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Group Decisions in Value Management

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Abstract

This research deals with a technique to expedite group decision making during the selection of technical solutions for value management process. Selection of a solution from a set of alternatives is facilitated by evaluating using multi-criteria decision making techniques. During the process, every possible solution is rated on criteria of function and cost. Function deals more with quality than with quantity, and cost can be calculated based on the theoretical time value of money. Decision-making techniques based on satisfying games are applied to determine the relative function and cost of solutions and hence their relative value. The functions were determined by function analysis system technique. Analytical hierarchy process was applied to decision making and life-cycle cost analysis were used to calculate cost. Cooperative decision making was shown to consist of identifying agreement options, analyzing, and forming coalitions. The objective was attained using the satisfying game model as a basis for two main preferences. The model will improve the value of decision regarding design. It further emphasizes the importance of performance evaluation in the design process and value analysis. The result of the implementation, when applied to the selection of a building wall system, demonstrates a process of selecting the most valuable technical solution as the best-fit option for all decision makers. This work is relevant to group decision making and negotiation, as it aims to provide a framework to support negotiation in design activity.

Abstrak

Keputusan Kelompok dan Koalisi pada Manajemen Nilai. Penelitian ini berkaitan dengan penyusunan model untuk mempercepat pengambilan keputusan kelompok selama pemilihan solusi teknis dan membangun sistem alternatif untuk proses manajemen nilai. Pemilihan solusi dari serangkaian alternatif dilakukan menggunakan teknik pengambilan keputusan multikriteria dengan kriteria fungsi dan biaya. Proses hirarki analitis diterapkan untuk pengambilan keputusan, dan analisis fungsi serta analisis biaya siklus hidup digunakan untuk menentukan nilai bagi solusi terbaik. Pengambilan keputusan kelompok disusun secara kooperatif melalui identifikasi pilihan, analisis, dan pembentukan koalisi. Model ini akan meningkatkan nilai keputusan pada proses desain. Hasil pelaksanaan, yang diterapkan pada pemilihan sistem dinding bangunan, menunjukkan proses pemilihan solusi teknis sebagai pilihan terbaik untuk semua pengambil keputusan. Riset ini relevan dengan pengambilan keputusan kelompok dan negosiasi, karena bertujuan menyediakan kerangka kerja untuk mendukung negosiasi dalam kegiatan desain

Keywords: building wall system, satisfying games, value-based decision

1. Introduction

This paper discusses a proposed model of group decision making in value management (VM) for the selection of a building system in a construction project. Choosing a one alternative from a set of alternatives is complicated because there are various participants with different concerns because of differing preferences, experiences, and background. VM is an integrated, full-team approach to identifying the needs of the project, and of proposing and developing alternative ways of meeting those needs. VM is a method that facilitates group decision making when many stakeholders anticipate different outcomes [1] by enhancing communication and common understanding between team members. In the construction industry, where a tool for team decision making is necessary, group decisions and negotiation will be appropriate.

Kelly et al. [2] stated that VM is a multidisciplinary, team-oriented approach to problem solving. This concept, supported by Ashworth and Hogg [3] and Kirk et al [4], describes the value-based approach as a new methodology that involves a multidisciplinary team representing the owner, the user, the facility manager, and the builder. Real-time decisions are reached using value-based methods in a team setting; these methods are function analysis, group of creativity and innovation, and life cycle costing [5]. Thomas and Thomas [6] explained that group decision making and teamwork exist at all stages of the VM process.

Previous studies of group decisions in VM have been reported. Among them is the simple multi-attribute rating technique (SMART) [7]. Group decision support (GDS) [8], and an extension of the research of [8] was presented [9], who applied a computer model to it. Even though GDS does not adopt any artificial intelligence algorithms, it is very useful for completing all phases of the VM process. A similar model of GDS, the interactive value management system (IVMS) [10] and case-based reasoning on VM [11] were reported.

