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RELIABILITY EVALUATION IN CONSTRUCTION QUALITY BASED ON COMPLEX VAGUE SOFT EXPERT SET METHOD

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ABSTRACT

The control of the construction quality is very important in the construction industry. In this paper, the fuzzy reliability and construction quality are linked together to establish a specific quantitative evaluation model, which not only can help to make up for the lack of the traditional reliability qualitative evaluation methods, but also can avoid the inaccuracy of fuzzy quantitative evaluation of construction quality to a certain extent. This paper firstly selects some influencing factors of construction quality, and then makes use of complex vague soft expert set theory to study the construction quality and reliability. By the operational relationship and quantitative evaluation index, the membership functions of each subset are obtained, and different evaluation intervals are divided, it is helpful to draw the quantitative evaluation results of quality within a reasonable range and improve the accuracy of the quality and reliability. The presented hybrid method and detailed steps can provide some references for the reliability evaluation of construction quality.

KEYWORDS

Engineering, Vague soft expert set, Membership function, Reliability, Construction, Quality

1 INTRODUCTION

Under the changeable market competition environment, for the sustainable development of the construction industry, quality control is a crucial process. Since the construction phase is an important part of the whole process, the quality of this phase will directly affect the entire process. To ensure the quality of this stage, the construction industry can better achieve high quality goals. As the construction quality of construction projects affects the economic development and social harmony, it is necessary to evaluate the quality of the construction process. Construction quality is often affected by staff, materials, technical means and other multi-dimensional interference factors. Among the many factors that affect construction quality, some of them have a certain direct or indirect impact on the construction quality assessment results due to their own certain ambiguity, even have the loss of "reliability and validity" of the evaluation work, these factors are also known as fuzzy factors. In reality, because there are some objectively ambiguous factors in each project, the application of these factors in construction quality evaluation standards will affect quality supervision and evaluation. Therefore, it is necessary to deal with interval partitioning of the construction quality from the perspective of fuzzy reliability.

2 DEFINITIONS OF SOME CONCEPTS AND COMPARATIVE ANALYSIS OF RELATED LITERATURES

2.1 The connotation definition and literature analysis about construction or engineering reliability

As a comprehensive discipline involving many fields such as aerospace, nuclear energy, communications, and civilian industry, the reliability theory has achieved fruitful influence not only in electronics, instruments, but also in strengthening the defence forces, and this theory is also widely used in management science in recent years.

In the field of construction or engineering field, more and more scholars apply reliability theory to the construction and make a concrete study. Zhang [1] proposed a comprehensive system identification and reliability assessment framework for stochastic building structures. Through the combination of system identification method based on statistical moment and reliability assessment method based on the probability density evolution equation to respectively evaluate random component reliability and system reliability of a structure. Skrzypczak [2] adopted the methods of simulation FORM and SORM and Monte Carlo simulation to calculate the structural reliability index and the probability of failure so as to ensure the rules and requirements of structural safety, practicability and durability. Lehky [3] solved the problem of reliability design by using artificial neural networks and two-cycle optimization methods, then used the method in steel structures and steel plates. With the development of structural reliability, construction reliability has drawn increasing attention in recent years. Simanaviciene [4] supplemented the previously proposed multi-attribute decision-making synthesis method with the sensitivity analysis of decision making and improved the reliability of the method to determine the reliability of construction decision-making, thus improving the structure, technology and safety of the building Decision-making level. Saputra [5] measured the reliability of a project with time and cost by considering the uncertainty of resource availability, and used the Monte Carlo model to provide a technical solution to this type of problem. Bernardino [6] presented a computational tool that aims to help practitioners to design material-efficient structures for multi-storey buildings frames. The tool is based on an optimization framework, which –given a small set of input parameters defining the overall frame geometry and the system of loadings– seeks for optimized cross-sections for each structural member, based on a finite set of commercially available section profiles.

