Achieving sustainability through reducing construction waste during the design process

A value management perspective

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Abstract

Purpose – The purpose of this paper is to investigate the role of Value Management towards achieving sustainability through reducing the construction waste during the design process.

Design/methodology/approach – To achieve the abovementioned aim, a research methodology consisting literature review and survey questionnaire is designed to achieve the following objectives: first, building a comprehensive understanding of the research topic through reviewing literature related to the nature of the construction industry, waste in construction, sustainability, the design phase and Value Management; second, presenting and analysing two case studies to validate the role of Value Management towards reducing waste in construction projects; third, conducting a survey questionnaire with a representative sample of architectural design firms (ADFs) in Egypt to evaluate their perception and application of Value Management towards reducing the construction waste during the design phase; and finally, proposing a business improvement framework to facilitate the integration of Value Management into the design phase as an approach for reducing construction waste.

Findings – The construction waste has a negative impact on achieving sustainability objectives. The design process plays a major role in generating waste throughout the project life cycle. This is a result of improper decisions taken during the design phase. Egypt as a developing country does not have the required technical or financial resources to deal with the huge amount of waste generated during the construction process. The Egyptian Sustainable Development Strategy 2030 focussed on eradicating the waste from its source (i.e. design phase). Integrating Value Management into the design phase will help developing creative ideas and better decisions, which will enable achieving sustainability objectives and reducing construction waste.

Originality/value – The Egyptian Sustainable Development Strategy 2030 has discussed the importance of dealing with the wastes from the source. Although the construction waste is a dangerous type of waste, most research studies have not focussed on the design process as a source for the construction waste. In this research, the design phase was discussed as an important element in reducing the construction waste by using Value Management approach.

Keywords Design, Material, Value management, Construction waste, Waste reduction, Sustainability, Design phase

Paper type Research paper

1. Introduction

The construction industry is one of the biggest industries worldwide. It plays a significant role towards attaining the national and international sustainable economic and social development objectives. Economically, the construction industry contributes about 7 to 10 per cent of Gross Domestic Product (GDP) of highly developed economies and around 3 to 6 per cent for underdeveloped economies (Wibowo, 2009; Lowe, 2003). In

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addition, it employs about 10 (e.g. Algeria) to 30 per cent (e.g. Mauritius) of populations around the globe (CIA, 2015). Moreover, governments worldwide use the construction industry as a means to develop the national economy through increasing public expenditure to overcome the impact of recession and decrease the ratio of unemployment. Furthermore, the output of the construction industry is a major component of investment and part of fixed capital assets and infrastructure. Prosperity of the construction industry encourages and improves the performance of other supporting industries (Ball and Wood, 1995). Socially, the construction industry is concerned with fulfilling community needs through providing end users with facilities for housing, education, culture, medication, business, leisure and entertainment. In addition, it constructs infrastructure projects including roads, water and electricity stations as well as telecommunication networks to enable these projects to perform their intended functions effectively (Metcalf, 2017). Conversely, the construction industry is blamed to be a non-sustainable business in terms of its massive amount of wastes produced. According to Hong Kong government statistics, the construction industry is accountable for about half of the waste generated annually. (Environmental Protection Department, 2016). In the UK, about 32 per cent of the landfill is resulted from construction waste (sharman, 2018). The Egyptian report of waste management published in 2014, stated that 4.5 per cent of the total waste in Egypt is construction waste (German Federal Ministry for Economic Cooperation, 2014). The construction industry generates many types of wastes such as material wastes and construction and demolition waste. While the first type refers to the materials that have been bought and never used, the second refer to the waste generated due to the construction process. These wastes either disposed by dumping in water or deserted areas, which act as a threat towards the environment (Sapuay, 2016). Every construction project has its own value represented in the client investment. From the client's perspective, the value of the project is materialised through achieving its objectives on time, within budget and as specified (Connaughton and Green, 1996). However, the value of the project decreases as the waste increases. According to Osmani *et al.* (2006) one third of construction waste produced can be avoided by taking the right decisions during the design process. In Egypt, one of the main objectives of the Sustainable Development Strategy: Egypt's Vision 2030 (SDS 2030) is to prevent the generated waste from its source (Ministry of Planning, M.a.A.R, 2015). Therefore, decisions taken during the design phase should be informative and precise to eliminate the waste as much as possible. As construction projects increase around the world, wastes resulted also increase. The construction waste has a great impact on the economy, environment, and society. Millions of dollars are charged each year as a cost of the waste generated due to construction. In the UK, about 200 million Euros are paid annually as landfill taxes. Construction materials are one of the most expensive elements in the project cost. However, most projects end up with about 20 per cent of materials unused (Dajadian and koch, 2014). Therefore, this waste is considered as a loss of money which decreases the value of the delivered project. In Egypt, about 10,000 tons of construction waste are generated daily; which is nearly third the total amount of waste resulted everyday (Al-Ansary *et al.*, 2017). The construction waste is bulky, heavy and toxic if compared to wastes generated from other industries. It is usually disposed through illegal ways such as burn, bury, mix with home wastes, or even throw it in the forest, desert or water. These ways result in environmental serious problems (Sapuay, 2016). Socially, the construction waste affects the social life of citizens as it has a negative impact on people's health and welfare. In addition, preventing the construction waste at the pre-construction phase is the most effective way to achieve sustainability. Thus, decisions made in the early design

