Critical Success Factors Framework of Value Management for Design and Build Infrastructure Projects

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Abstract

The Design Build (DB) approach is gaining popularity in many countries as it allows a single entity to handle both design and construction, making it a preferred choice for infrastructure projects. With the design process carried out by a team to achieve design constructability, implementing Value Management (VM) in Design Build projects is advantageous and can lead to cost-effective designs. While most studies have concentrated on identifying the important criteria that lead to the effective deployment of VM in infrastructure projects in general, the success factors of VM in DB delivery systems remain unknown. This study aims to identify the critical success factors (CSFs) in the three main stages of the VM workshop and their supporting factors in infrastructure projects delivered under DB system. To achieve the research aim, a questionnaire was distributed to DB contractors involved in infrastructure projects in Indonesia. The Relative Important Index approach was applied to 28 factors, and the analysis revealed the CSFs for each stage of the VM workshop, along with a critical supporting factor. The analysis revealed that there are three CSFs for the pre-study and study stages and one for the post-study stage. The identified CSFs provide a framework for VM success in Design Build projects. The three CSFs in the pre-study stage relate to VM objectives, project information completeness, and personnel involved in the VM workshop. At the study stage, VM success depends on the VM process, the development of alternative designs, and the VM team's innovation. In the post-study stage, VM success is linked to the VM implementation process and developing an execution plan. The cooperation of all stakeholders in implementing the VM workshop results is a critical supporting factor for VM in a DB project.

Keywords: *value management; design build; critical success factor; framework; infrastructure*

1. INTRODUCTION

The project delivery system refers to the entire construction process, including planning, design, and construction. Project delivery in construction such as Design-Bid-Build (DBB) is a most prevalent system where consultant as designer and contractor as project executor are two entities employed by owner separately (Hale et al., 2009). Design-Build (DB) project delivery system, on the other hand, is one in which the owner enters into a contract with a single entity to carry out both design and construction, representing a single commitment (Tenah, 2001; Rostiyanti et al., 2019). Both of these systems have its own characteristics which depend on scope, type, complexity, purpose and other consideration factors of a project. It is critical to select the right system because it has a direct impact on key performance indicators namely cost, schedule, quality, and project execution (El-Sayegh, 2008).

Project delivery as DBB system was initially used to procure highway projects in the United States. However, since the 1990s the DB approach has been introduced to highway projects (Shrestha et al., 2012). The DB as a procurement system, which resulted in project efficiency, saw an increase in its implementation in the early 2000s, with at least 140 highway projects using this approach. Not only in highway projects in the US, the DB approach is also widely used in other infrastructure projects (Gad et al., 2019; Fathi et al., 2020) and in other countries (Harrington-Hughes, 2002; Lam et al., 2004; Cho et al., 2010; Dang & Le-Hoai, 2016). The DB procurement approach is also adopted in Indonesian infrastructure projects. This is encouraged by the Government of Indonesia (GoI) through regulations issued such as Indonesia Ministry of Public Works and Public Housing Regulation Number 25/2020. DB system is considered more efficient in terms of cost and scheduling performance, and it should be applied to accelerate the Indonesia infrastructure project development. GoI recognizes that infrastructure is a solid foundation for supporting and sustaining Indonesia's economic growth (PwC, 2016). According to the President of Indonesia, there is a significant need for infrastructure investment which can stimulate the National Growth Domestic Product (GDP). These various infrastructure projects are Indonesian Government's pledge to strengthen the reliable infrastructure equally which have set in the Indonesian laws.

The adoption of DB has been popular worldwide and its distinctive features can cope up the problem of traditional DBB system (Lam et al., 2008). As DB delivery system is a contract between owner with a single entity who responsible for both the design and construction services, so many studies investigated and have claimed that DB project experienced efficiency in budgeting and scheduling (Konchar & Sanvindo, 1998). The contractor, as a single entity, is not only responsible for construction, but also coordinates and designs the entire project, providing benefits such as (1) single point responsibility for the entire project delivery, establishing and integrating a high-performance teamwork environment; (2) involvement since the design stage potentially resulting cost savings and early completion; and (3) constructability design to minimize owner's risk (Muriro, 2015). During the design process of a DB project, a contractor with complete control has the ability to create the best and most profitable design in terms of cost, time, and quality (Ling & Leong, 2002). As a result of this likelihood, the contractor has a strong chance of implementing Value Management (VM).

As one of the challenges in financing the infrastructure projects is the budget limitation (Tagen, 2007; Khodeir, & El Ghandour, 2019). The Indonesian infrastructure projects also are experiencing the same obstacle and the poor quality of project preparation exacerbates this issue (KPPIP, 2017). As a result, VM is seen as a viable and innovative solution to mitigate these significant risks associated with infrastructure construction projects. The application of VM by contractors can result in cost-effective outcomes without compromising the quality of the project (Paek, 1994). Although some differences exist among terms such as Value Analysis (VA) and Value Engineering (VE), VM can be used as a representative term for value methodologies (Shen & Liu, 2003). In this regard, the implementation of Value Management workshops is crucial to ensure the success of the project.

