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INVESTIGATION OF PRACTITIONERS' PERCEPTIONS FOR DEVELOPING BUILDING INFORMATION MODELLING (BIM) - BASED VALUE ANALYSIS MODEL

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ABSTRACT

As the architecture, engineering and construction (the AEC) industry is expanding the size, and more complex in recent years, there are various approaches to enhance efficiency and effectiveness in the AEC industry. Building Information Modelling (BIM) is regarded as one of responses to such a change in the market. While the application of BIM might focus on the enhancement of efficiency and collaboration of all the stakeholders during construction projects, value engineering (VE) has been prevalent to maximise the value of the projects and customers' satisfaction. The South Korean Government has established the regulations to adopt VE as a means of amelioration of the nature of the AEC industry. Although BIM and VE would have a significant impact on the cost optimisation and performance enhancement for construction projects, it is scant that the research in terms of combining BIM and VE for more synergic effect towards the AEC industry. This research was a part of a three years research project to develop an add-on of BIM software which would make it possible to evaluate of individual objects' value. The aim of this research was to confirm the users' perceptions towards BIM and VE as well as to corroborate their usefulness by practitioners from construction firms and design companies in South Korea. In this study, approximately 87% of the research participants has already recognised BIM and its practicability in the AEC industry. Additionally, the respondents were asked their perceptions towards the usefulness of BIM-based VE analysis software. Majority of the survey participants, which accounted for 67.35%, replied that the intended add-on software for BIM would be applicable to analyse the value of their projects. With the users' requirements, the research participants answered the basic unit of VE analysis in conjunction with BIM software. The respondents indicated that components would be the basic unit for assessing and analysing the value of a building. This result was in accordance with our intention to develop BIM-based VE analysis software. In addition, this reaction might reflect that

our planned software would be highly helpful for practitioners and professionals in the AEC industry to carry out VE analysis in their projects.

Key words: BIM; VE; value analysis; object-based; the AEC industry; BIM software.

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1. INTRODUCTION

As the architecture, engineering and construction (the AEC) industry is expanding the size, and more complex in recent years, there are various approaches to enhance efficiency and effectiveness in the AEC industry. Building Information Modelling (BIM) is regarded as one of responses to such a change in the market. Academics and practitioners in South Korea also consider that BIM would be a potential solution to deal with larger and more complex construction projects. While there are variety of definitions in terms of BIM, BIM is a 3D object-based parametric modelling system which would be able to integrate all the stakeholders in a single construction project with the same model (Eastman et al., 2011) [1]. In other words, BIM is not only a newly developed computer-aided technology but also a communication pathway to enhance the efficiency of the construction project.

According to the announcement of Public Procurement Service in South Korea (2016) [2], the total number of 21 cases, which were equivalent to approximately 4.3 trillion Korean Won (KRW) has been tendered by a BIM-based tailored design and contract method. The total number of tendered in 2016 was 50 cases and the size of the contracts was about 2.1 trillion KRW. The Public Procurement Service of South Korea has published 'The guidelines of BIM-based procurement for construction and civil engineering projects' which would be make it easy for any contractors or design firms who will take part in the public projects. The guidelines stipulate the minimum requirements of BIM-based tendering by the size of the projects, and the role of all the stakeholders (designers, contractors and other parties) involved in the project in order to insure the quality of the public projects. In addition, the guidelines would be able to alleviate the potential disputes and risks amongst all the stakeholders which would be arisen by not providing the roles and liability. It is expected that the application of BIM will expand the scale and scope incrementally for a long while by a number of experts. Moreover, it is inevitable that the small and medium sized construction and design firms will have to be adopted in this new ecology. The Public Procurement Service of South Korea has released the different level of details (LODs) guidelines for different size of construction and design companies. Along with such trend of implementing BIM, it is expected that more companies and stakeholders in the AEC industry will take part in harnessing BIM from the initial phase of their projects.

While the application of BIM might focus on the enhancement of efficiency and collaboration of all the stakeholders during construction projects, value engineering (VE) has been prevalent to maximise the value of the projects and customers' satisfaction. The South Korean Government has established the regulations to adopt VE as a means of amelioration of the nature of the AEC industry. According to the VE regulations, when Tier 1 construction projects which the budget is over 0.5 billion KRW will have to conduct VE investigation in order to eliminate the potential inefficiency and make sure cost reduction factors. In addition, the VE regulation has been tightened from 0.5 billion KRW to 0.1 billion KRW in Tier 1 construction projects. In this revised regulation, the VE investigation will have to be carried

out during the schematic design and construction documentation procedure by the contractors or design firms.

