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Project Cost Prediction for Building Complexes Based on Grey BP Neural Network Model

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Abstract: Engineering cost prediction is a common topic in the construction field, but there is a problem of large prediction error. In order to avoid investment loss, a method of project cost prediction for building complex based on gray BP neural network model is designed. The construction area is divided into two factors: above-ground construction area and underground construction area, the cost influencing factors of the construction project are extracted, the density of data points at the center of the construction point is defined, the pricing model of the construction group project is optimized, the cost of similar projects is projected, and the cost prediction method is designed using the gray BP neural network model. Experimental results: The average values of relative errors of the designed construction group project cost prediction method and the other two construction group project cost prediction methods are: 3.596%, 6.505% and 6.213% respectively, indicating that the designed construction group project cost prediction method is more practical after combining with the gray BP neural network model.

1. Introduction

In the process of carrying out the project cost forecast of the construction group project, the key and important links of cost and project management lie in how to effectively control the project cost. From the perspective of investment, the management of building complex engineering mainly includes investment estimation in the early stage, design estimate in the stage of scheme design expansion design and construction drawing design, project budget in the bidding stage, project settlement and project final account after completion, etc [1-2]. The focus of construction group project management is on the investment estimation of construction cost. Among them, pre-construction cost estimation is particularly important, not only affecting the preparation of investment plans, but also playing a key role in the cost control of later projects. Experience statistics show that accurate cost forecasting increases the likelihood of the whole project by 30 -75 %, therefore, accurate and scientific cost forecasting is crucial for the smooth implementation of the project. The investment estimation of the construction cost of a building complex directly determines the profitability of a project, and an important part of the investment estimation of a building complex project is the cost of construction and installation works, i.e., the cost of a building complex project [3-4]. In the past, the prediction of construction cost of building complex

projects often focused on traditional statistical analysis and simple regression theory. At present, the empirical evaluation method is usually used to predict the cost of construction projects, and most of the project cost prediction still stays on the basis of “three sexes and one static”, i.e., the uniformity, directive and comprehensive of the quota, and the static nature of work, material and machine, which causes the cost prediction to take a long time, large workload, slow speed, time lag of prediction, and accuracy of prediction. The time lag and the accuracy of the forecast are poor. Due to the many and complex factors influencing the construction cost of the construction group, and the collection of data of previous construction cost has high randomness and vagueness, and when selecting indicators for estimation, most of them have a certain consistency and are uniform in a region or construction industry field, etc., without taking into account the management level of construction units, professional ability and factors such as project quality, safety and construction period, and the market The economic system is also not well adapted to the market. In addition, if there is a large error in the cost forecast, it will reduce the rationality of investment decision, and may also adversely affect the quality of on-site construction, and in serious cases, it may lead to reworking or even stoppage of the project, thus causing significant property losses. Therefore, it is necessary to conduct a detailed study on the project cost prediction of building complexes.

2. Extraction of Cost Impact Factors for Construction Projects

China usually adopts the bill of quantities pricing method to measure and price the construction group project. When using the bill of quantities pricing, the main parts of the project cost are component project cost, measure project cost, other project cost, fees and taxes. The cost of the construction group project refers to: the cost of the construction group project is the total price of the construction project, which refers to the total price of the transaction formed in the expected or actual market transaction activities for the completion of a certain project, here the cost of the construction group project mainly refers to the total cost of the construction and installation works of the construction project. Among them, other project costs mainly contain provisional amounts, provisional estimates, day labor, general contracting service fees, etc. The fees and taxes are non-competitive costs, and thus should be considered in determining the main characteristic factors of the project from the distribution of sub-project costs and measure project costs. The sum of the costs incurred during the construction and installation is called the construction and installation engineering cost, that is, the engineering cost[5-6]. It includes direct and indirect costs, profits and taxes, mainly composed of interior decoration costs, construction costs and equipment and installation costs. Among them, the construction cost is mainly composed of structures, buildings, special decoration works, etc., and the equipment and installation cost is composed of water supply and drainage, electrical lighting, elevators, gas pipelines, etc. Through data analysis, it is found that the cost of reinforced concrete project accounts for as much as 25%-42% of the total project cost, and accounts for as much as 50% of the civil division project cost, so it is necessary to focus on the characteristic factor of reinforced concrete. The factors influencing the cost of construction projects are shown in Figure 1.

