Jurnal Teknologi

Full paper

A Conceptual Model of Agreement Options for Value-based Group Decision on Value Management

Christiono Utomo[a*], Rosli Mohamad Zin[b], Rozana Zakaria[b], Yani Rahmawati[a]

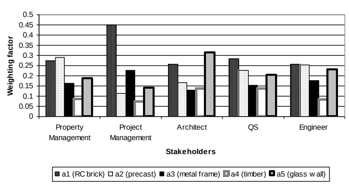
[a]*Institut Teknologi Sepuluh Nopember, Indonesia*
[b]*Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia*

*Corresponding author: christiono@ce.its.ac.id, christionoutomo@gmail.com

Article history

Received :1 May 2014
Received in revised form :
14 September 2014
Accepted :1 Oktober 2014

Graphical abstract



Abstract

A group decision must be made when a design process is conducted by more than one person. In this situation, negotiation plays an important role in many design decision. Value Management (VM) is one of design decision methodology in construction. By involving multi disciplines, collaboration and teamwork, negotiation becomes an important role on VM using a value-based group design decision. This paper provides an approach to develop a conceptual model of agreement options for group decision in building wall system selection using value criteria which are function and cost. The characteristic of value criteria has not been applied on previous researches. Existing models which are commonly accepted are optimization-based models, for example aggregation methods, but these are not able to solve the problem of value criteria on VM. Group decision needs to identify the goals that can be optimized and those that can be compromised in order to reach an agreement among decision makers. Agreement options are determined by identifying the potential decision makers followed by determining the optimal solution for each sub-group. Five stages are conducted to identify and determine agreement options as a conceptual model which are determining the weighting factor of criteria for each decision maker; grading alternative for each evaluation criteria; scoring every alternative for every decision maker; determining the optimal solution; and determining the fitness factor of an alternative solution The agreement option model is facilitated to better design decision. The model developed in this research can be used for any development research on group decision and negotiation in design process within the construction industry. Future research in the application of this methodology in many field of decision will build a wide range of knowledge to solve the theoretical and practical gap between automated design and automated negotiation.

Keywords: Value; agreement; design; decision

■1.0 INTRODUCTION

All designs involve creativity and choice among those alternatives, both are ineffable and mysterious [1]. When design is conducted by more than one person, communication becomes fundamental [2]. Decision must be made jointly in a group. Many techniques, methods, and tools have been developed and studied for group decision making [3, 4]. In this situation, negotiation plays an important role in many design decision, and is usually conducted informally [5]. Decision making of all kinds involves the choice of one or more alternatives from a list of options. The aim of rational decision making therefore is to maximize the positive consequences and minimize the negative ones [6]. Rational decision making involves choice within the context of multiple measures of performance or multiple criteria [7].

Design decision is one of the decision making processes with multiple criteria that rank a number of alternatives, each of which is ranked separately by several ranking of criteria [8, 9]. This problem of multiple criteria is different with social choice problems (10). The difference makes decision with multiple criteria has deep implications for the applicability of the theorem to design decision making. Decision making is integral to the civil engineering and building construction design process, and is an important element in nearly all phases of design [11, 12, 13]. Viewing design as a decision making process recognizes the substantial role that decision theory can play in design [14, 15, 16]. Decision making in a particular design can be helpfully visualized as a collection of activities of generating and refining design alternatives, and then selecting a single design or a set of designs [17] in the context of completing technical or functional requirements [18]. At this point, decision making can be viewed as a process of modeling a decision scenario resulting in a mapping from the design option space to the performance attribute space. In this outlook, Thurston [19] suggested that a utility function is constructed that reflects the designer preference while considering trade-offs among system attributes and the risk attitude towards uncertainty.

Tate [20] stated that 'in design, decision making is most important'. This is because designer must make many types of decisions for example the choice among various alternatives in order to create or select the best design, (or) the development of a set of suitable requirements.' Many researchers [19] supported Tate argument and suggested the role of decision making in engineering design. Li [21] derived from Hazelrigg, noted that decision making is the core of all design activities. It starts at problem definition stage by deciding the customer/client's requirements, and defining constraint and targets and at alternative generation phase by exploring design space and selecting concept [22].

Negotiation is a fundamental form of human interactions. In the context of Value Management (VM) process, negotiation is part of group dynamics and team skills [23]. In the VM process, negotiation as an attempt to resolve interests and not positions. The position is clear and explicit, but interests are deeper issues such as: fears, desires, and motivations that lie behind positions. Negotiation aims towards agreement and not necessarily the achievement of agreement. Some definitions of negotiation that consider multiple criteria decision making problem are presented by [24].