stages should consider waste reduction as a factor to achieve value for the project (Nagapan *et al.*, 2012). Ametepey *et al.* (2015) stated that by 1940s, Value Management came to the light and was used as an approach to enhance the delivered project value through waste reduction. Hence, this paper aims to investigate the role of Value Management in achieving sustainability through reducing construction waste during the design process.

2. Research objectives and methodology

To achieve the above mentioned aim, a mixed qualitative and quantitative methodology, based on literature review and survey questionnaire was designed to accomplish the four objectives:

(1) Providing a comprehensive background about the research topic through covering the nature of the construction industry, waste in construction, sustainability, the design phase and Value Management. This objective was achieved through conducting in-depth literature review depending on textbooks, academic and professional journals, conferences and seminars proceedings, dissertations and theses, organisations and government publications as well as Internet and related Web sites.

(2) Validating the role of Value Management towards reducing construction waste in construction projects. This objective was attained through presenting and analysing two case studies from Indonesia and India.

(3) Evaluating the perception and application of Value Management towards reducing construction waste during the design phase. This objective was accomplished through a survey questionnaire conducted with a representative sample of architectural design firms (ADFs) in Egypt,

(4) Developing a framework to facilitate the integration of Value Management into the design process as an approach for reducing construction waste.

3. Waste in the construction industry

3.1 An overview

Construction waste is defined as relatively clean, heterogeneous building materials generated directly or indirectly from the various construction activities (Tchobanoglous *et al.*, 1993). Construction waste consists of unwanted material such as bricks, concrete, wood, electric wiring, nails and insulations that are damaged or unused for various reasons during construction. The increasing need for new buildings to fulfil community requirements, ultimately increases the amount of construction waste (Ikau *et al.*, 2016). Although the quantity and quality of construction waste generated from any specific project would vary depending on the project's circumstances and types of materials used, construction waste represents about 35 per cent of all wastes generated by other industries (Polat *et al.*, 2017).

3.2 Causes and impacts of construction waste

This section explains the causes and impacts of construction waste. Causes of construction waste are divided into main causes, primary causes and secondary causes where their impact was analysed in the light of their effect on sustainability aspects namely, economy, society and environment (Table I).