Several critical success factors (CSFs) identified in the VM workshop contribute significantly to the project's accomplishment (Ramly et al., 2015). Furthermore, Shen and Liu (2003) also have stated that VM is the best effective methodology to achieve "best value for money" for employer of construction industry around the world. The application of Value Management itself begins with the pre-workshop stage and continues through the post-workshop stage as a systematic process. It follows a job plan that begins with information phase, moves on to function analysis, creative, evaluation, development, and concludes with the presentation phase (SAVE, 2007).

According to Hunter and Kelly (2007), the CSFs in VM may be impacted by differences in political, economic, cultural, and project delivery systems. However, there is a lack of research specifically focused on identifying the crucial factors that contribute to the effective implementation of VM in infrastructure projects carried out under the DB delivery system, particularly in Indonesia. While some studies have explored the CSFs of VM workshops in construction projects generally (Shen & Liu, 2003; Ramly et al., 2015; Hwang et al., 2015; Kineber et al., 2021; Thneibat & Al-Shattarat, 2021), the aim of this research is to investigate the critical factors required for the successful application of VM in infrastructure projects with a DB delivery system. It is based on the fact that the nature of the DB delivery system is distinct from other systems.

2. LITERATURE REVIEW

2.1. VM in DB Delivery System Projects.

VM is a technique which originated by Lawrence Miles in manufacturing industry in 1940s and has employed to other industry including construction (Shen and Yu 2012). It has been increasingly applied to public or infrastructure project in the world including in Indonesia. The development of VM in Indonesia was first introduced by Suriana Chandra in 1986 and was applied to building construction projects (Ariadi, 2017). As the VM was expanded quickly in the construction industry and is pivotal to a project's success, there are some countries that requires VM as a mandatory action in public or infrastructure projects. For instance, according to Cheah and Ting (2005), VM programs are required to be included in larger federal projects under US federal procurement law. Other than that, in Australia, VM practice is mandatory to all government projects which have particular project costs (Daddow & Skitmore, 2005). Therefore, Cheah and Ting (2005) asserted that the government necessitate take the lead in promoting and developing VM practices for public or infrastructure projects.

Public or infrastructure projects had applied VM study because it was proved that VM resulted in massive impact to the government projects' procurement process. A study conducted in Malaysia found that implementing VM on all infrastructure projects with a budget of more than 12 million USD resulted in a monetary savings of 23.53 percent of the total cost (Jaapar et al., 2012). Moreover, In Indonesia, mega infrastructure projects such as bridge and tunnel which had completed VM study not only achieved cost efficiency but also increased life cycle cost through additional functions and innovation to infrastructure projects (Berawi et al., 2014).

Most of public or infrastructure projects conduct the DB delivery system and one of its project control methods applied is VM (Reshaid & Kartam, 2005). In DB contracts, the contractor's success is measured by its ability to carry out a design process that yields the 'best scheme.' A scheme that provides better value for money for the employer ultimately results in the contractor being rewarded (Janssens, 1991). Hence, VM is the best and effective way if it is employed in DB contract projects.

As one of the benefit DB is cost savings and value, VM will be more effective because all of the construction team is working as one entity during the design process. Working as a design-build team, design professionals and construction personnel evaluate alternative materials, building systems, and methods in an efficient, accurate, and creative manner (Beard et al., 2004). VM study works best as a collaborative and integrated process (Maurer, 1996). Additionally, when VM is applied to infrastructure projects through the Public Private Partnership (PPP) scheme, the design stage is considered the best practice for conducting VM because it allows for the exploration of effective alternative designs, the preparation of specifications for each design, and the connection of these specifications with available resources to achieve the best cost, time, and quality (Selim et al., 2017). Thus, DB's team approach gives VM its rightful home because as Shen and Liu (2003) confirmed that if all parties can work together effectively from the pre-design stages, the potential for VM is highest.

2.2. VM as an Approach to Cost Efficiency.

Project success is defined by not only cost management to achieve efficiencies, but also the creation and improvement of value. These components help project stakeholders understand the actions and resources required to fulfil project objectives (Venkataraman & Pinto, 2011). The ultimate goal of VM is to achieve the best value and cost by optimizing functional performance and embracing primary functions while reducing secondary functions, hence enhancing quality and removing needless costs (Clifford, 2013). VM is a creative and problem-solving approach to maximizing the functional value of a project with the structures process towards the project employer's requirements (Male et al., 1998). These definitions clearly imply that project costing is inextricably linked to value management that any attempt to increase the value of a project without a thorough understanding of its cost implications is meaningless.

The idea of cost reduction or cost cutting and VM is actually diametrically opposed, and numerous writers have highlighted incorrect perceptions of VM as a cost reduction or cost cutting technique (Kim et al., 2016). Cost reduction focuses primarily on the cost element by keeping costs to a minimum, whereas VM strives to maximize the ratio of functional performance to project costs (Thneibat & Al-Shattarat, 2021).

VM is a method that is organized and structured, with the primary goal of reducing project costs. This method consists of a series of activities carried out in stages in the form of a workshop.

