Value management / value engineering (VM/VE) application in Malaysian public construction projects: application of VM/VE study improved roads project sustainability

Mukhzani Abd Latif and Zawidatul Asma Ghazali

Value Management Unit, Public Works Department Malaysia, 50400, Kuala Lumpur, Malaysia

E-mail: mukhzani.jkr@1govuc.gov.my

Abstract. The application of Value Management/Value Engineering (VM/VE) in project development has a significant impact on the sustainability of a project. There is a relationship established between VM/VE methodology/process with the sustainability concept, which enables to enhance and achieve the intended project values. As such, to ensure value for money projects, the Malaysian Government has introduced the application of VM/VE in the development of public projects. Public Works Department (PWD) Malaysia is the organization responsible for VE application in public project development. In relation to sustainability, PWD has developed a sustainable rating tool known as Penarafan Hijau JKR (pH JKR) as a mean to determine the sustainability level of projects. This paper elucidates the relationship of the application of VM/VE towards sustainability of road projects by using selected VE case studies. Verification was done between the findings of VE for the selected case studies with the sustainability criteria of pH. It shows a significant result whereby VE findings improved the sustainability of road projects. It also provides evidence that the application of VE contributes to the sustainability of the project.

1. Introduction

1.1. Value Management/Value Engineering (VM/VE) in Malaysia

VM in Malaysia is defined as a structured multidisciplinary team approach to seek functional requirements of programmes/projects/products/services to achieve optimization in delivering the client's perceived value [1]. This is consistent with other established definitions, such as by SAVE International [2], which defines VM as a systematic process that follows a Job Plan, involving a multidisciplinary team to improve the value of a project through the analysis of functions.

To achieve value for money in public projects, the Malaysian Government has ordered implementation of VM in public programs and projects valued at MYR 50 million and above through a directive circular by The Economic Planning Unit (EPU), Prime Minister Department in December 2009 [3] and updated circular in November 2015 [4]. The requirement is mandatory and failure to implement it may result in the rejection of the programs and projects.

To further enhance VM implementation in public projects, EPU in 2011 has launched Value Management Implementation Guide in Government Programs and Projects [5] with the intention to introduce the major VM intervention points in the project lifecycle and stipulate the process of VM implementation in public programs and projects. The VM study interventions are known as Value
Assessment (VA) at Strategic Planning Stage, Value Engineering (VE) at Design Stage and Value Review (VR) at Operation Stage which applied at various stages of the project’s lifecycle. Aligned with this, PWD has established VE Application Guidelines for Public Projects which outlines the policies on VE governance, framework and study interventions focusing on PWD work process, and as well as to set standards of VE practice in public projects [1]. Additionally, PWD has also developed Value Engineering Facilitation Kit to provide quality information and practical assistance to facilitators in conducting VM/VE studies for public projects [6]. The kit outlines the concept of facilitation, the methodology of facilitating of VM/VE study and application of tools and techniques commonly used in facilitation VM/VE studies, which also known as VEMM. Both documents are in line and complement the circulars and VM Guide published by EPU.

1.2. Sustainable Development & Sustainable Construction
Sustainable development is defined as development that meets the needs of the present without compromising the ability of the future generations to meet their own needs [8]. To ensure sustainable development is achieved, it is crucial to integrate and harmonize the three pillars of sustainability, which are the economic, environmental and social factors. Balancing these factors are important and crucial; therefore, it needs to be sustained for the future survival and well-being of individuals and societies [9].

Sustainable development implicates improvement in the quality of life of humanity, the transformation of natural resources into the productive output, environmental conservation and economic progress. Consequently, United Nation in 2016 has outlined seventeen (17) goals of sustainable development to improve the lives of people as well as protecting the planet [9], which universally it applies to all countries/governments.

Meanwhile, sustainable construction is described as the subset of sustainable development philosophy. It explores the responsibilities of the construction industry to attain sustainability [10]. Therefore, to ensure sustainable construction delivered in the construction industry, cooperation is needed from the industry players such as the policymaker, clients, implementers, designers, contractors, and suppliers. These industry players are required to take necessary actions and play their roles towards achieving sustainability in the planning, design, construction, and operation of the building and infrastructure. Willingness and participation of all parties to explore new approaches in related fields in construction are required and crucial to ensuring the success of sustainable construction [11].

