

# Tender Evaluation Method about Bidding of Construction Based on Set Pair Analysis

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**Abstract:** A comprehensive optimum seeking model using identical degree of set pair analysis and analytic hierarchy process has been built; it is efficacious for tender evaluation of bidding of construction. The rationalization of the model and method is verified with an example.

## Introduction

Bidding of construction is an important part of engineering construction; tender evaluation is an important work of bidding of construction. The tender evaluation result is primary reason which investor decided winning bidder, and affects the quality of bidding of construction.

Due to factors that affect building construction tender evaluation is multifaceted, various factors are mutual restraint and mutual influence, so tender evaluation is essentially a multi-objective and multi-criteria decision problems. It is worth exploring that how to deal with the relation of many contents in tenders and determine accurately to the overall level of tenders and realize to fair and equitable. A comprehensive optimum seeking model about bidding of construction using identical degree of set pair analysis and analytic hierarchy process has been discussed.

## Identical Degree Concept of Set Pair Analysis

Set pair analysis is a method for analysis of a system for dealing with uncertainty problems; it was founded by Chinese scholar Zhao Keqin at 1989. Set pair comprises two sets that relationship is closely related. The idea of set pair analysis is that two sets were put on one pair, and then do sameness and difference counter-analysis, and then establish contact degree expressions. Identical degree of set pair analysis is ratio of the number ( $S$ ) of common features in the two sets and the total

features number ( $N$ ) of two sets  $N$ , set  $a = \frac{S}{N}$ . If the two sets are nonnegative rational number, their identical degree is ratio of the smaller rational number and larger rational number, such as identical degree of 3 and 4 is  $\frac{3}{4}$ , identical degree of 9 and 6 is  $\frac{6}{9} = \frac{2}{3}$ .

## Set Pair Analysis Model for Bidding of Construction

**Integrated Evaluation Index System for Bidding of Construction.** The factors affecting evaluation of construction bidding includes project quoted price, construction guarantee measures, corporate reputation etc. The relationship of influencing factors in figure 1.

Some item such as project quoted price, construction scheme, construction cycle, preparation of construction and business performance are included in the bidding document.