2.3. VM Workshop

The process and implementation of the VM workshop play an important role in project success. Depending on the size of the project and the stage of work, all VM workshop activities are divided into flexible work plans (Jaapar et al., 2012). According to Society of American Value Engineering (SAVE), there are three stages including (1) VM pre-study; (2) VM study; and (3) VM post study which is shown in Figure 1.

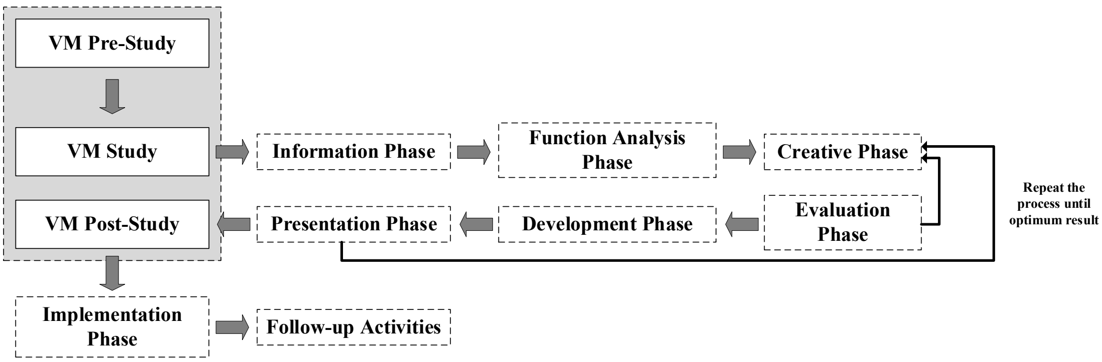

Figure 1. Flow of value management process
Source: Adapted from SAVE (2007)

(1) VM pre-study

The pre-study stage is the first step in preparing for the next one. At this stage, planning and organizing the value study stage is carried out by ensuring each party's support and responsibility, gathering basic information, and preparing project VM team members. At this stage, it is critical to comprehend the prioritized strategies, as well as the perspective formed on the possibility of generating sufficient value within the stipulated terms, and the knowledgeable team members. The outcome of this stage is to know that how VM will increase organization value and achieve the project's objectives as the crucial initial step for the subsequent phases of VM.

(2) VM study

This stage consists few phases or also known as job plan (SAVE, 2007):

- *Information phase*
  This phase aims to improve understanding of the current situation and constraints that may affect project decisions. Based on relevant information gathered from all parties, this insight brings all team members to a similar level of understanding of the project.
- *Function analysis phase*
  While the previous phase focuses on ensuring a shared understanding of the project, the function analysis phase concerns on developing a comprehensive understanding from a functional standpoint. In this context, intense discussion is used to raise questions about what the project

should do in order to see aspects that are not usually considered. Functional Systems Analysis Techniques (FAST) are applied to develop function models, and the results are analysed.
The Function Analysis System Technique (FAST) is used as a tool to develop function models and evaluation of functions. The identification of the value-mismatch function becomes the focal point for project improvement.

- *Creative phase*
  Creative phase aims to generate a number of concepts that highlight alternative ways or methods of performing functions. Activities that will generative creative idea are conducted including brainstorming and other techniques which can build the idea from all the VM members. The outcome obtained in this phase generate of ideas that offer variety of possible alternatives to fulfil the function which can enhance the value of project.
- *Evaluation phase*
  In this phase, the created alternatives are analysed and evaluated. The results of this evaluation will identify useful alternatives for further study that have the greatest potential for cost efficiency, saving time, or having a positive impact on the project's life cycle cost.
- *Development phase*
  The purpose of development phase is to prepare written suggestions or final recommendation for the chosen alternative. The final possible implementation recommendation includes taking into account technical and economic factors on fully developed alternative. As a result, low to high-risk scenarios are generated, and options that address the pre-workshop strategic objectives are presented.
- *Presentation phase*
  The last phase in this study stage aims to convince and encourage stakeholders or decision makers of the project about value alternatives which have fully developed by VM team. It is important to make sure that all the VM study products are completely presented. This phase will make all key stakeholders understand the rationale of the value alternatives.

(3) VM post-study

This stage is to ensure that all the VM products are implemented and its benefit have been realized with establishing action plans. It is necessary to specify when and how the VM-proposed alternative will be implemented. Additional studies may be required in some cases if stakeholders have specific requests for further research. Therefore, implementation management by VM team is a key role to realize each VM alternative.

2.4. Success Factors of VM in DB Project Delivery System

Society of American Value Engineering (SAVE) determines three stages of VM study consisting pre-study, study, and post-study stage. The success of the VM implementation is influenced by the proper execution of each stage of the VM. In order for the VM implementation to proceed as intended, factors affecting the success of each stage of the VM must be considered. As a result, it is critical to measure and identify the critical success factors of each VM stage in order to meet the implementation objective (Shen & Liu, 2003). Table 1 shows 32 success factors of VM from literature review.