In this paper, a conceptual modeling was used to represent agreement options among all decision makers as agent negotiation involved in VM process. Decision maker of multi-criteria decision making problems usually evaluates the alternative solution from different perspective, making it possible to have a dominant solution among the alternatives. Each needs to identify the goals that can be optimized and those that can be compromised in order to reach an agreement with others. The model for identifying agreement options acts as a solution filter [25], so that only promising solution (agreement options) are available to decision makers for detailed negotiation.

Contributions to the field of conceptual modeling have come from research areas such as artificial intelligence, programming languages and database design [26, 27, 28]. Conceptual modeling is the process of identifying high-level concept and tools to solve the problems posed by the complexity of a new application. The result of the conceptual modeling process is a model which can be defined as a collection of specification statements that are relevant to some problem and represents abstraction, assumptions, and constrain about the system being modeled [29].

■2.0 CONCEPT OF VALUE-BASED GROUP DECISION

The term VM was first used by the United States General Service Administration in 1974 to reflect value techniques. The techniques were not confined to technical issues but evolved into more management activities and company policy [30]. VM is focused on the examination of functions aimed at identifying and eliminating unnecessary cost [23] but there is no deterioration of quality parameters while eliminating cost. VM is used to resolve soft, dynamic and multifaceted problems on strategic level [23, 31]. In construction process, the scope of VM covers all phases of construction from inception to operation.

Clemen [6] argued that decision analysis techniques can then applied to determine the relative value of the alternative solutions for performing the function. Value-based decision on a value analysis as a new approach involves the use of a multidisciplinary team [32] that includes representatives of the owner, user, facility manager, and constructor. Decision for selection of best idea in VM was distinguished in two stages in the job plans that are evaluation phase and development phase [23]. It is suggested that organizations adopting value based decision should review the criteria used to measure and evaluate performance.

2.1 Value Criteria: Function and Cost

Value criteria describe the efforts to establish performance standards and approach for governing the effective application of the value disciplines [31, 33]. There are two criteria, the first is function. Understanding of functionality is important because it represents a part of the design rationale. In conceptual design, a designer decomposes a required function into sub function called functional decomposition. Kitamura and Mizoguchi [34] proposed a knowledge server to provide alternative ways to achieve required function. They suggested that function depends on the context but should be local in description. Kaufman [31] defined function as 'an intent or purpose that a product or service is expected to perform'. The classifications of functions as they relate to product performance are basic function and secondary function.

Function Analysis is the systematic process of identifying functions and their associated costs, and assessing the necessity of those functions based on established criteria for the product or service [23, 31]. Function analysis should include identification of functions, classification of functions, functional models, establishing function worth, cost functions, establishing value index and selection of function for study. On the ontology of the functional concepts proposed by [34], there are two different groups of functions based on function type and Meta function. Function type represents the type of goal achieved by the function. On the other side, Meta functions represent a role of a base function called an agent function and objective function. There are several methods of function analysis, one of the most important and useful is FAST (Function Analysis System Technique) by [32].

Cost in form of life cycle cost (LCC) is the second criteria in value. The term 'LCC' means a process for evaluating the total economic worth of a usable project segment by analyzing initial costs and discounted future costs [23]. LCC can be implemented at any level of the design process and can be an effective tool for evaluation of existing building systems. LCC can be used to evaluate the cost of a full range of projects, from an entire site complex to a specific building component [35]. As defined earlier, LCC is the total discounted cost of owning, operating, maintaining, and disposing of a building or a building system over a period. LCC equation can be broken down into three variables: the pertinent costs of ownership, the period of time over which these costs are incurred, and the discount rate that is applied to future costs to equate them with present day costs [23, 31].

2.2 Group Decision on Value Management

The decision for selecting the best idea in VM is distinguishable in two stages in the job plans, which are evaluation phase and development phase. Many decision methods for screening and selection techniques have been proposed for VA, VE, and VM [36]. Weighting and scoring technique is relevant in VM exercise [37], where a decision needs to be made in selecting an option from a number of competing options, and the best option is not immediately identifiable. A paired comparison is done to determine the weighting to be given to each attribute [38, 39]. The combination of paired comparison method with fuzzy mathematics was used by many researchers [40].