Many researchers have suggested applying game theory to automated group decision and negotiation (GDN) but none of them discusses GDN support for VM. This research investigates the creation of a framework for the diagramming of a multi-criteria group decision process based on satisfying games. The framework was applied in the selection of technical solutions of wall-construction systems. The group decision involved three decision makers which are the architect, the property manager and the project manager

2. Methods

A review of decision making [7] demonstrated that none of the rational rules of decision theory succeeded in explaining how people actually make decisions in practice. Green and Simister [12] gave three different decision models that depend on rationality for distinguishing value for money. Value for money is seen to depend not upon substantive rationality, but on procedural rationality. Stirling [13] recognizes the limitations of bounded rationality and therefore seeks to satisfy rather than to optimize.

There are many methods to apply in the selection of building systems. One is explained in the important research of Warszawski [14], who found six main criteria: architectural design, physical performance, technology, management, economics, and marketing. Other researchers have also reported criteria for selecting building systems for such things as concrete floors [15], roofs [16], industrialized housing [17, 18], and building automation [19].

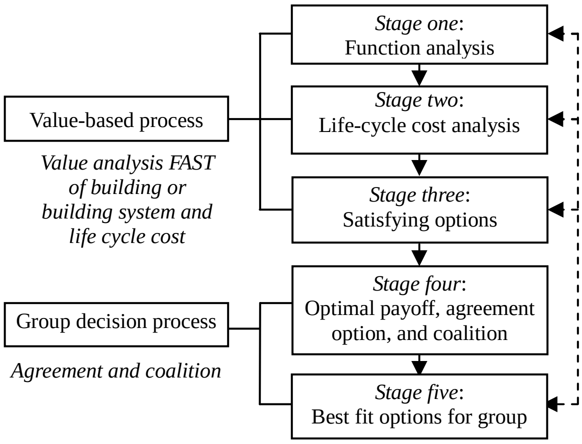

Figure 1. Methodology for Group Decisions in VM

The general goal for coalition formation is to maximize utility, but the actual reasons for forming coalitions are normally different [20, 21]. The methodology consisted of value-based and multi-criteria decision-making processes [22]. Determining the value and cost of each function is the basis for the methodology. In the value-based process, function and life cycle cost (LCC) are analyzed [23]. Also applied was the analytical hierarchy process (AHP), which can be used successfully with group decisions [24] and negotiation [25]. The AHP has been widely applied at the strategic level [26] and the operational level [27]. The AHP is also applied in different areas of construction management [28]. Even though the AHP has been proven in many applications, it is weak in assessing the relative importance of some criteria [29]. Figure 1 presents these processes.

In group decision making, a satisfying option is applied by correlating the function and cost to get the value of a technical solution. The optimal payoff and best fit options are based on the value of agreement options and coalition formation [30]. Although the technique is based on the game theory model of the cooperative n-person, it does not require the decision makers to share preferences for the evaluation criteria. Once every stakeholder is aware of the negotiation options, they can analyze them to determine what they gain or lose if any given alternative is selected.

3. Result and Discussion

The first stage of the process is function analysis. Understanding of functionality is important because it represents a part of the design rationale [31]. In conceptual design, a designer decomposes a required function into sub functions in what is called 'functional decomposition' [32]. Function and value are related by the solutions that yield such value and the functions such solutions perform [33]. Value increases when functions are optimally aligned with processes, outcomes, and purposes [34]. There are several methods of functional analysis; one of the most important and useful is the function analysis system technique (FAST). FAST is an evolution of the Value Analysis (VA) process [5] that permits people with different technical backgrounds to effectively communicate and resolve issues that require multidisciplinary considerations by building complex systems that link simple verb-noun predications. The other two methods are natural or intuitive search and interactions with the external environment [35]. Figure 2 shows the FAST diagram, which identifies eight functions of the wall system that were to become the attributes of the system.

The second stage was the LCC analysis, the total discounted cost of owning, operating, maintaining, and disposing of a building or a building system over time [36]. The 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 [37]. The LCC can be used to evaluate the cost of a full range of projects, from a specific building system component to an entire site complex [36, 37]. The cost drivers of the wall system which are initial cost and operation and maintenance (O&M) are identified in Table 1, which presents the cost of the wall system for each technical solution.

