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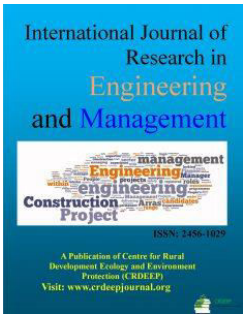

Full Length Research Paper

Application of Value Engineering in the High Rise Buildings: A Review

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ABSTRACT

During the past decades, various structural systems have applied to build several multi-story buildings. Since a large segment of the public and private sectors' expenditures and the time is spent on the construction industry especially the construction of the multi-story building, it is essential to think about how to properly direct this time and a considerable amount of money spent on this critical industry. Nowadays, value engineering considers as a tool of construction management that can help companies to improve their procedures, services, and final products regarding the client's needs, as an end-user, concerning time, cost and quality. The subject of decision support system and value engineering is very rich in the context of the definitions, designing and developing models and measurement issues many researchers explored topics with varying perspectives and using different methodologies. With these issues as the focus, this present study is undertaken to understand the value engineering and decision support system. Value Engineering is a Decision-Making Methodology. Applications of Value Engineering are many and varied and include; Strategic Decision Making – Cost Improvement – Project Management – Project Risk analysis – Product /Process Design and Improvement – Customer/Supplier Interacts – Industry Forums – Team Building (with strategic focus/alignment). The main purpose of this paper is to presents a literature review related to the decision support system in the construction industry for high-rise buildings by using value-engineering process.

Introduction

Although the multi-story buildings are a relatively specialized field of design and construction projects, which is concerned with the design, construction, operation, and maintenance of different project elements according to various purposes. During the past decades, various structural systems have applied to build several multi-story buildings. Since a large segment of the public and private sectors' expenditures and the time is spent on the construction industry especially the construction of the multi-story building, it is essential to think how to properly direct this time and a huge amount of money spent on this critical industry.

The decision support system by using value engineering leads to saving a lot of time and costs in these projects. The most discussed at this point did not pay attention to applying the value engineering and decision making in a multi-story building in the different stages as a whole, but research in general about the value engineering in the projects in construction projects only and some of them discussed the construction projects only or in the design stages. A critical review of scientific research on the decision support system using value engineering in the construction industry for high-rise buildings is presented. The scientific literature on the decision

support system using value engineering to select the optimal structural system for multi-story buildings was reviewed to identify the documented best practices and areas for further exploration. Various engineering databases, conference proceedings and journals including ASCE Civil Engineering Database (for ASCE journals and conference proceedings), Civil Engineering Abstracts, ProQuest Dissertation and Theses, SciFinder Scholar, google scholar were searched. International journals such as Construction Management and Economics (UK), Engineering, American Journal of Civil Engineering (US), International Journal of Civil Engineering and Technology (IJCIET) (India), Procedia Engineering (Netherlands), International Journal "Information Technologies & Knowledge (UK), Journal of Financial Management of Property and Construction (UK), Engineering, Construction and Architectural Management (UK), Indian Journal of Computer Science and Engineering (IJCSE) (India), International Journal of Lean Thinking (Turkey), Journal of Construction Engineering and Management (US), and Journal of Information Technology in Construction (Sweden). Information Technology, Building Research, and Information were searched for relevant research papers. Also, various best practices used in construction projects that could impact the decision support system to select the optimal structural system using value engineering analysis for multi-story buildings are evaluated for their relevance to the research. The below table shows some publications in the last periods, and *it is classification according to the relation to this research study, Table 1 shows the classification for literature review in this study;*

- High Rise Building
- Value Engineering
- Decision Support System
- Identification of Issues and Knowledge Gaps

Review of value engineering from the previous study

These are the points of interest to researchers in the field of value engineering in general:-

Definitions related to a value engineering analysis in the construction industry

The Society of American value engineers defines value engineering as the systematic application of recognized techniques, established a value for that function, and provide the necessary function reliably at the lowest overall cost.