Previous research has shown that VM workshops improve the success of construction projects. The VM factors that contribute to project success vary depending on the type of construction project. However, most studies only discuss CSF on VM implementation from the perspective of a general construction project. Because the DB system differs from the DBB system and other types of general construction projects, the applicable CSF for DB projects may also differ slightly. The results of the pilot study conducted to the expert produced 28 CSFs that were in accordance with the implementation of the VM workshop on projects with a DB system from the 32 CSFs in Table 1.

Table 1. Success Factors of Value Management Studies

Stages	#	VM Success Factors	References
VM Pre-Study Stage	1	Clear objective of VM Study	Shen & Liu (2003); Ramly et al. (2015); Tanko et al. (2018)
	2	Academic qualifications of the VM team	Romani (1975); Tanko et al. (2018)
	3	Professional experience and knowledge of VM team in their own disciplines	Kelly et al. (2015); Tanko et al. (2018); Thneibat & Al-Shattarat (2021)
	4	VM knowledge and experience of the VM team	Kelly et al. (2015)
	5	Preparation and understanding the project information (update drawings, project's state, specifications, historical data, etc.)	Leung & Yu (2014); Ilayaraja & Eqyaabal (2015); Park et al. (2017)
	6	Conducting VM study before the construction phase (timing of VM study)	Shen & Liu (2003); Olatunji et al. (2017); Ramani & Pitroda (2017)
	7	Conducting site visits	Ramly et al. (2015)
	8	Allocating time for VM study	Palmer & Kelly (1996); SAVE (2007)
	9	Knowing about characteristics and type of project which has successful possibility of VM implementation	Chen et al. (2010)
	10	VM clause or policies in the construction contract	Mandelbaum & Reed (2006); Tanko et al. (2018)
	11	Applying VM to high-cost projects	Ilayaraja & Eqyaabal (2015)
	12	Venue of the VM workshops*	Ramly et al. (2015)
	13	Clear responsibilities and roles of stakeholders*	Hwang et al. (2015)
VM Study Stage	14	VM study with identifying the high-cost areas or works of the project	Ramly & Shen (2012)
	15	VM study based on the availability of construction drawing	Chandra (2014); Ramly et al. (2015)
	16	Use of functional analysis	Dell'isola (1982); Fartookzadeh et al. (2018)
	17	Conducting workshop according to the VM job plan (information, function, creativity, evaluation, development and presentation phase)	Pucetas (1998); Oke & Aghimien (2018)
	18	Making several alternatives that can fulfil the main function	Jaapar et al. (2012); Ekanayake & Sandanayake (2017)
	19	Making several alternatives of construction method that can save budget of project	Jaapar et al. (2012); Latif et al. (2020)
	20	Comparing the initial design with alternative designs from engineering perspective	Younker (2003); Mousakhani et al. (2017)
	21	Comparing the initial design with alternative designs from cost perspective	Barrie & Paulson (1992); Shahhosseini et al. (2018)
	22	Comparing the initial design with alternative designs from time perspective	Barrie & Paulson (1992); Selim et al. (2017)
	23	Choosing the most feasible alternative which can help in cost saving and possible implementation	Ilayaraja & Eqyaabal (2015)

Stages	#	VM Success Factors	References
	24	Generating creative and innovative ideas which can give maximum cost efficiency	Moon (1966); Mao et al. (2009); Wao (2018)
	25	End-user participation*	Kineber et al. (2021); Ramly et al. (2015)
VM Post-Study Stage	26	Client's support and active participation in the VM implementation	Shen & Liu (2003); Tanko et al. (2018)
	27	Develop and plan for implementation the result of VM	Shen & Liu (2003); Hwang et al. (2015); Kineber et al. (2021)
	28	Incentives to VM team as a result of project cost efficiency	Cheah & Ting (2005); Kissi et al. (2017)
	29	VM feedback mechanism*	Tanko et al. (2018); Kinebar et al. (2021)
VM Supporting Factors	30	Cooperation, follow-up trailing, and support from all related parties (stakeholders) of project to implement VM	Shen & Liu (2003); Tanko et al. (2018); Thneibat & Al-Shattarat (2021)
	31	Active cooperation, interaction, and brainstorming among VM team, during pre-study until implementation of VM result	Maurer (1996); Tanko et al. (2018)
	32	Logistics and financial support to implement the result of VM	Gunduz & Almuajebh (2020)

* *General CSFs of VM which was not considered as CSFs VM in DB project after validation by experts*

3. RESEARCH METHODOLOGY

This study was conducted to determine the critical success factors (CSFs) of VM implementation in Indonesia infrastructure DB projects. CSFs play a main role and great influences to the successful of VM. In this study, there are some consecutive steps which is shown in Figure 2. Prior to the survey, a thorough literature review was conducted. The literature review aims to obtain CSFs VM implementation which was then developed into a questionnaire survey. The questionnaire was refined and developed on the basis of related previous studies on VM and validated by experts which covers 28 CSFs VM as shown in Table 2. The questionnaire survey contains a five-point scale ranking to identify the degree of importance of CSFs VM, with 1 indicating very unimportant, 2 unimportant, 3 neutrals, 4 important, and 5 very important.