Construction waste main causes	Primary causes	Secondary causes	Impact
Design	Design and detailing errors Incomplete details (Osmani *et al.*, 2006) Project type, location, complexity and unclear project and details Poor selection of materials Frequent changes in design Overordering (Elgizawy *et al.*, 2016; Polat *et al.*, 2017)	Inexperienced team Lack of communication between project parties Hesitated client (Polat *et al.*, 2017)	Cost of material due to redoing and overdoing (economic impact) (Osmani *et al.*, 2006) Frequent changes cause waste in material which can be thrown and causes release of harmful gasses (environmental impact)
Procurement	Mistakes in quantity Shipping or suppliers' error Materials purchased not matching with required (Polat *et al.*, 2017)	Human errors Unclear details (Osmani *et al.*, 2006)	Overbuying and waste in resources
Storage	Poor storage of materials on site Methods used for storage are improper (Osmani *et al.*, 2006)	Limited resources Lack of knowledge (Polat *et al.*, 2017)	Poor storage can result in material composition (environmental impact)
Workers	Damages caused by workers Mistakes (Polat *et al.*, 2017)	Overtime Poor site conditions Lack of training and experience Time pressure (Polat *et al.*, 2017)	Pressure in work can result in human mistakes and improper usage of materials
Site Management	Cutting in uneconomic way Unused materials Usage of incorrect materials Delay in passing information Poor on-site lighting (Osmani *et al.*, 2006)	Lack of site-control Lack of experience Lack of communication between workers and management Poor planning Lack of awareness (Polat *et al.*, 2017)	Cost of material due to redoing and overdoing (economic impact)
External Factors	Weather condition (Osmani *et al.*, 2006) Theft Political reason	Unpredictable conditions (Polat *et al.*, 2017)	Material destroying and waste of resources

Source: Developed by authors

Table I. Causes of construction waste generation

3.3 Methods of construction waste disposal

Disposing waste is the process of transporting waste materials from the site to another place. About 30 per cent of the total construction waste is basically dumped into landfills (Polat *et al.*, 2017) through illegal ways (Sapuay, 2016).There are other different ways to dump construction waste including throwing into the water, dumping in a deserted area, dumping in forests, burying under the ground, collecting and then burning it, mixing with other types of wastes. Construction waste dumped in the environment is bulky and toxic. Construction waste is known for its chemical components such as asbestos, persistent compounds, and volatile compounds. Thus, it has a negative impact towards the environment; causing water contamination, fire risks, air pollution and attraction for pests (Polat *et al.*, 2017). Furthermore, Dajadian and Koch (2014) noted that 40 per cent of the

natural resources around the world are wasted due to the construction industry. Thus, not only it is harmful for the environment, but also waste of money and resources. The materials are considered as the main financial consuming element in any construction project; about 20 per cent of the materials in the project end up as unused wasted materials.

4. The design phase

Any construction project passes through a series of phases. One of the most important phases is the design phase; where the client requirements are translated into technical drawing and specification. In addition, crucial decisions that affect the performance of the building throughout its life cycle are made. The design process is considered as guidance towards the development of the project through setting consecutive actions. These actions are arranged according to their importance. Thus, the value of an action determines its priority in the project (Bragança *et al.*, 2014). Great benefits are expected when Value Management principals are applied during the early stages of the project life cycle (especially the design phase) (El-Alfy, 2010), as it focuses on delivering the required function through creative solutions that balance between quality and cost (Kirk, 1989).

4.1 The RIBA plan of work

The RIBA plan of work is a plan developed by the Royal Institute of British Architects (2011) to provide the clearest image of the stages for the construction industry. It is frequently updated to keep up with the needed technological and sustainable development approaches. In the RIBA plan of work, waste elimination has been integrated in the sustainable processes. In the design brief, a site waste management plan is developed to enable designers to make decisions, which reduce waste. In addition, in the concept stage, the designer considers the complexity of the project as a factor for waste generation. Moreover, in the design development stage, the designer needs to identify the opportunities, which help minimising waste as much as possible. Finally, in the tender document stage, requirements for the contractor are stated to enable minimising the waste by using the material efficiently (RIBA, 2011).

4.2 Impact of the design process on construction waste generation

Dajadian and Koch (2014) noted that 33 per cent of construction waste results from failure in reducing waste during the design process. The design process is considered as the main cause of construction waste generation. Some design factors affect waste generation such as incomplete information, late design changes, unclear specification, lack of communication, over ordering, and detailing errors. The design phase is the main source of errors and mistakes, which result in increasing the construction waste. As the cost for disposing waste from the construction sites is high, construction organisations will benefit from reducing waste from the first place rather than dealing with the waste after it was produced. In Egypt, during the current economic situation, the country is in need for developing new buildings to meet community requirements, but at the most cost effective manner. Thus, reducing waste will help improving the economy and development of the country. Moreover, reducing waste in the design phase helps avoiding environmental problems and protecting natural resources, avoiding landfills, reducing pollution, reducing contamination of water, reducing gas emissions and global warming. Although construction waste is a significant problem that encounters the construction industry, the precautions taken to reduce it are mostly carried out during the construction phase. However, some solutions were held through the design phase to minimise the waste production by choosing suitable type of construction systems, using pre-fabricated elements and making proper material selection decision (Australia's Government, 2017). Value Management application should not only be

considered to enhance the value of the project but also to achieve sustainability objectives (El-Alfy, 2010). Designing out waste at an early stage of the project helps multiplying the opportunity for waste minimisation (Baldwin and Austin, 2014).