History of Value Engineering

In 1947, Lawrence D. Miles created and introduced the techniques of value analysis and value engineering at General Electric. Soon after he developed this systematic methodology, his concepts were recognized as a powerful approach to problem solving through function-based techniques, and they found their way outside GE to many parts of the world and many environments, including industry, healthcare, and government services. Miles' techniques have saved design engineers, manufacturing engineers, purchasing agents, and service providers millions of dollars by showing users "why so many unnecessary costs exist in everything we do and how to identify, clarify, and separate costs which bear no relationship to customers' needs or desires." Larry Miles was confident enough to articulate that many decisions are based on honest but wrong beliefs and that his methods provide the highest customer acceptance at the lowest cost. He acknowledged how many professionals identify as solutions that they want to do and not what needs to be done. Value management is not restricted to the types of projects mentioned above but can apply to any project/building or asset. Value management can be used to parts of buildings or subdivisions of projects. The general feel is that value management is more beneficial on projects that are more significant because there are certain costs associated with a value management study.

The benefits of a value management study

Value management has many advantages ranging from financial benefits to helping to build the morale of the professional team. Value management will affect everyone associated with the project, otherwise known as stakeholders. Value management can address most of these needs directly or indirectly, thus bringing a degree of satisfaction to all the stakeholders involved.

The difference between Value Management and cost management

Cost management does not make any significant changes to the scope and concept of a project while value management looks holistically at the project as a whole and scope changes are often considered when conducting a value management study. The key differences are that value management is favorable. Value management is also structured, accountable and aims to maximize the creative potential of all project participants. Value management, on the other hand, is beneficial to cost management because it lists ideas that could save costs even if it is only at a later stage.

Table 1: Shows the classification of the previous researchers

Research Name	Year	Researcher Name	Project Life Cycle	Classification
Innovative Application of Dispersed Shear Wall to a Kilometer-High Concrete Skyscraper	2016	Feroz Alam	Analysis and Design	High Rise Building
The possibility of Using Value Engineering in Highway Projects	2016	Renata Schneiderova Horakova	Construction Industry	Value Engineering
High-Rise Residential Reinforced Concrete Building Optimisation	2015	Haibei Xiong, Miguel Angel Hidalgo Calvo	Analysis and Design	High Rise Building

Value engineering in residential house construction	2015	Nayana Tom, V. Gowrisankar	Construction Industry	Value Engineering
Value management of construction project	2014	F. Rangelova, M. Traykova	Construction Industry	Value Engineering
Value Engineering For Low-Cost Housing Construction In Egyptian Expansion Urban	2014	Fatma A. Agrama, Maher T. Al-Nemr, and Mohamad A. Abdo	Construction Industry	Value Engineering
Analysis and Design of Diagrid Structural System for High Rise Steel Buildings	2013	KhushbuJania, Paresh V. Patel	Analysis and Design	High Rise Building
Application of Value Engineering in Construction Projects	2013	SenayAtabay and NiyaziGalipogullari	Construction Industry	Value Engineering
An integrated framework of designing a decision support system for engineering predictive maintenance	2012	Daniela Borissova, Ivan Mustakerov	Knowledge Management	Decision Support System
Value engineering analysis for the educational buildings in egypt	2012	M.A. Youssef, I.A. Mohammed, A.N. Ibraheem, and I.M. Hussein	Analysis and Design	Value Engineering
Diagrid Structures for Complex-Shaped Tall Buildings	2011	KYOUNG SUN MOONa	Analysis and Design	High Rise Building
An analysis of value management in practice: the case of Northern Ireland's construction industry	2011	Srinath Perera, Carolyn S. Hayles, and Stephen Kerlin	Construction Industry	Value Engineering
A Decision Support System to Compare the Transportation Modes in Logistics	2010	Eren Özceylan		Decision Support System

Value engineering in the construction industry

A corresponding value engineering analysis model put forward for using the theory of value engineering and analytic hierarchy process (AHP), and the research of project management optimization technology, based on the actual cause of a high-rise building, however. Based on the model to evaluate its function, cost, deduce the corresponding model parameters (Chong Zhou et al., 2014).

