The Construction Of Carbon Emissions Control Theory Research

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ABSTRACT: Although construction stage possesses shart time in building life cycle , comparing to operations period,   energy of consumption and carbon emissions concentrated. How to control carbon emissions at the construction stage.After investigating and researching.it summarized 24 main influencing factors.Then it was reduced by the representative of the state for the 80 and 2 decision strategies adopted in these conditions.This article summarizes a series carbon emission control rules,thus screening of potential bidders whether responses to energy saving and emission reduction in bidding stage.

THE CONSTRUCTION OF CARBON EMISSIONS CONDITION AND DECISION ATTRIBUTE DECISION

In rough set, condition attributes was going to collect and determine the factors affecting carbon emissions on construction phase. Judgment decision attribute was the determination of the construction of carbon emission control standards.

The principle of rough set was to reduce redundancy of the system.Then we deleted the redundant factors and those did not affect the decision-making ability of the system. [1]

To determine the condition attribute

Condition attribute refers to the characteristics of things.The value refers to describe   the feature of the characteristics. There were qualitative and quantitative description. The influencing factors were men, material, machine, environment and management,which could be named condition attributes.

We have collected 24 factors, which affected the construction of carbon emissions, the condition attributes were expressed in Ci (i = 1 ~ n). As shown in table 1.

To determine the decision attribute

Decision attributes were expressed in Dj (j = 1 ~ n). Decision attributes is carbon emissions per unit area of the building. The decision attribute as two states, namely, 0 and 1, representing the (*, 21.55], and [21.55 *).

（1）Carbon emissions per unit area of the building

To simplify the research, we used the carbon emissions per unit area of the building to describe the different projects for the construction of carbon emissions. As in formula 1. The unit is kg/m^2。

Carbon emissions per unit area of the building =

$$\frac{\text{Total carbon emissions in construction process}}{\text{Totle building area}}$$

（2）Carbon emissions standards for building construction

The standard refered to carbon dioxide emissions per unit space on construction site[2]。 The standard was an important prerequisite and guarantee for the work of energy-saving emission reduction. [3]Taking Xi'an city as an example，By the early investigation and study，we had calculated The current construction carbon emission standard is 21.55kg/m2 in Xi'an.

In rough set,we use 0 and 1 instead of（*，21.55] and [21.55，*).That is to verify individual carbon emissions qualified or not.

TO HANDLE THE ATTRIBUTE VALUE OF ENERGY SAVING AND EMISSION RE-DUCTION

Data collection

Data collection should avoid human errors, omissions or missing data. If there exist the null data, it should be controlled in the range of 3%～6%.

We seted condition attribute "the choice of mode of transport" as an example to illustrate how to collecte and determine the attribute data. Generally,we transported with highway, railway, air and sea, by using the four numbers 1, 2, 3,4 to express thoes transport modes.

Tab.1The construction energy conservation and emissions reduction condition attributes

number	condition attributes	number	condition attributes
C_1	Transport mode	C_{13}	Level of qualification
C_2	Steel transportation distance	C_{14}	Structure type
C_3	Cement transportation distance	C_{15}	Building area
C_4	transportation efficiency	C_{16}	Soil type
C_5	Operation skill	C_{17}	Temperature
C_6	Mechanical wear	C_{18}	Altitude
C_7	Energy savingl rate	C_{19}	Earthwork
C_8	The insulation performance	C_{20}	The amount of cement
C_9	Living and office lighting	C_{21}	The amount of reinforcement
C_{10}	Management ability	C_{22}	Electricity consumption
C_{11}	Energy efficiency	C_{23}	Diesel consumption
C_{12}	floors	C_{24}	Gasoline usage

Discrete

There are two kinds of datas continuous and discrete in the system, respectively,we using quantitative and qualitative this two ways to describe the characteristics of data.In rought set,they always used discrete data.so the quantitative data in accordance with the laws of some segmentation. [4]

In this paper we used Boolean reasconing algorithm to discrete data, The discrete result of cement are shown in Table 2.

Attribute reduction

Deleting redundant information in the system is attribute reduction. However, the reduction results is not the only, without special requirements, we choosed the most simple one.

In this paper we used the method of Johnson and genetic.The method of Genetic was studied by Davis and Lingra [5]。

In this paper, the energy consumption data of 50 have been built from the already built and under construction projects.

