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

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SUPERVISOR'S DECLARATION

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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ABSTRAK

Perubahan kerja (VO) merupakan salah satu cabaran utama dalam bidang industri pembinaan di Jordan. Perubahan kerja (VO) bermaksud suatu perubahan di dalam Dokumen Kontrak yang berbeza daripada Dokumen Kontrak yang asal. Perubahan ini menyebabkan pengubahsuaian dari segi kualiti, kuantiti atau rekabentuk yang menyebabkan perubahan dalam sesebuah projek. Walaupun banyak penyelidikan serta cadangan telah dijalankan bagi mengenalpasti punca kewujudan VO, namun masalah ini masih menjadi isu di dalam industri pembinaan. Pembangunan Model Berinformasi (BIM) merupakan salah satu cara bagi mengurangkan VO yang tidak lagi digunakan Jordan. Penyelidik telah mengenalpasti industri pembinaan di Jordan masih mempunyai jurang yang besar dalam ilmu serta kesedaran mengenai BIM. Kajian mendapati industri pembinaan di Jordan agak ketinggalan jauh dalam BIM. Tujuan kajian ini dijalankan adalah untuk membangunkan rangka kerja bagi mengurangkan VO dalam projek kerajaan di Jordan. Untuk mencapai matlamat ini, penyelidikan ini bermula dengan menjalankan kajian sastera intensif terhadap kedua-dua, penyebab VO dan BIM di seluruh dunia. Kajian ini dijalankan melalui kaedah tinjauan. Data dikumpul menggunakan sejumlah 150 soal selidik. Penyiasatan ini mencapai kadar pulangan sebanyak 70%. Parameter Minimum Separa (PLS), peratusan, dan Indeks Kepentingan Relatif (RII), digunakan untuk menganalisa data yang dikumpulkan. Data dianalisa melalui dua tahap utama, di mana tahap pertama melibatkan analisis awal data. Proses ini adalah penting untuk memastikan data mencukupi dengan andaian asas dalam menggunakan Model Persamaan Struktur (SEM). Secara umum, set data semua item diedarkan secara normal dan bebas dari kegagalan, nilai-nilai yang hilang dan outlier yang univariat. Peringkat kedua menggunakan kedua-dua peringkat SEM. Peringkat pertama termasuk penubuhan model pengukuran untuk pembinaan laten dalam penyelidikan. Selepas mengesahkan uni-dimensionaliti, kebolehpercayaan dan kesahihan pembinaan dalam peringkat pertama, tahap kedua ditubuhkan untuk menguji hipotesis penyelidikan melalui pembangunan model-model struktur. Sehubungan itu, dua model struktur telah dibangunkan untuk mengkaji 12 kesan langsung hipotesis. Ini dilakukan dengan menjalankan analisa laluan menggunakan SMART-PLS dan menguji signifikan pekali jalan untuk setiap laluan hipotesis. Hasilnya menunjukkan bahawa Pihak Kontrak, Perunding, Kontraktor dan Hal-hal Lain mempunyai kesan negatif yang signifikan dalam meminimumkan VO. Walau bagaimanapun, kesan Aplikasi Reka BIM, Simulasi Operasi Kemudahan, Skenario Reka Bentuk Eksplorasi, Pengesanan Reka BIM, Pengeluaran Kuantiti BIM dan Anggaran Kos pada pengurangan VO didapati positif. Penyelidikan ini diharap dapat memberikan sumbangan yang bermanfaat melalui pendekatan teori yang mengenalpasti punca VO bermula dalam kerja-kerja pembinaan, faktor-faktor bagi pesanan VO dan bagaimana pesanan VO diuruskan dalam sektor pembinaan yang memberi motivasi kepada pihak berkepentingan di Jordan untuk menggunakannya. Kajian ini juga menegaskan bahawa tiada sistem pengurusan VO yang ada untuk projek-projek kerajaan di Jordan. Pendekatan BIM, akan membantu mengurangkan berlakunya VO.

ABSTRACT

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 VO. 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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LIST OF ABBREVIATIONS

AEC	Architecture, Engineering and Construction Industry
AECO	Architecture, Engineering, Construction and Owner/Operator
BIM	Building Information Modelling
BIMDA	BIM Design Applications
C&D	Construction and Demolition
CFA	Confirmatory Factor Analysis
CNP	Contract Parties
CNS	Consultant
CNT	Contractor
COBie	Construction Operations Building Information Exchange
DCI	Design Changes Caused by Improvement
DCO	Design Changes Originated by Owner
DCP	Design Changes Originated by Professionals
DSD	Design Detection
EDS	Exploration Design Scenarios
FIDIC	International Federation of Consulting Engineer (Fédération Internationale Des Ingénieurs-Conseils)
FM	Facilities Management
FOS	Facility Operations Simulation
GDP	Gross Domestic Product
H	Hypothesis
IFC	Industry Foundation Class
IPD	Integrated Project Delivery
JOD	Jordanian Dinar
MPWH	Ministry of Public Work and Housing
OBG	Oxford Business Group
OWN	Owner
PCA	Principle Component Analysis
PGI	Programmatic Integration
PLS	Partial Least Squares
QTCE	Quantity Take-off and Cost Estimation
RII	Relative Importance Index

SD	Standard Deviation
SEM	Structural Equation Modelling
TOC	Taking-Over Certificate
TPP	Technology, Process and Policy
UNFV	Unforeseen Variations
VIS	Visual Simulation
VO	Variation Order
VOM	VO minimizing

LIST OF SYMBOLS

AVE	Average Variance Extracted
CR	Construct Reliability
N	Total Number of Population
Nf	Sample Size from Finite Population
P	Probability
Q2	Quantification
R	Regression
S2	The Standard Error of Sampling Population
V	The Variance of the Population Elements

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