Since both BIM and VE pursue the enhancement and improvement of project quality and customers' satisfaction, combining these two approaches would lead potential and practical benefits to all stakeholders of construction projects. Ranjbaran and Moselhi (2014) [3] proposed 4D-based BIM approach which would improve the comprehension of project participants and stakeholders. In this system, the authors developed a new system which integrated the appraisal of the value of the components with 3D-BIM. However, this newly suggested system did not consider the value and function of each component. Although BIM and VE would have a significant impact on the cost optimisation and performance enhancement for construction projects, it is scant that the research in terms of combining BIM and VE for more synergic effect towards the AEC industry. Especially, evaluation the function and performance of the individual object or component would be practical to choose alternatives during the early design phase.

2. LITERATURE REVIEW

1.1. What is Building Information Modelling (BIM)?

The definition of Building Information Modelling (BIM) varies depending upon researchers' point of views and their research interests. Whilst some of the academics point out that BIM is a new technological development which is enhanced technology from Computer Aided Design (CAD), others consider BIM is a whole new approach in the architecture, engineering, and construction (the AEC) industry which will enhance collaborative work and ultimately materialise Integrated Project Delivery (IPD) through BIM. American Institute of Architecture (AIA) (2006) [4] pointed out that BIM is much more than 3D rendering or transferring electronic versions of paper documents.

Moreover, Azhar (2012) [5] exhibited that a BIM is not only a digital representation of buildings or structures but also a shared knowledge resource for more reliable information of a building during the entire life cycle of the building. According to Gu and London (2010) [6], BIM is "An IT enabled approach that involves applying and maintaining an integral digital representation of all building information for different phases of the project lifecycle in the form of a data repository". They emphasise the significant changes of BIM in a technological aspect. In a nutshell, it is evident that BIM is a whole new technological advancement as well as an emerging momentum for paradigm shift in the entire AEC industry.

While a number of academics focus on and underline the technological side of BIM, the dominant view in terms of BIM in recent years is a combined and comprehensive viewpoint which considers both the technological and the procedural features of BIM. According to Succar (2009) [7], BIM is a constellation of the integrated set of policies, process and technologies with harnessing digital format throughout the entire lifecycle of a building. Similarly, Miettinen and Paavola (2014) [8] view that BIM is not only a representation of buildings or facilities which is materialised object-based three-dimensional model, but also a repository of project information that can be facilitated interoperable software or applications. Moreover, the authors point out that through utilisation of BIM with collaborative manner, it will be able to achieve to reduce mistakes as well as increase the productivity of the construction industry. In a similar vein, Azar (2011) [9, 10] indicated that BIM is a process and software rather than just software to make three-dimensional models. He asserted that

BIM means not only using three-dimensional intelligent models but also making significant changes in the workflow and project delivery processes.

Demian and Walters (2014) [11] state that recently developed tools and application of BIM would be able to utilise as a means for communication and information management between project stakeholders. They suggest potential benefits of information management through BIM technology as follows: 1) enhancing accessibility and interpretation of large volumes of construction information; 2) to help and foster more accurate, on-time, and appropriate exchange of information between project participants; 3) to promote earlier creation of critical information which would be significant impact on the later phase in projects; and 4) to foster greater collaboration between project participants. Although there would be great impact on improving information management using BIM, the authors forecast that such utilisation is more useful in a small project or smaller organisations rather than large-sized projects.

The potential benefits from using BIM is quite evident and it would be categorised into three folds. Firstly, a number of researchers has indicated that applying BIM would be one of the potential stimulators to reduce the overall cost of construction buildings. Arayici et al. (2011) [12] stated that utilisation of BIM would be able to eliminate waste of time and money by reflecting on the customers' and stakeholders' feedback in real time. Bryde et al. (2013) [13] viewed that one of the baggiest returns from implementing BIM would be cost reduction during the design phase. The second potential benefit of BIM might be improved communication and enhanced collaboration amongst all the stakeholders.