1.3. VM/VE and Sustainability
The integration of VM/VE with sustainability does not alter the VM/VE process. However, the study only emphasizes and focuses on sustainability [13]. Therefore, it is crucial to determine the sustainability of projects during the project development stage as well as other related factors involved (sustainability cost, planning, etc.). Well defined sustainability goals ensure sustainability issues/elements are addressed accordingly in the study in addition to other client values such as cost, functionality, quality, to achieve the best possible solutions or proposal for the projects. A structured process of VM/VE (stages and phases) provides guidance to the project team in achieving sustainability in the projects at the same time fulfilling the objectives and outcomes of the project.

1.4. pH JKR
PWD as the technical agency to the Malaysian Government has introduced several sustainability initiatives in the implementation of public projects. Recently in May 2017, PWD Sustainability and Green Mission 2.0 [12] was established to outline the activities to be carried out by PWD to ensure all government / public projects are executed sustainably. One of the activities is to utilize pH JKR as a green rating tool to determine sustainability the level of a project, which comprises of building and roads projects. pH JKR provides guidance to the road designers and project managers in considering sustainable elements in design and construction, further ensuring projects are delivered to the desired
level of sustainability [7]. Seven criteria are used as rating criteria in pH JKR as listed in Table 1. Meanwhile Table 2, describes the classification of pH JKR rating specifically for road projects.

**Table 1. Criteria of pH JKR.**

| Abb. | Criteria                                      |
|------|-----------------------------------------------|
| SM   | Sustainable Site Planning & Management        |
| EW   | Environment & Water                           |
| AE   | Access & Equity                               |
| CA   | Construction Activities                        |
| MR   | Material & Resources                          |
| PT   | Pavement Technologies                         |
| IN   | Innovation                                    |

**Table 2. pH JKR rating Classification.**

| Percentage (%) | Star   | pH JKR Ratings                      |
|----------------|--------|-------------------------------------|
| 40 - 49        | ★★     | Potential recognition               |
| 50 - 69        | ★★★    | Best management practices           |
| 70 - 84        | ★★★★   | National excellence                 |
| 85 - 100       | ★★★★★  | Global excellence                   |

2. Improving Road Project Sustainability Through Application of VM/VE

The methodology of this study is outlined in Figure 1:

2.1 Relationship VEMM and Sustainability

This study investigates the relationship between PWD VM/VE methodology or known as Value Engineering Methodology Matrix (VEMM) in relation to sustainability for road projects. From the study, a relationship was established between VEMM and sustainability of roads projects. During the earlier stages of the VM/VE study (pre-lab stage, information phase and function analyses in the lab stage), VEMM activities ensured that sustainability issues are discussed and addressed accordingly. The application of appropriate tools and techniques as outlined in VEMM helped to identify issues, concerns, details, directions, and others on the sustainability of the road projects. Meanwhile, the later stage of the VM/VE study (creative phase, evaluation phase, development phase, presentation phase and post-lab stage), focusses on resolving the sustainability issues by generating new/alternative ideas, evaluate and further develop the ideas into workable solutions. Table 3 summarizes the relationship between VEMM and sustainability.
### Table 3. The relationship between VEMM with sustainability.