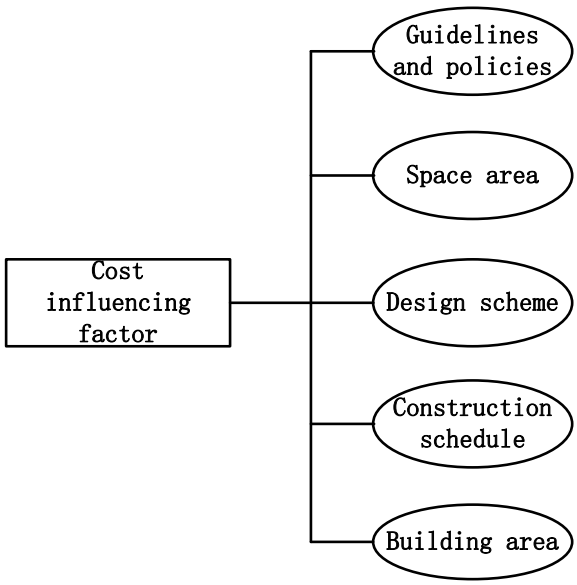

Fig.1 Cost Influencing Factors of Construction Projects

According to Figure 1, it can be seen that there is a significant range fluctuation in the proportion of the costs accounted for by the component works other than reinforced concrete works because each building will differ in the construction form and engineering characteristics. Building group projects are often affected by some uncertainties in the construction process, and these uncertainties can cause the project cost to drop or rise. Therefore, the cost of the whole process of construction projects is closely related to the influencing factors affecting the cost of construction projects during the whole construction cycle of construction projects [7-8]. Building area refers to the product of the outsourcing dimensions of the length and width of the building multiplied by the number of floors. Due to the fluctuation of material price, change of supply quantity and different level of quotas in different regions, it will cause changes in price and quantity of labor, machinery and materials that make up the project cost, thus affecting the accuracy of estimation of total project cost. The building area is composed of usable area, auxiliary area and structural area, and the building area is divided into two factors: above-ground building area and underground building area. Standard floor construction area that belongs to the standard residential use of building floors of floor space. The pile foundation category of the construction project is also one of the important factors affecting the construction project cost. The pile foundation of the construction project mainly includes prefabricated pipe piles and bored piles as well as artificially dug piles, etc. The difference in construction project cost is also more obvious due to the different choices of pile foundation. The quality level of the project is also one of the factors affecting the cost of construction projects. The main reason is that the increase of building area will cause the increase of doors, windows, scaffolding and other materials required for construction, which will affect the cost of construction and thus the accuracy of cost estimation. In addition, the number of building floors, building functions, pricing methods, and contracting methods will all have an impact on the level of cost estimation. Based on the above description, the steps to extract the cost influencing factors of the construction project are completed.

3. Optimizing the Project Pricing Model for Building Complexes

From the perspective of the owner (investor), the construction cost refers to the investment cost of fixed assets required in the whole construction process of the project, i.e. the construction cost of the project, which is the measure to determine the price and measure the investment benefit when

the investor sells the project as the main market supplier. Based on the optimization of the construction plan and design plan, in order to ensure that the construction cost is controlled within a reasonable range and does not exceed the approved cost limit, effective measures and methods need to be taken at each stage of the construction process. In the fixed price model, the volume of work and the fixed unit price multiplied, the sum of the total will get the price of the project, this method will be a combination of volume and price, is a widely used in the early engineering cost pricing model. In other words, the estimated cost of the preliminary design stage should be controlled on the basis of the estimated investment price, the revised estimate of the technical design stage should be controlled on the basis of the estimated cost, and the budget cost of the construction drawing design stage should be controlled on the basis of the revised estimate, so as to finally achieve a reasonable use of human, material and financial resources and achieve better investment efficiency [9-10]. China has adopted a single fixed-rate pricing model for a long time, and this pricing method, as an engineering cost management system, is compatible with the early planned economy of China. For the reasonable determination of engineering cost, it is to reasonably determine the investment estimate, estimated cost, revised estimated cost, budgeted cost, contracted contract price, settlement price and completed final price in each stage of the project construction process, among which the investment estimate is the first stage and its importance is particularly important. In the process of optimizing the project pricing model of the building complex, the density of data points at the center of the building point is defined:

$$G_{\varepsilon} = \sum\sum\left(\frac{\left\|\alpha_{\varepsilon} - \beta_{\varepsilon}\right\|}{\gamma}\right)^{2} \tag{1}$$