Professor Cong [7] first conducted a series of collations on the research results of engineering structural reliability and summarized them. Until now, the research and application of reliability in the field of project construction management are still under exploration, and the definition of the reliability of construction system in China is also very vague. Although the construction reliability has not yet come to a clear concept, along with numerous engineering quality problems, technical problems of construction and production and management problems in the construction process, the focus of construction reliability has gradually been paid attention by many scholars.

Reliability engineering and theory have been popularized and applied in many fields. However, based on the system reliability, there are only some research results on the reliability of the construction system of construction project. The theory and research on the reliability of the construction system in engineering project are relatively new topic.

Reliability means the ability to perform a specific function under a limited set of conditions [8]. Therefore, Yufang [9] defined the reliability of construction system. Ning [10] proposed that the construction system reliability is the reliability of the total construction system formed by the combination of duration reliability, quality reliability, cost reliability and safety reliability. As the three major objectives of project management are the duration, cost, quality. People use time to measure the duration, use cost money to measure cost, but there is no effective measure of quality. In the current literature, there are many papers studying engineering projects and reliability issues from a single point of view, such as quality and duration [11, 12]. For example, Shijing [11] regarded a construction project as a complex construction network system and used a network system optimization theory to optimize the project duration cost. From a double perspective, there are also literatures on engineering projects and reliability studies [13, 14]. By establishing a multi-objective genetic algorithm model, Yongbo [14] made a series of optimization on the duration and cost objectives and obtained the optimal Decision-making program. In addition, Wei [15] used ant colony algorithm based on the three major goals of project management to optimize the project's system reliability.

Simanaviciene [16] offered a new method for multiple attribute decision synthesis, SyMAD-3, which helps to choose an effective construction project alternative from multiple alternatives by assessing various construction, technological and occupational safety solutions, based on a set of quantitative attributes; and supplemented the SyMAD-3 method with decision sensitivity analysis (SyMAD-3 with SA) to improve the reliability of the SyMAD-3 method and assess the reliability of the obtained decision. Nosenko [17] carried out the forecast based on the known regularities of change in the reliability of analogs and prototypes of the investigated modules and their elements. The units and parts of modules limiting reliability are used for the assessment of reliability. Alfred [18] developed a method to determine the influence of time-independent variables on the development of failure probability over time. This method can also be used to evaluate target reliability indices of other civil and geotechnical structures.

2.2. The definition and literatures of construction quality and reliability

Because of there are many uncertain factors in quality risk, and the complexity of the risk theory, analysis far exceeds schedule and cost risk, this paper focuses on the study of quality reliability. Evaluating the reliability of construction quality of the project is the coordination between reliability and quality. There is relatively little literature on reliability issues from a single quality objective.

Tao [19] established SRO model of system reliability optimization, first determine the reliability of structural functions, and then use Levenberg-Marquard global optimization method to optimize project construction quality and improve the quality of project performance; Tiejun [20] defined the reliability of construction quality and pointed out that the quality reliability is the degree of reliability of the construction system in achieving its quality objectives. Ning [21] established the construction process reliability model using entropy method, and finally calculated the quality, reliability of each subsystem, the construction process of the three goals can be quantitatively managed. Liqiong [22] continued to propose the OBDD method and applies it to the assessment system of construction quality reliability. It is concluded that this method is suitable for the conclusion of large-scale construction projects. Acıkara [23] determined the attitudes of construction project participants towards quality management. For this purpose, a questionnaire was administered to 120 participants of construction projects in Turkey. Rekleiti [24] focused on studying the validity and reliability of the Greek edition of DQOL-BCI. DQOL-BCI includes 15 questions-elements that are evaluated on a 5-grade scale like Likert and two general form-shapes. Bright [25] evaluated the usefulness of OpenStreetMap [OSM]data for researching the spatial availability of alcohol, a field which has been hampered by data access difficulties; they showed how OSM quality metrics can be used to select areas with more complete alcohol data. The ease of access and use may create opportunities for analysts and researchers seeking to understand broad patterns of alcohol availability.