Many researches on group decision in VM [39] have been reported. The group can be consisted of facilitator, project manager, architect, landscape architect, civil engineer, cost estimator, concession facility operator, operations and housing officer. To date, there have been two types of approaches to computerizing the decision in VM process. The computer tools consist of database, knowledge based system, expert system and internet based computer application. Many researches on application of computer in value-based group decision have been reported. Among others are SMART (Simple Multi Attribute Rating Technique) methodology by [41], ESVMDOB (Expert System for Value Management in the Design of Office Building) [42], VEESSHD (Value Engineering Expert System in Suburban Highway) [43], GDSVM (Group Decision Support for Value Management)[44], IVMS (Interactive Value Management System) [39] and Case-based reasoning on VM [45].

The proposed methodology by [41] combined the practicality of traditional VM with theoretical rigor of operational research. By applying a longitudinal case study by naturalistic inquiry, Green provided the wider theoretical justification for the proposed methodology with reference to the established typology of social science. By identifying the GDS methodology for the purpose of VM within the context of building design, the proposal by [41] contrasted the dominant paradigm of VM. The GDS was based on an underlying ontological position of social constructivism. The work of [41] gave a huge benefit to the theoretical basis and foundation of group decision support on VM. A proposal of Group Decision Support (GDS) in VM and the extension of the research was also presented by [44] by applying a computer program to run an experiment of their proposed GDS. The group decision support system (GDSS) is an interactive computer based information system that combines the capabilities of communication technology, database technology, computer technologies, and decision technologies to support the identification, analysis, formulation, evaluation, and solution of semi-structured or unstructured problems by a group in a user friendly computing environments. A similar model of GDSS named IVMS was reported by [39]. Even though the GDS does not adopt any artificial intelligent algorithms, the GDS is very useful when it comes to completing all phase of VM process.

A lot of work has been done in decision, group decision and computerization in VM, but none of them discusses a negotiation support for VM.

Kelly *et al*. [23] stated that VM is a multidisciplinary, team oriented approach to problem solving. This concept, supported by [41], describes value based approach as a new approach and methodology. Real-time decisions are reached using value based methods in a team setting: function analysis, quality modeling, group creativity/innovation techniques, life-cycle costing, design/cost simulation modeling, and choosing by advantages [39]. It means that VM becomes an approach that enhances the communication of a common understanding between team members. In the natural characteristic of construction industry, it means that a tool for decision team is necessary.

When the decision environment becomes more complex, decision making requires multiple perspectives of different people because one decision maker does not have enough knowledge to well solve a problem alone. There is a need to distinguish between non cooperative multi member decision making and cooperative group decision making. Lawson [46] observed in engineering system context that many group decision making problems are influenced by non cooperative behaviors of stakeholders. However there are many examples where group decision making processes are cooperative that is to find the best possible solution to a technical problem.

■3.0 MODEL OF AGREEMENT OPTIONS

Identification of agreement options acts as second-level filter of value-based decision process [47]. The first is the screening based on the search criteria, while the second filter is based on decision makers' preference. The negotiation process should lead to single agreement options that will changes as the negotiation progresses.

3.1 Methodology

The methodology combines value-based processes, multi-criteria decision-making process, and negotiation base agreement options and coalition [5, 47]. The model was tested for solving group choice decision making problems to choose a wall system of a construction building. This model presents five decision makers (DMs), namely property manager, project manager, architect, quantity surveyor and project engineer. They are the parties in the decision process.

There are many applications of method in building system selections, one of which is from the key literature by [48] that compiled six main criteria consisting of architectural design, physical performance, technology, management, economics and marketing. In this research, the criteria are taken from the basic theory of VM which is function and cost. Function is determined from Function Analysis System Technique (FAST) and Cost is calculated from the concept of Life Cycle Cost (LCC). The main reason for using FAST is the ontology of design, that every design of technical solution should have a function [33, 34].

Five stages are involved to determine agreement options [47]. The first three stages came from individual decision. The results from these first three stages are used to determine the agreement options in the last two stages.

3.2 Development of the Model

Stage one is determining the weighting factor (weight of preferences) of criteria for each decision maker (DM). The relative importance of pair-wise comparison [49] of decision input could be: equal (1), moderate (3), strong (5), very strong, demonstrated (7) or extreme (9). Sometimes one needs to compromise judgments (2; 4; 6; 8) or reciprocal values (1/9; 1/8; 1/7; 1/6; 1/5; 1/4; 1/3; 1/2). There are two judgments involved in this decision - the first is criteria judgment for each DM and the second is technical solution judgment for each criterion. Figure 1 presents that each DM has own preference. Observe that project manager and architect contrast in preferences. Project manager argues that c1 is the most important criterion, whereas architect puts f8 as the highest priority on the decision to select a wall system of a construction building.