Shengjian et al. 2014 presented an estimation model of intelligent jack-raising form construction technology. Then through the concrete data analysis of the Guangzhou east tower project, a more reasonable value analysis and evaluation model of intelligent jack-raising form construction technology are given. In 2001, Jacqueline et al. reported the findings of research on innovation in the UK construction industry. Also, in particular, changes in reinforced concrete building technology. The EPSRC sponsored the research project entitled 'Assessing Concrete Technology Innovation using Value Engineering' (ACTIVE). It was aimed to make recommendations to direct future R&D initiatives in the reinforced concrete building industry. The work also proposed to define and categorize the general factors or issues that characterize, or are associated with, take-up of innovation in the UK construction industry. Transportation projects were proposed a value engineering teamwork by involving construction, design, and maintenance staff review the construction project features and look for ways to improve quality, control costs and time. It was described value engineering and quality, cost schedule planning, application of value engineering, cost parameters, the relationship of value, function, cost, and worth (Amiruddin et al., 2010). Applied value-engineering technique on the educational building to maximize the utilization of the available construction and maintenance budget. It was used to a model of primary school and suggested that the General Authority for Educational Buildings (GAEB) should construct a value-engineering department included in its organizational structure. Finally, it draws overall conclusions about the application of value engineering in the GAEB in Egypt. Also, to get the optimum set of activities, alternatives for cost-saving and maximize the utilization of the available funds for new construction and maintenance works. The value engineering technique application is based on data collected from GAEB (M.A. Youssef, 2012). Increase the application of change proposal methodology in the civil projects of the country and utilized its benefits. It was introduced this methodology by investigating the fundamental concepts of this method and pointing to the advantages of this managerial technique) Khademi and Beheshti, 2013). The theoretical perspective of value engineering is subject geographical location and the contract under which the project is being administered. The North American process typically occurs at design/scheme stage in a forty-hour workshop using a secondary design team. This Value Engineering process is tailored for the North American construction / civil engineering sector due to their favoritism towards early contractor involvement. It was revealed that a system needs to be developed to analyze components and elements in a systematic manner that can explain the positives and negatives of any proposal. These positives and negatives can be used to „sell" the proposed value engineering proposal to the client(s) or contractor(s) (Samuel and Charles, 2013).In 2014, Chougule and Patil studied the application the value engineering during any stage of a project's design development cycle. However, the most significant benefit and resource saving are typically achieved early in the development and conceptual design phases. It is essential

available and compares the quality elements of the design with the owner's requirements. The application of Pareto Law 20/80 states that around 20 % of the functions constitute about 80% of the cost. Also in 2016, Heralova studied the possibility of using value engineering in highway projects. The reasons for criticizing highway projects are usually three.

Application of value engineering in construction projects

The valuation methodology was analyzed, and the use of the weighted-analysis method in the evaluation phase of the conventional VE process was found to be limited relative to sustainable design and construction. Specifically, the research aim was to refocus the traditional engineering of the value process to improve building sustainability outcomes (Ochieng, 2017). Meanwhile, in 2017, Arivazhagan et al. conducted a questionnaire survey for Tamilnadu State, India. The questionnaire survey mainly focuses on how effectively value engineering is applied in the construction industry and how much the employees are aware of the concept of value engineering and its effectiveness. Identified the clarify the concept of value management in the construction industry, via literature review, and references and books the use of value engineering on a global level and to present a short description of the extensive know-how. That achieved by a historical review of value engineering and by the illustration of the most common definitions and a thorough terminology review. Also, it presented three different markets applying value engineering worldwide, the U.S.A., the E.U. and the Japan Standards for value engineering (Ali and Pandey, 2016).

In 2016, Rad and Yamini revealed that value engineering could be used as a helpful tool from the beginning of studies to the end of designing, constructing, exploiting, and maintaining processes and overcome civil designs' challenges and complexities. In 2016, Rane focused on new techniques, methods, and materials that can be adopted in the construction industry, in which, its cost, quality, process time and feasibility are considered. Value engineering focuses on accomplishing the required functions at the lowest overall cost. It helps in eliminating or minimizing wastage of material, time, and unnecessary cost, which improves value to the customer.

Introduction of computer applications in value engineering

In 2000, Assaf et al. presented an easy, quick, and accurate way of implementing value-engineering studies by introducing an integrated computerized system for the value engineering technique and life-cycle cost as a checkout system. The value engineering computer program was designed using a database computer program, FoxPro Window.

