OPTIMIZATION OF DESIGN PLAN BY COMPUTER- AIDED SELECTIVE SYSTEM IN PRELIMINARY PHASE

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ABSTRACT

Optimal design is an important process in the preliminary design phase of construction project. In this phase it is important to verify whether the technology of the optimal design is advanced, whether the engineering structure of the optimal design is safety, whether the cost control of the construction object of the optimal design is the best.

In this paper Value Engineering theory is used in analyzing. Because the analysis workload is heavy and it will cost much time and expenses in the preliminary design phase, it is necessary to look for a one - shot solution to the problem.

After studying of technical and construction feature, every possible design plan is analyzed from the technical and economic view by the application of value engineering theory. The artificial intelligence frame is set up by means of computer program. After running through the possible designs, the computer will pick out a design that would meet requirements of the owner as much as possible at the lowest cost.

The computer-aided selective system has been applied in some construction projects and acquired good effect.

KEY WORDS

computer-aided elective system, optimal design, preliminary design phase , value engineering theory

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INTRODUCTION

Engineering project design includes three design phases: conceptual design, preliminary design and construction drawing design. The capital invested during preliminary design phase is merely 2-10% of the total cost, but the fluctuation of the total cost produced in this phase should be higher than 30%. So the design process must be strictly supervised and the technology of optimal design must be used during this phase.

In conceptual design phase, the main scantling, structure and equipments have been decided, so optimal design in preliminary design phase should mainly aim at foundation. To make the work more convenient and more exact and to avoid heavy calculating workload, it is necessary to use computer-aided selective system.

ECONOMIC ANALYSES PRINCIPLE

Norm

"Preliminary estimate norms of construction projects" provided by management sector of norms in Shanghai,

"Shanghai estimate norms of building engineering"(1993)

Because the method of techno - economic analysis is Value Engineering, the date in the process of economic analysis is not necessarily using absolute value of the design plans. Dependent on this cause, using norms of Shanghai is feasible.

Project cost formation

Under the legal papers of construction department[2003]206， the cost of project includes direct cost, indirect charge, profit and tax. In this paper, the theory of comprehensive unit price will be applied to evaluate the base cost.

Process of evaluate

Evaluating the cost of superstructure by "preliminary estimate norms of construction projects".

Evaluating the cost of base by "Shanghai estimate norms of building engineering" （1993） .

TECHNICAL ANALYSIS PRINCIPLE

In preliminary design phase， according to features of design plans and typical project 's experience evaluate every plan.

TECHNO - ECONOMIC ANALYSIS

The theory of techno - economic analysis is Value Engineering。

$$VI = \frac{FI}{CI} \tag{1-1}$$

VI -- VE index,

FI -- Function index,

FI -- Function index.

$$CI_i = \frac{C_i}{\sum C_i} \tag{1-2}$$

CI_i -- Cost index,

C_i -- The real cost of the evaluation object ”i”,

$\sum C_i$ -- The total cost of the entire evaluation object.

$$FI_i = \frac{F_i}{\sum F_i} \tag{1-3}$$

FI_i -- Function index,

F_i -- The scores of the evaluation object ”i”,

$\sum F_i$ -- The scores of the evaluation object ”i”

According to calculating result, choose the plan whose VE index is the highest as optimal design.

COST OF SUPERSTRUCTURE

In accordance with rules of “preliminary estimate norms of construction projects”, the cost of superstructure of every possible design plan can be calculated with the dates, which are fed into the compute from the interface (Table 1) of computer-aided selective system while running the program.

There are three types of base that distinguished the design plans. Plan A: Strip foundation, Plan B: Mat foundation, Plan C: Pile foundation.

Table 1: Input-parameters Table of Superstructure

Indicator	Name	Unit	A	B	C
A1	Building area	m2	*	*	*
B1	Structure types		*	*	*
D1	The number of layer	F	*	*	*
E1	Building height	m	*	*	*
F1	Hydrant water system		*	*	*
G1	Self extinguishing system		*	*	*
H1	Substation-system	KVA	*	*	*
M1	Air conditioning system		*	*	*

Remark: the mark “ * ” expresses needing input-parameters
A1：building area，input data on fact.
B1：structure types，frame, input date “ 1 ” ,masonry structure，input date “ 2 ” ,shear wall, input date “ 3 ” , other structure type, input date “ 4 ” 。
D1：the number of layer，input data on fact。
E1：building height，input data on fact
F1：hydrant water system, having the system, input date “ 1 ” ；contrary to it, input date “ 0 ” .
G1：self extinguishing system, having the system, input date “ 1 ” ；contrary to it, input date “ 0 ” .
H1：substation-system，input data on fact.
M1：air conditioning system，having the system, input date “ 1 ” ；contrary to it, input date “ 0 ” .