3 THE EVALUATION INDEX SYSTEMS ON THE CONSTRUCTION QUALITY

In this paper, we refer to 124 engineering quality accidents related to the Ministry of Housing and Urban-Rural Development, reference [26, 27], online materials and media materials from 2012 to the first half of 2017. Based on the experts' opinions in the quality field and considering the scientific nature of each factor, the accident statistics and classified data analysis. After analysing, according to the construction staff experience, construction technology, structural design and analysis, reasonable degree of material selection, construction accuracy and the quality of inspectors and other fuzzy factors, accidents are divided into the following categories: collapse, cracking, settlement, leakage, hollowing, shedding, elevator failures and accidents, construction electricity failures and accidents, bearing capacity decline and others, a total of 43 kinds of influencing factors.

3.1 The construction quality evaluation model

These factors are interrelated. In order to accurately grasp the fuzzy factors that affect the construction quality of the project, made on-site investigation of 12 construction projects under Shanjian, Zhongtian, Guangsha, Changfeng and Changye, obtained 43 kinds of factors weight situation, identified and processed the data to obtain the quality evaluation model. Each project had 20 quality questionnaires, the questionnaire was issued for more than three years relevant work experience of the construction workers, technicians and supervisors, the questionnaire method is to use Likert5 scale fuzzy evaluation method. A total of 178 valid questionnaires were collected, with an effective rate of 74.2%. The study used SPSS17.0 to test the overall reliability of the sample.

3.2 Screening key influencing factors

Genetic algorithms (GA) are used to screen the fuzzy factors that affect construction quality because of the large amount of data that can be processed by this method. By the questionnaire method, 43 scores of influencing factors were collected. The chromosome length was set as 43, the gene on each chromosome was set as 0 or 1, and the gene was 1 if the gene was involved in construction and 0 otherwise. When running GA, select the fitness function:

$$f(x)=\frac{1}{\sum_{i=1}^{n}(t'_i-t_i)^2} \tag{1}$$

Where: $T=\{t_1, t_2, \ldots, t_n\}$ is the true value of the data; $T'=\{t'_1, t'_2, \ldots, t'_n\}$ is the predicted value of the collected data; "n" is the number of samples. Select the proportion operator as:

$$P_k=\frac{f(x_k)}{\sum_{k=1}^{n} f(x_k)} \tag{2}$$

Where P_k is the various factors that affect the proportion of fitness; $f(x_k)$ is the various factors of fitness. After using Matlab to run the program, get blurred fuzzy influencing factors as Table 1:

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Tab. 1 - The project quality accident classification and statistics

Target layer	Phenomenon layer	Factor layer	Frequency
Construction Quality Evaluation (*A*)	Collapse (B_1)	Formwork support system (C_1), Earthwork, foundation pit and fence (C_2), Steel truss (C_3), Scaffolding (C_4)	33.9%
	Cracking (B_2)	Wall (C_5), Body Structure (C_6), Floor and Foundation (C_7)	43.5%
	Settlement (B_3)	Wall cracks (C_8), Wall water seepage and perfusion (C_9), Ground subsidence and Slide (C_{10}), Building inclination (C_{11})	22.6%
	Leakage (B_4)	Wall seepage (C_{12}), Roof seepage (C_{13}), Ground seepage (C_{14}), Pipeline seepage (C_{15})	9.7%
	Emptying (B_5)	Wall hollowing (C_{16}), Ground and ceiling decoration hollowing (C_{17})	8.9%
	Lost (B_6)	Beam column structure, shedding (C_{18}), Inside and outside the wall off (C_{19})	6.5%
	Elevator Accident (B_7)	Steel cord breakage (C_{20}), Improper use and maintenance (C_{21})	9.7%
	Construction Electricity Accident (B_8)	Electrical Equipment (C_{22}), Fault Line Leakage (C_{23}), Improper Use and Maintenance (C_{24})	7.2%
	Bearing Capacity Decrease (B_9)	Column bearing capacity decreased (C_{25}), Beam capacity decreased (C_{26})	8.6%
	Others (B_{10})	Fire (C_{27}), Explosion (C_{28})	6.8%