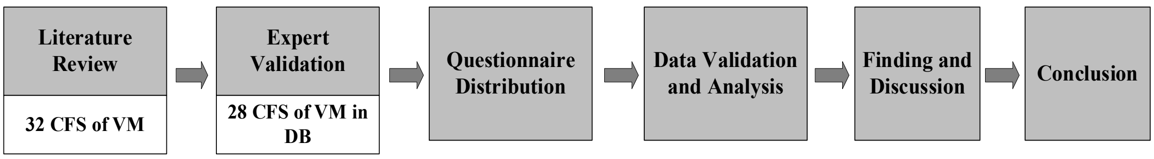

Figure 2. Research flowchart

The questionnaire was distributed among contractor from both state-owned companies and private enterprises that involved in the Indonesian infrastructure project. The respondent target was expected to have not only experience in construction project but also familiarity in VM process. Distribution of questionnaire was through email and short message with attachment as well as project and construction office visit. More than 70 percent of respondents returned the completed questionnaire. However, only 74 percent of the completed questionnaires were found to be suitable for further analysis. Using the sample size statistics formula by Hogg and Tannis (2009) the reliable data is still sufficient for the further analysis. In addition, according to the recommendation by Sekaran and Bougie (2016), the sample size larger than 30 from a population is appropriate and effective for most research studies.

The collected data is then validated and its reliability is calculated. To determine the validity and reliability of the data, the collected data was analysed using IBM SPSS Statistics for Windows. Data reliability was measured using Cronbach's alpha. Cronbach alpha coefficient is considered good when it is greater than 0.7 and close to 1.00. (Cronk, 2019). Furthermore, if the corrected item-total correlation is greater than 0.325, the instrument is considered valid. The analysis result shows that Cronbach's Alpha is ranged from 0.722 to 0.890. The corrected item-total correlation with a range of 0.461 to 0.617 was also achieved. As a result, it is possible to conclude that the data obtained in this study are valid and reliable.

Rostiyanti et al. (2020) have used Relative Importance Index (RII) method to analyse the barrier factors faced by women to pursue their career in construction industry. The same technique was also adopted in this study. The collected data were analysed and calculated using the RII formula as shown in Eq. (1).

$$RII = \frac{\sum W}{(A \times N)} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5 \times N} \qquad (1)$$

RII is a relative importance index value with the range from 0 to 1. The greater the RII value, the more important the CSFs are for VM. W represents the weighting given to each factor by respondents on a scale of 1 to 5. Other notations include A for the highest weight, which in this case is 5; and N for the total number of respondents.

4. RESULTS AND DISCUSSION

To determine what CSFs to be more important in every stage of VM, the RII was adopted to rank the CSFs of VM in each stage. Analysis was conducted based on the Eq. (1). The results of analysed data are shown in Table 2. Based on the ranking in each stage of VM workshop, the most important factor of VM in DB infrastructure project then can be formed into a framework as shown in Figure 3.

Table 2. RII and Ranking of Critical Success Factors VM DB Project at Each Stage

Stages	Code	VM Success Factors	RII	Rank
VM Pre-Study Stage (A)	FA1	Clear objective of VM Study	0.914	2
	FA2	Academic qualifications of the VM team	0.746	10
	FA3	Professional experience and knowledge of VM team in their own disciplines	0.859	5
	FA4	VM knowledge and experience of the VM team	0.886	3
	FA5	Preparation and understanding the project information (update drawings, project's state, specifications, historical data, etc.)	0.962	1
	FA6	Conducting VM study before the construction phase (timing of VM study)	0.849	7
	FA7	Conducting Site visits	0.881	4
	FA8	Allocating time for VM study	0.762	9
	FA9	Knowing about characteristics and type of project which has successful possibility of VM implementation	0.795	8
	FA10	VM clause or policies in the construction contract	0.854	6
	FA11	Applying VM to high-cost projects	0.638	11

Stages	Code	VM Success Factors	RII	Rank
VM Study Stage (B)	FB1	VM study with identifying the high-cost areas or works of the project	0.843	10
	FB2	VM study based on the availability of construction drawing	0.859	8
	FB3	Use of functional analysis	0.865	7
	FB4	Conducting workshop according to the VM job plan (information, function, creativity, evaluation, development and presentation phase)	0.822	11
	FB5	Making several alternatives that can fulfil the main function	0.849	9
	FB6	Making several alternatives of construction method that can save budget of project	0.897	4
	FB7	Comparing the initial design with alternative designs from engineering perspective	0.892	5
	FB8	Comparing the initial design with alternative designs from cost perspective	0.924	1
	FB9	Comparing the initial design with alternative designs from time perspective	0.886	6
	FB10	Choosing the most feasible alternative which can help in cost saving and possible implementation	0.903	3
	FB11	Generating creative and innovative ideas which can give maximum cost efficiency	0.908	2
VM Post-Study Stage (C)	FC1	Client's support and active participation in the VM implementation	0.811	2
	FC2	Develop and plan for implementation the result of VM	0.854	1
	FC3	Incentives to VM team as a result of project cost efficiency	0.805	3
Supporting Factors (D)	FD1	Cooperation, follow-up trailing, and support from all related parties (stakeholders) of project to implement VM	0.876	1
	FD2	Active cooperation, interaction, and brainstorming among VM team, during pre-study until implementation of VM result	0.870	2
	FD3	Logistics and financial support to implement the result of VM	0.778	3

The three pre-study and study stage factors are discussed below, based upon the ranking of the CSF groups in Table 2. These factors all play roles and are regarded as the most important for VM implementation in DB infrastructure projects. The focus of the post-study stage is solely on the most important factor, which is also applied to the most supporting CSF.

