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# An analysis of systematic model of engineering claim management

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**ABSTRACT**

*A systematic engineering claims management model is established, which is discussed systematically on the basis of the claims process and relationship between the relevant parties, based on system theory, neural networks and game theory. This model can predict the possibility of the project claim and solve the procedure. Corresponding measures are proposed on how to improve effectively the interests of both sides and play the biggest role in claims management to ensure the quality and effectiveness of the project.*

**Key words:** Claims management, Systematization, Neural networks

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In the international construction market , project claim for compensation is the effective means of protecting the contractors' legitimate rights and interests, making up for the loss of the engineer and improving economic efficiency. Many international projects have improved incomes through a successful claim, even the claim sizes are more than the construction contract values. The standard dictum of "winning the bid by low price, profited by the claim" is one of the tricks of the trade for many international contractors. Based on the data from abroad, the profit of contracting project accounts for approximately from 3% to 10% of the contract price under normal conditions, whereas in many international projects the amount of the claim for compensation is up to from 10% to20% of the contract price. Moreover, in some cases the engineering claims will exceed the amount of the contract. Most of the project cycles are long and need large amount of investment, and the claims factors are complicated. Therefore, building a systematic engineering claims management model is particularly important.

## FUZZY MATHEMATICS USED IN ENGINEERING CLAIMS MANAGEMENT SYSTEMATIC MODEL

Fuzzy set between the operators

Set A and B for two subsets, the inner product of A and B is to take a smaller value from two elements of the degree of membership for the calculation result, and then to take a larger value of the final results for the final results; the outer product of A and B is to take the larger value as the result of the operation, the degree of membership in the first two elements the results take smaller value of the final result of the operation. Example:

$$A=\frac{1}{t_1}+\frac{1}{t_2}+\frac{0.85}{t_3}+\frac{0.9}{t_4}+\frac{0.6}{t_5}\quad ;\ B=\frac{1}{t_1}+\frac{0.95}{t_2}+\frac{0.85}{t_3}+\frac{0.8}{t_4}+\frac{0.85}{t_5}$$

The inner product of A and B

$A \circ B = (1 \wedge 1) \vee (1 \wedge 0.95) \vee (0.85 \wedge 0.85) \vee (0.9 \wedge 0.8) \vee (0.6 \wedge 0.85) = 1 \vee 0.95 \vee 0.85 \vee 0.8 \vee 0.6 = 1$

The outer product of the A and B

$A \oplus B = (1 \vee 1) \wedge (1 \vee 0.95) \wedge (0.85 \vee 0.85) \wedge (0.9 \vee 0.8) \wedge (0.6 \vee 0.85) = 1 \wedge 1 \wedge 0.85 \wedge 0.9 \wedge 0.85 = 0.85$

To determine the membership function value

The process of determining the nature of the membership function value that should be objective, but the fact still

does not have a completely objective evaluation standards. In many cases, it is often initially identified rough membership function, and then by "learning" and Practice Tests gradually modified and improved, and the practical effect is the inspection and adjustment of the basis of the membership function.

We can preliminarily determine a value, and then selected the same type of processing 4-6 typical engineering event, each other in turn intended to be estimated project and each project is a collection of the same element, locate the benchmark, the general election is more complex, higher cost element basis, whichever is the membership function value of 1, the other the same elements as the benchmark, engineering specific circumstances and experience at the same time, in the closed interval [0,1]. taken membership function value. Finally, you can take advantage of the predictive model formula to test its accuracy.

To determine engineering blurred fuzzy relationship of the various elements of the collection coefficient (degree of membership), that is, the determination of the membership function, need to pay special attention to: the determination of the membership function in the fuzzy set with a certain degree of subjectivity is subjective conferred, usually based on experience or statistics. According to relevant statistics, identify each item (elements) coefficient in proportion to (0, 1) interval method of mathematical statistics, the establishment of the project unilaterally direct fee tables ", as an important reference to determine the membership function value. Its practice: each other by rotation for For estimated project the 5-7 selected the same type have been built in the typical engineering benchmark for comparison, and in the collection of the same elements in each event to find out its membership function value is 1, compared to others of the same elements and the elements of this benchmark, closed interval [0, 1], combined with the specific circumstances of the project, based on experience subjective given the elements of the membership function value, recycling estimation formulas to test the accuracy of the known typical engineering in order to establish "Contrast engineering fuzzy relationship coefficient table[1].