Stage two is grading alternative for each evaluation criteria. Figure 2 presents that a5 or glass wall is the 'best fit' for criteria of f1, f2, and f8 whereas a1 or brick wall is the 'best fit' for criteria of f3, f4, f6, and c1.

Stage three is scoring every alternative for every DM. The AHP measures the overall consistency of judgments by means a consistency ratio [49]: CRA_{ck} = CIA_{ck} =RC_n. The higher the consistency ratio, the less consistent the preferences are. The value of the consistency ratio should be 10% or less. Under this condition the priorities can be calculated. Figure 3 shows the difference of the best option as solution alternative. In this case only property manager chose precast (a2) as the best option, architect chose a5, engineer choose a2 and other two decision makers choose a1 as the best solution for wall system.

Stage four is determining the optimal solution (payoff optimum). The determination of the optimal solution for each decision maker in a coalition is based on a cooperative multi-person games with complete information in which coalition-formation among sub-group members are allowed. DMs should rank the attributes of the technical solution, hence providing the value of a_{ij}. In this research which was based on two main evaluation criteria as the objectives of technical solution selection, every a_{ij} was evaluated on function based on FAST (Function Analysis System Technique) and cost based on LCC (Life Cycle Cost). The first is more of quality than quantity, and the second can be calculated based on the theoretical time value of money.

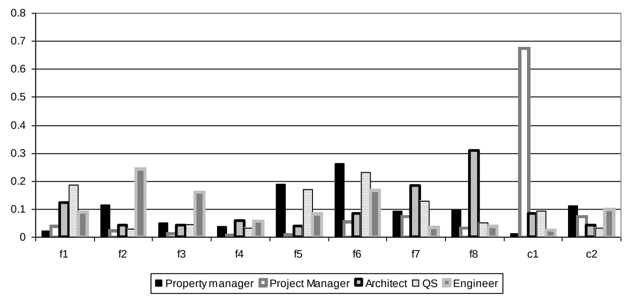


Figure 1 Weight of preferences for each stakeholder

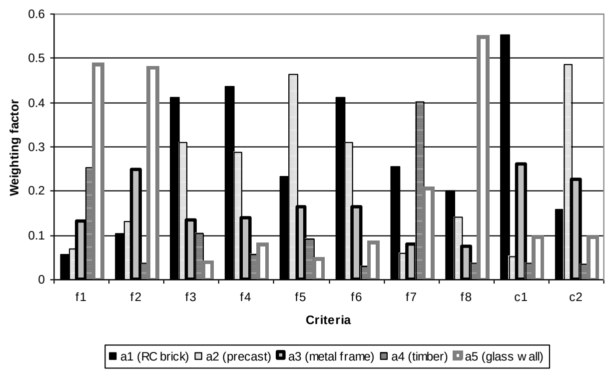


Figure 2 Weighting factor of each alternatives to each criteria

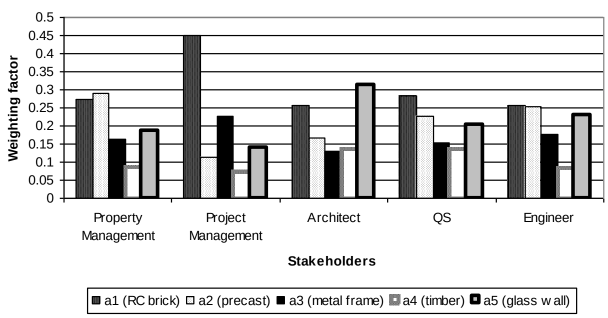


Figure 3 Weighting factor of each option for each decision maker

In the context of Game Theory, [50] presented a proof that the formation of coalitions among subsets of negotiating entities provides a means for achieving Pareto optimality, since every member in a coalition acts in such a way to benefit the entire coalition. A linear programming formula is used to determine the Pareto optimal payoff for each stakeholder in each coalition [25]. The objective function is to minimize deficit that a coalition may suffer during the distribution of resource with two preemptive priorities which are total payoff of coalition and function of goal constraint every scenario.

There are five constraints in the model. The first constraint ensures that the total earning of stakeholders is equal to the available resources. The second constraint ensures that no stakeholder earns less than what it can obtain when acting alone. The third constraint minimizes the deficit of any coalition. Constraint 4 is number of coalition member. Constraint 5 ensures that summation of functional scenario higher than dysfunctional scenario on the mathematical model of negotiation styles and outcomes correlation [51].