Set up indicators set  $X$

$$X = (X_1 X_2 \cdots X_k \cdots X_K), \quad k = 1, 2, \cdots, K$$

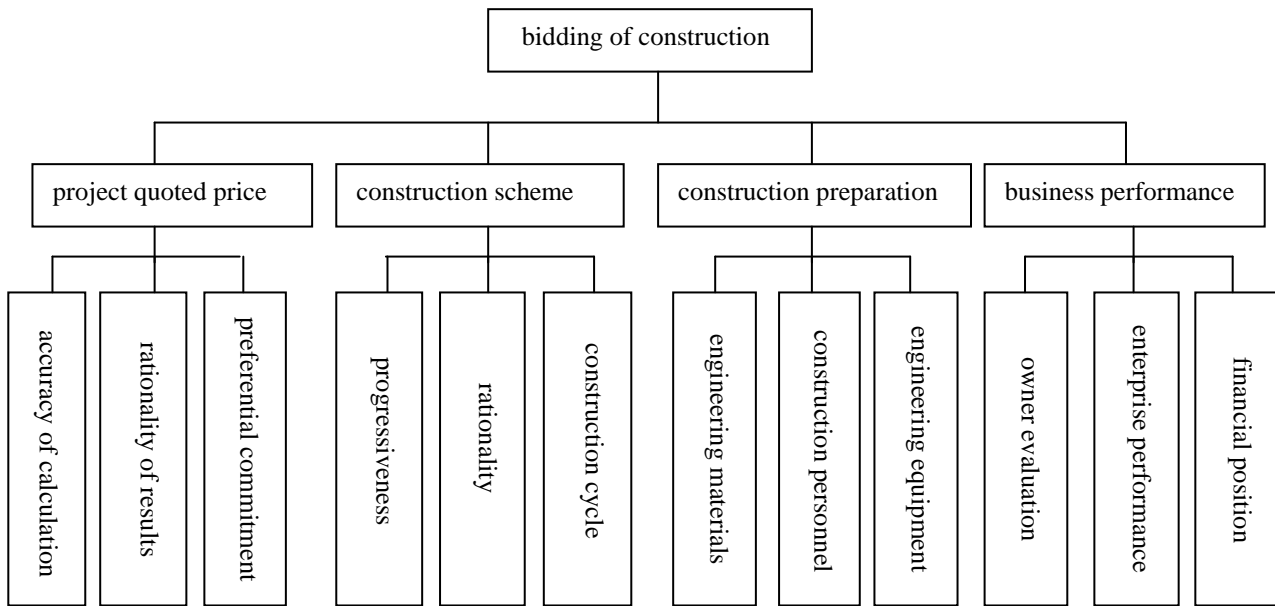


Figure 1 The relationship of influencing factors

**Determine the Weights of Each Factor Using Analytic Hierarchy Process.** In bidding document of bidding of construction, the influence degree of each index for evaluation is different and some indicators are not easy to measure quantitatively, these indicators only were compared and judged according to expert experience, because there are more factors to compare, it is difficulty to judge accurately, This problem can be solve with analytic hierarchy process. Human thinking process was thought to be layering and quantification in analytic hierarchy process, whole factors were not compared together on every one layer but the importance of factor was ascertained through multiple comparisons, analytic hierarchy process is a method for the analysis of qualitative and quantitative. Scientific and accurate of judgment could be elevated through to ascertain the weight of influence factors according to analytic hierarchy process. Set the weight sets of each indicator as:

$$\omega = (\omega_1 \quad \omega_2 \cdots \omega_k \cdots \omega_K), k = 1, 2, \cdots, K$$

$$\sum_{k=1}^K \omega_k = 1$$

Taking two factors  $X_j$  and  $X_k$  every time,  $C_{jk}$  is influence ratio of  $X_j$  and  $X_k$  for goal, formed comparison matrix  $C = (C_{jk})_{K \times K}$ ,  $C_{jk}$  values range from 1 to 9 according to group of experts, table 1.

Intermediate states of each of the two grade,  $C_{jk}$  values 2, 4, 6 and 8; equations  $C_{jk} = \frac{X_j}{X_k}$ ,  $\frac{X_k}{X_j} = \frac{1}{C_{jk}}$ .

Determine largest character value and weight vector of matrix  $C$  using approximate calculation, if the inconsistency of matrix  $C$  is acceptably, weight vector is the weight distribution set  $\omega$ ; if the inconsistency of matrix  $C$  is not acceptably,  $C_{jk}$  value of matrix  $C$  would be adjusted, until the inconsistency of matrix  $C$  is acceptably.

Table 1 Value Standard of  $C_{jk}$ 

$X_j$ over $X_k$	Equal	Slightly strong	Strong	Stronger	Definitely stronger
Value of $C_{jk}$	1	3	5	7	9

**Select Building Construction Unit Using Set Pair Analysis Theory.** Build sets for bidding documents and the ideal bidding document, the ideal bidding document is constituted by the  $N$  optimal value of index in bidding documents. In the ideal bidding document, the benefit index is the maximal value in similar index; the cost index is the minimum value in similar index. If the identical

degree of evaluation value  $x_k^{(n)}$  and the optimal value  $x_k^{(0)}$  of the ideal bidding document  $A_0$  is  $a_k^{(n)}$ ,  $x_k^{(n)}$  is evaluation value of index  $k$  of  $N$ -th bidding documents  $A_n$ . We can get the following indicators based on identical degree concept of set pair analysis:

the benefit index ( $x_k^{(n)} < x_k^{(0)}$ ):

$$a_k^{(n)} = \frac{x_k^{(n)}}{x_k^{(0)}}, \quad k = 1, 2, \dots, K; n = 1, 2, \dots, N \quad (1)$$

the cost index ( $x_k^{(n)} > x_k^{(0)}$ ):

$$a_k^{(n)} = \frac{x_k^{(0)}}{x_k^{(n)}}, \quad k = 1, 2, \dots, K; n = 1, 2, \dots, N \quad (2)$$

Considering the index weight  $\omega_k$ , the identical degree  $a^{(n)}$  of bidding documents and the ideal bidding document is:

$$a^{(n)} = \sum_{k=1}^K \omega_k a_k^{(n)} \quad n = 1, 2, \dots, N \quad (3)$$

The evaluation order of all bidding documents ( $N$ ) is determined by numerical value of  $a^{(n)}$ , the larger value of  $a^{(n)}$ , the better.