Close to the degree of calculation method
Set mapping relationship between F (U) × F (U) → 0,1 (A, B) as the paste progress. If you meet the
(1) (A, B) = 1
(2) (Φ, U) = 0
(3) (A, B) = (B, A)
(4) A B C (A, C) ≤ (A, B) ∧ (B, C)

Reference of the project events, the calculation of the close of the two projects, the key issue is to reflect the similarity of their works through rational calculation mode, the maximum decomposition, according to the two main features of the project elements. Nearness calculation mode is selected, to take full advantage of the engineering characteristics factors, reflects the similarity of the project to ensure the accuracy of the estimate.

set n typical projects known as A1, A2, A3, ..., An, whose works feature set T = {t1, t2, ..., tm, | tj feature elements} ,set feature vectors for $\{\mu_{Ai}(tj) \mid i = 1, 2, 3, ..., nj; \mid j = 1,2,3 ..., m\}$, works close degree of $A_P$ and $A_Q$:

$$\sigma(A_p, A_q) = \frac{\sum_{k=1}^{m}(\mu_{Ap}(\mu_k) \wedge \mu_{Aq}(\mu_k))}{\sum_{k=1}^{M}(\mu_{Ap}(\mu_k) \wedge \mu_{Aq}(\mu_k))} \quad (p, \ q = 1, 2, 3 \ \ldots, \ n) \tag{1}$$

It can be proved that the formula (1) meet the nearness axiom system. Project event estimation, by the decomposition of the feature quantity (feature element), a comprehensive analysis estimated determination. Lot of practice shows that the effect of the engineering characteristics' amount of engineering events as the same, so they affect the size of the weight $\omega_1, \ \omega_2, \cdots, \ \omega_m$. And $\sum_{k=1}^{m} \omega_k$

Formula (1) can be changed

$$\sigma(A_p, A_q) = \frac{\sum_{k=1}^{m}(\mu_{Ap}(\mu_k) \wedge \mu_{Aq}(\mu_k))}{\sum_{k=1}^{M}(\mu_{Ap}(\mu_k) \wedge \mu_{Aq}(\mu_k))} \quad p, \ q = 1, 2, 3 \ \ldots, \ n \tag{2}$$

In the formula (2), determination of the weights is generally based on the feature amount of the typical engineering

analysis, to determine for its engineering relationships between events. I set for the differences due to nearness to reflect the degree of similarity between fuzzy sets (or nearness), and better able to characterize the relationship between sets of the same subset different subsets. Typically, select nearness formula, considering Hamming approach degree or (1) the nearness calculation method. Under normal circumstances, Hamming distance is reflected in the difference between the set and the set a preferred mode[2].

There are two Fuzzy set A, B, and their membership function $\mu_A(x)$ and $\mu_B(x)$ Hamming approach degree

Discrete circumstances:

$$\sigma(A,B)=1-\frac{1}{n}\sum_{k=1}^{m}\left|\mu_A(\mu_k-\mu_B)\right| \tag{3}$$

a continuous situation:

$$\sigma(A,B)=1-\frac{1}{\alpha-\beta}\int_{\beta}^{\alpha}\left|\mu_A(x),\mu_B(x)\right|dx \tag{4}$$

(3), (4) two formulas represents the average value of the curve and the same portion. $\mu_A(x)$ and $\mu_B(x)$

While (1) to determine the set of A, B closeness degree, the membership function for continuous values into

$$\sigma(A,B)=\frac{\int_{\beta}^{\alpha}\min\{\mu_A(x),\mu_B(x)\}dx}{\int_{\beta}^{\alpha}\max\{\mu_A(x),\mu_B(x)\}dx}=\frac{k_1}{k_2} \tag{5}$$

The above formula, and the area of the same portion of the two curves, and the two curves surrounded maximum area. This formula reflects the set of A, B of the same portion of its overall ratio. Depicts the relationship between the collection of the same subset and the overall. Calculating the nearness order to overcome, when the two functions are compared, regardless of its nature, shape, as long as the cross the same area, they close on the same "disadvantage of using the weighted average method to solve that was formula (6).

$$\sigma(A_p,A_q)=\frac{\sum_{k=1}^{m}\omega_k(\mu_{Ap}(\mu_k)\wedge\mu_{Aq}(\mu_k))}{\sum_{k=1}^{M}\omega_k(\mu_{Ap}(\mu_k)\wedge\mu_{Aq}(\mu_k))} \tag{6}$$

Mining projects, the characteristics of the project engineering events is not the same, they affect the size of the more scientific weight indicators, and at the same time can be seen to determine through statistical analysis of a typical project, event ratio (1) or (2) Hamming approach degree amendment, therefore, select (2) in this mine engineering event prediction formula based on nearness.