Crotty (2012) [14] criticised that document-based design and construction might lead a lot of difficulties and problems over the entire lifecycle of a building. He stressed that inappropriate information supply normally was caused by the paper-based workflow. However, BIM would lessen such potential cumbersome situation through comprehensive participation of the projects and real-time communication and exchange of information and relevant data. Elmualim and Gilder (2014) [15] maintained that the accurate documentation of building development would be a source of efficient collaboration among stakeholders and reduce potential mistakes and omissions caused by miscommunication.

1.2. Value Engineering (VE)

Value engineering (VE) is a method not only to reduce the cost but also to enhance the performances of a project such as saving time, reducing the construction cost and so forth. It is regarded as one of effective methods to increase the profit of the company and improve the firm's capabilities. VE is a systematic and creative activities to balance between cost and performance by examining any uncertainties and unexpected expenses and tasks. Through the levelling between the cost and performance, it would be able for a firm to make a proper decision without affecting any harm to the quality of the conducting project. Kim (2000) [16] proposed a method to assess the appropriateness of design alternatives reflecting on the detailed job planning. In this method, each index to evaluate the performance would be weighed dependent upon its significance and impact to the design alternatives.

Kwon (2003) [17] analysed the data from VE contests sponsored by Korea Land and Housing Corporation. The researcher pointed out that the evaluation of VE in most of the construction projects in the contest was mainly focused on the economic aspects and effects rather than other influencing elements. This research also found that the results of VE assessment were considerably varying depending upon the individual assessor. In order to

resolve the subjective nature of VE evaluation process, Kwon [17] proposed a new approach which harnesses AHP technique for more objective and optimal VE evaluation process.

Despite a number of studies have been carried out to state the usefulness and effectiveness of BIM and VE separately, the research in terms of combining and maximising the applicability of BIM and VE is rare. In order to fill this gap, this study tried not only to integrate both of them but also make it possible to use BIM and VE in the early design phase.

3. RESEARCH METHOD

This research was a part of a three years research project to develop an add-on of BIM software which would make it possible to evaluate of individual objects' value. In this newly developed add-on of BIM, the user of BIM would be able to harness BIM and VE at the same time during the designs phase with ease. In addition, this add-on would be satisfied with both the practical and legal requirements of BIM and VE in South Korea.

The aim of this research was to confirm the users' perceptions towards BIM and VE as well as to corroborate their usefulness by practitioners from construction firms and design companies in South Korea. As the first stage of the overall project, this study had three objectives: 1) investigate the current status of BIM adoption and VE understanding in Korean construction and design companies; 2) comprehend users' requirements of VE or value analysis during the design stage; and 3) establish a guideline of an integrated add-on to analysis the value of the individual objects with BIM software which would be make it possible to evaluate the value in the early design phase.

In this research, a quantitative research method, which was a survey, was adopted in order to satisfy the research objectives. The total number of 60 questionnaires were distributed to practitioners (i.e. project managers, engineers, and architects) in construction companies and design firms. The minimum working experience of the research participants was limited to 5 years. The questionnaires were a means to grasp the overall attitudes and practical point of views towards BIM and VE. The distributed questionnaire had three parts which would be able to reflect on the practitioners' perspective towards BIM and VE. The first part was intended to design to comprehend the overall tendency in terms of BIM and VE. The second part of the questionnaire was the usefulness of BIM-based VE. The last section of the survey was designed to acquire requirements of our newly developed BIM-based VE and perceptions towards new BIM add-ons. The total number of 49 questionnaires was returned and the response rate was 81.6%.

4. DATA ANALYSIS AND DISCUSSIONS

4.1. Current status of BIM and VE

The analysed data were acquired from a survey of 49 professionals from construction companies and design firms in South Korea. Respondents completed a questionnaire assessing the usefulness and effectiveness of BIM and VE as well as the necessity and requirements of the individual object evaluation software which would be served as an add-on of BIM software.

Table 1 Types of respondents' companies

Types of companies	Number of respondents	Percentage (%)
Contracting	2	4.08
Design	12	22.49
General construction	11	22.45
SME	11	22.45
Construction management	12	24.49
Others	1	2.04

While there are several sub-categories in the AEC industry, it was categorised into six sub-categories as contracting companies, design companies, general construction companies (large-sized construction companies), small and medium-sized construction (SME), construction management companies and others in this study. As shown in Table 1, twelve respondents were from design firms and construction management companies respectively, while eleven participants from general construction firms and small and medium-sized construction firms respectively. Besides, two respondents worked for contracting companies and one participant was a researcher in a research and development centre (see Figure 1).

