INDEXING METHOD OF COST SCORE AND FUNCTION SCORE THAT CAN BE USED IN BUILDING DESIGN VE

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Abstract - Value Engineering is used as a way to improve the value of buildings.In the design VE, the optimal design is selected by comparing the cost index and function index of the alternatives.However, the calculation range of the function index and the calculation range of the cost index vary depending on the indexing method.As a result, the client is confused by the decision-making process of selecting the optimal design.This study proposed a method to index cost and function scores using vector normalization method.

Keywords - Building Design VE, Cost Score, Function Score, Indexing.

I. INTRODUCTION

Design VE is a way to reduce the cost of a building project and improve the performance of a building by creating an alternative design [1].

However, the following points were pointed out in design VE. (1) Even if excellent alternatives are created, objective evaluation of function and cost, which are factors for evaluating alternatives, is not made [2]. (2) There are various methods for evaluating the function and the evaluation result is different according to the evaluation method even when the evaluation subject is the same [3].

To solve these problems, a method of indexing function scores and cost scores is used. The client compares the alternatives using the function and cost indices. However, the calculation range of the function index and the calculation range of the cost index vary depending on the indexing method. Because of this, the client has difficulty in making the decision to select the optimal design and decide whether to apply it.

The purpose of this study is to select the method of indexing the functional scores and the cost scores calculated in the design VE among decision-making techniques.

II. INDEXING METHOD OF COST SCORES AND FUNCTION SCORES

In design VE, it is an important decision-making activity to select the optimal design by comparing the cost index and the function index of the alternatives.

Types of decision-making are multi-objective decision-making and multi-attribute decision-making [4].

Table 1 summarizes the characteristics of multi-objective decision-making and multi-attribute decision-making.

Classification	Multi-Objective Decision-Making	Multi-Attribute Decision-Making
Criteria	Purpose	Element
Alternative	Infinite	Finite
Purpose	Explicit	Implicit
Element	Implicit	Explicit
Constraint condition	Active	Inactive
Use	Design	Select/Assessm-ent

Table1: Types and characteristics of decision-making

Decision-making in a building project includes both characteristics of multi-objective decision-making and multi-attribute decision-making.
However, design VE corresponds to multi-attribute decision-making and the reason is as follows
(1) Design VE compares finite alternative designs.
(2) Design VE has a common purpose of improving the value of buildings.
(3) Design VE excludes other alternatives designs in order to select the optimal design.

In multi-attribute decision-making, items with different evaluation criteria must be converted to the same criteria according to attributes [5]–[7]. The methods of indexing function scores and cost scores calculated through design VE are as follows.
(1) Linear transformation method for dividing the maximum value among evaluation values by the remaining evaluation values,
(2) Normalization method using average value of evaluation values,
(3) Normalization method using median value of evaluation values,
(4) Vector normalization method of dividing

evaluation value into norm of evaluation values.
The first linear transformation method is an appropriate method when the higher the evaluation value, the better the item and the lower the evaluation value, the better the item coexist. Therefore, the linear transformation method can be converted to the same preference by rearranging the evaluation values with different preferences. However, since the linear transformation method converts the lowest score to '0', it is not suitable for indexing the function score and cost score of the design VE.

Second, the normalization method using the average value of the evaluation values assumes that the average value of the evaluation values is '0'.

Third, the normalization method using the median value of the evaluation values assumes that the median value of the evaluation values is '0'. The normalization method using the average value and the normalization method using the median value set the average value or the median value as '0' and place the other evaluation values on the left and right. Therefore, the normalization method using the average value and the normalization method using the median value become a negative value when the normalization value becomes smaller than a standard value of '0'. Thus, it is not appropriate to index function and cost scores.

Fourth, in the vector normalization method, the norm of the vector is set to '1' and the ratio of each vector is calculated. The vector normalization method is suitable for indexing function and cost scores because the evaluation values can be converted to a certain range (0 <x <1).

III. VECTOR NORMALIZATION METHOD

The vector is a directed line segment from the starting point x to the ending point y of the two-dimensional space.

Therefore, the vector is an ordered pair of two points on the coordinate. Here, the vector has a size and a direction. Equivalent is a vector of the same size and direction. There are a number of position vectors on the coordinate that are the same but differ only in the point of view. However, if the viewpoint of all vectors is moved to the origin '0', the vectors can be represented by a single position vector by the end point. The n real number sequence column that determines the position of the end point is called the coordinate of the vector.
The norm, the size of the vector, is $\sqrt{a^2 + b^2 + c^2 +, \cdots, +n^2}$ [8]. The vector normalization is a calculation of the ratio of each vector by referring to the defined norm as '1'. Vector normalization is obtained by dividing each column vector by the norm [4].
Thus, function and cost scores can be normalized using the method below.

IV. INDEXING MODEL DESIGN

A. Indexing model of cost scores

By defining the cost score norm of alternative designs as $\| \text{Cost} \|$,

$$\| \text{Cost} \| = \sqrt{\sum_{i=1}^{n} \text{Cost}_i^2}.$$

Therefore, the cost index (Hereinafter, CI) can be calculated by dividing the cost of the alternative design i to be indexed by ‖Cost‖.
Thus, the indexing model of cost scores is defined by the following equation (1).

$$\text{CI}_i = \frac{\text{Cost}_i}{\|\text{Cost}\|} = \frac{\text{Cost}_i}{\sqrt{\sum_{i=1}^{n} \text{Cost}_i^2}} \qquad (1)$$

Here, CI_i is the cost index of alternative i, C_i is the cost score of alternative i, C is the cost score and i is the alternatives (i = {1, ..., n}).

The cost index is calculated by dividing the cost score of alternative i by ‖Cost‖. Therefore, the cost index is calculated as 0 <CI <1.

B. Indexing model of function scores

By defining the function score norm of alternative designs as ‖Function‖,

$$\|\text{Function}\| = \sqrt{\sum_{i=1}^{n} \text{Function}_i^2}.$$

Therefore, the function index (Hereinafter, FI) can be calculated by dividing the function scores of the alternative design i to be indexed by ‖Function‖.
Thus, the indexing model of function scores is defined by the following equation (2).

$$\text{FI}_i = \frac{\text{Function}_i}{\|\text{Function}\|} = \frac{\text{Function}_i}{\sqrt{\sum_{i=1}^{n} \text{Function}_i^2}} \qquad (2)$$

Here, FI_i is the function index of alternative i, F_i is the function score of alternative i, F is the function score and i is the alternatives (i = {1, ..., n}). The function index is calculated by dividing the function score of alternative i by ‖Function‖.
Therefore, the calculation range of the function index is 0 <FI <1.

V. CONCLUSION

This study was carried out to select a method to index cost and function scores calculated through design VE

of the building.

The main results of the study are as follows.The methods that can be used to index function and cost scores calculated through design VE are as follows.
(1) Linear transformation method,
(2) Normalization method using average value of evaluation values,
(3) Normalization method using median value of evaluation values,
(4) Vector normalization method of dividing evaluation value into norms of evaluation values

Among the four indexing methods, vector normalization is the most appropriate method for indexing cost and function scores. The vector normalization method can be indexed by converting the cost and function scores into a certain range (0 <x <1).

The vector normalization method indexes the cost and function scores to the same range. Therefore, it is possible to shorten the time required for the decision-making to select the optimal design among the designs. In addition, a consistent assessment of alternatives with varying cost and functional characteristics will be possible.

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