In the actual calculation, as close to the actual simplify the calculation, we often use the deformation formula (2), that is calculated using of Professor Wang Peizhuang raised close degree formula.

$$(A,B)=1/2[A\circ B+1(-A\oplus B)] \tag{7}$$

Systematic model of fuzzy mathematics used in engineering claims management

First elected to the same type has built 5-7 Typical events, and lists the typical collection of events that affect the name of each element of the value of the claim;

In similar elements to identify the baseline for comparison, the membership degree of 1, the other elements and then were compared to this reference element, in the closed interval [0, 1] in combination with event-specific circumstances according to the experience subjective conferred membership initial establishment of the "the contrast event fuzzy relationship coefficient table";

Turns calculate approach degree between the elements of the known typical event, and press order sorted, whichever

unit works in the collection corresponding fuzzy relation coefficient $T_{a1}$, $T_{a2}$, $T_{a3}$;

λ were calculated according to the formula of the typical engineering adjustment factor into;

In selected typical project, the nearness closest to a typical event likened For estimated the event, come to claim value intends to claim the event[3].

## THE CONSTRUCTION OF A SYSTEMATIC ENGINEERING CLAIMS MANAGEMENT MODEL

The claim is a science dealing with the engineering technology and the law. The claims issues involving a very range of content , require the relative personnel to have abundant engineering knowledge and practical experience in construction so that the claims issues raised are scientific and rational. They have the legal basis and factual evidence and skills in the claims file preparation, compilation and negotiations. Finally, the solution to the claims shows a certain degree of scalability and flexibility.

We analyze the problem as a model of neural network control problem, mainly through the three main objectives of the input of the control factors, systematic processing, and the output of the project claim effective control. In addition , neural network control model is multilateral feed forward network model which trained by multilayer feed-forward neural network. The model could be learnt and stored

massive of input - output mode mapping relationship, and do not need to reveal the illustration for mathematical equations of mapping relationship.. By using the method of steepest descent, the learning skill adjust the network's weights and threshold values substantially through the approach of back propagation

All in all the topology of the neural network model including input layer (input), hidden layer (hide layer) and output layer (output layer).

The model' assume
Inputs and outputs are analog in parallel;

It is input-output relationship of the network that determined by connection weights of each single layer, and there is no fixed algorithm;

The right adjustment factor adjust itself by acquiring information. The more it acquired, the more intelligence it will be;

the more hidden layer, the higher the accuracy of the network output, and damage to the individual weighting factor to have considerable impact on the network output Unless when wish to limit the output of the network? for instance, for instance, between 0 and 1, the S-type activation function should be included in the output layer. S-type activation function , generally, is in the hidden layer and output layer with linear activation function.

Nouns convention Symbol Description

$$a = f(\sum_{i}^{\Re} WiPi - \theta)$$ ---- Model input fitting formula

$$y = \sigma(s)$$ ----- response subfunction

$$\sigma(s) = \begin{cases} 1 & s \geq 0 \\ 0 & s < 0 \end{cases}$$ ----- threshold unit

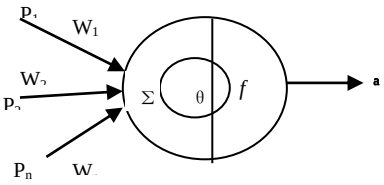
$$y = \sigma(s) = s$$ ----- linear elements

P = [p1 p2 ... pr] output vector
A = [a1 a2 ... as] T ----- output vector
Lr ----- learning rate, and 0 <lr <1, generally in the range 0.01 to 0.3,
Pj ------ normalized after a process input.
Gi ------ target control output (current input with two major database standard comparisons)
The response function is a Multilayer Network in terms of generalization WH learning rules as well as full value training to the differentiable nonlinear functions

Weight adjustment using learning algorithm of back-propagation, moreover, it is a multi-layer forward feedback neural network which the neurons transform function is S-shaped function. The output is a continuous quantity of

between 0-1; it can achieve the nonlinear mapping from input to output any.