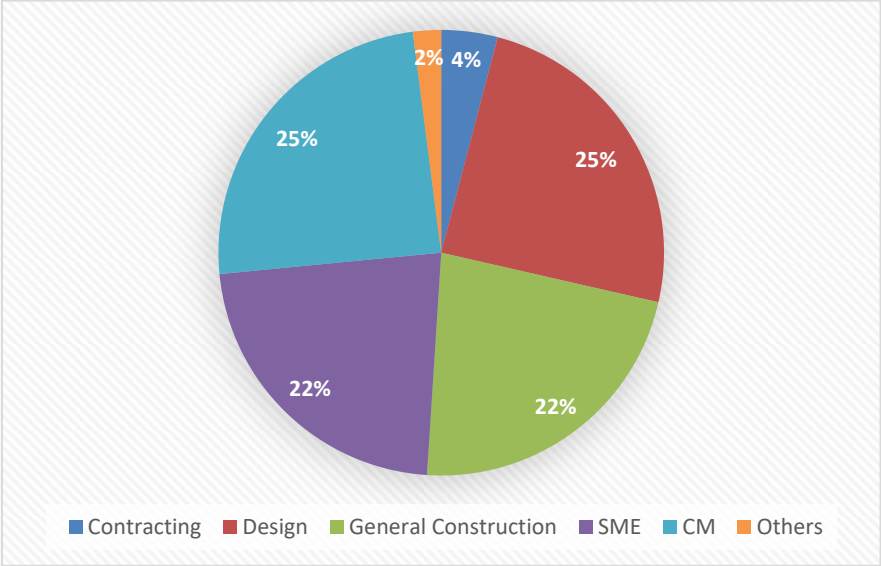

Figure 1 Types of companies for the respondents

In addition, the researchers also carried out an examination of the individual respondents' tasks in their companies. As shown in Figure 2, the survey result showed that fourteen of the 49 respondents were engaged in architectural design and building construction, which was accounting for 28.57% respectively. The number of respondents in charge of construction management and engineering was 12, and 9 respectively.