4.1. CFSs of VM Pre-study in DB Project

The preparation and understanding the project information was the most important factor to VM workshop in the pre-study stage (RII = 0.962). Adequate and good preparation, as well as understanding the project's related information at an early stage, are essential and key factors for the VM team to run the VM workshop smoothly. Commencing a project earlier is an advantageous course of action that can yield benefits such as cost reduction, resource conservation, and attainment of superior quality outcomes when implementing modifications or addressing new concerns (Isa, Kamaruzzaman & Mohamed 2019). The VM team should prepare and collect project information such as update drawings, cost data, project status, specifications, historical data, and so on. If some participants do not understand VM, the VM facilitator should give a brief introduction to the project before the VM workshop begins (Shen & Liu 2003). In infrastructure projects employing the DB delivery system, it can be deemed advantageous and a critical success factor due to the fact that team members come from a single entity.

The second most important factor in the VM pre-study stage is clear objective of VM study factor (RII = 0.914). Both projects and the VM workshop are initiated as a result of well-defined objectives and a deliberate strategy (Thiry, 2002). The term objectives refer to how far the team should go to achieve the VM workshop's goal. Determine a clear VM objective and play a map role for the team to reach the main goal of the VM workshop. The objectives of the VM study are the client's expectations, which should be determined during the pre-study stage.

The third factor is the VM team's knowledge and experience (RII = 0.886). Experience and knowledge of VM workshops are required to comprehend the stage of VM. Team members must work together until the results are implemented. When team members in infrastructure projects have limited experience with VM workshops, it is difficult to achieve the goal of VM because their receptivity to VM was low and sceptical (Japaar et al., 2012). Indeed, Hwang et al. (2015) discover that a lack of VM experience may be a critical risk factor. As a result, when selecting VM team members, VM knowledge level and experience should be considered.

4.2. CSFs VM DB Project at VM Study Stage

Comparing the initial design with alternatives design from cost perspective was the most important factor in the VM study stage (RII = 0.924). VM is a method for achieving project cost efficiency. The created alternatives should be compared to the original design to determine whether the alternatives provide budget efficiency or not. It should be noted, however, that alternative designs must perform the desired functions.

The second most important factor was generating creative and innovative ideas which can give maximum cost efficiency in the creative phase of VM study stage (RII = 0.908). Creativity is critical to the success of the VM process, and there are numerous methods for improving and stimulating the creativity of the VM team. It adds more benefits, such as better teamwork and productivity, to the DB project where the team member comes from a single entity. Brainstorming is carried out smoothly, allowing VM team members to be more creative in order to produce valuable results. Furthermore, Takim et al. (2013) asserted that infrastructure project contractors using DB systems are required to use VM because the resulting innovative solutions have a significant impact on the project's success.

Choosing the most feasible alternative which can give cost saving and possible implementation (RII = 0.903). Choosing the most feasible alternative in the final step before presenting the VM results to stakeholders and decision makers is critical to the success of VM at the VM study stage. The chosen design alternative must demonstrate cost savings while maintaining its constructability. Through the concepts of constructability and VM, Al-Fadhli (2020) discovered that infrastructure projects in Iraq save money, time, and improve quality.

4.3. CSF VM DB Project at VM Post-Study Stage

Develop and plan for implementation the result of VM is the most important factor in VM post-stage (RII = 0.854). In the implementation process, a certain amount of diplomacy and policy is required especially in public or infrastructure projects. This finding is similar with the results obtained by Shen and Liu (2003) that a clear and deliberate plan is critical to the success of VM results (proposals) implementation. The team in charge of developing VM proposals not only reports to the client, but also presents the proposals to representatives from various departments. This finding supports the results of Kineber et al. (2021), who defined this factor as a standardization of VM implementation in residential buildings.

4.4. CSF VM DB Project (supporting factor)

The supporting factor such as cooperation, follow-up trailing and support from all related parties of project to implement VM is the critical factor (RII = 0.876). Cooperation, follow-up, and support from all parties involved in project implementation are critical after the VM proposal has been realized. This factor can be implemented through activities such as holding regular VM implementation meetings and managing the VM implementation plan. Furthermore, the government's support and active participation in the implementation of VM on the infrastructure project has a significant impact on VM's success (Tanko et al., 2018).