The neural network meta-model
The common model



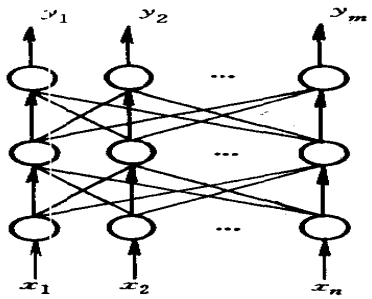

A summation operation

$$a = f(\sum_{i}^{\Re} WiPi - \theta)$$

Response function

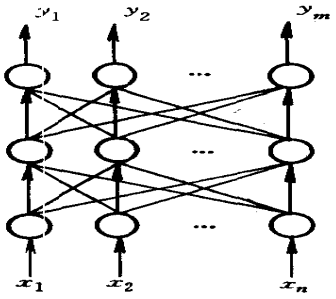
$$y = \sigma(s)$$

The neural network submodel
Before the network (a)



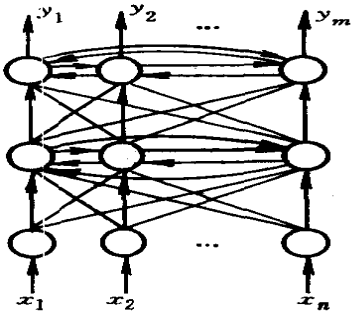

a)

Before the feedback from the output to the input to the network (b)




a)

Is used to store a certain pattern sequence layer interconnect to the network (c)




c)

the model response function

The threshold value unit $\sigma(s) = \begin{cases} 1 & s \geq 0 \\ 0 & s < 0 \end{cases}$

Linear unit $y = \sigma(s) = s$

Nonlinear unit: Sigmoid function

$$\sigma(s) = \frac{1}{1+e^{-s}}$$

$$\sigma(s) = \tanh(\beta s)$$

The main principle of the network model:

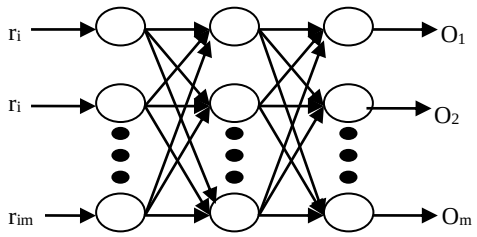
Function Approximation: training a network with an input vector and a corresponding output vector approximation of a function

The pattern recognition and classification: with a particular output vector with the input vector linked; the input vector to be classified as defined in a suitable manner;

Data Compression: reduce the dimension of the output vector in order to transmit or store

has a strong generalization performance: make the network the learning function smoothly, so that the network can be a reasonable response other than training input generalization performance only on the training input / output of the maximum range of the data, that is, the network within the interpolation characteristic, and having an outer interpolation. Input exceeds the maximum training value is bound to produce a large output error.

Multilayer BP network is a three or more multi-layered neural network, each layer consists of a plurality of neural elements, is shown in Figure 1, each neuron in its left and right between the layers to achieve fully connected, that each neuron left layer each neuron and right layer by connection, no connection, and up and down the neurons[4].




**A model of neural sub-networks**

Located at the network input vector: P = [P1 P2 ... PR], T corresponding network output vector: A = [A1 A2 ... AS] T

Input vector through the network before the transmission network competition, the activation function for hard limit binary function, competitive network activation function of the weighted input, output, while the output of other neurons are 0 and won the largest node. Weight adjustment (in training while working) competitive network through competition and obtained the winning node, the winning node connected weights to adjust. The purpose of adjusting the weight is to make the right value as its input the difference between vectors is smaller and smaller, so that the competition after training the network weights to be able to represent the characteristics of the corresponding input vector.

The formula of the competing networks correction weights Δwij = lr * (pj-wij) where in lr is the learning rate, and 0 <lr <1, generally in the range 0.01 to 0.3, PJ elapsed after the normalization process inputs. Each of the layer closest to the input vector neurons, each weight value adjusted by leaving weight vector gradually tends to these input vectors. Thereby competing networks by learning identification appears in the network input vector, and is divided into a certain category.

Competitive network learning and training process, in fact the divided input vector clustering process, making the winning node between the input vector representative of the weight vector victory input vector, the competitive

input layer of the network node r known input vector decision. Competitive layer neuron number s is determined by the designer, under normal circumstances, according to the dimension of the input vector and estimates, and then appropriately increase some number to determine.