Equalized and normalized the probability distribution of each kind of accident phenomenon [28], using the formula:

$$y_k = g(x_k) = \sum_{i=0}^{k} \frac{n_i}{N} = \sum_{i=0}^{k} h_i, k = 0,1,\ldots L-1 \tag{3}$$

The new probability is:

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Tab. 2 - Project quality accident (B) statistical table

Accident	Phenomenon layer B									
	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8	B_9	B_{10}
Frequency	21.5%	27.6%	14.3%	6.2%	5.7%	4.1%	6.2%	4.6%	5.4%	4.4%

It can be seen from the Table 2 that the collapsing, cracking and settling caused by the fuzzy factors is frequent quality accidents with the probability of 21.5%, 27.6% and 14.3% respectively.

The above accidents not only affect the quality and appearance of buildings, but also affect the personal and property safety. Therefore, the construction quality of construction projects has become a particularly important issue. Controlling the quality of construction not only can reduce the number of casualties of construction workers, but also can reduce the economic losses caused by construction quality problems.

4 THE PROPOSED HYBRID METHOD

4.1 The evaluation interval based on vague soft expert set hybrid method for quality reliability

As the previous methods evaluating the construction quality are more subtle and subjective, the quality is judged based on the management experience of the management staff, so there is a lack of objectivity. The introduction of quality and reliability can effectively solve this problem. Using fuzzy linguistic variables as a measure to measure the degree of quality, reliability and calling it "degree", we use fuzzy language operators to make a scientific assessment of construction quality management and make a reasonable division of construction quality reliability, then come to its evaluation interval, make a more scientific and accurate project quality conditions.

The language operator is used to divide the construction quality, reliability into different basic fuzzy subsets, and combine these subsets with vague soft expert sets. By using the Vague set evaluation index system, different membership functions of vague soft expert sets about construction quality, reliability are established, and can solve the membership function to get the range of different subsets. Vague soft expert sets represent a certain extent, so calculated results are more intuitive and accurate.

4.2 The fuzzy language variables

Professor Zadeh proposed fuzzy set theory in 1965 and marked the birth of fuzzy mathematics [29]. From then on, fuzzy set theory was promoted in many fields. Fuzzy theory uses the single-valued membership function to represent "a certain degree of belonging", but this theory cannot represent neutral evidence and therefore has obvious drawbacks [30]. Gaussian and Burchere [31] proposed the vague soft expert sets in 1993 and used this fuzzy theory to deal with fuzzy information. Bustince [32] recapitulate the definition given by Atanassov (1983) of intuitionist fuzzy sets as well as the definition of vague sets given by Gau and Byehrer (1993) and see that both definitions coincide.
Javier Gutiérrez_García [33] demonstrates two meta-mathematical propositions concerning the increasingly popular "intuitionistic" (= vague) approaches to fuzzy sets and fuzzy topology, as well as the closely related interval-valued (= grey) sets and interval-valued "intuitionistic" sets: (1) the term "intuitionistic" in these contexts is historically inappropriate given the standard mathematical usage of "intuitionistic"; and (2), at every level of existence—powerset level, topo-logical fibre level,

categorical level—interval-valued sets, interval-valued "intuitionistic" sets, and "intuitionistic" fuzzy sets and fuzzy topologies are redundant and represent unnecessarily complicated, strictly special subcases of standard fixed-basis set theory and topology. This theory applies the membership function to solve the traditional fuzzy set of defects. The degree of subordination is used by the expression method of interval, so it expresses the relation of "belonging to within a certain interval", and can deal with the fuzzy information that Fuzzy Sets cannot achieve. In this paper, the fuzzy mathematical theory is used to study the reliability of construction quality. Vague soft expert sets and language operators are used to determine the membership functions, and finally the evaluation interval is divided.

As a new subject, fuzzy mathematics has achieved good results in many fields, such as fault diagnosis and decision-making. In real life, many things cannot be described in precise language, which requires using vague language in fuzzy mathematics. Fuzzy mathematics has broad prospects of economic development, business management and so on. For example, customers evaluate a service, can use the" good service"," poor service" and other vague terms, and cannot use accurate values to express the value of this service. In the quality evaluation process, you cannot use the exact value to evaluate the quality of good, but instead of fuzzy language variable assessment instead of accurate evaluation.