| Study stages / Lab phases | Key VEMM activities | Sustainability Focus |
|---------------------------|---------------------|----------------------|
| Pre Lab Stage             |                     |                      |
| • Check project readiness for VE Study | • Interface with project team | • Client direction on project sustainability |
| • Gather and synthesize project information | • Collate relevant and sufficient project information | • Compliance status of authorities’ requirements (EIA, EMP, TIA, RSA, pH JKR Rating) |
| • Plan and prepare for VE Lab activities | • Commence the initial study | • Compliance status of project objectives, eg: road user safety, road user comfort, impacts to the environment and local surrounding |
|                           | • Develop lab program and arrange logistics for VE Lab execution | • Design concept and alignment selection – impact to sustainability |
|                           |                     | • Economy aspect of the latest project cost |
|                           |                     | • Identification of Subject Matter Expert (SME) to advise on project sustainability |
| Lab Stage - Information Phase |                     |                      |
| • Develop an understanding of the project and share the required details | • VE study briefing | • Client direction on sustainable elements made explicitly |
| • Gather, synthesize and verify project information | • Project information briefing | • Confirmation / verification status on authorities’ requirements |
|                           | • Confirmation VE study model(s) - as baseline for optimization / improvement. | • Confirmation / verification status on the economic status of the latest project cost |
|                           | • Confirmation of Client Value System (value criteria to be incorporated into the design solutions and project deliverables) | • Confirmation / verification status on project objective’s performance |
|                           | • Confirmation Lab working groups and VE study scopes | • Relevant sustainability cost allocation, i.e., OSHA, EPW, etc. |
|                           | • Establishment of project parameters to be studied. | • Issues, risks, and implication arise on project sustainability |
|                           | • Client direction on sustainable elements made explicitly | • SME input/views on project sustainability |
|                           | • Confirmation / verification status on authorities’ requirements | • Identification and analysis of project / elements / components / systems functions related to sustainability |
|                           | • Confirmation / verification status on the economic status of the latest project cost |                      |
|                           | • Confirmation / verification status on project objective’s performance |                      |
|                           | • Relevant sustainability cost allocation, i.e., OSHA, EPW, etc. |                      |
|                           | • Issues, risks, and implication arise on project sustainability |                      |
| Lab Stage - Function Analysis Phase | • Verification project functions |                      |
| • Understand the functions of the project/elements / components / system | • Analyse functions of elements / components / systems |                      |
| • Identify mismatches and potential value improvement on functional requirement | • Identification of value mismatches |                      |
| Lab Stage - Creative Phase | • Generation of alternative ideas to the original design proposal that may improve the value of the project. | • Generation of alternate ideas to improve/overcome sustainability issues/problems arise during the information phase and function analysis phase |
| • Generate a broad list of creative and innovative ideas as alternative ways to enhance the value of the project. | | |
Table 3. The relationship between VEMM with sustainability (continued)

| Lab Stage - Evaluation Phase | Evaluation of generated ideas by: | Lab Stage - Development Phase | Development of shortlisted sustainability ideas into workable options | Lab Stage - Presentation Phase | Presentation of VE study recommendations and findings | Post Lab Stage | Prepare and submit VE report | Dissemination of VE Study Report | Follow up on agreed Action Plan | Monitoring and assessing the implementation and performance of sustainability elements |
|------------------------------|---------------------------------|------------------------------|---------------------------------------------------------------|------------------------------|--------------------------------------------------|--------------|---------------------------|-----------------------------|-------------------------------|--------------------------------------------------|
| Shortlist the generated ideas to potential ideas for value improvement | Judgment of ideas | Consensus on the best solutions as VE Study recommendations (through a plenary session) | Consensus on best solutions selected ideas | Highlighted ideas/achievement related to sustainability | Documentation of recommendation and findings related to sustainability elements. | Review and identification of lessons learned. | Monitor and assess implementation of VE Study recommendation and finding | Monitoring and assessment of the implementation of VE recommendations and findings | Monitoring and assessing the implementation and performance of sustainability elements | |
| Lab Stage - Development Phase | Categorization of the judged ideas | Development of all recommended ideas and findings | Development of an action plan for post-lab activities | VE Study achievement review and identification of lessons learned. | Development of shortlisted sustainability ideas into workable options and determine the best solutions | VE Study achievement review and identification of lessons learned. | Assess performance of VE Study implementation | Assessment of performance VE Study implementation | |
| Lab Stage - Development Phase | Development of shortlisted ideas into workable options | Summarization of all recommended ideas and findings | Registration of further action required on project sustainability in post lab action plan | VE Study achievement review and identification of lessons learned. | Development of shortlisted sustainability ideas into workable options and determine the best solutions | VE Study achievement review and identification of lessons learned. | Documentation of any lesson learned related to sustainability in the report | | |
| Lab Stage - Presentation Phase | Present and gain acceptance from stakeholder | The consensus from lab team members/stakeholders on VE Study recommendations and findings. | Documentation of VE Study outputs. | Monitoring and assessing the implementation and performance of sustainability elements | Documentation of recommendation and findings related to sustainability elements. | Documentation of VE Study outputs. | Dissemination of VE Study Report | Follow up on agreed Action Plan | |

2.2 VE Case Studies Selection
Six (6) VE case studies were selected for the validation process. To represent the uniqueness of road projects, various types of projects such as upgrading works, new construction works, and rehabilitation works have been considered for this study. For all the selected VE case studies, the VE intervention level is set at the development of details design and development of a bill of quantities. The VE study scope involved are elements and components of the road design. Listed below are the details of the VE case studies selected and Table 4 summarizes the findings and achievements VE case studies.