There are two kinds of kinds of Pareto Optimum payoff that represent the value criteria for VM namely function and cost [52]. Table 1 presents the determination of payoff optimum for 'Cost' and 'Function' respectively. The payoff optimum in both tables refers to each stakeholder in each coalition. The value of (max-min) payoff for a stakeholder is used to determine the payoff optimum by applying the coordinating scenario. This means that no one stakeholder has higher importance than others.

Stage five is determining the fitness factor of an alternative solution. There are two parameters to determine the best option, which are the negative value and positive value. Wanyama and Far [53] determined these values by comparing stakeholder's payoffs with Pareto optimum. There are two categorize of best options which are best for function and best for cost. Based on the two categorize, a best option for all decision makers can be determined by value equation which is Function/Cost. For both value criteria, the best selectability option is the one with the least negative value. However, if two alternatives have the same negative value, then the one with higher positive value of is better. The rationale is that if the negative value is close to zero, then most stakeholders earn a payoff close to their Pareto optimum. A high negative value means that some stakeholders earn higher than their Pareto optimum

Table 2 shows the alternative ranking for possible coalitions on grand coalition among decision makers. It can be seen that each alternative is chosen as agreement options for all. In this model a5 is the 'best-fit' solution. It is required that systems are evaluated in isolation, with respect to each category of evaluation criteria, Function and Cost, and every sub-criterion for both evaluation criteria. During negotiation in the building system selection process, trade-off is the gateway to reaching an agreement on the building system product to be selected [52]. It is necessary that only the most promising products are available to decision makers for trade-off because it is one of such product that are most likely to be agree on. In this research every alternative was evaluated on function and cost. The first is more of quality than quantity, and the second can be calculated based on the theoretical time value of money.

3.3 Validation of the Model

This research applied decision maker preference validation for the model of agreement option. The validation was conducted using a questionnaire. Descriptive statistics was applied to analyze a set of data from survey questionnaire. The questionnaire asked a group of decision makers on group in order to compare three models of group decision making. They are Model 1 is single weighting factor, Model 2 is aggregations, and the proposed model from this research as Model 3. The questions consisted of two variables, which were 'the satisfaction of decision makers on every group decision method' and 'the perception of decision makers on the performance of every group decision method.'

This analysis used average and standard deviation to show the comparison between three models. There were two criteria to present the difference between decision models, which are (a) satisfaction of respondent as measured by three questions: understand, confident, and helpful, (b) performance of model as measured by three questions: reliability, full information, and collaborative. The answer scale is using agreeable likert scale from 1 to 9. The result can be seen in Table 3. The Table shows that Model 3 fulfilled the highest satisfaction of stakeholder and performance of the model. Based on the two descriptive statistic to compare three models of group decision, the proposed model of agreement option was found to be better than the two others model. It was measured in terms of stockholder's satisfaction and their perceptions on the model's performance.

Table 1 Payoff optimum for grand coalition for each stakeholder based on cost and function criteria

Coalition	Alternatives					Payoff Optimum (Cost)	
Decision maker 1+2+3+4+5	a1	a2	a3	a4	a5	Max-min	Optimum
Property manager	0.031	0.145	0.270	0.246	0.308	0.276	0.123
Project manager	0.282	0.220	0.263	0.205	0.030	0.253	0.282
Architect	0.295	0.285	0.197	0.202	0.021	0.274	0.295
Quantity surveyor	0.203	0.217	0.243	0.218	0.120	0.124	0.243
Project engineer	0.249	0.251	0.220	0.210	0.070	0.180	0.251
	1.060	1.117	1.194	1.080	0.548		1.194
Coalition	**Alternatives**					**Payoff Optimum (Function)**	
Decision maker 1+2+3+4+5	**a1**	**a2**	**a3**	**a4**	**a5**	**Max-min**	**Optimum**
Property manager	0.254	0.220	0.301	0.162	0.063	0.238	0.063
Project manager	0.147	0.196	0.123	0.145	0.389	0.265	0.389
Architect	0.105	0.189	0.139	0.165	0.403	0.299	0.403
Quantity surveyor	0.169	0.201	0.188	0.157	0.285	0.128	0.285
Project engineer	0.137	0.195	0.163	0.161	0.344	0.208	0.344
	0.811	1.001	0.915	0.789	1.485		1.485

Table 2 The best technical solution for grand coalition among all stakeholder

Coalition		Technical Solution Options (Alternative)									
		Alternative a1		Alternative a2		Alternative a3		Alternative a4		Alternative a5	
		function	cost	function	cost	function	cost	function	cost	function	cost
Grand	w-	14.75	5.20	139.02	87.91	172.80	319.91	151.34	208.12	8.08	22.46
	w+	0.00	0.00	0.00	8.08	0.00	0.00	0.00	0.00	8.08	28.29
	Ranking	2nd		3rd		5th		4th		1st	

