as, the structure of the thesis.

Chapter 2: Literature Review

This chapter provides a review of the extensive literature in BIM, VE, sustainable development, sustainable buildings rating systems and examines the method that can enhance decision support using AHP.

Chapter 3: Research Methodology

This chapter described the detailed adopted methodology of research. Which is based on the questionnaire survey and develop a multi attributed decision environment to choose an optimum design alternative. By developing a 5D model, analysis of VE, the development of criteria and alternatives.

Chapter 4: Data collection

This chapter discussed the entire data collection process for this study, which included a questionnaire, case study and interviews.

Chapter 5: Questionnaire Analysis

This chapter focused on achieving an overview of the importance of BIM use and VE in the Egyptian construction industry. Also, the effect of integrating BIM with VE to improve building design.

Chapter 6: Development of 5D Model and Sustainable Design

This chapter presents a conceptual approach to the development of a 5D BIM model within the scope of structural design. In order to obtain a detailed digital representation of alternatives design. Also, presents a study on the impact assessment of buildings designed to know the conditions for achieving sustainability principles. By assessing the relative environmental impacts of building materials used in the alternatives design and determining the performance of the LEED rating systems for the alternatives.

Chapter 7: Integration of Building Information Modeling with Value Engineering to Develop a Decision-Making Process for Alternatives Selection

This chapter provides an explanation of a case study using a model in which different criteria for alternatives are applied and the AHP model is presented to support decision-making in evaluation process, and the choose of design alternatives. Also conduct interviews to solicit the opinion of practicing professional on the developed framework.

Chapter 8: Conclusion and Recommendations

This chapter includes the conclusion, presents research contribution, limitations, recommendations and the recommendations for future research work. Some of thesis contributions are:

1. Study the effect of the benefits of using BIM with VE in the Egyptian construction industry.
2. The development of the 5D BIM model to assist VE specialist in the process of generating creative alternatives in the creative phase.
3. Provide the opportunity for the VE job plan to analyze the results and the consequences of each element, change, identify different elements that have the most impact on cost in almost real time.
4. Understand the environmental impacts of alternatives design using the LCA tool to analyze and classify the environmental impacts of sustainable design.
5. Develop a decision support model to choose the appropriate design alternative for sustainable buildings. The model aims to support stakeholders during the design phase in choosing the most appropriate alternative to design by providing a visualization of the design cost and time performance on the BIM model.

Key words: BIM, VE, Sustainability, Energy Efficiency, Environmental Impacts, Life Cycle Assessment, LEED and AHP.

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Statement

This thesis is submitted as a partial fulfilment for the requirements of the degree of Doctor of Philosophy in Structural Engineering, Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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