Competing networks containing two weights, so the activation function of the weighted input and is also divided into two parts: from the input node of the weighted inputs and N from competitive layer mutual inhibition of the weighted input and G. For the i-th neuron, the weighted input from the input node and the weighted input from layer mutual inhibition for

$$g_i = \sum_{k \in D} w_{ik} \times f(a_k)$$

For the i th output neuron, assuming the competition winner, ak = 1, k = i,

Thus AK = 0, k = 1,2, ... s, k $\neq$ i,

$$g_i = \sum_{k=1}^{s} w_{ik} \times f(a_k) = w_{ii} > 0$$

Competition after the i-node "lose" and "win" node l,

$$g_i = \sum_{k=1}^{s} w_{ik} \times f(a_k) = w_{il} > 0$$

ak = 1, k = l, and thus AK = 0, k = 1,2, ... s, and k $\neq$ l,

BP network is trained by learning on learning mode is provided to the network, the activation value of the neuron from the input layer through the intermediate layer is transmitted to the output layer, the output of each neuron in the output layer corresponding to the input mode network response. Then, reduce the desired output and the actual output error of principle, from the output layer through the middle layer, and finally back to the input layer correction connection weights. This correction process is conducted from the output to the input layer by layer, so to call it "the error back propagation algorithm. With correct this error back propagation training is ongoing, and the network in response to the input mode will continue to improve.

BP network hidden layer in the middle position and the corresponding learning rules to follow, such a network can be trained, so that it has the ability to identify nonlinear model for dynamic processing of claims database[5].

The network model's characteristics

Input and output data are parallel analog

The input-output relationship of the network layers is decided by connected weight factors, there is no fixed algorithm

The right factors are regulated by learning signal. More learning, more intelligent network the more hidden layer, the higher accuracy of the network output, And damage to individual rights factor will not have a big impact on the network output, Only when hope to restrict the output of the network. Such as limited between 0 and 1, then only when S-type activation functions should be included in the output layer. S-type activation function in general, is in the hidden layer and output layer with linear activation function.

Seen from the above, the work on the claims has complex and comprehensive basic characteristics. So to construct a claims management system is by no means a new idea but to satisfy the rapid development of the international engineering. Interpretation, processing and solving the sensitive and significant issues in the claims during the construction process, is not just a purely technical issue. Within the global economic system and the knowledge-based era, to solve the problem with the system theory is one of the feasible ways. From the properties of the system, combined with the characteristics of the work on the claims, claims management system can be classified as input system, integrated analysis system, and the output system. Input system includes four input factors: changes of contract conditions, changes of engineering condition, schedule changes, and changes of the construction plan; output system includes two impact indicators of time and cost; integrated analytical system includes the analysis of the indicate change caused by the claims, calculation of integrated content claim and so on. The specific systematic model is shown in Figure1