In computer-aided selective systems, the program will analyze the parameter entered from table 1 and some features of plan begin to form automatically. There is a one - to - one relationship between every feature of a design plan and the cost according to “preliminary estimate norms of construction projects”, So the cost of superstructure of plan A, C1A, the cost of superstructure of plan B, C1B, and the cost of superstructure of plan C, C1C, can be calculated.

COST OF BASE

In accordance with rules of “Shanghai estimate norms of building engineering” （1993）, the cost of base of every design plan can be calculated with the dates which are fed into the compute from the interface(Table 2) of computer-aided selective system while running the program
There are three types of base that distinguished the design plans. Plan A: Strip foundation, Plan B: Mat foundation, Plan C: Pile foundation.

Table 2 input-parameters table of base

Indicator	Name	Unit	A	B	C
P	Site		*	*	*
H	Depth of foundation	m	*	*	*
h	Difference between inside and outside ground levels	m	*	*	*
C	Concrete mark		*	*	*
R	Types of foundation		*	*	*
S0	The area of compaction grouting	m2	*	*	
h0	The depth of compaction grouting	m	*	*	
L1	The length of strip foundation	m	*		

S1	The sectional area of strip foundation	m2	*		
h2	The depth of mat foundation	m2		*	
n3	The number of pile	amount			*
s3	The sectional area of pile	m2			*
H3	The length of pile	m			*
P3	The sectional area of pile cap	m2			*
N3	The number of pile cap	amount			*

Remark: the mark " * " expresses needing input-parameters

P：site, Pudong and other places in the country, input date" 1 ",Puxi, input date" 0 "。

H：depth of foundation，input data on fact. If needing well point, input depth date with the mark " # " before.

h：difference between inside and outside ground levels，input data on fact.

C：concrete mark, input data on fact, " C20 "， " C35 " .

R：types of foundation, having foundation beam, input date" 1 "；contrary to it, input date " 0 " .

S0：the area of compaction grouting, input the area of foundation mat.

h0：the depth of compaction grouting, input data on fact.

L1：the length of strip foundation, input data on fact.

S1：the sectional area of strip foundation, input data on fact.

h2：the depth of mat foundation, input data on fact.

n3：the number of pile,s3：the sectional area of pile, input data on fact.

H3：the length of pile , P3：the sectional area of pile cap, input data on fact.

N3：the number of pile cap input data on fact.

In the program, because comprehensive unit price of strip foundation with concrete mark " C20 " has been defined as " C0 " and lays down the datum mark for other types of foundation, correction coefficients can be established.

Table 3 :correction coefficient of foundation embedment $\delta 1$

Depth of foundation	**≤2.0m**	**≤3.0m**	**≤4.0m**	**≤3.0m (Well point)**	**≤4.0m (Well point)**
Strip foundation	1.0	1.2	1.2	1.1	1.2

Mat foundation	1.3	1.4	1.5	1.3	1.4
Pile foundation	1.3	1.3	1.5	1.3	1.3

Table 4: correction coefficient of concrete δ2

C20	C25	C30	C35	C40	C45	C50
1.0	1.02	1.04	1.07	1.09	1.1	1.11

Table 5: correction coefficient of foundation types δ3

Types of foundation		≤2.0m	≤3.0m	≤4.0m	≤3.0m (Well point)	≤4.0m (Well point)
Strip foundation	R=1	1.0	1.0	1.0	1.0	1.0
	R=0	0.99	1.02	1.02	1.0	1.0
Mat foundation	R=1	1.0	1.0	1.0	1.0	1.0
	R=0	0.82	0.86	0.94	0.86	0.94
Pile foundation	R=1	1.0	1.0	1.0	1.0	1.0
	R=0	1.08	1.08	1.19	1.10	1.10