A vague linguistic variable is represented by a five-tuple [34] $(X,\ T\ (X),\ U,\ G,\ M)$. " X " is the language variable name. "$T\ (X)$"is a collection of X's language values."U " is the domain."G "is the grammas' rule that produces" X " . "M "is a semantic rule.

4.3 The division evaluation interval of Fuzzy language operator

In natural language, there are still some words that play a role in modification. For example, "very", "slightly"..... putting these words in front of a word changes the affirmation of the meaning of the word and turns the original word into a new word. Therefore, we regard these kinds of words as an operator, respectively, as a language operator.

The language operator is defined as a mapping $H_\lambda : F\ (U)\ \rightarrow F\ (U)\ (\lambda > 0)$. H_λ transforms the fuzzy set ".on "U" into a fuzzy set $H_\lambda A$. The relationship between the two is: $(H_\lambda A)(U) = \left[A(u)\right]^\lambda$.

When $\lambda > 1$, H_λ is called the centralization operator; when $\lambda < 1$, is called a diffusive operator and can be properly named, for example: H_2 = "Very", $H_{\frac{1}{2}}$ = "Pole", $H_{\frac{1}{4}}$ = "micro"[34].

Here we use the language operator to evaluate the construction quality, reliability and divide it into six basic fuzzy subsets: V_1 is very reliable, V_2 is reliable, V_3 is slightly reliable, V_4 is slightly unreliable, V_5 is unreliable, and V_6 is very unreliable.

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4.4 Vague soft expert sets and membership function

4.4.1 Vague soft expert sets

Definition [35]: Let the domain $X = \{x_1, x_2, ..., x_n\}$ and $x_1, x_2, ..., x_n$ belong to "X". A vague set "A" in "X" is described by the true membership function t_A ,and the pseudo membership function f_A ,which are denoted by $t_A : X \rightarrow [0,1]$ and $f_A : X \rightarrow [0,1]$ respectively. For $x \in X$, $t_A(x)$ is the lower bound of the affirmative membership of "x" determined by support , $f_A(x)$ is the lower bound of the negative membership of "x" determined by the opposition "x", and $1 - f_A$ represents the upper bound, and $t_A(x) + f_A(x) \leq 1$ .Then the solution of the membership function of "x" with respect to A is denoted $[t_A(x), 1 - f_A(x)]$,expresses this interval as the vague value of "x" in "A", denoted as $v_A(x)$. "x"unknown degree of "A": $0 \leq \pi_A(x) = 1 - t_A(x) - f_A(x) \leq 1$ .When $\pi_A(x) = 1 - t_A(x) - f_A(x) = 0$, "A" degenerates into a general fuzzy set of "X". Therefore, vague soft expert sets can be regarded as a complement to Fuzzy sets. For example: if $[t_A(x), 1 - f_A(x)] = [0.1, 0.9]$. This result can be interpreted as follows: "U" belongs to the Vague set "A "is 0.1, not to "A" is 0.1, hesitation is 0.8.

When "X" is a continuous set, the Vague set "A" in "X" can be written as $A = \int_X [t_A(x), 1 - f_A(x)] / x$. When "X" is a discrete set, recorded as $A = \sum_{i=1}^{n} [t_A(x_i), 1 - f_A(x_i)] / x_i$

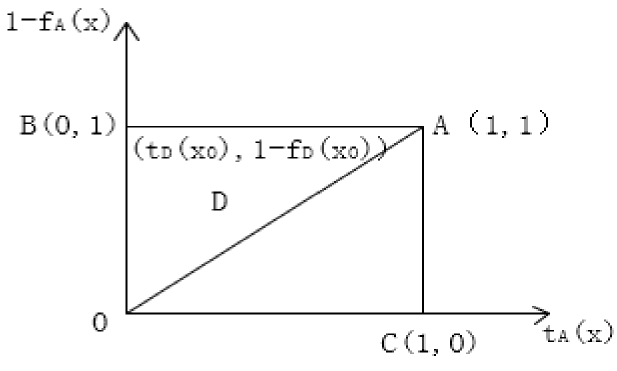

Fig 1 - The geometric meaning of vague set

4.4.2 Determine the membership function

Before making a comprehensive evaluation, determine the value of each parameter "X" evaluation, that membership. The fuzzy set of membership degree is expressed by membership function.