Review of decision support systems from the previous study

Decision Support System is a computer technology solution that is used to support complex decision-making and problem solving. Decision support systems process mass data and provide managers and decision-makers decision options. These systems use to run complex statistical, mathematical models, data analyses and support decisions. The decision support system should help decision-makers in all levels, supports decision-makers in all management levels individually and group and in semi-structured decisions, provide simulating and analyses tools for the decision-maker to relate to general data station and has sufficient flexibility to coordinate different management methods. These are the points of interest to researchers in the field of decision support systems in general:-

Definitions related to decision support systems

Decision support systems are a subset of computer-based information systems (CBIS). The general term 'computer-based information systems' is a constellation of a variety of information systems such as office automation systems, transaction processing systems, management information systems, and management support systems. Management support systems consist of a decision support system, expert systems, and executive information systems. Yi-Kai et al. presented an on-line housing condition assessment and refurbishment decision support system. The system is composed of three major parts: an interface module, an analysis module, and a database module. It was presented a genetic algorithm (GA) based on-line decision support system to help residents efficiently conduct the housing condition assessment and offers optimal refurbishment actions considering the trade-off between cost and quality.

Two refurbishment models, budget priority and quality priority, are developed to explore the relationship among the life cycle cost, restoration cost, and improved quality. Elbeltagi et al., examined the usage of a decision support system in local Egyptian authorities using an adapted Technology Acceptance Model (TAM). Chief Executive Officers had rolled out the centrally developed decision support system to 27 Governorates in Egypt for use. The results demonstrated that TAM could be applied to a specific system within a developing country. Both perceived ease of use (PEU) and perceived usefulness (PU) had a significant direct effect on decision support system usage. PEU dominated over PU whose effect on decision support system usage was adverse. It was indicated that the importance of taking into account external factors when examining IT technology adoption globally. In particular, many aspects of culture, including the background and characteristics of the decision-maker will strongly influence the perception of management support systems. The decision support systems are a subset of computer-based information systems (CBIS). The general term 'computer-based information systems' is a constellation of a variety of information systems such as office automation systems, transaction-processing systems, management information systems, and management support systems (Sean, 2001).

Application of Decision Support System in Previous Studies

The optimization of isolator parameters for structural systems to withstand potentially catastrophic transient vibrations. The final product is a user-friendly Decision Support System for use with both civil and military applications. Based on different types of base motions and the inherent dynamics of the structure, this decision support system is capable of optimizing isolator parameters to meet a user-specific objective (Hernandez, 2003). The selection of an optimal transportation mode using an AHP-based model was evaluated for logistics activities (Özceylan, 2010). A framework of decision support system for predictive engineering maintenance for civil engineering. The proposed framework integrates traditional decision support systems with the advances of the expert system. While the conventional decision support system constitutes data management, decision methodology and user interface the advances of expert systems embrace symbolic reasoning and explanation capabilities (Daniela and Ivan, 2012). Comparing decision support systems and other information processing systems that observed decision support systems use to help semi-structured decisions and single and having a quick change and use by managers in user-friendly and easy access to information (Khodashahri and Sarab, 2013).

In 2013, Khodashahri and Sarabi mentioned comparing decision support systems and other information processing systems that observed decision support systems use to help semi-structured decisions and single and having a quick change and use by managers in user-friendly and easy access to information. Applied the SEM approach and built a model that explained and identified the critical factors affecting quality in social infrastructure projects. Developed a quantitative method using smart-PLS version 3.2.7., and determined that better planning and monitoring and evaluation should be designed to address better and control the quality defects by decision-makers, project managers as well as contractors (Shahid et al., 2018).

Previous Studies of Decision Support System using value Engineering

In 2017, Wang et al. introduced the theory of value engineering in the green building investment decision-making stage. In terms of Green Building Evaluation Standard for green building assessment, it establishes the evaluation index system of green building and brings to the fuzzy comprehensive evaluation method for green building schemes in the function of the need to be taken into account, additional cost and value to do a quantitative analysis.