5. Value management

Value Management is a well-established technique dated back to 1940s. It is the European name given to a service concerned with providing the product or service demanded by a customer at the required quality and at the optimum cost (Male *et al.*, 1998). Value Management helps clients ensuring that their investment in construction is cost effective (Connaughton and Green, 1996) and enables the designer providing better solutions for complex problems (New south wales Government, 2004). Value Management is characterised by providing the client with the benefits expected for the project by applying certain techniques to enhance and maximise the benefits while minimising the use of resources. It is a management approach that focuses on improving the performance of organisations through delivering better values to the customers at lower cost. Although, Value Management is popular for its cost reduction, it is much more than just cost reduction exercise. Value Management helps enhancing the value delivered to customers and the quality of the delivered product. In addition, it helps defining the stages of the project which makes it easier to take decisions. It encourages providing innovative solutions for the faced problems (Serebryakova and Musayelyan, 2016). Value Management application during the design phase helps improving sustainability of the building expressed in economic, social and environmental aspects (El-Alfy, 2010).

5.1 Value management phases

Value Management is basically depending on creating team spirit by performing good communication environment between the team members which ultimately enables the team to develop successful creative alternatives and decisions. Table II shows the 5 phases of Value Management job plan (Toy, 2017).

5.2 Contributions of Value Management towards the construction industry

The construction industry is a team-based business, which depends on team cooperative work to perform a certain task. Value Management has great benefits towards construction projects as follows (Oke and Aigbavboa, 2017):

- helps defining a clear image of the project objectives and enhance its value;
- helps identifying the unnecessary cost;
- improves communication between project stakeholders and team spirit;
- helps achieving maximum efficiency and proper decisions throughout the design phase;
- provides proper analysis to project elements and processes;
- encourages innovative ideas and efficient designs;
- improve the client involvement in the design decision-making process;
- helps identifying the project constrains and issues; and
- provides a well-defined role for everyone in the project (Oke and Aigbavboa, 2017).

6. Case studies

This section represents two practical case studies from Indonesia and India to show how applying Value Management concept contributed towards reducing construction waste in

Phase	Explanation
Information phase	The objective of this phase is to establish a good understanding of the project, its design and operation, the functions of the project itself, and its constituent elements, and to determine areas with the greatest potential for saving and needed improvements
Creativity phase	This phase includes any of various creativity/motivational techniques to generate alternative ideas to achieve the same basic functions at lower costs or to achieve necessary improvements. The most often used method is the brainstorming technique
Evaluation phase	Various evaluation methods may be used during this phase to analyse and highlight the best ideas generated during the creativity phase. Ideas are evaluated, both on economic and non-economic criteria such as aesthetics, environmental impact, etc.
Development phase	The ideas for alternatives selected during the evaluation phase are now developed into fully detailed proposals, which generally comprise: Description of both the original and the proposed design A narrative on the advantages and disadvantages of each proposal Initial and life cycle cost consequences of the proposals Detailed technical calculations, sketches, etc. Proposals must be detailed and avoid ambiguity otherwise they may be rejected with little consideration by decision-makers
Presentation phase	This phase includes a presentation of the refined and developed proposals to enable decision makers and other interested parties make their decision. Proposals are summarised, and the life cycle cost saving presented as well as the rationale behind each of the recommendations presented

Source: (Toy, 2017)

Table II.
Phases of value management

construction projects. Due to the lack of Value Management application during the design phase in Egypt, the selection of both case studies was based on being from developing countries that are similar to Egypt in many aspects of the construction industry.