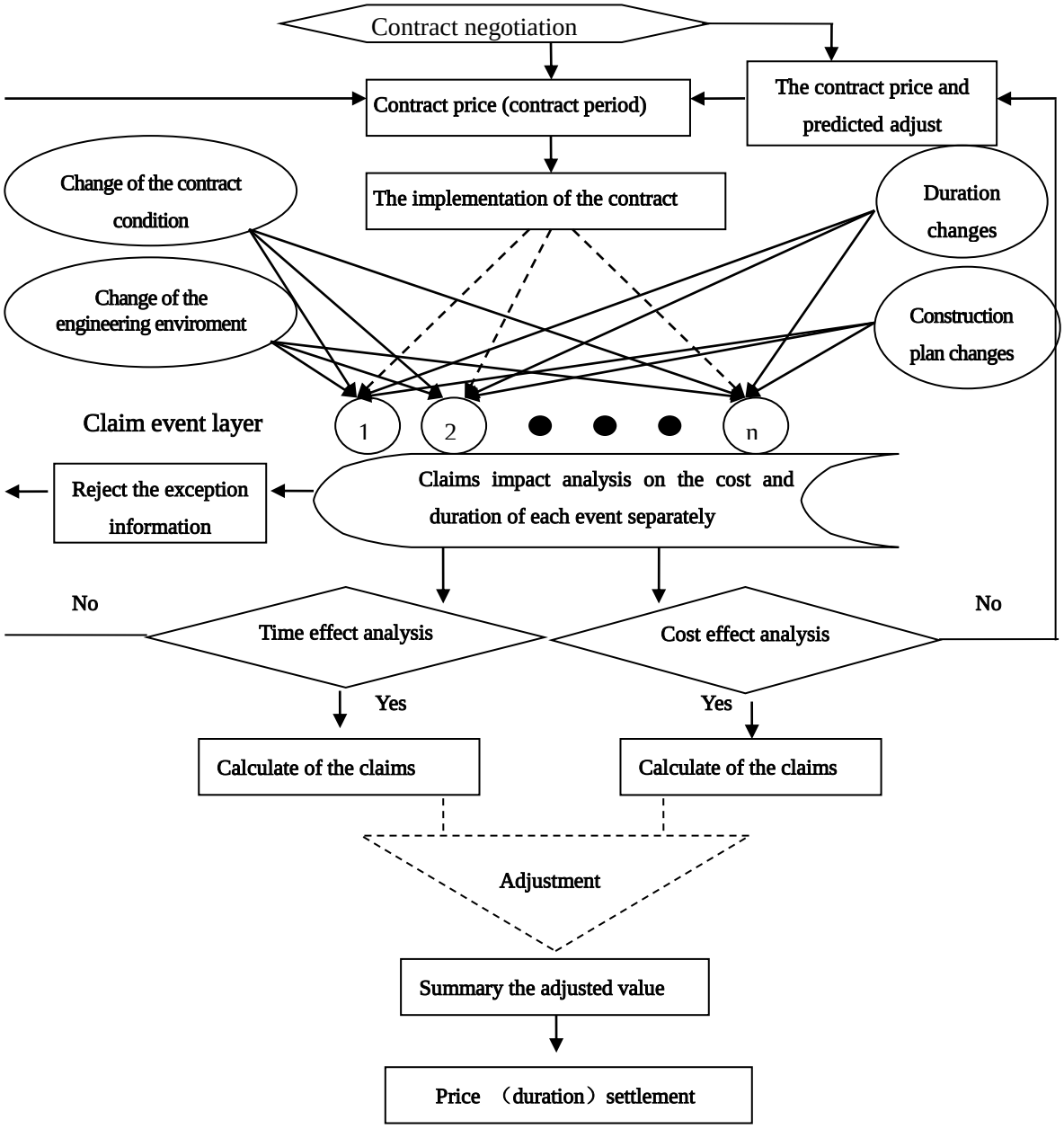



**Fig.1. Systematic model of project claim management**

## THE KEY TO CONTROL THE SYSTEMATIC MODEL OF PROJECT CLAIM MANAGEMENT

The project claim management system is divided into three subsystems, including the input system, a integrated analysis system, and the output system; each subsystem includes the specific work. The control points of the model are the key points of these three subsystems.

*1. To control the model input system of the model*

There is a lot of variation in each contract involved in the project. How their combined effects are? Whether they can cause the project claim? If the owner is able to get a qualitative judgment in advance, he can master the initiative in the construction claims. Therefore, to seize the cause of the claims and determine the basic types of the claims are the premise of the claims management system and the foundation of operating the claims management system. In this paper, we call them the claims management input factor system. It is a key to evaluating whether to start and how to start the claims.

Based on the digital statistics from the engineering and the causes of the claims, the reasons for the claims in the model can be divided into the following categories: contract conditions changes, engineering environment changes, schedule changes, and construction plan changes. We put these four major categories of factors into the system, and

then summarize each class of claims caused by the similar events to get the claim event layer.

Contract Management is the first link to control the project claim management system

In accordance with the project claim systematic management model, we find that contract management has become the most important part of the project claim management system. The key checking points of the contract management system includes cost control, schedule control and quality control.

The cost control is based on the contractor's planning costs. In claim management, the reasonable planning cost of the project is a very important means of response for the contractor to find the claim opportunities and potential claims opportunities. We can analysis the costs variance through comparing the plan cost with the actual cost as well as financial records to get the chance for claim.

The schedule control directly affects the maximization of the cost-effectiveness of the project. The schedule control in claim management should not be overlooked, and it is one of the necessary conditions to provide strong support for the claim, so both sides of the contract are trying to use it to prevent claims and counterclaims. In order to identify the reasons for the claim, the actual comparative law and variance analysis method should be used. For this purpose, the contractor's schedule table should be well-prepared and the critical path should be adjusted.