The steps to determine the membership function are shown as below:

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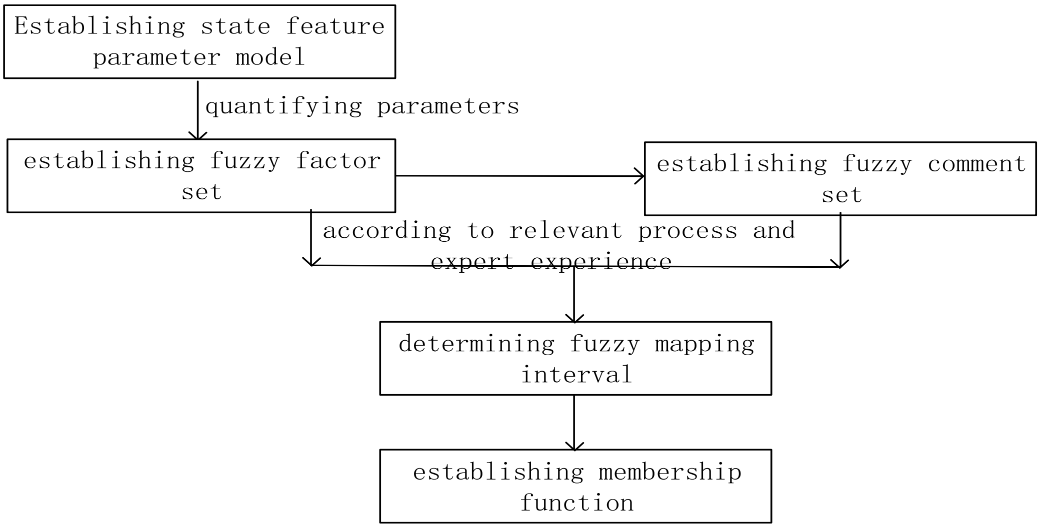

Fig. 2 - Membership functions determination model

Vague values are determined as follows:

This article evaluates the reliability of construction quality in a construction project and adopts such vague language as "very reliable", "reliable", "slightly reliable", "slightly unreliable", "unreliable", "very unreliable", and so on. As can be seen from the above vague language, the higher the reliability of the better, so the use of the larger the more excellent evaluation index; the lower the degree of unreliability is better, so the smaller the more superior type evaluation index [36].

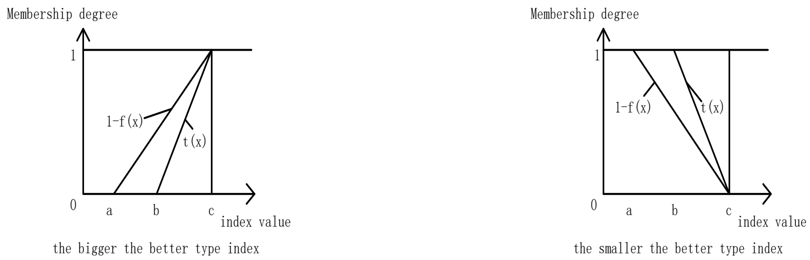

Fig 3 - Vague soft expert set membership function graph

For the bigger and better evaluation index, the Vague set membership function can be expressed as:

$$V=[t(x),1-f(x)]=\begin{cases}[0,0] & x<a\\ [0,\dfrac{x-a}{c-a}] & a\le x<b\\ [\dfrac{x-b}{c-b},\dfrac{x-a}{c-a}] & b\le x<c\\ [1,1] & c\le x\end{cases} \tag{4}$$