6.1 Governmental building, Jakarta, Indonesia

The project is a governmental building consists of 17 floors located in Jakarta, Indonesia. The project duration was 371 days with a budget of 38 million USD. The Value Management study was conducted by the Faculty of Civil Engineering, University of Teknologi, Malaysia. The aim of study was to reduce the waste and enhance the performance of the project (Firmawan *et al.*, 2012). The study consisted of three stages:

(1) Stage 1: This is the planning stage of the project. It depends on collecting data which, will be used later in the study. Organising the activities, schedule, and team composition will pave the road for an effective Value Management study.

(2) Stage 2: This is the core stage of the Value Management workshop and it is divided into 6 phases namely, information phase, function analysis phase, creativity phase, evaluation phase, development phase and reporting phase.

(3) Stage 3: In this stage, implementation of the previously discussed ideas takes place, in addition to following up the process.

During the evaluation process of an idea; if the idea is acceptable, the team must proceed to the development phase, if no they should go back to the creativity phase and try to brainstorm more alternatives. Moreover, in the third stage if the result is acceptable, the team should proceed to the implementation and follow up, but if the results are unacceptable, the team should go back to the creativity phase to think of more suitable ideas (Firmawan *et al.*, 2012).

The functional analysis is considered as the most important core of Value Management approach. In this project, the functional analysis conducted by using FAST (Functional Analysis System Technique) diagram. The method for analysing the function of elements is by expressing the function as a concise phrase. There are two types of phrases; the active and passive phrases. The active phrase consists of an active verb followed by a noun, the active verb expresses action like protect, hold, attract, and enclose. While the passive verb is vaguer like allow and provide. The active phrase is preferred in the functional analysis as it provides more description precisely. According to Firmawan *et al.* (2012) if a function couldn't be defined in two words only, then there is insufficient information available. Combining between different functions should be avoided and the distinction between primary and secondary functions should be facilitated. Figure 1 shows the FAST diagram of the case study.

In the fast diagram, the aim of the Value Management study was to protect the environment. By going through Value Management stages; some decisions were taken to achieve this aim such as maximise value, segregate waste in the construction site to facilitate its reuse or recycle. In addition, changing the frameworks from wooden frameworks to adjustable steel frameworks helped eliminating the waste of wood. Moreover, using precast concrete system enabled eliminating the concrete waste and wood framework waste. As a result of the case study, the following lessons are learned:

- using environmental friendly construction materials to avoid toxics substances and minimise the usage of nature resources;
- designing in an innovative way to excavate for the piles for minimising the waste produced;
- designing draining pits for the site to drain water and save it for another use;
- using concrete precast systems to minimise the waste of concrete;
- using a steel adjustable formwork panel system to minimise the waste of wood;
- making insulation from wasted materials on the site; and
- using leftover concrete as car stopper.

6.2 Pharmaceutical plant, Karnataka, India

The project is a pharmaceutical plant in Karnataka, India. The aim of the study was to eliminate or minimise the construction waste by using Value Management and going through reducing, reusing and recycling processes. The company handles the construction waste by preparing a waste management plan accompanied with successful implementation. A Value Management study was conducted by the

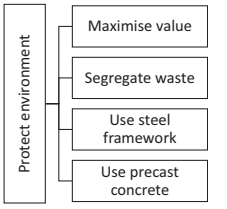

Figure 1.
Fast diagram

Source: Firmawan *et al.*, 2012

company then a comparison between pre-study and post study was established to show how the Value Management approach has succeeded to reduce the construction waste. The company's Value Management approach depends on data collection, waste identification and elimination as well as comparing and analysing results (Gudigar *et al.*, 2014). Results of the case study showed that foundation pits were designed according to the site characteristics and bearing capacity of the soil. This helped reducing the foundation and pit excavation by 1109 m^3. In addition, the plain cement concrete (PCC) was eliminated from some footings which helped decreasing PCC by 84.7 m^3. Moreover, shattering for soil was eliminated in most of the excavation sites, which decreased by 1,542.56 m^2. Furthermore, it was decided to use partition walls for the interior walls instead of using concrete blocks. This resulted in reducing the square area by 12.7 m^2. Finally, eliminating plastering from columns saved 190.24 m^2 of plaster and revisiting the structural design resulted in changing the type of the steel from FE 415 to TMT 500 which saved 409 tons of steel. By comparing between pre and post Value Management study; it was obvious that a proper Value Management study can result in massive waste reduction.