Quality control is equally important to the project claim. Contractor should be responsible for the following items: construction quality of the projects under construction, the damage caused by the risk other than the owners bear, defects defined by the contract, and construction quality in the liability period. So contractor shall take methods to prevent owners from planning counterclaims, including drawing up the project quality control objectives, establishing accountability system for project quality, ensuring good subcontractors, making the quality information for date and standardization, and acting according to the contract quality and technical requirements in the contract.

*To control the integrated analysis system and output system*

According to the systematic model of the project claim management, we input the claim events into the model to analyze the effect, and then format the new claim events layer in accordance with the effect on the cost and the duration, to analyze the result of the new claim events. According to the main factors of the claim, the comprehensive project claim results can be divided into the following four categories :(1) Prolongation claim (2) Cost claim (3) Prolongation claim and cost claim (4) No claim. Project claim is very complicated and tricky, the contractor shall be responsible for the claim event to assess the claim and list its items in detail to analyze and evaluate. They should focus on the following four aspects: whether the claim events or interference event are conclusive; whether the claim goals are accurate and the items of the claim are seamless; whether the calculations of the amount of the claim are in line with the principle of fairness and reasonability; whether all the analysis methods are based on ideas, whether the steps and solutions are careful[6].

## THE PRACTICE OF IMPROVING PROJECT CLAIM MANAGEMENT AND CLAIM MANAGEMENT SYSTEM IN CHINA

The claim management in construction projects in China is still not scientific or standard enough. There is still a considerable gap between the construction contract management, enterprise management and claim work requirements. And this gap is particularly evident compared with foreign mature claim management and dispute settlement mechanism. According to systematic model analysis for project claim management in this paper, domestic construction enterprises should strengthen awareness of contract and claim, enhance the ability of self-protection, and establish a project management system as the core of the project claim.

The input stage of the claim management systematization model, we need to establish the correct treatment of the concept of claim. It is very necessary for contractees to share risk together under the conditions of market economy, changeable design and construction. The contractor or the owner should be normal to deal with the claim between them.

In the implementation phase of the claim management systematization model, we need to improve the quality of the management team, strengthen the raining and the application of specialized claim personnel, and pay highly for the employed foreign personals and experts so as to catch up with the international standards better and faster. Claim is not only a science and management, but also an skill. It is a science in the edge of the natural science and the social science, involved in the engineering, project management, accounting, law, public relations, and many other sciences. The claim personnel should focus on the integrated application of the combination of knowledge in the course of practice with continuous learning, experiencing, and constantly summing up in order to do well in the work of claim and establishment of the perfect management system. The project claim is focusing on the basis. A

successful project claim should follow the claim procedure. Following the items of FIDIC Conditions of Contract and the basic structure of the management system as previously described, and establishing a perfect management system is the key work and a basic way to solute problems existing in our project claim management work. A higher successful rate of claim depends on a well-organized claim plan, which is based on a clear and detailed management system. For the construction enterprises, we should set up a claim management department and the project manager is indirectly responsible for it. The claim management department records working matters in diary form, and collect the proof materials, such as the letters from the owner. Once the claim event occurs, the claim management department can claim to owner by following the procedure of FIDIC Conditions of Contract and executing strictly in accordance with the various laws and regulations.

In the output stage of claim management systematization model, we carefully adjust the value of each claim, summary the adjusted claim, and make the final claim results. It's not necessary to use all skills in the adjustment and dispute settlement process, we should start from the lower precautions to try to resolve the issue through consultations and negotiations. From the domestic and foreign existing experience, we should establish and learn from the following claim technology: firstly ,the system of dispute consideration; secondly, the mechanism of dispute mediation; thirdly, the binding arbitration.

In short, the use of system approach to deal with and solve problems of project claim emphasizes on claim managers with overall, relevance, optimal, practical and comprehensive qualities. The claim work has always been throughout the project. The contractors that do not pay enough attention to the claim at the beginning of contract or lack of claim experience in the performance of contract often suffer losses. Therefore, it's essential to establish an adaptive model of project claim analysis. With the continuous development of China's construction market and the increasingly fierce competition in contractors, the claim management has paid much attention to carrying out work on claim. The full understanding of the claim, the correct treatment of claim, the specification of claim behavior, the mastering skills of claim and processing claim business, and establishing an efficiency claim management system with efficient operation, could respond to the needs of market competition.

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