Table 1. Cost of Wall System

Cost category	Present Worth (1000USD)				
	a1	a2	a3	a4	a5
(c1) Initial	250	1600	800	1600	1200
(c2) O/M	800	200	400	2000	800

Key: a1, reinforced brick; a2, precast concrete; a3, metal frame; a4, paneled timber; a5, glass.

The third stage is to select a satisfying wall system. Stirling [13] defines satisfying as being good enough. The satisfying option requires a comparison of positive and negative attributes of each option. In order to obtain a good representation of the problem, the problem of selection has to be structured into different 'activities'. Figure 3 shows that the goal of the problem (G = "To select a wall system") is addressed by splitting it into sub problems, stating the alternatives (A = a1, a2, a3, a4, a5), the value criteria which are function and cost, and the evaluation criteria which are f1, f2, f3, f4, f5, f6, f7, f8, c1, c2. In this study, initial cost and O&M are identified as 'cost', and the other eight criteria are identified as 'function'.

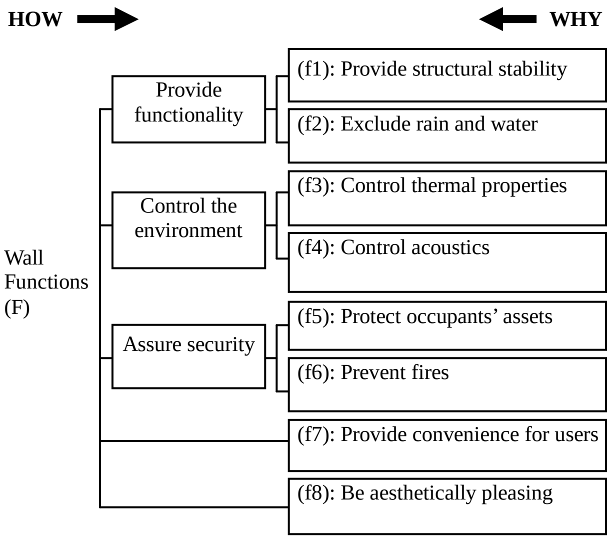

Figure 2. The FAST Diagram of the Wall System

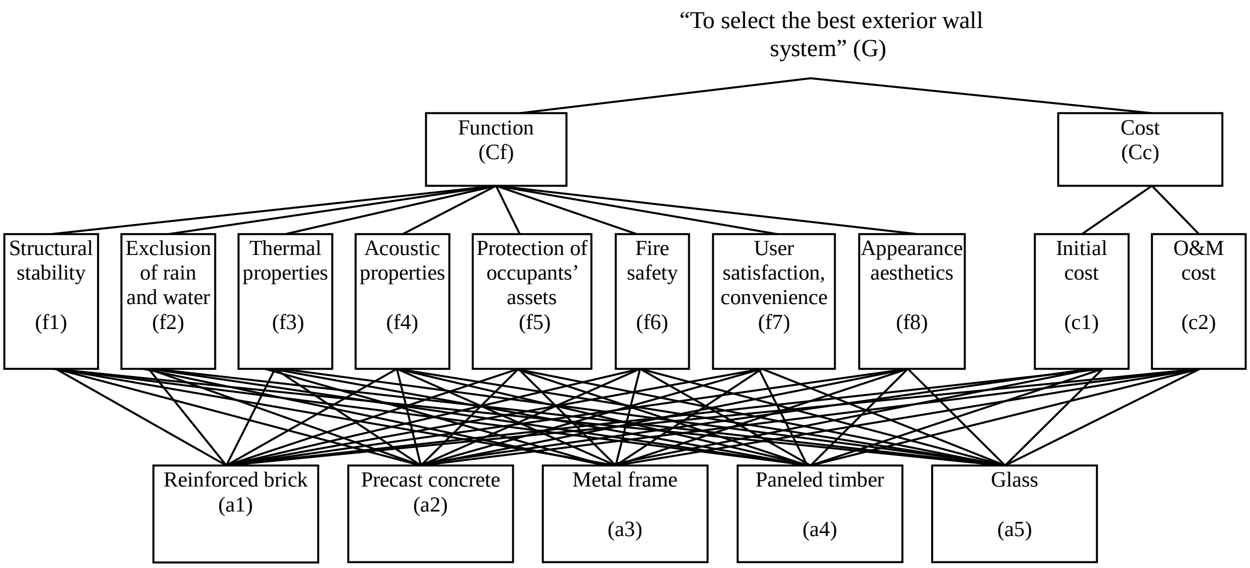

Figure 3. Decision Hierarchies for Wall System Selection

Table 2. Cost and Function of Wall System Options

	Cost		Function								Normalization	
	c1	c2	f1	f2	f3	f4	f5	f6	f7	f8	Cost	Function
a1	0.554	0.158	0.058	0.103	0.411	0.437	0.234	0.412	0.255	0.202	0.037	0.264
a2	0.051	0.486	0.069	0.132	0.311	0.288	0.463	0.310	0.059	0.140	0.128	0.222
a3	0.261	0.227	0.132	0.249	0.133	0.139	0.163	0.164	0.079	0.074	0.154	0.142
a4	0.037	0.034	0.253	0.037	0.105	0.056	0.091	0.030	0.402	0.037	0.372	0.126
a5	0.096	0.096	0.487	0.480	0.040	0.080	0.048	0.085	0.205	0.547	0.309	0.247

A technical solution to be determined by comparing the function and cost, both must be represented on the same scale. This may be done by creating selectability (Ps) and rejectability (Pr) functions [38] and normalizing the problem so that the decision maker has a unit of function and a unit of cost to apportion among the options. Table 2 shows the utility of cost and function for each wall system and the selectability and rejectability, which respectively represent the function and cost of the technical solution of the wall system.

