THE ROLE OF BUILDING INFORMATION MODELLING DESIGN APPLICATION IN MITIGATING THE VARIATION ORDER IN JORDANIAN CONSTRUCTION INDUSTRY

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We hereby declare that We have checked this thesis and, in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Doctor of Philosophy of Science in Civil Engineering.

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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Thesis submitted in fulfillment of the requirements for the award of the degree of Doctor of Philosophy

Faculty of Civil Engineering & Earth Resources
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ABSTRAK

Variation order is a major challenge facing the construction industry. It can be defined as changes to the contract documents in the original agreement. It might be a change in quality, or quantity or any forms of change that affect the project. Several researchers in Jordan have inspected the variation orders sources, and a variety of clarifications have been recommended to minimize their causes, nevertheless variation order kept hardly influencing the construction industry. Though, Building Information Modelling (BIM) as a tool to minimize the variation order effects in Jordan has not been examined. Moreover, researchers confirmed a knowledge gap, in terms of BIM awareness through Jordanian construction industry. Literature indicates that the use of BIM in the Jordanian construction industry is lagging behind. The aim of this study is to develop a BIM framework to minimize the variation orders causes on the governmental construction project in Jordan. To meet that aim, a comprehensive literature review was conducted in terms of BIM capability to reduce V.O. impact on construction project around the world. Furthermore, the researcher designed a questionnaire to collect the data required in regard of VO causes and the BIM capability to address this issue. The response rate was around 70% (105/150). The questionnaire answers were analyzed descriptively and statistically by Partial Least Squares (PLS), and Relative Importance Index (RII). The causes of variation order in the Jordanian construction industry were further categorized into four main groups, namely client-related causes, contractor causes, consultant causes and causes arising from unforeseen circumstances of the project. The outcomes of this research (dependent on a relative importance index (RII)) indicate that the most frequent causes of variation orders in Jordan construction industry were, inaccurate quantity take-off, unskilled labourers, missing material specifications, logistic delays, internal politics, shortage of equipment and tools, technology changes, shortage of human and equipment Resource, absence of construction manuals and procedures, unavailability of the required labour skills, change of scope or plans by owners. It was also found that 50% of these causes were initiated by consultants, 20 % by clients and unforeseen variations, while 10 % only were initiated by contractor. Moreover, it was found that BIM Design Applications, Facility Operations Simulation, Exploration Design Scenarios, BIM Design Detection and BIM Quantity Take-off and Cost Estimation were found to be significantly capable to minimize V.O. The research concluded that there is a significant positive relationship between the use of BIM applications and minimizing in the variation order in Jordanian construction industry. This means that the variation orders will decrease significantly if BIM applications is used and supports a case for using BIM as a means of reducing the variation order in the Jordanian construction industry. Finally, focus group workshop was used to validate this framework. Focus group workshop was used to investigate the relationship between the causes of variation order and the functions and features of BIM, which validated the positive effects of using BIM in terms of minimizing the variation order by minimizing the main causes. This research introduced a helpful contribution through a detailed BIM design application framework to minimize variation order, the study recommended to use this framework to solve many problems related to construction industry.
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<tr>
<td>AEC</td>
<td>Architecture, Engineering and Construction Industry</td>
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<tr>
<td>AECO</td>
<td>Architecture, Engineering, Construction and Owner/Operator</td>
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<td>BIM</td>
<td>Building Information Modelling</td>
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<td>BIMDA</td>
<td>BIM Design Applications</td>
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<td>C&amp;D</td>
<td>Construction and Demolition</td>
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<td>CFA</td>
<td>Confirmatory Factor Analysis</td>
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<td>CNP</td>
<td>Contract Parties</td>
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<td>CNS</td>
<td>Consultant</td>
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<td>CNT</td>
<td>Contractor</td>
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<td>COBie</td>
<td>Construction Operations Building Information Exchange</td>
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<td>Design Changes Caused by Improvement</td>
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<td>DCO</td>
<td>Design Changes Originated by Owner</td>
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<td>DCP</td>
<td>Design Changes Originated by Professionals</td>
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<td>DSD</td>
<td>Design Detection</td>
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<td>EDS</td>
<td>Exploration Design Scenarios</td>
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<tr>
<td>FIDIC</td>
<td>International Federation of Consulting Engineer (Fédération Internationale Des Ingénieurs-Conseils)</td>
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<tr>
<td>FM</td>
<td>Facilities Management</td>
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<td>FOS</td>
<td>Facility Operations Simulation</td>
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<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>H</td>
<td>Hypothesis</td>
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<td>IFC</td>
<td>Industry Foundation Class</td>
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<td>IPD</td>
<td>Integrated Project Delivery</td>
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<td>JOD</td>
<td>Jordanian Dinar</td>
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<td>MPWH</td>
<td>Ministry of Public Work and Housing</td>
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<td>OBG</td>
<td>Oxford Business Group</td>
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<td>OWN</td>
<td>Owner</td>
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<td>PCA</td>
<td>Principle Component Analysis</td>
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<td>Programmatic Integration</td>
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<td>PLS</td>
<td>Partial Least Squares</td>
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<td>QTCE</td>
<td>Quantity Take-off and Cost Estimation</td>
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<td>RII</td>
<td>Relative Importance Index</td>
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<td>Abbreviation</td>
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<td>SD</td>
<td>Standard Deviation</td>
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<td>SEM</td>
<td>Structural Equation Modelling</td>
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<td>TOC</td>
<td>Taking-Over Certificate</td>
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<td>TPP</td>
<td>Technology, Process and Policy</td>
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<td>UNFV</td>
<td>Unforeseen Variations</td>
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<td>VIS</td>
<td>Visual Simulation</td>
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<td>VO</td>
<td>Variation Order</td>
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<td>VOM</td>
<td>VO minimizing</td>
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<td>Symbol</td>
<td>Description</td>
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<td>AVE</td>
<td>Average Variance Extracted</td>
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<td>CR</td>
<td>Construct Reliability</td>
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<td>N</td>
<td>Total Number of Population</td>
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<td>Sample Size from Finite Population</td>
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<td>P</td>
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<td>The Standard Error of Sampling Population</td>
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<td>V</td>
<td>The Variance of the Population Elements</td>
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