Review of structural system from previous studies

Steel structural is widely used as a building material, because of some factors including its mechanical properties, availability in a variety of useful and practical shapes, economy, design simplicity, and ease and speed of construction. Steel can be produced with a range of properties to suit different requirements. The prevailing conditions are strength, ductility, weldability, and corrosion resistance. In 2012, KATKHODA and KNAA Used application for a solution to the issue of optimization in the selection of structural systems for the design of reinforced concrete (RC) high-rise residential buildings; it was applied by the study and design of three models of RC high-rise structure buildings consisting of (10-15-20) stores. Rebielak showed the examples of shapes of structural systems that proposed with definitions of their numerical models prepared in the programming language Formian. The construction of high-rise buildings using the different techniques and for the growth of population demand of the high-rise building. Also for the high rise, building the requirements that are essential for it is mentioned (Thapa et al., 2013).

Review of multi-story buildings from previous studies

The design of steel high-rise buildings concerning the main structural-related functions controlling the design configurations and their impact on the value of the building. The process of value engineering as standardized by SAVE International is utilized in the value analysis model proposed in the study (Eldash, 2002). In 2014, Nishant and Siddhant presented briefly some of the significant structural forms systems employed in tall building structures and drawn on their importance in the performance of tall building structures. Since tall buildings enjoy rapid evolution and innovations and with the development of increasingly taller buildings structures serviceability issues like lateral sway, floor vibration, and occupant comfort need to be given more attention. Kavilkar and Shweta (2014) studied the availability and use of fly ash in various proportions, which can be used in Indian high-rise residential buildings. It was indicated that fly ash concrete can be used to reduce the cost of construction and has the potential to minimize the damage caused due to high temperatures. KYOUNG (2011) studied the structural performance of diagrid systems employed for complex-shaped tall buildings such as twisted, tilted and freeform towers. For each miscellaneous form category, tall buildings are designed with diagrid systems, and their structural efficiency is studied in conjunction with building forms. Robert (2007), contributed to the reduction of the significant gap between the state-of-the-art of structural design optimization in research and its practical application in the building industry. It was focused on structural topology optimization, investigating three distinct methods through the well-known example of bracing design for lateral stability of steel building frameworks. HING (2006), discussed the common difficulties/ irregularities and technologies occur in the Hong Kong construction industry.

Conclusion

Although there is previous research work for value engineering and decision support system conducted individually in each country, there is limited research work concentrating in some countries as groups, the construction industry in these countries are very similar. Most of the previous research work was conducted to

determine the value engineering in industry projects and construction projects. Also, some research works were conducted to present a decision support system by using value engineering analysis. In the review of the literature, none of the studies reviewed accounted for the factors while analyzing for selecting the optimal structural system using value-engineering analysis for high-rise buildings. The analysis of literature demonstrates the absence of a study that quantitatively identifies the best practices that will help to select the optimal structural system using value-engineering analysis for high-rise buildings. Table 2 shows the Summary of earlier researches in multi-story optimization, and table 3 shows the frequency for the literature in the different topics related to the research. Figure 1 and figure 2 show the diagram of the literature review related to publishing papers. Undoubtedly, from literature reviews and a pilot study, this assessment appears to be affected by some decision-making problems. These decision-making problems can cause significant adverse impacts on a project such as delays, increase in expenses, increase in man-power of a building project, and inadequate professional relationships. The necessity of using the construction industry and the findings generally acknowledge the application of value engineering indicate that value engineering is recognized as an effective construction industry Management tool. The books supported the findings of the literature review that the early application of value engineering within a project's life increases the rewards that can be reaped from focusing on design functions and construction objectives, highlighting how the budget cost can be achieved while maintaining quality and performance standards.