4.5. CSF VM in DB Project

The outcomes of the research indicate that the identification of CFS in every stage of the VM process signify the key activities towards realizing the objectives of construction projects. This finding is consistent with the assertion of Madushika et al. (2020), which emphasizes the crucial role of the three primary VM processes, namely the pre-workshop, workshop, and post-workshop stages, in achieving the optimal performance of project construction.

The success of VM in DB delivery system depends on several factors in different stages of the VM process. In the VM pre-study stage, it is essential to prepare and understand the project information, including updating drawings, project state, specifications, and historical data. In DB delivery system, VM pre-study stage's importance lies in establishing a comprehensive understanding of the project's objectives, requirements, and constraints. This stage involves updating the project drawings, state, specifications, and historical data needed for decision-making process. Without proper preparation and understanding of the project information, the contractor may not be able to identify opportunities for value improvement or ensure that the project objectives and requirements are met. Park et.al. (2017) and Leung and Ju (2014) emphasized that collecting information from diverse sources, identifying specific issues, sharing each other's needs, and understanding the current state and constraints of the project at the beginning will help in identifying key issues and understanding the project as a whole. Participants in the early stage must openly share specific information that can stimulate spontaneous idea generation, positive attitudes and prompt idea generation for the next stage. The teams should collect and classify numerous data from past ideas, drawings, and specifications of materials etc., related to the current project. Othman et al. (2021) discovered that one of the most significant barriers to VM implementation was insufficient preparation. Inadequate preparation can result in a lack of information acquired at the earlier process, which later can cause issues when generating creative and innovative alternative ideas.

During the VM study stage, the project team generates alternative designs that meet the project objectives and requirements. This process aligns with the DB approach, which allows the contractor to explore different design options to achieve the client's goals. By evaluating each option's value and cost, the project team can identify the most effective solution that meets the project's goals while also considering cost implications. Another advantage is that in DB delivery system, the comparison of the initial design with alternative designs from a cost perspective enables the project team to identify opportunities for cost reduction while still ensuring quality and performance. It is similar with Shahhosseini, et.al. (2018) whose study found that the use of the suitable problem-solving principles with regard to type of the project could help generating the useful ideas in the creative stage. After investigation of all options including the initial design, it was shown that it is possible to reduce construction costs by adapting VM.

In the last stage of VM workshop, the project team develops an action plan to implement the VM recommendations. This process aligns with the DB approach, which emphasizes continuous improvement to achieve the project's goals. This stage involves developing an action plan to implement the VM recommendations and monitoring the progress of the implementation. The successful implementation of VM results ensures that the project objectives and requirements are met, which is crucial for achieving the project's overall success.

4.6. VM Framework in DB Project

A framework that describes the interrelationships of all the factors can be formed from the seven CSFs in the three stages of the VM workshop and one critical supporting factor. Figure 3 depicts the framework provided.

The objectives of the VM implementation, the project to be handled, and the personnel involved are the three main factors for the success of the VM workshop during the pre-study stage. The VM workshop should be centered on the goal of its implementation. This is an important consideration because the success of the VM workshop is dependent on the clarity of agreed-upon goals. Aside from the VM goal, careful project preparation and clear information will lay the groundwork for a successful VM workshop. Personnel involvement is important addition to the success of the VM workshop pre-study stage. Each personnel's knowledge and experience will be pooled to form a work team that will complement one another during the VM's implementation.

At study stage of VM workshop, the primary focus of VM is no longer on the goal, but on the process. The VM process is used to generate various design alternatives so that the most cost-effective option for saving construction costs can be obtained later. It is also necessary during this process to consider the selection of alternatives in terms of constructability. The process of selecting design alternatives demonstrates that VM at the study stage is more focused on design than on the project as a whole, as considered earlier in pre-study stage. Each alternative design is compared with the initial design to obtain cost savings. The interesting aspect of this stage is that it is no longer individual personnel who will determine the success of the VM workshop, but rather the team as a whole. The synergy formed within the team can generate innovative and creative ideas during the VM process so as to achieve maximum cost savings.

The success factor for the post-study stage, which was the final stage of the VM workshop, is achieved through the implementation of the previous process's results. The implementation of VM results must be specified in a detailed plan. Diplomacy and policy considerations are critical in developing and planning the implementation of VM results so that every stakeholder accepts the VM results as a mutually agreed-upon outcome.

The VM workshop also includes a critical supporting factor that is essential for the success of the VM in the DB system. VM cannot be realized without the cooperation of all project participants. The implementation of VM results will be impossible without the cooperation of all stakeholders. While a single entity involved in a DB delivery system appears to be less risky than other systems, it has its own risks if all participants involved do not cooperate. Because both processes are carried out by the same entity, the VM workshop held during the design stage should make the construction stage easier. Regular meetings attended by parties involved in infrastructure projects with a DB procurement system are one way to ensure the implementation of VM results. In a DB system, VM workshops conducted in the design phase should facilitate the implementation of the construction phase because both processes are carried out by the same entity. One way to ensure the implementation of VM results is through regular meetings attended by parties involved in infrastructure projects with a DB procurement system.