VE Case Study 1
The proposed project involves the upgrading works of the existing main trunk road to the city center which experiences severe congestions in the morning and evening. It is located in an urban area and the major scope of works involves widening works of existing 4 lanes dual carriageway to 6 lanes dual carriageway (U5 standard) for almost 8.1 km, construction of 4 interchanges (flyover) and 2 new bridges along the road. The proposed project is expected to improve the level of services (LOS) of the
road segments as well as the relevant intersections. The approved project cost is approximately RM 420 million. In the VE study, 74 ideas for improvement have been generated whereby 43 ideas have been recommended for implementation. Generally, VE study manages to optimize project design and documentation with a cost saving of 0.23%.

VE Case Study 2
The proposed road project involves the upgrading works of existing rural coastal road to the Standard of R5. The existing road is experiencing road safety and congestion issues as there is no median provided along the 4 lanes roads and overcapacity of the existing intersections. The project scopes involve upgrading works (inclusive of geometric improvements, pavement rehabilitation) of 50 km road which comprises of 45 km of 4 lanes single carriageway to 4 lanes dual carriageway (with median) and 5 km of 2 lanes single carriageway to 4 lanes dual carriageway. It also involves upgrading 5 grade junctions to interchanges (flyover), construction of U-turns, single span bridge and pedestrian bridges for road crossing. The total project cost is estimated about RM 630 million. 99 ideas have been generated in the study and 59 numbers are recommended to be implemented. Generally, design and project cost have been optimized during the VE study with improvements to the design, item rates, and quantities as well as engineering judgment made (due to insufficient data). A cost saving of 0.87% has been recorded during the study.

VE Case Study 3
The proposed road project is to complete the remaining work of abandoned road alignment as well as damages that have occurred since 2011. It involves rehabilitation works and construction of a new road for a length of 20 km which include incomplete road alignment inclusive of road works and structure works. The road is categorized as the major road linking the west coast and east coast of Malaysia and has been designed to R5 Standard. The scope of works consist of construction of new road and structures (for incomplete road), repair works (for the road, structures, and drainage) and other related works. The cost is approximately RM290 million. In the VE study, 25 ideas have been generated and 19 are accepted for recommendations. 0.45% of cost saving has been achieved, and project/design elements are also reviewed during the VE study.

VE Case Study 4
The proposed road project involves the rehabilitation of pavement works of a 40km existing road inclusive of bridge replacement and drainage improvement along the segment. This project will improve the safety and comfort of the road users as the condition of the existing road experienced severe defect and damages. Furthermore, the existing bridges are narrow and the drainage system are improper. The approved project cost is RM 85 million. In the VE study, 39 ideas for improvement have been generated and 26 ideas have been recommended for implementation. Generally, some improvements on sustainability have been achieved during the VE study and 1.05% of cost have been saved. The VE study also managed to review the construction and project elements as well as the project documentation.

VE Case Study 5
The proposed project is to construct a 25 km new bypass road which conforms with JKR R5 standard and is 4 lanes dual carriageway. The construction of this new road will ease the congestion of the existing road and provide an alternative road for the locals to access the town. The total project cost is estimated at around RM 370 million. 75 ideas have been generated to improve and optimise the project value. However, only 33 are accepted for recommendations. Generally, VE study manages to optimize the project design and cost with a cost saving of 0.95%.
VE Case Study 6
The proposed road project involves the construction of a new alternative road for approximately 7 km with the configuration of 4 lanes dual carriageway. The project is a part of the overall alignment of a new road which consists about 75 km. However, due to cost constraint, only few packages have been approved and VE case study 6 is one of the approved package. The proposed new road will be connect the existing road networks to the surrounding area. The approved project cost is about RM 190 million. In the VE study, 48 ideas for improvement have been generated with 23 ideas have been recommended for implementation. Generally, VE study manages to optimize the project design and cost with a cost saving of 0.03%.