Contrary to the above evaluation index, the smaller the more superior evaluation index, Vague set membership function can be expressed as:

$$V=[t(x),1-f(x)]=\begin{cases}[1,1] & x<a\\ [\frac{c-x}{c-a},1] & a\le x<b\\ [\frac{c-x}{c-a},\frac{c-x}{c-b}] & b\le x<c\\ [0,0] & c\le x\end{cases}\quad(5)$$

The membership functions of the defined six vague soft expert sets are expressed respectively by $V_1(X)$, $V_2(X)$, $V_3(X)$, $V_4(X)$, $V_5(X)$, $V_6(X)$.The definition of fuzzy language operator can be respectively derived membership function of six vague soft expert sets:

$$[Very\ reliable]V_1(x)=\begin{cases}[0,0] & x<a\\ [0,\frac{2(x-a)}{1-a}] & a\le x<\frac{1+a}{2}\\ [1,1] & \frac{1+a}{2}\le x\end{cases}\quad(6)$$

$$[Reliable]V_2(x)=\begin{cases}[0,0] & x<a\\ [0,\frac{x-a}{0.563\text{-}0.563a}] & a\le x<\frac{1+a}{2}\\ [\frac{x-0.5(1+a)}{0.063-0.063a},\frac{x-a}{0.563\text{-}0.563a}] & \frac{1+a}{2}\le x<0.563+0.437a\\ [1,1] & 0.563+0.437a\le x\end{cases}\quad(7)$$

$$[Slightly\ reliable]V_3(x)=\begin{cases}[0,0] & x<a\\ [0,\frac{2(x-a)}{1-a}] & a\le x<0.437+0.563a\\ [\frac{x-0.437-0.563a}{0.063-0.063a},\frac{2(x-a)}{1-a}] & 0.437+0.563a\le x<\frac{1+a}{2}\\ [1,1] & \frac{1+a}{2}\le x\end{cases}\quad(8)$$

$$[Slightly\ unreliable]V_4(x)=\begin{cases}[1,1] & x<\frac{1-a}{2}\\ [\frac{2(1-x-a)}{1-a},1] & \frac{1-a}{2}\le x<0.563(1-a)\\ [\frac{2(1-x-a)}{1-a},\frac{1-x-a}{0.437-0.437a}] & 0.563(1-a)\le x<1-a\\ [0,0] & 1-a\le x\end{cases}\quad(9)$$

$$[Unreliable]V_5(x)=\begin{cases}[1,1] & x<0.437(1-a)\\ [\frac{1-x-a}{0.563-0.563a},1] & 0.437(1-a)\le x<\frac{1-a}{2}\\ [\frac{1-x-a}{0.563-0.563a},\frac{2(1-x-a)}{1-a}] & \frac{1-a}{2}\le x<1-a\\ [0,0] & 1-a\le x\end{cases} \quad (10)$$

$$[Very\ unreliable]V_6(x)=\begin{cases}[1,1] & x<\frac{1-a}{2}\\ [\frac{2(1-x-a)}{1-a},1] & \frac{1-a}{2}\le x<1-a\\ [0,0] & 1-a\le x\end{cases} \quad (11)$$

According to the above six Vague set membership function, using Matlab to make interval map, as shown below.