Table 3 Validation result

	Respondents Satisfaction			Performance of Model		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Property Manager	4	3	7	3	5	6
Project Manager	3	5	6	2	3	7
Architect	4	5	8	3	4	6
Quantity Surveyor	3	6	7	4	5	6
Project Engineer	2	3	7	3	3	7
A	3,2	4,4	7	3	4	6,4
SD	0,8366	1,3416	0,7071	0,7071	1	0,5477

Notes:
A : Average
SD : Standard Deviation

■4.0 CONCLUSION

The model deals with a technique of negotiation during selection of technical solution on a VM process, by identifying the agreement options. Once every decision maker is aware of the negotiations options, they analyze to determine what they get gain or loss if each alternative is selected. This agreement options process provides additional functionality to negotiate a joint representation of the problem. The proposed model can help decision makers to evaluate and rank the solution alternatives before engaging into negotiation with others. It considers function of cost on preference weight of each alternative to each decision as the preference value of each stakeholder. Follow up research is particularly required, primarily in the study of automated negotiation on multi criteria group decision on value analysis process. Future research in the application of this methodology in many field of decision will build a wide range of knowledge to solve the theoretical and practical gap between automated design and automated negotiation.

Acknowledgement

The writers appreciate the recognition and awards in forms of research grant and fellowship from "Program Penelitian Unggulan BOPTN ITS 2014"

References

[1] Scott, M. J. 1999. *Formalizing Negotiation in Engineering Design*. Ph.D. dissertation, California Institute of Technology, Pasadena, California.

[2] Durham, D. R. 2006. The Need for Design Theory Research in Lewis *et al* (Eds.). *Decision Making in Engineering Design*. ASME, Three park Avenue NY.

[3] Keyvanfar A., M. Z. A. Majid, A. Shafaghat, H. Lamit, A. Talaiekhozan, M. W. Hussin, C. T. Lee, R. M. Zin, M. A. Fulazzaky. 2013. Application of a Grounded Group Decision-making (GGDM) Model: A Case of Micro-organism Optimal Inoculation Method in Biological Self-healing Concrete. *Desalination and Water Treatment*. 52(19): 3594–3599.

[4] Lamit H., A. Shafaghat, M. Z. Abd. Majid, A. Keyvanfar, Mohd. Hamdan Bin Ahmad, T. A. Malik. 2013. Grounded Group Decision Making (GGDM) Model. *Advanced Science Letter*. 19(10): 3077–3080.

[5] Utomo, C., A. Idrus, M. Napiah. 2009. Methodology for Multi Criteria Group Decision and Negotiation Support on Value-Based Decision. *International Conference on Advanced Computer Control International Association of Computer Science and Information Technology* (IACSIT) and IEEE Society, Singapore, January. 22–24: 365–369.

[6] Clemen, R. T. 2001. *Making Hard Decisions with Decision Tools*. 2nd ed. Duxbury Press/Thomson Learning, Pacific Grove, California.

[7] Simon, H. 1997. *Administrative Behavior: A Study of Decision Making Processes in Administrative Organization*. 3rd ed. The Free Press, NY.

[8] Wang, J. 2007. *Essay on Multiple Criteria Decision Making and Negotiations*. Ph.D. dissertation, State University of New York.

[9] Yadollahi, M., R. Anzari, M. Z. A. Majid, C. H. Yih. 2014. A Multi-Criteria Analysis for Bridge Sustainability Assessment: A Case Study of Penang Second Bridge, Malaysia. *Sructure and Infrastructure Engineering*. 1–17.

[10] Lamit, H. B., M. Z. A Majid, A. Shafaghat, A. Keyvanfar. 2012. Sidewalk Design Decision Making Model Based on Walking Behavior Pattern Recognition: Proposal Validation. *OIDA International Journal of Sustainable Development*. 4(1): 27–34.

[11] Rad, M. S., H. M. Dahlan, Iahad, N. A., R. Zakaria. 2014. Assesing the Factors that Affect Adoption of Social Research Network Site for Collaboration by Researchers Using Multicriteria Approach. *Journal of Theoretical and Applied Information Technology*. 65(1): 170–182.