In equation (1), α denotes the data points of the range building clusters, β denotes the density index value, γ denotes the data point vector, and ε denotes the clustering influence radius. On the basis of Equation (1), the density correction formula of data points is derived as follows.

$$F = \left(\frac{\left\|\alpha_{\varepsilon} - \beta_{\varepsilon}\right\|}{\gamma}\right) - \exp\left(\left|\varphi - \varpi\right|^{2}\right) \tag{2}$$

In equation (2), φ denotes the input variable and ϖ denotes the number of clustering centroids. In this pricing model, the state generally sets a unified standard of quotas, and in this way achieves the purpose of macro-control and management of prices in the construction market. The bill of quantities is an itemized list prepared in accordance with the relevant regulations, which includes the names and quantities of each component project, It runs through the whole process of project implementation. In order to further seek the maximization of cost savings, it is necessary to control the construction cost within the scope of the plan, that is, on the premise of ensuring the construction period and quality requirements, take appropriate management measures to reasonably control the space-time cost, including organizational and economic measures. The bill of quantities is an important part of the bidding document. Its pricing model is used to determine the final cost of the project. It is mainly based on the quantities calculated according to the unified rules, using the obtained price information or empirical data, and finally multiplying the two for confirmation. It plays a vital role in the process of project bidding. In the project proposal stage, the construction unit, according to the relevant national standards and preliminary design documents, after review and verification by the relevant departments and approval, as the proposed project real estate developers to carry out preliminary work and long-term plans to control the cost. The bill of quantities pricing model reflects the characteristics of price determination by the market in a free

competitive market, because in this pricing model, buyers and sellers in the construction market are free to bid based on the current situation of supply and demand, etc., and reach an agreement to determine the final price of the project and sign the project contract. Therefore, the bill of quantities pricing mode is a pricing method gradually formed under the precondition of continuous development, growth and maturity of the construction market, which is a sign of the increasing perfection of the construction market. According to relevant regulations, the investment estimate of the project in the feasibility study stage is prepared, which is reviewed and verified by the relevant departments and approved as the control cost of the construction project, and the purpose of cost control at this stage is to control the estimated price within the control cost of the project proposal. At present, China adopts the bill of quantities pricing mode, which is more in line with the goal of "gradually establish a price mechanism based on market price formation" in the reform of construction cost system, its ultimate goal is to improve the efficiency of resource allocation and let the construction market and buyers and sellers jointly determine the price. In the preliminary design stage, the total preliminary design estimate of the construction project is prepared in accordance with the relevant provisions, and after being examined and verified and approved by the relevant departments, it will be used as the maximum limit of the project cost of the proposed project, and the purpose of cost control at this stage is to control the estimated price within the estimated price.

4. Design of Cost Prediction Method Based on Grey BP Neural Network Model

The gray BP neural network model has a strong ability to find and grasp the law, he can quantify the actual problem, find the law that is not easy to be found in the actual question, and learn through the law, and constantly pursue the change and development of things [11-12]. Engineering cost prediction means to predict the cost of the whole project. According to the different objects of engineering cost, there are differences in the prediction of engineering cost. Engineering cost prediction precisely refers to the analysis and statistics of the staff through similar construction cost data in the past in the early stage of the construction of engineering projects. The use of gray BP neural network model for the prediction of engineering cost of building complexes can solve some sample nonlinearity problems to some extent [13-15]. The input and output values of the gray BP neural network model are derived under the condition that the input values are known, and the expression formula is as follows.