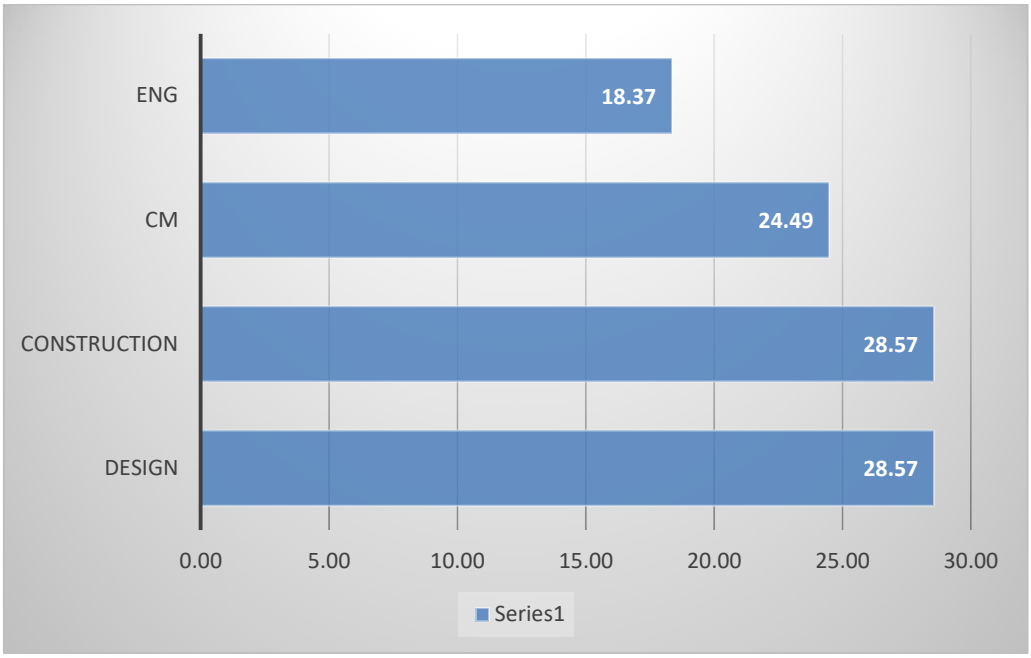

Figure 2 The individual respondents' tasks in their companies

4.2. Recognising and understanding of VE and BIM

The main goal of this research is to develop an add-on which would be able to be operated in BIM software to analyse the value of each object. In order to achieve this research goal, the first priority of the research progress was to grasp the research participants understanding, awareness and readiness of BIM and VE. In recent year, it is inevitable for anyone who works in the AEC industry to harness BIM as well as to apply VE for performance enhancement. Thus, it might be the foremost to comprehend attitudes towards BIM and VE for achieving the research aim.

While VE has been one of the mandates in the large and tier 1 construction projects in South Korea, 63.27% respondents which were 31 people, responded that they had any experience to conduct VE activities in their projects. On the other hand, 18 respondents did not have any previous experience to carry out VE. Most of the respondents have experienced VE since the budget of the construction projects has been tightened from 0.5 billion KRW to 0.1 billion KRW. Thus, more construction professionals have to carry out VE check-up, when they bid constriction projects.

Respondents of VE experience reflect a broad variation in their number of years of VE experience (see Figure 3). While nineteen survey participants have between ten and twenty years of VE experience in their work, nine people have experience of between five and ten years and three respondents have experience of more than twenty years. None of the respondents is less than five years' experience of VE and three persons have more than twenty years' experience of VE. The overall survey result shows that the person who had VE experience have substantial experience and understanding about the progress and significance of VE in the AEC industry.

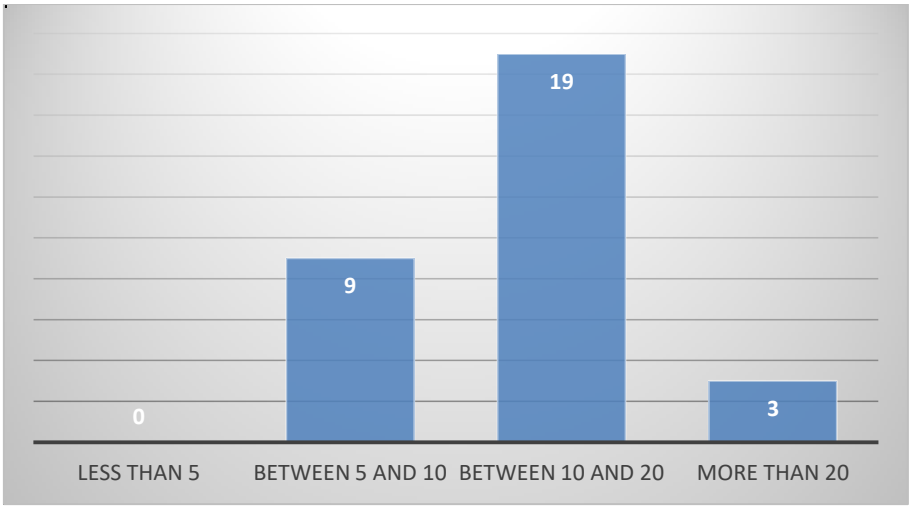

Figure 3 Respondents' experience of VE

With awareness of varying experience and understanding of VE, the respondents of this research were asked to answer the recognition and experience of BIM. BIM is not only a newly developed 3D rendering and digital representation of physical model (BuildingSmart, 2008) but also a set of interacting policies, processes and technologies utilising a single digital format (Succar, 2009) [7]. This means that, BIM is a paradigm shift in the AEC industry rather than one of the newly developed or released software or technology. All the survey participants were asked to answer the aware of BIM and 41 respondents answered that they have recognised BIM. 33 research participants answered that they have recognised the existence of BIM. On the other hand, only 8 people responded that they did not know BIM. The test result indicated that BIM is an irreversible trend in the AEC industry and most of the AEC professionals and practitioners of the research participants have acknowledged BIM in their field of works.

However, it was difficult to interpret that the person who knew BIM had any experience to harness BIM for their work. Recently, BIM is a vital tool for checking clash detection, post-occupancy evaluation using as-built model, scheduling, quantity take-off and so forth. In order to fill this problem, 41 respondents who recognised BIM were asked to respond previous experience of using BIM in their work. The survey result showed that 29 participants, which accounted for 70.73%, had practically utilised BIM for their projects. In contrast, 12 respondents answered that they did not have any experience of using BIM.