Table 2: Summary of earlier researches in multi-story optimization

Research Name	Year	Researcher	Description
Innovative Application of Dispersed Shear Wall to a Kilometer-High Concrete Skyscraper	2016	Feroz Alam	Examined a new structural lateral system for RC Skyscraper using STAAD/PRO models
High-Rise Residential Reinforced Concrete Building Optimization	2015	Haibei Xiong, Miguel Angel Hidalgo Calvo	Suggested an optimization procedure for the RC slab floor system based on a set of CSI, SAFE 2014 models
Value Engineering In Residential House Construction	2015	Nayana Tom, V. Gowrisankar	A case study on VE of a residential RC building project
Value Engineering For Low-Cost Housing Construction In Egyptian Expansion Urban	2014	Fatma A. Agrama, Maher T. Al-Nemr, and Mohamad A. Abdo	Case Studies of VE using the weighted evaluation technique to evaluate the selection of the optimal construction system for RC building
Analysis and Design of Dia-grid Structural System for High Rise Steel Buildings	2013	KhushbuJania, Paresh V. Patel	Presented a procedure to analyze and design diagrid steel buildings using CSI ETABS software and compared the results of 36, 50, 60, 70 and 80 story steel buildings
Value Engineering Analysis For The Educational Buildings In Egypt	2012	M.A. Youssef, I.A. Mohammed, A.N. Ibraheem, and I.M. Hussein	Questionnaire & case study to determine the optimum alternative to maximize the utilization of the available construction and maintenance budget of educational buildings in Egypt
Diagrid Structures for Complex-Shaped Tall Buildings	2011	KYOUNG SUN MOON	Studied the structural performance and constructability of Tall buildings
An analysis of value management in practice: the case of Northern Ireland's construction industry	2011	Srinath Perera, Carolyn S. Hayles, and Stephen Kerlin	Questionnaire & case studies to summarize the experience of construction professionals in Northern Ireland

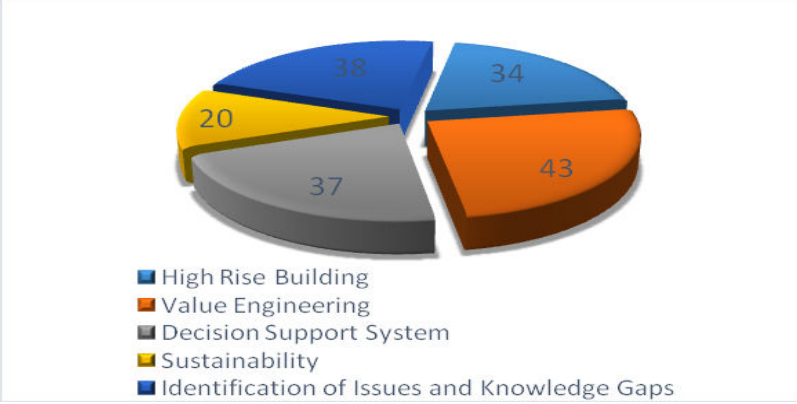

Fig (1): Number of Papers Focusing on Various Aspects

Table 3: Shows the main and sub classification for literature review

Main Classification	Frequency	Sub-items	Frequency
High Rise Building	34	Analysis and Design	11
		Steel	2
		Structural	9
		Reinforced Concrete	3
		Composite	5
		Dual	1
		Construction Industry	57
Value Engineering	43	High Rise Building	4
		Decision Support System	
Decision Support System	37		
Sustainability	20		
Identification of Issues and Knowledge Gaps	39		
Total	**173**		

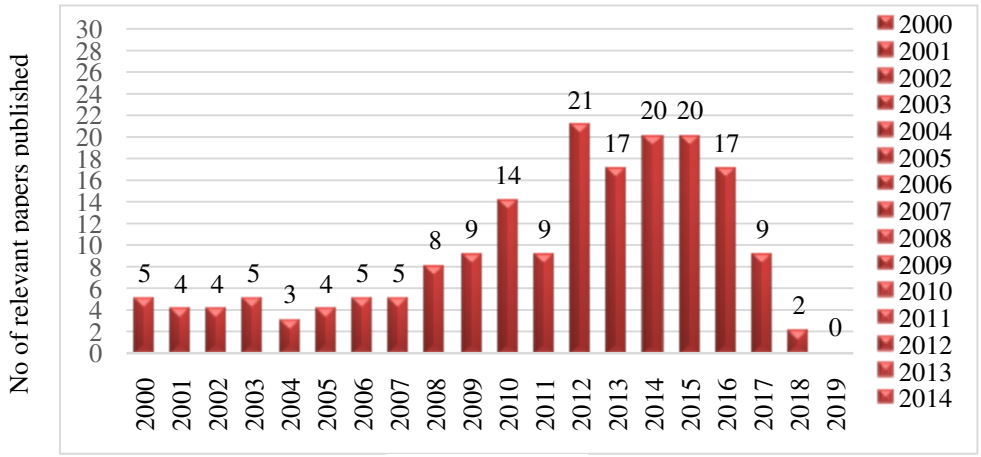

Fig (2) Number of relevant papers published yearly in the different journals from 2000 to 2019

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