$$E = \sum_{j=1}^{i} h_{ij} \times \left(\frac{\left| h_{ij} - 1 \right|}{2} \right) \tag{3}$$

$$net = \left(\frac{g - \sigma}{h_{ij}} \right)^2 \tag{4}$$

In equations (3) and (4), h denotes the tilt parameter, i denotes the number of neurons, j denotes the hidden layer output vector, g denotes the threshold function, and σ denotes the neural network row vector. Since the ultimate goal of adjusting the weights is to allow the error to decrease gradually, it is necessary to calculate the upper limit of the values taken by the variables, as follows.

$$\gamma = \sum \frac{1}{r} \times \left| w - k \right| \tag{5}$$

In equation (5), r denotes the weight vector corresponding to the neuron, w denotes the

interval gray number, and k denotes the neuron node. From the above expressions, it can be seen that the project cost refers to the investment in fixed assets of the project, which includes the purchase cost of equipment and utensils, construction and installation project cost, other costs of construction, interest during the construction period and reserve cost, etc. Then, on the basis of statistical analysis of previous engineering data, we summarize the law, analyze it in depth, and then project the current or future cost data of a similar engineering project. In the process of statistical analysis of cost data of similar engineering construction projects in the past, it is necessary to summarize the law of change of cost data of similar engineering construction projects in the past. From the perspective of a contractor or an issuer, the construction cost is the total price of construction works and building installation works expected or actually required for a certain project in the market of equipment, land, technology and labor through transactions such as bidding or tendering. Among them, a single project or a stage in the project can be used as the subject of bidding. And when summarizing the law of data change, it is often necessary to combine different mathematical theories to unfold. Different mathematical theories show different abilities in solving the problem of project cost prediction, i.e. different mathematical theories or models are selected for project cost prediction. For the preparation of construction drawing budget in the construction drawing design stage, it is mainly calculated according to relevant regulations and the initial design construction drawing, and the main purpose is used to verify whether the budgeted cost (construction drawing design stage) exceeds the approved preliminary design estimate. After an in-depth analysis, we found that the reason for the differences in the project cost prediction results is often due to the different methods chosen in the statistical analysis, which causes the change pattern of the summarized cost data to be different and, finally, causes the differences in the cost projection of new construction projects and affects the accuracy of the project cost prediction results. Project cost prediction occurs in the early stage of project construction, and can be used to understand the construction cost of the whole project. The project cost forecast is the basis for the construction unit to make bidding quotation, an important reference for the construction unit to make investment decision, and a tool for both A and B to control the cost. It is also one of the important management tools for both sides. The fund use plan in the whole construction stage is very important. It has an extremely important impact on all fund decisions in the construction process of the whole project and is the basic guarantee for the smooth implementation of the project. How to make reasonable investment of funds depends on the time value of funds, when and how much funds are invested in the construction process are related to the cost of the construction phase, and reasonable investment of funds can reduce the interest on loans during the construction period to reduce the cost. The procedure of fixed-price pricing mainly includes the calculation of engineering quantity and engineering price. After the engineering quantity is determined according to the unified calculation rules, the corresponding engineering fixed-price can be applied to calculate the engineering cost, and then profits and taxes are taken into account to determine the final engineering cost or bidding price. The most important thing is to maintain the accuracy and speed of the project cost prediction. A fast and accurate construction project cost prediction can provide good decision support for investors. For Party B, especially the general contractor of construction, it increases the valuable time for thinking about bidding. Of course, the accuracy of the construction cost forecast will also directly affect the cost, progress and quality control of the later project construction progress.

5. Simulation Experiments

5.1 Selecting the Data Set

In order to ensure the accuracy of engineering cost data estimation of the proposed project, it is necessary to collect engineering data similar to the selected engineering cases as training samples. The case in this chapter is a residential project in S city area. In the process of collecting data, considering the different price levels of labor and materials in different areas, and the differences in construction techniques and technical solutions, residential projects in S city and its surrounding cities are selected for the sample selection. The cost indexes of human, material and machine cost issued by the cost management department were used to adjust the cost indexes of each sample project to reduce the impact of dimensional differences on the results, and the calculation formula was as follows.