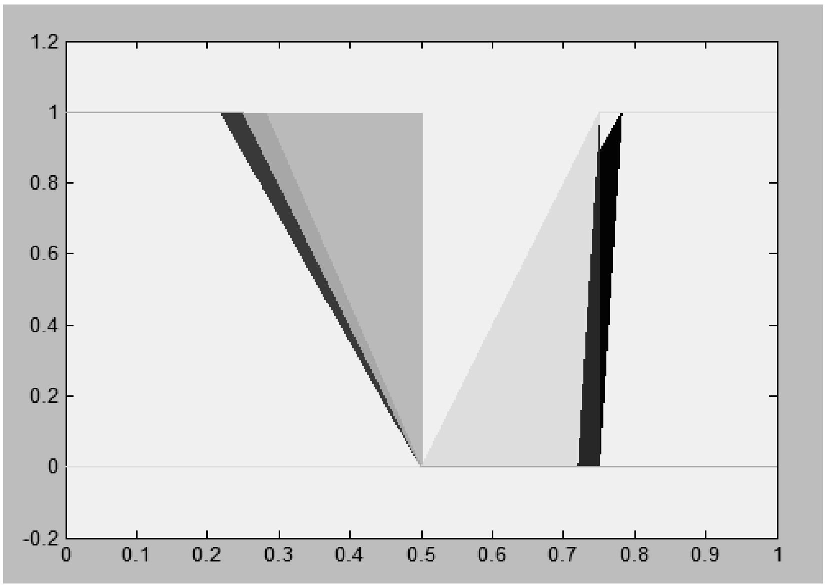

Fig 4 - Membership function interval diagram

The range of reliability is between [0, 1], and each membership function corresponds to one graph. According to the principle of maximum membership, the value range corresponding to the x-axis can be judged as the reliability value of each fuzzy language.

4.4.3 The solution of the membership function interval

Because each membership function is a piecewise function, and for each function, the interval is not the same according to the range of values of “x”, so each function is expressed in terms of surface. As can be seen from the functional formula, the value of the parameter “a” determines the division of the evaluation interval. Different items, “a” value is different. Therefore, when using this model in actual projects in different regions, we should make statistics on the projects in the area in advance and select the representative projects to determine the reasonable value of “a”.

5 CASE ANALYSIS

5.1 Project background

Taking Galaxy Center 1 # building project as an example, it is located south of the junction of Chaoyang Road and Shengli Road in Bengbu City, south of China Life Insurance Building. Design from the ground floor and underground space development. The project covers an area of 10683.63 square meters. 27 floors above ground, 1 underground, with a total construction area of 43489.43 square meters, of which construction area of 37,950 square meters on the ground floor, underground building area of 5539.43. On the ground 1-4 for commercial development, 5-27 layers for the office area, the ground floor of the parking lot.

5.2 The reliability rating of construction quality

Due to the technical complexity of the project, large scale and long construction period, developers hope that the data quality can be used to judge the construction quality of the project. Therefore, the interval value of the reliability of construction quality is calculated to ensure the successful completion of the project. Through the statistical analysis of the most representative engineering data in the city, the value of “a” is determined to be 0.5.

Tab.3 - Construction quality, reliability evaluation interval

Vague language	Grade	Range	Degree of hesitation
Very reliable	VG	[0.75,1]	0.25
reliable	G	[0.7186.0.75]	0.0314
Slightly reliable	FG	[0.5,0.7186]	0.2186
Medium reliable	M	[0.5,0.5]	0
Slightly unreliable	FP	[0.2814.0.5]	0.2186
Unreliable	P	[0.25,0.2814]	0.0314
Very unreliable	VP	[0.0.25]	0.25

In this paper, the Fuzzy set calculation method is used in the previous literature [29], and a new interval evaluation method based on vague soft expert sets is proposed. The difference between the two is that fuzzy membership is represented by a single value, and the six membership functions are respectively calculated to obtain the final degree of membership. The vague membership is expressed in intervals, and each membership function corresponds to an interval, the range belongs to [0, 1], the result is more intuitive. Vague set theory can use the support degree, opposition degree, the hesitation degree to represent the work information of the object; fuzzy set cannot express hesitation degree information. In contrast, vague soft expert sets are simpler and the expression of fuzzy information is more accurate.

6 CONCLUSIONS

In order to make up for the drawback of traditional construction, reliability methods, this paper established a quantitative evaluation model of quality, reliability based on Vague set and fuzzy language operator, and reached the following conclusions:

(1) With the appearance of numerous quality accidents every year, quality problems has become a problem that cannot be ignored. Therefore, the reliability of single index quality is studied from construction reliability.

(2) This paper made the interval partitioning of reliability of construction quality based on the fuzzy language operator. The membership functions of the six vague subsets are derived based on the relations among the language operators, as well as the larger and more superior indexes and the smaller one. The result of the final evaluation interval is affected by the value of “a”, because of different projects, “a” value is also different, so the quality of different projects reliability evaluation interval is different

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