The respondents who had used BIM for their projects were asked to answer the types of BIM software applied to their projects. Although there are several BIM software packages in the market, only a few of them from traditional CAD vendors such as Autodesk, ArchiCAD and Bentley are popular among the users. According to Khosrowshahi and Arayici (2012) [18], while Revit and ArchiCAD were the most popular BIM software packages in the UK, variety of BIM software packages such as Bentley, Tekla, Allplan and so forth were also widespread and utilised by many firms. However, the software used in South Korean construction and design firms was quite limited to only a few options. The responses to this question were divided only two software packages into Autodesk Revit and ArchiCAD as shown in Figure 4. 28 participants had any experience to use and only five respondents had used it before. Revit was the most popular BIM software among the survey respondents since the overall interfaces and compatibility with previous AutoCAD were the main reason for preferring Revit for BIM software package. It was quite surprised that ArchiCAD is well-made and popular in Europe but it was rare to use it in South Korean construction market. In

addition, none of the survey participants replied the harness of Digital Project and Bentley, even though they would be useful for large projects and atypical architecture.

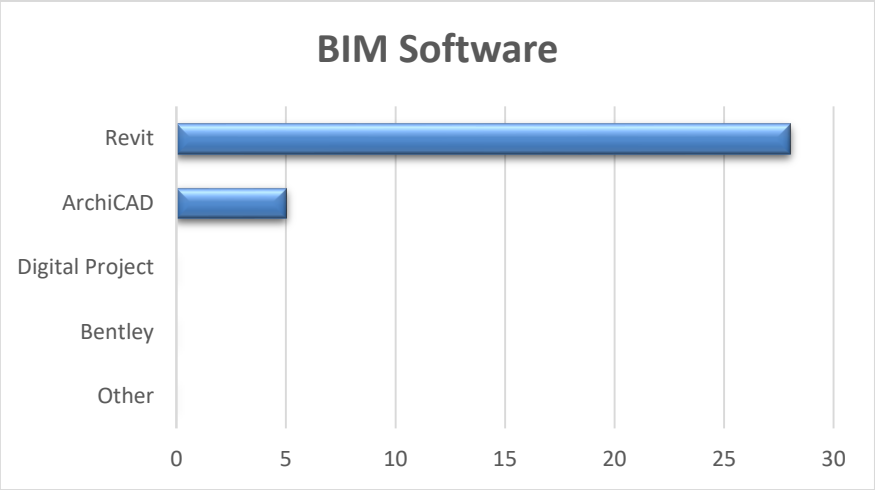

Figure 4 Respondents' experience of BIM software

4.3. Requirements of New Software

While it is expected that combining BIM and VE would be beneficial for professionals and practitioners in the AEC industry to deliver construction projects, reflection of their requirement would be significant to establish the target of developing BIM-based VE software. That is, the survey respondents were asked the requirements of BIM-based VE software. The survey results showed that the most important information of VE as for the users' perspectives is the details regarding cost-effectiveness (see Figure 5). Recently, it is quite common trends to pursue economic efficiency in most of the economic and industrial sectors and the AEC industry is also following such social movements. In addition, the respondents answered that the information in terms of Life Cycle Cost (LCC) and performance are the secondly and thirdly demands for the newly developed software in BIM. BIM is not only a new 3D modelling software but also an integrated solution to simulate and combine all the information regarding VE and other building performance. Through this way, VE would be more accurate and timely manner to offer all the relevant information in the right place and right time for the users.