[12] Majid, A., H. B. Lamit, A. Keyvanfar, A. Shafaghat. 2012. Conceptual Intelligent Building (IB) Design Framework to Improve the Level of User Comfort Towards Sustainable Energy Efficient Strategies: Proposal Validation. *OIDA International Journal of Sustainable Development*. 4(1): 11–18.

[13] Rashvand, P., M. Z. A Majid, K. Yahya, R. M. Zin, R. Zakaria. 2013. Critical Review on the Customer Satisfaction Metrics for Project Success in Construction. *Advanced Science Letter*. 19(10): 3014–3016.

[14] Adnan, A., R. Zakaria, C. K. Wah, A. L. B. Saleh, K. B. Yahya, M. Mustaffar, M. R. A. Shakri. 2012. Decision Making Framework for Earthquake Resistant Building. *Advanced Science Letter*. 13: 827–830.

[15] Movahednejad, H., S. Ibrahim, M. Sharifi, H. Selamat, A. H. Lashkari, S. G. Tabatabaei. 2014. Novel Security Conscious Evaluation Criteria for Web Service Composition. *Research Journal of Applied Sciences, Engineering and Technology*. Maxwell Scientific Organization. 7(4): 673–695.

[16] Movahednejad, H, S. Ibrahim, M. Sharifi, H. Selamat, H. Selamat, A.H. Lashkari, S. G. Tabatabaei. 2014. QoS-Aware Evaluation Criteria for Composition of Web Services. *Journal of Theoretical and Applied Information Technology*. 59(1): 27–44.

[17] Li, Y. 2007. *An Intelligent Knowledge-based Multiple Criteria Decision Making Advisor for System Design*. Ph.D. dissertation, Georgia Institute of Technology.

[18] Scott, M. J., E. K. Antonsson. 2000. Arrow's theorem and Engineering Design Decision Making. *Research in Engineering Design*. 11(4): 218–228

[19] Thurston, D. L. 2006. Utility Function Fundamentals in Lewis *et al* (Eds.). *Decision Making in Engineering Design.* ASME, Three Park Avenue, NY. 15–19.

[20] Tate, A. 1995. Integrating Constraint Management into an AI Planner. *Journal of Artificial Intelligence in Engineering*. 9(3): 221–228.

[21] Li, X., R. Woodhead, F. Ball. 2004. Incorporating Value Analysis into the Design and Performance Evaluation Process. *Proceeding of Second International Working Conference Performance Modeling and Evaluation of Heterogeneous Networks*. West Yorkshire, U.K. Monday 26th–Wednesday 28th July. T12/1–T12-11.

[22] Geslin, M. M. 2006. *An Argumentation-based Approach to Negotiation in Collaborative Engineering Design*. Ph.D. dissertation. University of Southern California.

[23] Kelly, J., S. Male, D. Graham. 2004. *Value Management of Construction Project*. Blackwell Publishing, Oxford UK.

[24] Du, T.C., H-L. Chen. 2007. Building a Multiple Criteria Negotiation Support System. *IEEE Transactions on Knowledge and Data Engineering*. 19(6): 904–817.

[25] Wanyama, T. 2006. *Decision Support for COTS Selection*. Ph.D. dissertation, University of Calgary.

[26] Ghods, M., H. Najafpour, H. B. Lamit, N. Abdolahi, M. S. F. B. Rosley. 2014. Evaluation of the Effective Factors on Online Internet Usage in Organization. *Life Science Journal*. 11(1): 58–63.

[27] Majid, M. Z. Abd.**,** W. Z. Zakaria, H. Lamit, A. Keyvanfar, A. Shafaghat, E. S. Bakti. 2012. Construction Information Systems for Executive Management in Monitoring Work Progress. *Advanced Science Letter*. 5(1): 169–171.

[28] Chong, H. Y., R. M. Zin, S. C. Chong. 2013. Employing Data Warehousing for Contract Administration: E-dispute Resolution Prototype. *Journal of Construction Engineering and Management*. 139(6): 611–619.

[29] Lindland, O.I., G. Sindre, A. Solvberg. 1994. Understanding Quality in Conceptual Modelling. *IEEE Software*. March: 42–49.

[30] Macedo, M. C., P. V. Dobrow, J. J. O'Rourke. 1978. *Value Management for Construction*. John Wiley & Sons, New York.

[31] Kaufman, J. J. 2001. *Value Management: Creating Competitive Advantage*. Financial World Publishing, Canterbury, Kent, UK.

[32] Bytheway, C. W. 2007. *FAST Creativity and Innovation: Rapidly Improving Processes, Product Development and Solving Complex Problems*. J. Ross Publishing, Florida.

