Using sequential analysis procedures to rank the influencing factors of public work’s quality

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Abstract: In order to improve the efficiency in management of public work projects, screening and controlling influencing factors affecting the quality of a public work project is essential. This study synthesized 9 influential categories including 91 factors related to quality management of public works in Taiwan using a sequential analysis procedure. According to the Borda-values of influencing factors obtained from a first stage questionnaire, the number of primary factors selected by the responsible entities and the design-supervisory entities were 44 and 45 respectively. A Fuzzy Analytic Hierarchy Process (FAHP) was used to prioritize and rank these factors. The top five factors ranked by the responsible entities were (1) introduction of the earned value analysis, (2) working efficiency, (3) environmental laws and regulations, (4) price-index fluctuation, and (5) on-site safety management. The top five factors ranked by the design-supervisory entities were (1) man power, (2) laws and regulations, (3) price-index fluctuation, (4) traffic conditions, and (5) faulty design.

Key words: FAHP, Public works, Quality management, Influencing factors

INTRODUCTION

Based on the definition of quality in ISO-9000-1, the quality of public works is derived from the planning, design, tender, and construction phases. In recent years, the strategies that have been implemented to enhance the quality of public works in Taiwan since 1990 are: (1) the “Regular Supervision Meeting of the Public Building Committee” founded in 1991, (2) the “Quality Management System of Public Works” policy issued for enforcement in 1993, (3) the “Public Construction Commission” founded in 1995, (4) the “Procurement Act” passed in 1996, (5) the “Main Points for Quality Management Process of Public Works Act” passed in 1997, and (6) the “Review of Public Works Act” enacted in 2002 (Kuo, 2001).

There are many factors affecting the quality of public work projects, and these primary factors must be screened to ensure quality management of public work projects. By strengthening control of these factors, quality management can be assured. Therefore, this study used a sequential analysis procedure for tentatively ranking these quality management factors. The public transportation works (road, railway, airport and harbor) in Taiwan were the targeted work projects.

SEQUENTIAL ANALYSIS PROCEDURES

Synthesizing the influencing factors of the work’s quality

Data were collected in order to gain understanding of the factors influencing quality management of public works. The data sources included the Control Yuan, the Public Construction Commission, and the Ministry of Transportation and Communication (Executive Yuan, Taiwan, 2002; Public Construction Commission, 2003; Review Meeting of Public Works, Ministry of Transportation and Communication, 2003). This study compiled 91 fac-
tors related to the quality management of public works. In order to systematically observe the weights of various factors, the systematical structure of the Analytic Hierarchy Process (AHP) was adopted (Saaty, 1986; Deng and Zeng, 1989). The 91 factors were placed into nine categories making each force in the same hierarchy independent from each other if possible. The nine categories included were policy (10 factors), technology (11 factors), economy (9 factors), environment (8 factors), management (9 factors), administration (8 factors), construction (16 factors), planning (11 factors), and supervision (11 factors).

Conducting first stage of the questionnaire survey

The first stage of the questionnaire survey was conducted to screen the primary factors from the nine categories. In each factors category, the participants chose the linguistic variables for each factor on a seven point scale (i.e. \( P_i = 6, 5, 4, 3, 2, 1, 0 \)) (Zadeh, 1975).

One hundred and fifty responsible entity officers and 150 design-supervisory entity staffs were surveyed. The responsible entities included the Taiwan Highway Bureau, the Taiwan Area National Expressway Bureau, the Taiwan Harbor Bureau, and the Taiwan Railway Reconstruction Bureau. The design-supervisory entities included consultants and project control management companies. Those who were surveyed included senior engineers with five years or more of experience whose work sites were distributed throughout Taiwan. A total of 300 questionnaires were issued in April of 2003, and 210 questionnaires were returned at a return rate of 70% return rate. One hundred and eight officers and 102 staffs returned useable surveys.

Screening primary influencing factors

Eq.(1) was used to calculate the Borda-value \( f_{ai}(x) \) of the influencing factor \( x \):

\[
f_{ai}(x) = \sum_{i=1}^{6} \left( x : n_i \cdot P_i \right),
\]

where \( n_i \) is the number of questionnaires preferring \( P_i \) for influencing factor \( x \).

In principle, the number of factors in each category were reduced to five primary factors according to the values of \( f_{ai}(x) \). If, the \( f_{ai}(x) \) value of factor was not more than 50% of the preceding one, it was not chosen (Bellman and Zadeh, 1970). The number of primary factors selected by the responsible entities was 44 while the number selected by the design-supervisory entities was 45.

Conducting second stage of the questionnaire survey

The second stage of the questionnaire was re-edited to include only the primary factors in the nine categories. In this questionnaire, the language variables among the primary factors were divided into nine grading scales. The value of the grading scale was one to nine. The same participants as those in the first stage questionnaire were surveyed. There were 210 questionnaires issued in June of 2003, and 191 questionnaires were returned at a return rate of 90%. Ninety-seven questionnaires were returned from the responsible entities, and 94 were returned from the design-supervisory entities.

Performing consistency’s test

Pair-wise comparisons were first conducted for the primary influencing factors in the same category. Then, the pair-wise comparisons were extended to all the primary factors in the nine categories. Eq.(2) is the pair-wise comparison matrix \( A \).

\[
A = \begin{bmatrix}
w_{1i} / w_{1j} & w_{1i} / w_{2j} & \cdots & w_{1i} / w_{nj} \\
w_{2i} / w_{1j} & w_{2i} / w_{2j} & \cdots & w_{2i} / w_{nj} \\
\vdots & \vdots & \ddots & \vdots \\
w_{ni} / w_{1j} & w_{ni} / w_{2j} & \cdots & w_{ni} / w_{nj}
\end{bmatrix},
\]

where \( i, j = 1, 2, \ldots, n \) is the number of primary influencing factors in a hierarchy. \( a_{ij} = w_i / w_j \) is the value of grading scale for primary influencing factor \( F_i \) to \( F_j \). \( a_{ij} = 1, a_{ij} = 1 / a_{ji}, a_{ij} > 0 \).

The value of \( C.I. \) can be calculated from Eq.(3), where \( \lambda_{max} \) is a maximum eigenvalue. \( C.I. > 0 \) represents matrix \( A \) as inconsistent, but if \( C.I. < 0.1 \) the consistency of matrix \( A \) is acceptable (Saaty, 1980; Chang and Cheng, 1989).

\[
C.I. = (\lambda_{max} - n) / (n - 1).
\]

The key of this sequential analysis procedure is