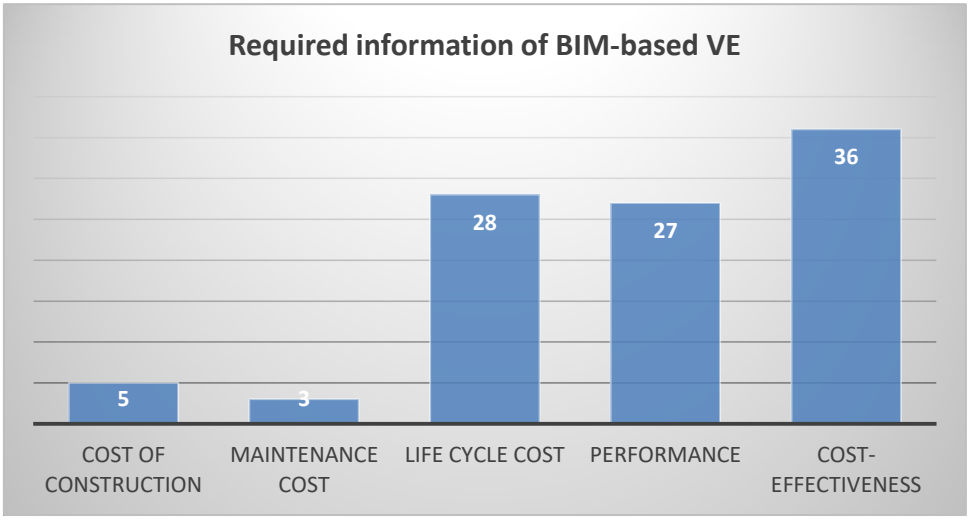

Figure 5 Required information of BIM-based VE

Along with the required information of BIM-based VE, each respondent was asked to weigh the score of all the aspect of the information which would be served for VE analysis by BIM (see Figure 6). The most weighed factor was performance, which was scored 4.41. The next significantly weighed item was life cycle cost and the score was 3.93. The third factor was cost-effectiveness, which was scored 3.86 then, maintenance cost and cost of construction were followed. For the practitioners' point of views, measuring the performance of component or object in a building would be more significant than the other factors such as cost or effectiveness. When the selected materials would not be able to meet the minimum level of performance, the designed building might be useless or should be re-designed in the worst case. Thus, majority of the survey respondents scored high marks on the performance options compared to others such as cost of construction, life cycle cost, maintenance cost and so forth.

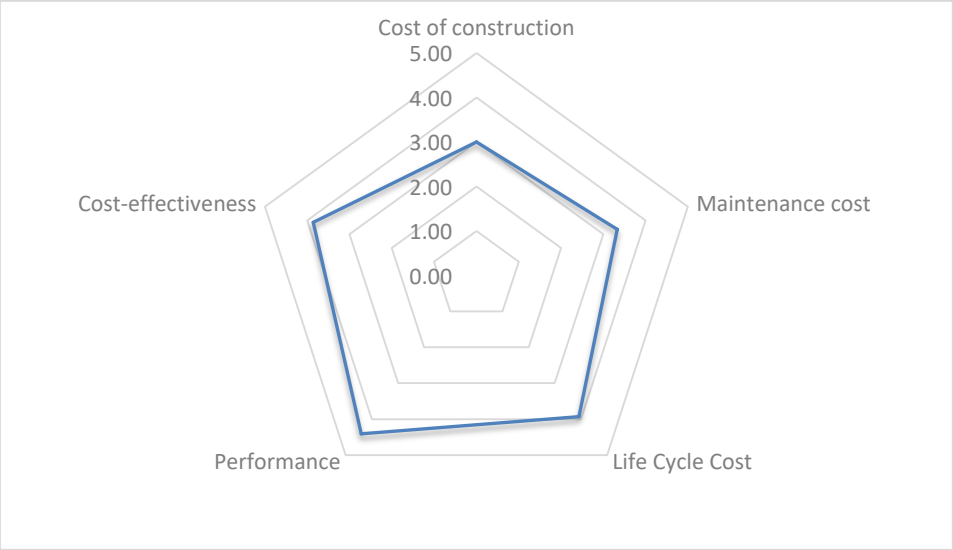

Figure 6 Weighed requirements of BIM-based VE information

Lastly, the survey participants responded that the basic unit of VE analysis of a building, when BIM-based VE software would be developed. This means, the value of a building would be assessed by various unit of measurement. A building is a constellation of variety of materials, components, floors or spaces so it would be needed to determine the basic measurement unit for better analysis of the value of a building. For the developers' point of views towards BIM-based VE, the basic unit of value analysis would be important to develop a new BIM-based software as well as to reflect on the users' requirements. Majority of the respondents answered that the components would be the basic unit of analysis of the value of a building (See Figure 7). The respondents' perceptions were identical to the researchers' intention to develop object-based value analysis utilising BIM. 37 survey participants replied that components would be the basic unit for assessing the value of a building using BIM. Besides, 23 respondents marked that materials might be useful basic unit to evaluate the value within BIM add-on.