Tab.2　Discrete process of condition attributes　"cement"

number	C_{20} (cement)		
	The original data	Discrete	The replacement data
1	369	[360.71, 482.69)	3
3	200	[*, 242.50)	1
5	485	[482.69, *)	4
10	254	[242.50, 360.71)	2
35	196	[*, 242.50)	1

（1）Introduce Rosetta tools

The rough set data analysis software was developed jointly by University of Warsaw in Poland and Norwegian University Science & Technology. It realized the data mining and knowledge discovery，A variety of functions, including data import and export data,completion, the discrete data, knowledge reduction,classification, rule generation and verification analysis. [6]

（2）Genetic reduction and Johnson reduction

Reduction results of the two methods are shown in Table 3 and table 4.

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Tab.3　Reduction algorithm of Genetic

Reduct	Support	Lenght
{C_9, C_{19}, C_{20}, C_{21},C_{22},C_{23},C_{24}}	100	7
{C_2, C_{12}, C_{13}, C_{14}, C_{19}, C_{20}, C_{21}, C_{23}，C_{24}}	100	8
{C_2, C_3, C_6, C_{14}, C_{19}, C_{20}, C_{21}, C_{23}}	100	8
{C_9, C_{12}, C_{14}, C_{17}, C_{19}, C_{20}, C_{21}, C_{22}, C_{23}}	100	9
{C_3, C_7, C_8, C_{11}, C_{15}, C_{20}, C_{21}, C_{22}, C_{23}}	100	9
{C_2, C_7, C_8, C_{11}, C_{17}, C_{20}, C_{21}, C_{22}, C_{23}}	100	9
{C_9, C_{11}, C_{14}, C_{17}, C_{19}, C_{20}, C_{21}, C_{22}, C_{23}，C_{24}}	100	10
{C_2, C_{11}, C_{12}, C_{14}, C_{15}, C_{19}, C_{20}, C_{21}, C_{22}，C_{24}}	100	10

Tab.4　Reduction algorithm of Johnson

Reduct	Support	Lenght
{C_9, C_{19}, C_{20}, C_{21},C_{22},C_{23},C_{24}}	100	7

We take the intersection of Genetic reduction and Johnson reduction algorithm results,which was { C_{19}, C_{20}, C_{21},C_{22},C_{23},C_{24}}

That was { Earthwork quantity, cement, steel works, power consumption, use of diesel, gasoline consumption }.

In the earthwork，construction machinery was used frequently in the construction stage，which had high energy consumption and large carbon emissions. Main project consumed a large amount of steel and the main material, which is high in carbon emissions. From this analysis, the results were basically consistent　with the actual situation after reduction. So in actual operation,those important factors should be the focus of monitoring.

CONSTRUCTION ENERGY CONSERVATION DECISION RULES

Decision rules introduced

In the decision-making system, after reduction,it generated the most streamlined decision-making table, which is a collection of different decision rules.

Definition of decision rules：$r_{ij} : des(X_i) \rightarrow des(Y_j), X_i \ \mathbf{I} \ Y_j \neq f^{[7]}$。

Among them，des( ) was description of equivalence classes。Deterministic factor is defined

$$m(X_i, Y_i) = \frac{|X_i \cap Y_i|}{X_i}, \quad \text{Obviously,} \quad 0 < m(X_i, Y_j) \leq 1 \quad [8]。$$

when $m(X_i, Y_j) = 1$, r_{ij} was identified.

when $0 < m(X_i, Y_j) < 1$, r_{ij} was uncertain.

Seeking decision rule

When seeking decision rules,firstly we added "Carbon emissions per unit area of the building"in that system. Secondly,adding the two decision-making attribute in the system. Then we used rough set theory,taking the 50 data into rosetta software to comput.So it formed a series of decision rules.

We selected decision rules of the accuracy is higher than 0.8, the coverage is greater than 0.05,and we got 165 optimal rules. A part of the rules as shown in Table 5. We extracted the fourth rule are explained in detail. The details are shown in table 6.The project which was represented by rule 4 conformed to the carbon emissions standards.