Figure 4, based on the data in Table 2, provides a cross plot of the technical solution options with *Pr* (rejectability) the abscissa and *Ps* (selectability) the ordinate. The technical solution will be “select” if (Ps/Pr) > 1 or “reject” if (Ps/Pr) < 1. Observe that a4 has the highest cost and low function, and a rational decision maker can legitimately conclude that this is unsatisfactory, since the function does not outweighs the costs. Options a3 and a5 are easily eliminated by the cost-function test. Option a1 gives the highest satisfaction, since it has a high function/cost ratio as defined by Bhushan and Rai [26] and Stirling [13].

The fourth stage is optimal payoff, agreement options, and coalition. Walls are important parts of buildings, so the selection of walls is an important part of designing the building. It is critical that the selected system sufficiently satisfy all the criteria, and the criteria used to select a wall system depend on the perspective of the individual decision makers. For example, an architect might be more interested in the influence of the wall system on the appearance of the building and on the user’s satisfaction, whereas a project manager might be more interested in constraints such as budget on initial cost. This makes it difficult for decision makers to agree on the evaluation criteria. The last stage is to determine the fitness of the best alternative solution. As stated by Aumann and Maschler [40], Thompson [41], and Barron [42], the best option for all stakeholders can be determined by looking at the function/cost ratio. For both value criteria, the best selectability option is the one with the lowest negative value.

It is common that any group decision comes from incomplete information. In this paper the determination of the optimal solution for each stakeholder is based on a cooperative multi-person game with complete information. It is a form of a game in which formation of coalitions among members of subgroups is allowed (20, 39, and 40). A linear programming formula is used to determine the optimal payoff for each stakeholder in a coalition [41, 43]. There are two kinds of Pareto optimal payoff that represent the value criteria for VM,