Table 6: correction coefficient of earth moving δ4

Types of foundation		≤2.0m	≤3.0m	≤4.0m	≤3.0m (Well point)	≤4.0m (Well point)
Strip foundation	R=1	1.44	1.74	1.74	1.73	2.12
	R=0	2	2.41	2.41	2.41	2.41
Mat foundation	R=1	1.46	1.83	2.17	1.67	2.02
	R=0	1.8	2.17	2.81	2.1	2.46
Pile foundation	R=1	1.43	1.43	1.63	1.54	1.65
	R=0	1.34	1.34	1.41	1.37	1.41

In computer-aided selective systems, it will analyze the parameter entered from table 2 and choose correction coefficient automatically. While the program is in progress, the cost of base of plan A, C2A, the cost of base of plan B, C2B, and the cost of base of plan C, C2C can be got according to the formula of the estimate norms which are written in the program.

COST INDEX

Adding up C1 to C2, the cost of design plans (CA, CB, CC,) can be got.

According to formula 1-2, cost index of design planscan be calculated.

THE PROCESS OF ANALYSIS OF FUNCTION INDEX

By means of an interface (Table 7) of the computer-aided selective systems, the function scores of design plans are ascertainable

Table 7 Evaluation of construction plan

Evaluation content	Evaluation criterion		Score
1. Preparation of construction	1.1	Need enough preparation	5
	1.2	Need preparation	10
	1.3	Need little preparation	20
2. Preparation of form	2.1	Need special form in large quantity	0
	2.2	Need standard form in large quantity	10
	2.3	Need standard form	20
3.construction influenced by the weather	3.1	Greatly	5
	3.2	Moderately	15
	3.3	Gently	20
4. earth moving	4.1	Greatly	5
	4.2	Moderately	10
	4.3	Gently	15
5. the influence of construction on surrounding buildings	5.1	Greatly	5
	5.2	Moderately	10
	5.3	Gently	20
6.project time	7.1	Longest	5
	7.2	Long	10
	7.3	Short	20
7.construction quality control	8.1	hard	5
	8.2	Easy	15
8.technical request	9.1	high	5
	9.2	ordinary	10
	9.3	low	20
9.safety in	10.1	hard	5

production	10.2	easy	15

Grade the plans according to the real situation, the function scores of plan A, FA, the function scores of plan B, FB and the function scores of plan c, FC, can be got.

According to formula 1-3, function index can be calculated.

VE ANALYSIS

According to formula (1-1), VE index are given and the optimal design is found while running the program. Optimal design is the plan whose VE index is the highest.

ANALYSIS RESULT

As figure 1 shows, running the computer-aided selective system, it will produce the chart based on the calculating result.

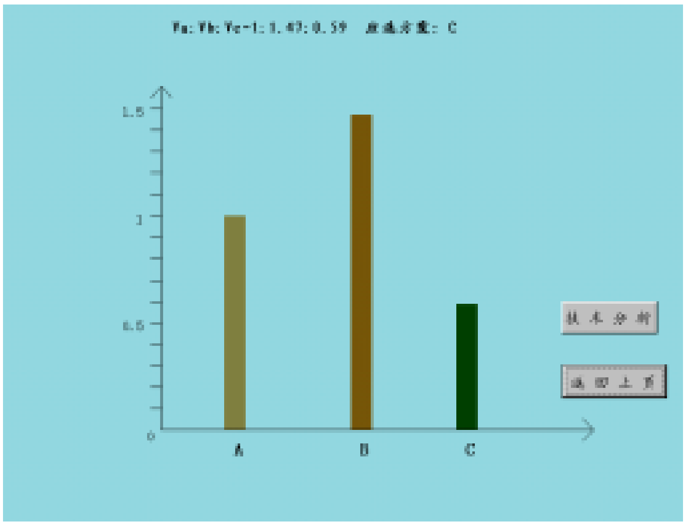

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Figure 1: Analysis result

CONCLUSIONS

This computer-aided selective system has a clear and friendly interface. The system is very convenient for use, and it meets the requirements of economic and technical analysis in the course of preliminary design phase. It is easy to select the optimal design, which will be benefit for project's economic results and can provide a better way to improve the design quality.

The computer-aided selective system has been applied in some construction projects and acquired good effect. For example, in the design of the 7th hospital in shanghai, in the design of Shanghai Hardware Tools Factory.

The application of the computer-aided selective system also has some locality. For example, in the computer-aided selective system, only three types of foundation have been analyzed, so work must be done on improving the application of the computer-aided selective system in the future.

REFERENCES

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