[33] Idrus, A., C. Utomo. 2010. Functionality of Negotiation Agent on Value-based Design Decision. *World Academy of Science, Engineering and Technology*. 4(3): 351–355.

[34] Kitamura, Y., R. Mizoguchi. 1999. An Ontology of Functional Concept of Artefacts. *AI-TR* 1

[35] Utomo, C., A. Idrus. 2008. Life Cycle Cost and Function Analysis in Value Based Design Decision. Life-Cycle Civil Engineering-*Proceedings of the 1st International Symposium on Life-Cycle Civil Engineering, IALCCE '08.*

[36] Idrus, A., C. Utomo. 2010. Cooperative Coalition Formation on Value-based Decision. Proceedings 2010 *International Symposium on Information Technology-System Development and Application and Knowledge Society*, ITSim'10.

[37] Utomo, C., Idrus, A. 2010. Value-based Group Decision on Support Bridge Selection. *World Academy of Science, Engineering and Technology.* 4(7): 153–158.

[38] Sanchez, M., F. Prats, N. Agell, G. Ormazabal. 2005. Multiple-criteria Evaluation for Value Management in Civil Engineering. *Journal of Management in Engineering*. 21(3): 131–137.

[39] Fan, S., Q. Shen, G. Lin. 2007. Comparative Study of Idea Generation Between Traditional VM Workshop and GDSS-Supported Workshop. *Journal of Construction Engineering and Management*. 133(10): 816–825.

[40] Hongxia, J., C. Zhipeng. 2007. Performance Appraisal on Supply Chain Based on Value Engineering and Multistage Fuzzy Comprehensive Evaluation. *International Conference on Wireless Communications, Networking and Mobile Computing***.** IEEE, 21–25 Sept.: 4722–4725.

[41] Green, S. D., S. J. Simister. 1996. Group Decision Support for Value Management on D.A. Langford and A. Retik (Eds.). *The Organization and Management of Construction: Shaping Theory and Practice* (Vol.Two). E&FN Spon, UK. 529–540.

[42] Shen, Q., P. S. Brandon. 1991. Can Expert Systems Improve Value Management Implementation? *International Conference of the Society of American Value Engineer*. 168–176.

[43] Hussain, M. A. D. 2001. *Value Engineering Expert System in Suburban Highway Design (VEESSHD)*. Ph.D. dissertation, University of Pittsburg.

[44] Shen, J. K. H. Chung, L. Heng, L. Shen. 2004. A Group Support System for Improving Value Management Studies in Construction. *Automation in Construction*. 13: 209–224.

[45] Naderpajouh, N., A. Afshar. 2008. A Cased-based Reasoning Approach to Application of Value Engineering Methodology in the Construction Industry. *Construction Management and Economics*. 26(4): 363–372.

[46] Lawson, C. M. 2008. *Group Decision Making in a Prototype Engineering System: The Federal Open Market Committee*. Ph.D. dissertation, Massachusetts institute of Technology.

[47] Utomo, C., A. Idrus, M. Napiah, M. F. Khamidi. 2009. Agreement Options and Coalition Formation on Value-based Decision. *Symposium on Computational Intelligence in Multi criteria Decision-Making*. IEEE Society Nashville, TN, March 30–April 2: 118–125.

[48] Warszawski, A. 1999. *Industrialized and Automated Building System: A Managerial Approach*. 2nd ed. Taylor and Francis.

[49] Saaty, T. L. 2004. Decision Making–The Analytical Hierarchy Process and Network Process (AHP/ANP). *Journal of System Science and System Engineering*. 13(1): 1–34.

[50] Caillou. P., S. Aknine, S. Pinson. 2009. Searching Pareto Optimal Solutions for the Problem of Forming And Restructuring Coalitions in Multi Agent System. *Group Decision and Negotiation*. 18(6).

[51] Utomo, C., A. Idrus. 2008. A Multi Agent System on Collaborative Value-based Design Decision. *12th International Conference on Computing in Civil and Building Engineering*. ISCCBE (International Society for Computing in Civil and Building Engineering) and Tsinghua University. Beijing, China.October 16–18. 283–286.

[52] Utomo, C., A. Idrus, M. Napiah, M.F. Khamidi. 2009. Agreement Options on Multi Criteria Group Decision and Negotiation. *World Academy of Science, Engineering and Technology.* 3(2): 359–363.

[53] T. Wanyama, B. H. Far. 2007. A Protocol for Multi-agent Negotiation in a Group-choice Decision Making. *Journal of Network and Computer Applications.* 30: 1173–1195.