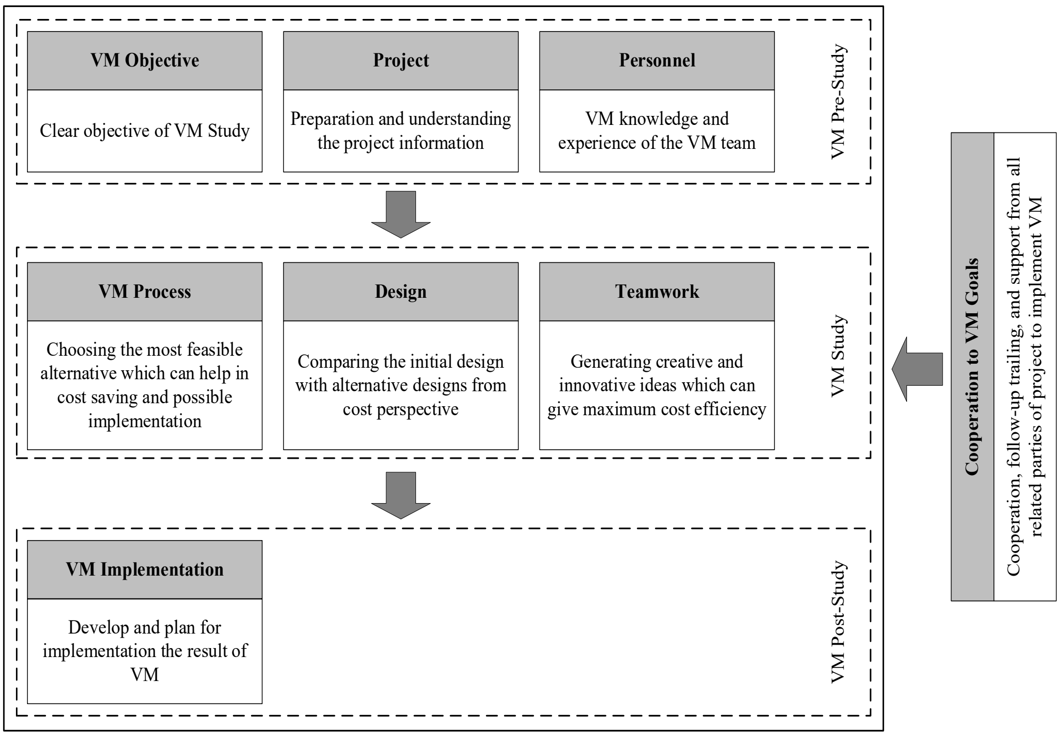

Figure 3. Framework of CSFs VM implementation in DB project

All CSFs on the VM workshop implementation in the DB project demonstrate that VM is the best way to get the best value for money. According to Lam et al. (2008), one of the critical success factors in DB projects is the use of innovative management approaches. The application of innovative management techniques, such as value management, is expected to provide the best alternative with the best value for money while not compromising performance quality. A VM that is started early in the project by involving a team that is capable of working together with the goal of optimizing project costs provides certainty for the DB project's success.

5. CONCLUSION

The DB approach to construction, particularly in infrastructure projects, has become increasingly popular in many countries. The advantage of a DB system in which the design and construction processes are implemented by a single entity makes the VM workshop more effective. It is because the construction team collaborates with the design team throughout the design development process. As a result, studying CSF VM allows for a better understanding of the critical factors influencing the success of VM on infrastructure projects using a DB approach.

This study investigates the CSF for VM implementation in a DB infrastructure project from the perspective of a DB contractor with experience implementing VMs. The study's findings indicate that the CSFs of VM workshops for DB projects differ from the critical factors of VM workshops in other types of project procurement systems, such as DBB. In contrast to CSFs for VMs workshops in projects with other types of procurement system, VM practices and the use of innovative management approaches become the strengths of DB projects in order to improve project performance.

The framework proposed in this study identifies seven critical factors that can lead to the most effective VM workshop implementation. The focus of the VM workshop in the DB project during the pre-study stage is on the VM objectives, the personnel who will be involved, and the complete project information. These three factors are critical before conducting a VM study. Once the VM objectives have been defined, complete project information has been gathered, and competent VM personnel have been met, the study VM focuses on the VM process, comparison of design alternatives with a cost-saving perspective, and innovative teamwork. These three factors are critical to the success of VM during the study stage. After the VM objectives are established during the pre-study stage, the VM process becomes a critical aspect in the VM study's success. In VM process, the CSF is choosing the most feasible alternative which can give cost saving and possible implementation. Furthermore, the DB system that combines design and construction into a single entity becomes a strength because the team works innovatively through the design process to develop buildable designs while prioritizing the value for money principle. The outcomes of the VM study stage's design alternatives are then applied to post-VM studies. The critical success factor of the post-study VM stage is VM implementation in terms of the development of an implementation plan. The supporting CSF VM workshop is the cooperation of every stakeholder in the implementation of VM result. Cooperation among stakeholders is required to maintain the implementation of the VM workshop's results and achieve its objective.

Although the Indonesian government has supported infrastructure development with a DB approach through national regulations, the government needs to set regulations on VM practices because VM is the best way to achieve value for money in development projects.

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