### Calculation Example

The bidding of construction of one office building, there are four bidders have been prequalified, five experts from different professional carry out evaluation. All evaluating indicator include project quoted price ( $x_1$ ), construction guarantee measures ( $x_2$ ), construction scheme ( $x_3$ ), construction cycle ( $x_4$ ), engineering equipment ( $x_5$ ) and business performance ( $x_6$ ).

**Evaluation Value and Ideal Value of Single Index of Bidding Documents.** Group of experts determine influence weight of evaluating indicator using analytic hierarchy process according to the characteristics of the office building, and then these evaluating indicators are graded by 9 level system. Every ideal value of the ideal bidding document  $A_0$  is the biggest corresponding value of the four bidding documents of bidders. Evaluation value and ideal value of single index of bidding documents, table 2.

**Determine the Weight of Each Index Using Analytic Hierarchy Process.** Determine the weight  $\omega_k$  of each index using analytic hierarchy process, table 2.

Table 2 Evaluation Value and Ideal Value of Single Index

Evaluating indicator $x_k$	Weight $\omega_k$ (%)	Bidder 1 $A_1$	Bidder 2 $A_2$	Bidder 3 $A_3$	Bidder 4 $A_4$	Ideal bidder $A_0$
Project quoted price $x_1$	19.26	6	6	7	5	7
Construction guarantee measures $x_2$	20.13	7	6	7	5	7
Construction scheme $x_3$	17.63	5	5	7	7	7
Construction cycle $x_4$	15.48	6	6	6	5	6
Engineering equipment $x_5$	13.57	7	7	6	7	7
Business performance $x_6$	13.93	5	7	4	6	7

**Determine the Identical Degree of Bidding Documents and the Ideal Bidding Document Using Set Pair Analysis.** According to the evaluation value and ideal value of single index shown as table 2, the identical degree  $a_k^{(n)}$  ( $n=1,2,3,4$ ) of evaluation value and ideal value of single index of the four bidding documents of bidders were calculated from equation (1), table 3.

Table 3 The Identical Degree  $a_k^{(n)}$  of Evaluation Value and Ideal Value of Single Index

$n$	$a_k^{(n)}$	$k$					
		1	2	3	4	5	6
1	$a_k^{(1)}$	0.857	1	0.714	1	1	0.714
2	$a_k^{(2)}$	0.857	0.857	0.714	1	1	1
3	$a_k^{(3)}$	1	1	1	1	0.857	0.571
4	$a_k^{(4)}$	0.714	0.714	1	0.833	1	0.857

Considering the weight  $\omega_k$  of each evaluation index, the identical degree of bidding documents and the ideal bidding document was calculated from equation 3. Ranking order of four bidders is determined, table 4.

The results show that bidder3 is best, then are bidder2, bidder1, bidder4.

Table 4 The Identical Degree and Ranking Order of Bidders

$n$	Bidder1	Bidder2	Bidder3	Bidder4
$a^{(n)}$	0.8822	0.8933	0.9208	0.8416
Ranking order	3	2	1	4

## Conclusion

In integrated evaluation index system for bidding of construction, the influence degree of each index is different and some cannot be quantitative measurement, only comparison judgment according to the expert experience. Because there are more factors need to compare, so that we cannot do it accurately. This problem can be solved by analytic hierarchy process.

The weight of evaluation indexes are determined by analytic hierarchy process, combined with the weight of each index, the identical degree of the ideal bidding document was calculated with set pair analysis. Ranking order of bidders can be determined by the identical degree of bidding documents and the ideal bidding document.

Compared with the method of fuzzy mathematics and grey relational theory etc. the tender evaluation method about bidding of construction based on set pair analysis is computationally simple and convenient to use.

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