Tab.5　The optimal rule table

number	Rule
1	$C_2(2)$ AND $C_8(4)$ AND $C_9(2)$ AND $C_{15}(1)$ AND $C_{21}(2)$ AND $C_{23}(0)$ => D(0)
2	$C_2(1)$ AND $C_8(5)$ AND $C_9(2)$ AND $C_{15}(1)$ AND $C_{21}(2)$ AND $C_{23}(0)$ => D(0)
3	$C_2(2)$ AND $C_8(4)$ AND $C_9(1)$ AND $C_{15}(1)$ AND $C_{21}(2)$ AND $C_{23}(0)$ => D(0)
4	$C_2(2)$ AND $C_3(0)$ AND $C_4(2)$ AND $C_9(2)$ AND $C_{20}(2)$ AND $C_{21}(1)$ => D(0)
5	$C_2(2)$ AND $C_8(3)$ AND $C_9(2)$ AND $C_{15}(3)$ AND $C_{21}(2)$ AND $C_{23}(0)$ => D(0)
6	$C_2(2)$ AND $C_7(1)$ AND $C_{15}(1)$ AND $C_{20}(1)$ AND $C_{21}(2)$ AND $C_{22}(0)$ => D(0)

Tab.6　Rule 4 specification table

number	condition attributes	Attribute state	The attribute number	Decision	Decision results
C_2	Steel transportation distance	2	[28.13，81.13)		
C_3	Cement transportation distance	0	[*，38.61)		
C_4	transportation efficiency	2	90%以上		
C_9	Living and office lighting	2	[1574.06, 7232.76)	0	(*，21.55]
C_{15}	Building area	1	[*, 19857.50)		
C_{20}	The amount of cement	2	[242.50，360.71)		
C_{21}	The amount of reinforcement	1	[*, 174.04)		
C_{22}	Electricity consumption	0	[*, 65933.70)		

Application of decision rules

Decision rules of energy saving and emission reduction can be applied to bidding decision.In the evaluation phase, when we inputted the project information, it could quickly determine whether the bidding documents in response to the mandatory of the The tender.

For example, there existing A, B two bidding document, we draw the basic information of A and B in the evaluation stage,then used language of rough set to describe factors.

When listing facts use either the style tag List signs or the style tag List numbers.

The bidding documents A：

$C_1(1)ANDC_2(1)ANDC_3(1)ANDC_4(1)ANDC_5(3)ANDC_6(1)ANDC_7(0)ANDC_8(3)ANDC_9(2)AN DC_{10}(3)ANDC_{11}(1)ANDC_{12}(4)ANDC_{13}(2)ANDC_{14}(3)ANDC_{15}(3)ANDC_{16}(2)ANDC_{17}(0)ANDC_{18}(1) ANDC_{19}(1)ANDC_{20}(1)ANDC_{21}(4)ANDC_{22}(0)ANDC_{23}(0)ANDC_{24}(3)$

The bidding documents B：

$C_1(1)ANDC_2(2)ANDC_3(1)ANDC_4(2)ANDC_5(2)ANDC_6(0)ANDC_7(0)ANDC_8(4)ANDC_9(4)AN DC_{10}(5)ANDC_{11}(2)ANDC_{12}(4)ANDC_{13}(2)ANDC_{14}(3)ANDC_{15}(1)ANDC_{16}(2)ANDC_{17}(1)ANDC_{18}(1) ANDC_{19}(3)ANDC_{20}(3)ANDC_{21}(2)ANDC_{22}(0)ANDC_{23}(0)ANDC_{24}(2)$

Then we inputted the main impacts to the rule base,such as the average distance of reinforced and cement、construction area, the transportation efficiency, energy consumption,Living and office lighting.So we could get the result:

Bidding document A $\rightarrow$ D (1)

Bidding document B $\rightarrow$ D (0)

Cconstruction carbon emissions of A $\in$ (21.55, *]

Construction carbon emissions of B $\in$ (*, 21.55]

Therefore, We should accept company B and reject company A.

Conclusion

In this article, we extracted 50 samples, these samples included the building　have been built and the being built one. By using the rough set method we got a series of rules about construction energy saving. In the bidding process, energy conservation has become an important assessment criteria.By the rule base, the tender　can quickly determine　whether the bidding documents　comply with the mandatory of tender documents about　energy conservation. From the organizational point of view, this paper replenished some theory about the pre-construction phase of building energy saving.

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