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Short Communication

Comparing non-structural fuzzy decision support system and analytical hierarchy process in decision-making for construction problems

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Abstract

Analytical Hierarchy Process (AHP) is a commonly used decision-aiding tool for resolving multi-criteria decision problems. However, users sometimes find it difficult to ensure a consistent pairwise comparison between voluminous decisions. The cause of which is that the Consistency Ratio (CR) is produced after the evaluation process and its global acceptance criteria is limited. When the derived ratio reports some inconsistency, it requires a long process to locate and rectify the problem. The major aim of this study is to look for an alternative decision-aiding tool to AHP, helping to avoid the above problem. The alternative approach proposed in this study is the Non-Structural Fuzzy Decision Support System (NSFDSS). The application of the system is illustrated with a worked example. The results generated by NSFDSS are compared against those generated by the conventional AHP that shows the effectiveness and some unique advantages of the proposed tool over AHP.

Keywords: Decision support systems; Multi-criteria construction problems; Non-structural fuzzy decision support system

1. Background of the research

The construction industry is characterized by continual changes, varying technologies, undesired working conditions, the involvement of numerous trades and operations which require enormous efforts to manage for acceptable outcomes. Owing to these, it is well-acknowledged that construction problems are often ill-structured and multi-criteria in nature, involving many uncertainties (variables) and variations (Li and

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Table 1
Summary of criticisms on AHP

Author (Year)	Asserted Shortfalls of AHP
Belton and Gear (1983) and Dyer (1990)	AHP suffered from the phenomenon of rank reversal
Belton and Gear (1985)	AHP lacked of a firm theoretical basis
Zahir (1991)	Uncertainties in the relative weights of any pairwise comparisons in AHP would affect the resulting priorities of the decision elements
Murphy (1993)	AHP suffered from limitations resulted from its application of consistency index
Paulson and Zahir (1995)	Judgmental uncertainty during pairwise comparisons in AHP could lead to rank reversals and weaken the decision maker's confidence on the results
Zeshui and Cuiping (1999)	AHP was time-consuming and impracticable to deal with the unacceptable consistency ratio

Love, 1998). As a result, multi-criteria decision-making techniques should be employed in solving these problems. The common approach is the Analytical Hierarchy Process (AHP) (Paulson and Zahir, 1995; Lipovetsky and Tishler, 1999; Zeshui and Cuiping, 1999). However, a number of criticisms have been raised on AHP over the last several years which are summarized in Table 1. This reveals that the method does bear some shortcomings in the problem solving domain. Although different variants or adaptations of AHP are emerged in recent decades, for simplification, this paper tends to focus on its original version which was developed by Saaty (1980, 1985, 1988, 1990, 1991).

In recent years, construction periods have become shorter and shorter due to high land prices and changing economic conditions. As a result, substantial liquidated damages have been imposed by developers on construction contracts to avoid project overruns. Designers and engineers in building and construction are often required to make speedy decisions to derive an optimal choice from an array of construction solutions to cope with the changing construction environment and customers' needs. Hence, research and development of multi-criteria decision-making tools are becoming more important for the industry. In this connection, this paper attempts to analyze and highlight some weaknesses of AHP in practical applications for construction. Besides, to exploit more decision-making tools for the current practitioners, an alternative approach—the Non-Structural Fuzzy Decision Support System (NSFDSS) invented by Chen (1998)—is compared, aiming at overcoming the weaknesses of AHP. Noteworthy, NSFDSS has been successfully applied on site layout planning (Tam et al., 2002a). Furthermore, Tam et al. (2002b) have modified the system to NSFDSS-II for application in construction safety management.

2. Case study

A construction design problem is used for illustration. There is a proposed high-rise commercial building project located in Hong Kong, 40-storey high with 3 m floor-to-floor height, a site area of 1600 m^2, with a medium degree of complexity of construction. The available options of construction design are steel structure (D1), reinforced concrete structure using traditional timber formwork (D2), reinforced concrete structure using proprietary formwork (D3), precast façade systems (D4) and concrete core braced systems (D5). The decision criteria include time (C1), cost (C2), project complexity (C3), safety (C4), resources (C5), quality (C6), structural and market considerations (C7&C8).

Using AHP to evaluate the construction design problem, the processes and results are shown in Fig. 1. The normalized values of priority in original order of decisions are shown as follows:

D1	D2	D3	D4	D5	
0.1851	0.1893	0.2519	0.1740	0.1997	(Solution A)