$$\begin{cases} M = T \times \dfrac{L}{L_0} \\ N = \sum_{e=1} x_e y_e \end{cases} \tag{6}$$

In formula (6), T and L is the comprehensive cost index of the proposed project corresponding to the construction team and the region before the regional adjustment, L_0 is comprehensive cost of each sample project corresponding to the period of regional preparation, y and x is material and labor costs of the construction team, and e is proportion of each cost to the cost. The project consists of a 42-story skyscraper office building, a 6-story commercial podium and a 3-story basement in a commercial office complex, with a total land area of about 15612 m2, a total construction area of 304369 m2, including a total above-ground construction area of 245626 m2 and a total underground construction area of 58743 m2. The highest building height of the office tower is 240m, and the highest building height of the commercial podium The 12 engineering feature indicators of each project are used as a fuzzy clustering feature quantity. The proposed project numbers to be audited are set, and then the 220 sample projects are numbered accordingly, and at the same time, the program is written using MATLAB.

5.2 Experimental Results

The project cost prediction method of building complex based on hierarchical analysis, the project cost prediction method of building complex based on data mining, and the project cost prediction method of building complex designed in this time were selected for comparison and testing, and the relative errors of prediction of the three methods were tested in different types of building structures respectively, as shown in Table 1.

Table 1 Relative Error of Prediction for Brick and Mortar Structures (%)

Number of experiments	Project cost prediction method for building complexes based on hierarchical analysis	Data mining based project cost prediction method for building complexes	Project cost forecasting method for this design of building complex
1	6.155	6.288	3.215
2	5.312	5.947	4.011
3	6.411	5.615	3.976
4	5.849	5.847	4.223
5	6.364	5.648	4.159

Table 2 Relative Error of Frame Structure Prediction (%)

Number of experiments	Project cost prediction method for building complexes based on hierarchical analysis	Data mining based project cost prediction method for building complexes	Project cost forecasting method for this design of building complex
1	4.615	4.122	2.005
2	4.548	4.366	2.134
3	3.619	4.519	2.697
4	3.884	3.878	1.465
5	3.647	3.749	1.708

Table 3 Relative Error of Cylinder Structure Prediction (%)

Number of experiments	Project cost prediction method for building complexes based on hierarchical analysis	Data mining based project cost prediction method for building complexes	Project cost forecasting method for this design of building complex
1	10.216	8.747	5.021
2	9.845	8.613	4.715
3	9.212	8.546	5.633
4	8.749	7.991	4.719
5	9.147	9.313	4.254

From Tables 1 - 3, it can be concluded that the average values of relative errors of the project cost prediction method of the building complex designed in this time and the other two project cost prediction methods of the building complex, as shown in Figure 2.

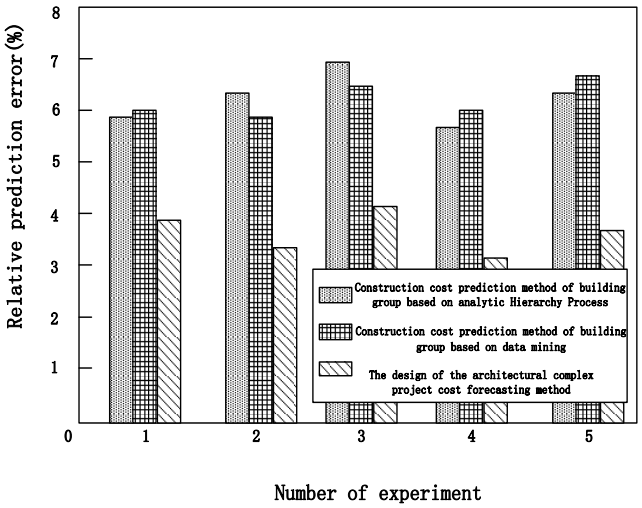

Fig.2 Average Value of Relative Error of Three Methods for Project Cost Prediction of Building Complexes(%)

In different building structures, the main materials used are different, and this difference will eventually be reflected in the cost of the building complex project. Comprehensive Figure 2 shows that the average values of relative errors between the cost prediction method of the building complex project designed in this time and the other two methods for predicting the cost of the building complex project are: 3.596%, 6.505% and 6.213% respectively, indicating that the error of the cost prediction method of the building complex project in the paper is lower.