7. Data analysis

A survey questionnaire was developed by the authors and distributed to a representative sample of Egyptian ADFs to evaluate their perception and application of Value Management as an approach for reducing construction waste during the design process. The survey consisted of open-ended questions (e.g. thoughts and opinions) and close ended questions (e.g. Yes/No questions, rating questions based on 1-4 Likert Scale). Collected date was analysed quantitatively and qualitatively.

The quantitative analysis was simply based on measuring the central tendency and dispersion of the questionnaire responses. The measure of central tendency was used to get an overview of the typical value for each variable by calculating the mean, median and mode. The measure of dispersion was used to assess the homogenous or heterogeneous nature of the collected data by calculating the variance and the standard deviation (Bernard, 2000). The data were analysed with the aid of Microsoft Excel spreadsheet. Analysis of the collected data showed close values of means, medians and modes, indicated typical central values and showed also low values of variance and standard deviation. This confirmed the quality and the homogeneity of the collected data as well as a low degree of dispersion resulting in reliable findings. As there is no quantification without qualification and no statistical analysis without interpretation (Bauer and Gaskell, 2000), during this paper qualitative data analysis was employed to support and interpret quantitative data analysis.

7.1 Sampling and response rate

To select a representative and non-biased sample to answer the survey questionnaire, the list of all ADFs registered in the Egyptian Engineers Syndicate (EES, 2018) was obtained resulting in a population of 44 firms. To calculate the sample size, the next two equations were applied (FluidSurveys Team, 2014). In this research, the confidence level chosen is 95 per cent and the margin of error is 5 per cent. The confidence level score corresponding to the confidence level of 95 per cent is 1.96:

$$\text{Sample Size Calculation} = \frac{\text{Distrubution of } 50\%}{\left[\text{Margin of error}\% \,/\, \text{Confidence Level Score}\right]^2}$$

$$\text{True Sample} = \frac{\text{Sample Size} \times \text{Population}}{\text{Sample Size} + \text{Population} - 1}$$

$$\text{Sample Size} = \frac{0.5 \times (1 - 0.5)}{\left[{}^{0.05}/_{1.96}\right]^2} = 384.16$$

$$\text{True Sample} = \frac{384.16 \times 44}{384.16 + 44 - 1} = 39.57 \sim 40$$

However, since the true sample size of 40 ADFs is only different from the population size in this case by 4; the whole population was considered the sample size for the survey questionnaire. A pilot study of the survey was tested with colleagues to determine its effectiveness and problems. They were asked to answer the questions as if they were received from someone unknown and go through the questionnaire again to point out any problem they noted with questions. After going over the responses of the preliminary test and making changes, the questionnaire was ready for formal testing (Baker, 1994; Czaja and Blair, 1996). A copy of the survey questionnaire was sent electronically to all 44 ADFs by contacting them at first through their formal e-mail addresses or directly by calling them depending on the available contact information. Out of 44 ADFs participated in the survey questionnaire, only 18 firms responded representing 41 per cent that supports the research findings and recommendations. Results of the survey questionnaire revealed that:

7.2 Construction waste perception and practices

- 71 per cent of respondents have a very good to excellent understanding of the issue of construction waste and its consequences in the construction industry with an average of (3.11/4) to (4/4).
- 82 per cent of respondents agreed that human errors, design errors and incomplete details are the main reasons behind construction waste generation with an average of (3.22/4) and (3.06/4) respectively.
- 76 per cent of respondents mentioned that the most wasted materials in construction sites are “bricks” where, 59 per cent respondents stated that the second highest wasted materials are “concrete”, “sand” and “gravel”.
- 64 per cent of respondents stated that the highest impact of wasted construction materials is “financial loss” where 57 per cent respondents mentioned that the second highest impact is “pollution &harmful gases releasing.
- 82.4 per cent of ADFs do not have a waste management specialist. This highlight the issue that construction waste is not considered as a major problem.
- 42 per cent respondents stated that construction waste is usually thrown in landfills or reused.