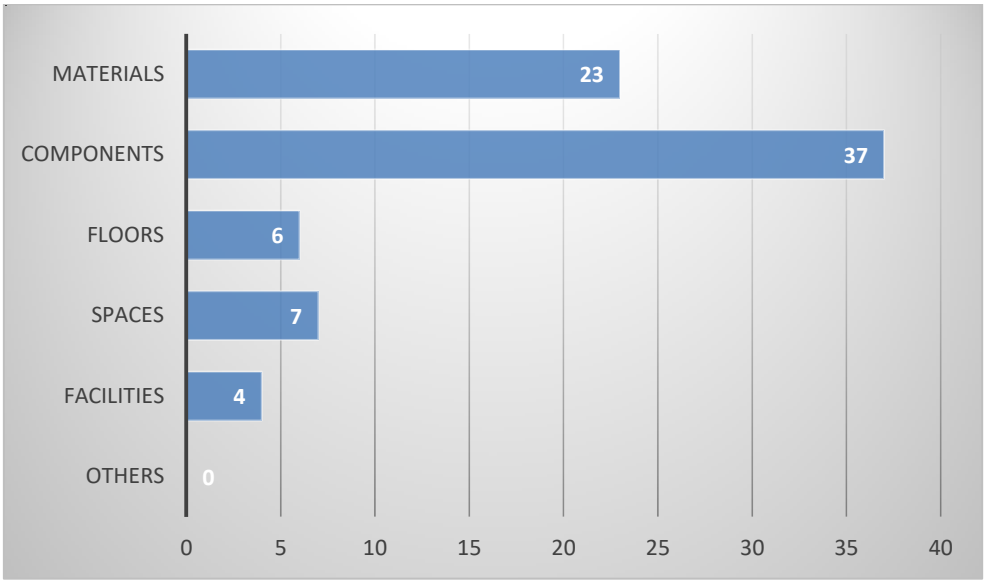

Figure 7 Basic unit of analysis for BIM-based VE

5. CONCLUSIONS AND FUTURE WORKS

BIM has been considered not only as one of the most crucial technological development and innovation but also a whole new paradigm shift in the AEC and FM industries. In this circumstance, the purpose of this research was to comprehend the potential users' perspectives and requirements towards BIM-based value analysis software in order to enhance its application and efficiency.

The main research method of this study was a quantitative research strategy using a questionnaire survey. In this study, approximately 87% of the research participants has already recognised BIM and its practicability in the AEC industry. Besides, about 70% respondents who acknowledged BIM have utilised BIM in their projects and the most popular BIM software among the target group was Autodesk Revit and ArchiCAD in order.

Additionally, the respondents were asked their perceptions towards the usefulness of BIM-based VE analysis software. Majority of the survey participants, which accounted for 67.35%, replied that the intended add-on software for BIM would be applicable to analyse the value of their projects. In contrast, only 12% of the replies reflected the negative aspect of the BIM-based VE approach proposed in this research. Therefore, the development of BIM-based VE analysis software (i.e. add-ons) would become a medium for enhancing the VE analysis and efficiency of its process integrating with BIM, when it would be developed and released in the market.

The researchers also tried to reflect on the potential users' demands of BIM-based VE analysis software. The first priority of the respondents' attitudes towards VE analysis was cost-effectiveness, LCC and performance in order. However, the results were slight different, when the respondents were asked to weigh each of the replied items. In this case, the elements which were given the highest mark were performance, followed by LCC and cost-effectiveness in order.

With the users' requirements, the research participants answered the basic unit of VE analysis in conjunction with BIM software. The respondents indicated that components would be the basic unit for assessing and analysing the value of a building. This result was in

accordance with our intention to develop BIM-based VE analysis software. In addition, this reaction might reflect that our planned software would be highly helpful for practitioners and professionals in the AEC industry to carry out VE analysis in their projects.

This research was carried out as the first phase of 3 years research project which would develop objects-based VE analysis add-on software within BIM environment. The purpose of this research was to investigate the practitioners' and professionals' perceptions towards BIM and VE. The main methodological strategy to fulfil the research aim was a questionnaire survey. However, the number of participants of this study was quite small, so it would be needed to conduct more questionnaire survey to reflect the users' requirements as well as to corroborate the purpose of our study. To do so, the planned add-on in BIM environment would be more useful and user-friendly software.

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