| VE Case Study | Type of Projects | Sustainability Achievements |
|---------------|------------------|-----------------------------|
| 1 Upping Works| Cost optimization (cost saving 0.23%) | Provision and improvement of Occupational Safety & Health (OSHA) items and rates |
|               | Optimization of land acquisition area and cost | Provision and improvement of the Traffic Management Plan (TMP) items |
|               | Improvement of pedestrian safety (improve the location of bus layby facilities, provision of pedestrian bridge) | Revision of earthwork quantities (cutting/filling) and omitting excess import material |
|               | Provision of maintenance items after construction (maintenance of bridges and culverts) | Provision of pavement performance monitoring after construction |
|               | Provision of pavement performance monitoring after construction | Revision of design concept of the bridge (bridges re-profiling proposed to improve safety and comfort) |
| 2 Upping Works| Cost optimization (cost saving 0.87%) | Provision of temporary protection for slopes (eroded & bare slope) |
|               | Revision quantities for site clearing and related works to minimize affected area | Provision and improvement of EPW design and quantities (for the physical works) |
|               | Improvement of road safety features (provision of road lighting) | Improvement of road safety features (provision of road lighting at bridges area and increase quantities for NJB to accommodate substandard curves) |
|               | Revision of access and junctions design (improve the length of auxiliary lanes) | Provision of Occupational Safety & Health (OSHA) items and rates |
|               | Reuse and recycle existing material for new construction (existing road base as new subbase material, milling waste as new road base material) | Improvement of Traffic Management Plan (TMP) items and rates |
|               | Provision of maintenance items after construction to ensure effective maintenance works (maintenance of bridges and culverts) | Revision of platform level in design to minimize earthwork quantities (cutting/filling) and right of ways (ROW) affected |
|               | Provision of pavement performance monitoring after construction | Provision of building information modeling (BIM) |
| 3 Rehabilitation works| Cost optimization (cost saving 0.45%) | Provision of pavement performance monitoring after construction |
|               | Revision of project length to improve safety and accessibility of the road user (to include existing junction improvement) | Provision of pavement performance monitoring after construction |
|               | Provision of temporary protection for slopes (eroded & bare slope) | Provision of pavement performance monitoring after construction |
|               | Provision and improvement of EPW design and quantities (for the physical works) | Provision of pavement performance monitoring after construction |
|               | Improvement of road safety features (provision of road lighting at bridges area and increase quantities for NJB to accommodate substandard curves) | Provision of pavement performance monitoring after construction |
|               | Provision of Occupational Safety & Health (OSHA) items and rates | Provision of pavement performance monitoring after construction |
|               | Improvement of Traffic Management Plan (TMP) items and rates | Provision of pavement performance monitoring after construction |
|               | Revision of platform level in design to minimize earthwork quantities (cutting/filling) and right of ways (ROW) affected | Provision of pavement performance monitoring after construction |
|               | Provision of building information modeling (BIM) | Provision of pavement performance monitoring after construction |
Table 4. VE case studies findings (continued)

| Case Study | Works                  | Findings                                                                                                                                                                                                 |
|------------|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 4          | Rehabilitation         | - Cost optimization (cost saving 1.05%)  
                          - Improvement of drainage system (earth drain to U drain – improves flow and maintainability)  
                          - Improvement of road safety features (traffic light system-vehicle actuated system provided)  
                          - Revision of access (closing conflict access near to the bridge)  
                          - Improvement of Traffic Management Plan (TMP) items  
                          - Provision items for pavement rehabilitation (milling, regulation, etc) |
| 5          | Construction of a new  | - Cost optimization (cost saving 0.95%)  
                          - Revision of bridge geometric design (for uniformity and comfort)  
                          - Provision and improvement of EPW design and quantities  
                          - Improvement of drainage system (provision of subsoil drain at cut areas)  
                          - Provision and improvement of Road Safety Audit items (Stage 1-5)  
                          - Review of access and junction design (provision of U-turns, from the roundabout to signaled junction)  
                          - Improvement of pedestrian safety (provision of bus layby facilities)  
                          - Provision of a Traffic Management Plan (TMP) items  
                          - Provision of maintenance items after construction to ensure effective maintenance works  
                          - Road lighting using LED technology for energy efficiencies  
                          - Provision of International Roughness Index (IRI) testing |
| 6          | Construction of a new  | - Cost optimization (cost saving 0.03%)  
                          - Optimization of land acquisition area and cost  
                          - Provision of slopes protection (turfing)  
                          - Improvement of drainage system (revision of culverts numbers)  
                          - Improvement of Road Safety Audit items (Stage 4-5)  
                          - Improvement of EPW design and quantities  
                          - Revision of design concept of the box culverts (from 2 numbers adjacent box culvert to single span bridge structure) |

2.3 Result Verification
Verification was made between VE recommendation ideas of the VE case studies with the pH JKR criteria and evaluated for relevant sustainable VE recommendation ideas. Figure 2, Figure 3 and Figure 4 show the verification results of this study.