6. Conclusion

In order to solve the problem of large error in engineering cost prediction in the construction field, and to scientifically and reasonably determine the investment estimation, avoid investment

loss, and simplify the preparation of investment estimation, this paper uses the grey system theory to design a cost prediction method based on the learning process of standard grey BP neural network model. Finally, compared with the other two groups of construction team project cost prediction methods, the results show that the design construction team project cost prediction method combined with the gray BP neural network model is more practical, creating a new value for the application of the construction complex cost prediction method, and also contributing to the stable development of the construction industry. In the future, we will focus on the impact of this design cost prediction method on complex projects in green buildings.

References

[1] Sdino L, Brambilla A, Dell'Ovo M, et al. Hospital Construction Cost Affecting Their Lifecycle: An Italian Overview[J]. Healthcare, 2021, 9(7):888.

[2] Oyieyo P A, Rambo C M, Ndiritu A. Ranking the prevalence of construction cost overrun risk factors in completion of public-private partnership projects[J]. International Journal of Research in Business and Social Science, 2020, 9(5):351-356.

[3] Jung S, Pyeon J H, Lee H S, et al. Construction Cost Estimation Using a Case-Based Reasoning Hybrid Genetic Algorithm Based on Local Search Method[J]. Sustainability, 2020, 12(19):7920.

[4] Alfraidi Y, Alzahrani S M, Binsarra F, et al. Impact of political risk on construction cost in PPP project in KSA[J]. International Journal of ADVANCED AND APPLIED SCIENCES, 2020, 7(5):6-11.

[5] Prokhorova Y S, Karakozova I V. Organizational Framework of Construction Cost Management in the Context of the Implementation of Targeted Investment Programs (Through the Example of Moscow)[J]. Economics and Management, 2020, 26(6):656-664.

[6] Yousif J H, Majeed S, Azzawi F. Web-Based Architecture for Automating Quantity Surveying Construction Cost Calculation[J]. Infrastructures, 2020, 5(6):45.

[7] Vm A, Shao Z B, Tlkr B. Early construction cost and time risk assessment and evaluation of large-scale underground cavern construction projects in Singapore - ScienceDirect[J]. Underground Space, 2020, 5(1):53-70.

[8] Musakanya M M. Construction Cost Estimates Related Risks[J]. International Journal of Sciences, 2020, 9(1):61-65.

[9] Kaiser M J, Liu M. Cost factors and statistical evaluation of gas transmission pipeline construction and compressor-station cost in the USA, 2014-2019[J]. International Journal of Oil Gas and Coal Technology, 2021, 26(4):422.

[10] Li Junda, Li Yuanfu, Wang Guangkai. A Highway Engineering Cost Prediction Model Based on CBR[J]. Journal of Highway and Transportation Research and Development, 2020, 37(6): 44-49, 67.

[11] Gu Runping, Lai Jinghan, Wei Zhiqiang. Prediction Method of Flightdelaybased on Grey GA-BPneural Network[J]. Computer Simulation, 2022, 39(5): 38-43, 59.

[12] Chai Zhijun, Ouyang Zhonghui, Yue Jiong. An Improved Prediction Model of Grey BP Neural Network[J]. Ordnance Industry Automation, 2020, 39(10): 84-88, 96.

[13] Feng Qianzhen, Huang Teng. Application of Gray BP Neural Network Combination Model in Dam Settlement Monitoring[J]. Journal of Gansu Sciences, 2020, 32(1): 14-17.

[14] Sun Chengsheng, Zhang Hongmin, Wang Yan, et al. An Improved Prediction Method of Photovoltaic Output Based on Grey BP Neural Network[J]. Journal of Chongqing Institute of Technology, 2020, 34(2): 217-221.

[15] Jin Lin, Ma Zhongyun, Wang Honghong. Forecasting of Carbon Emission Trading Price based on Grey BP Neural Network Model[J]. Journal of HeiBei University of Environmental Engineering, 2020, 30(1): 27-32, 41.