7.3 Sustainability and construction waste

- All respondents stated that they perceive the concept of sustainability and its pillars of environment, economy and society.

- 82.4 per cent respondents agreed that reducing construction waste will enhance sustainability of the built environment. This is because reducing waste will reduce its impact on the environmental, reduce financial loss in replacing and treating wasted materials and will uplift the quality of life of society.
- ADFs mentioned that they use different approaches to achieve sustainability including lean construction, reusing and recycling construction waste, applying total quality management, Value Management and planning and follow up process.

7.4 Value management and construction waste

- 92 per cent of respondents stated their understanding of Value Management concept and its application in constriction.
- 76.5 per cent of respondents apply Value Management as an approach for reducing construction waste. However, 50 per cent of them do not appoint Value Management facilitator.
- 71 per cent of respondents stated that ADFs increase the project value through reducing cost while keeping quality or enhancing quality with the same cost. In addition, 59 per cent of respondents considered eliminating waste is as important as cost reduction.
- 83 per cent of respondents agreed that Value Management application is difficult because it needs training and the lack of information.

8. Value management framework for construction waste reduction

8.1 Definition and importance

A framework is defined as an arrangement of series of concepts, tools and approaches needed to be integrated into a designed structure to complete a specific process and objective (Othman and Mia, 2008). The Value Management Framework for Construction Waste Reduction (hereinafter referred as VMFCWR or the Framework) is a proposed framework that describes the steps and procedures needed to facilitate the integration of Value Management concept during the design process as an approach for reducing construction waste. The need for the framework emerges from the necessity of achieve sustainability objectives through reducing construction waste during the design process. This is because decisions made during the early design phases have a crucial impact on the sustainability of the developed project. In addition, Value Management plays a significant role in developing creative solution that enable ADFs to reduce construction waste and achieve sustainability objectives.

8.2 Aim of the framework

The VMFCWR is a business improvement framework aims to facilitate the integration of Value Management into the design process as an approach for reducing construction waste. This will help enhancing the value delivered to the client and achieve sustainability of the built environment.

8.3 The conceptual description of the framework

Within this paper the framework has been viewed as project consists of five phases, namely:

(1) the initiating phase;

(2) the planning Phase;

(3) the executing phase;
(4) the monitoring and controlling phase; and
(5) the closing phase (Figure 2).

8.3.1 The initiating phase. "The Initiating phase" is an essential phase of this framework because it enables ADFs to identify the core causes that obstruct the integration of Value Management into the design process. It is of importance to build an effective team (including a competent team leader and Value specialist) to carry out the integration study. Achieving a balance between the need for participants who represent various areas of expertise and possess diverse background is fundamental for accomplishing the study objectives. The study team should contain between six and twelve full time participants to maintain optimum productivity (Norton and MCelligot, 1995). Performing an early orientation meeting will help in establishing strategic issues like study objectives, duration, resources required and assigning responsibilities to team members. Senior management has to be convinced with the benefits of Value Management towards reducing construction waste. This will facilitate the provision of needed resources and the adoption of study decisions and recommendations. Data collection methods (i.e. literature review, survey questionnaire, interviews and case studies) and data analysis techniques (i.e. quantitative and qualitative) must be defined and utilised. Brainstorming technique, team consensus and evaluation matrix must be used for identifying the root causes and rank them according to their importance.

8.3.2 The planning phase. "The Planning Phase" phase aims to set the procedures and actions necessary to integrate Value Management into the design process towards reducing construction cost. It will include a work breakdown structure and a responsibility matrix, where the first downsizes the work into manageable work packages and the later links the activity to be done and the responsible person. In addition, the plans should include expected risks and corrective actions to be taken in case of the plan did not go as intended. Furthermore, the communication plan between the study team has to be developed to portray the reporting structure during the integration process.