Figure 2. Relevancy of VE Case Studies against Sustainability.

Figure 3. Classification VE Recommendation Ideas.
2.4 Discussion of Result

The detailed findings of this study are described as follows:

1. VE application contributes to the improvement of the sustainability of road projects regardless of the type and scope of the project. Additionally, implementation of VE ensures sustainability issues/elements of road projects are discussed and addressed accordingly. Consequently, the sustainability of road projects is improved as shown in Figure 2.

2. VE improves the three pillars of the sustainability of road projects which are economic factor, social factor and environment factor. VE application has contributed significantly to the pH criteria representing social and economic factor as shown in Figure 3. While, for the economic factor, VE case studies have indicated cost avoidance/saving from the project costs ranging from 0.03% to 1.05%, which ensures that the final projects cost is within the approved project cost.

3. The total VE recommendation ideas related to sustainability was recorded as high as 80% as shown in Figure 4. Hence, it verifies that VE application to road projects contributes to sustainability.

In general, VE application using the VEMM approach shows a significant impact on the improvement of sustainability in road projects supported with appropriate VE tools and techniques. Table 5 highlights the area of VE recommendation ideas which contributes to the improvement of sustainability in road projects.

Table 5. Highlighted VE Recommendation Ideas Contributes to Sustainability.

| pH JKR Criteria | Area of VE Recommendation Ideas |
|-----------------|----------------------------------|
| Sustainable Site Planning & Management |  - Optimization of land acquisition area  
- Provision of temporary protection for slopes (eroded & bare slope)  
- Revision of design and quantities for site clearing and related works to minimize affected area  
- Revision of bridge geometric design (for uniformity and comfort)  
- Revision of project length to improve safety and accessibility of the road user |
| Environment & Water |  - Improvement of drainage system (culverts, surface drainage)  
- Provision and improvement of EPW design and quantities |
| Access & Equity |  - Improvement of road safety features (signboards, barriers, road marking, road lighting, traffic light system)  
- Improvement of pedestrian safety (bus layby facilities, pedestrian crossing)  
- Provision and improvement of Road Safety Audit items (Stage 1-5)  
- Revision of access and junctions design |
| Construction Activities |  - Provision and improvement of Occupational Safety & Health (OSHA) items (Safety officer, personal protective equipment, site safety, reporting, etc)  
- Provision and improvement of Traffic Management Plan (TMP) items (design and quantities, for temporary diversion, temporary works) |
Table 5. Highlighted VE Recommendation Ideas Contributes to Sustainability (continued)

| Material & Resources | · Revision of platform level in design to minimize earthwork quantities (cutting/filling) and right of ways (ROW) affected  
| | · Reuse and recycle existing material for new construction (topsoil, road base material, milling waste, etc)  
| | · Provision and improvement of maintenance items after construction to ensure effective maintenance works  
| | · Road lighting using LED technology for energy efficiencies  
| Pavement Technologies | · Provision of pavement performance monitoring after construction  
| | · Provision of an alternative method for pavement rehabilitation (partial reconstruction, CIPR, etc)  
| | · Using the latest pavement guidelines as design reference Arahan Teknik Jalan (ATJ) 5/85 (Pindaan 2013) – improve pavement performance  
| | · Provision of International Roughness Index (IRI) testing  
| Innovation | · Provision of building information modeling (BIM)  
| | · Revision of design concept (bridges re-profiling, a combination of structures, changes to the type of the structure, etc)  

3. Conclusion
This paper has demonstrated the VE application using the VEMM approach contributes to the improvement of sustainability in road projects. VE case studies validation provides evidence and quantifies the contribution of VE application in improving sustainability (economic factor, social factor and environment factor). Furthermore, VE application facilitates the designer to improve the sustainability elements in the road design although it has been considered at the earliest stage. This indirectly enhances and compliments the application of pH JKR as a sustainable rating tool for public projects although economic factor is excluded from the evaluation criteria in pH JKR. However, the result shown is subjective and may differ subjected to the comprehensiveness of sustainability consideration in road design by the designer prior to VE study and changes in project scenarios due to project issues, problems, information availability, new requirements, etc.

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