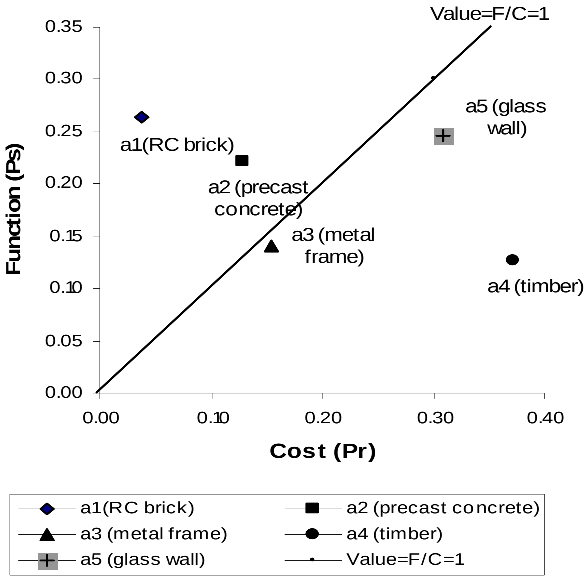

Figure 4. Basic Values of Wall System Options

Table 3. Payoff Optimum for Each Coalition

Coalition	Payoff Optimum			
	Cost		Function	
SH 1+2+3	Max-min	Optimum	Max-min	Optimum
SH1	0.276	0.123	0.238	0.063
SH2	0.253	0.282	0.265	0.389
SH3	0.274	0.295	0.299	0.403
Total		0.7		0.855

Key: SH1, architect; SH2, property manager; SH3, project manager.

Table 4. Best Technical Solution for the Wall System for All Coalitions

Coalition among Stakeholder (SH)		Technical Solution Options (Alternatives)									
		a1		a2		a3		a4		a5	
		f	c	f	c	f	c	f	c	f	c
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	1st	3rd	3rd	5th	5th	4th	4th	1st	2nd
SH1+2	w-	117.03	0.00	133.24	107.67	177.55	5.10	144.01	217.92	0.00	27.50
	w+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ranking		2nd	1st	3rd	4th	5th	2nd	4th	5th	1st	3rd
SH1+3	w-	9.19	32.53	125.27	61.58	164.00	32.65	140.58	214.23	0.71	8.49
	w+	9.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.49
Ranking		2nd	2nd	3rd	4th	5th	3rd	4th	5th	1st	1st
SH2+3	w-	15.56	14.85	157.63	89.80	177.50	16.12	162.84	216.06	9.90	26.16
	w+	0.00	0.00	0.00	0.71	0.00	0.00	0.00	0.00	9.90	26.16
Ranking		2nd	1st	3rd	4th	5th	2nd	4th	5th	1st	3rd
SH1		0.264	0.261	0.186	0.177	0.114	0.257	0.146	0.057	0.277	0.243
Ranking		2nd	5th	3rd	2nd	5th	4th	4th	1st	1st	3rd
SH2		0.275	0.280	0.147	0.280	0.120	0.274	0.146	0.049	0.312	0.243
Ranking		2nd	5th	3rd	4th	5th	3rd	4th	1st	1st	2nd
SH3		0.306	0.220	0.141	0.242	0.128	0.219	0.133	0.041	0.292	0.278
Ranking		1st	3rd	4th	4th	5th	2nd	3rd	1st	2nd	4th
Result		2nd		-		-		3rd		1st	

namely function and cost. The process of determining optimal payoff and the result are presented in Table 3. The values of maximum and minimum payoff for a stakeholder are used to determine the optimal payoff by applying the coordinating scenario. This means that no one stakeholder has higher importance than any other. This scenario can be changed to match the situation of any given project. If two alternatives have the same negative value, then the one with the higher positive value 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.

In the context of negotiation during the selection of a technical solution for building systems, the negative value of the grand coalition represents the amount of risk [44] associated with the corresponding alternative wall system. Table 4 presents the process and calculation for the best fit solution of each coalition. The payoff optimums for cost and function become the data for the best fit options algorithm. In this study, solutions a2 and a3 are not optimal choices for wall systems. In the first negotiation round, a5 was the best fit solution for the group. This means that glass is the best technical solution for the wall system.

4. Conclusions

The result demonstrates a process for selecting the best technical solution for wall system. It weighs the cost of each alternative as part of the preference value to each stakeholder. Some of the solutions will not be options if no individual stakeholder or coalition of stakeholders desires to select them. Each decision maker needs to identify the goals that can be optimized and those that can be compromised so an agreement can be reached with other stakeholders. The research was deliberately limited to addressing the component of value for money, so many issues relating to the difficulties of cost modeling have not been addressed. The research strategy adopted is also open to criticism because it focused only on one case study. Further research is required, primarily into automated negotiation on multi-criteria group decisions in the value analysis process, to integrate the process of eliciting support with the selection of the technical solution.

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