8.3.3 The executing phase. "The Executing Phase" integrates people and other resources to undertake the tasks developed in planning phase. The execution plans may require that employees involved in the integration process to be trained and equipped with all tools and techniques required to guarantee the successful execution of plans. This phase will include

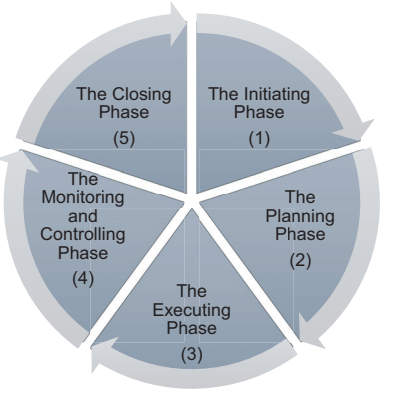

Figure 2.
The framework

the implementation stages of Value Management including information, creativity, evaluation, development and presentation. In addition, senior management support and offering the required facilities will help achieving the integration objectives. The execution function should use the work authorisation system, which verifies the predecessor activities and permits the successor activities to proceed. This ensures the quality of work performed.

8.3.4 Monitoring and controlling phase. The aim of this phase is to ensure that the integration of Value Management into the design process goes according to plans. Comments and feedback from the execution team will enable taking corrective actions if plans were not implemented as planned. Furthermore, this will help improving the performance of ADFs in future improvement projects.

8.3.5 The closing phase. "The Closing Phase" ensures that the project is completed as planned and evaluates the outcomes to avoid mistakes in the future projects. It aims to get a formal acceptance of the project and conclude it. The framework should ensure that the project succeeded to facilitate the integration of Value Management into the design process to reduce construction cost. A lesson learned document should be created to evaluate and measure what was achieved in the integration exercise and identify any issues that were raised. This will help ADFs to overcome these issues and improve their performance in future developments.

8.4 Benefits and limitations of the framework

The benefits of the framework will impact positively on ADFs and the community within which they operate. The benefits lie in reducing construction waste through integrating Value Management into the design process. The VMFCWR will help enhancing the value delivered to the client and achieving sustainability objectives through waste reduction. Implementing the framework will enhance the performance of ADFs, living conditions of communities and the environmental and economic sustainability of the built environment. However, the framework is hindered by the poor awareness of ADFs about the application of Value Management in real life projects. Moreover, the framework's success depends on the encouragement of ADFs and the government to facilitate the integration process. The application of the framework is a time-consuming process, which requires full dedication from the participants. Due to the nature of the construction industry and time constraints of projects, this framework may not be welcomed and ADFs may be reluctant to conduct this integration.

9. Conclusions and recommendations

The construction industry is one of the biggest industries worldwide. It plays a major role towards achieving the economic and social development objective of countries worldwide. At the economic level, the construction industry provides job opportunities, increases countries' GDP and supports other depending industries to excel. At the social level, it provides societies with buildings and infrastructure facilities that fulfil their needs and improve their quality of life. On the other hand, the construction industry is a non-sustainable business, which has a negative impact on the environment through producing massive amount of wastes such as bought and unused materials as well as construction and demolition waste generated during the construction process. These wastes remain as a main obstacle towards achieving sustainability objectives, delivering better value to the client and consequently influencing the national economy. This issue is maximised due to the dominated traditional approaches used to deal with generated waste. Literature review highlighted that about one third of the construction waste produced can be avoided by taking the right decisions during the design process. Hence, different and innovative approach is needed to prevent waste at source. This paper investigated the role of Value

Management in achieving sustainability through reducing construction waste during the design process. Hence, this paper aims to investigate the role of Value Management in achieving sustainability through reducing construction waste during the design process. This aim was achieved through conducting through literature review, presenting and analysing case studies and results of a survey questionnaire conducted with a representative sample of ADFs in Egypt. The research proposed a framework to facilitate the adoption of Value Management to reduce the construction waste during the design process. Based on the above, the research may recommend:

- escalating the awareness of ADFs towards the negative consequences of construction waste, which prohibit the achievement of sustainability objectives and the value delivered to the client;
- integrating the concept of Value Management during the design process will enable the design team to adopt value-based decisions that could help reducing waste generation in the different phases of the project life cycle;
- ADFs are required to include sustainability and waste elimination in their strategic vision, mission and objectives;
- providing architects with needed trainings to ensure the successful implementation of the developed framework and application of Value Management during the design phase as well as appointing waste management specialist; and
- adopting the proposed framework will help saving natural resources, reducing construction waste, achieving society needs and prosper the national economy.

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