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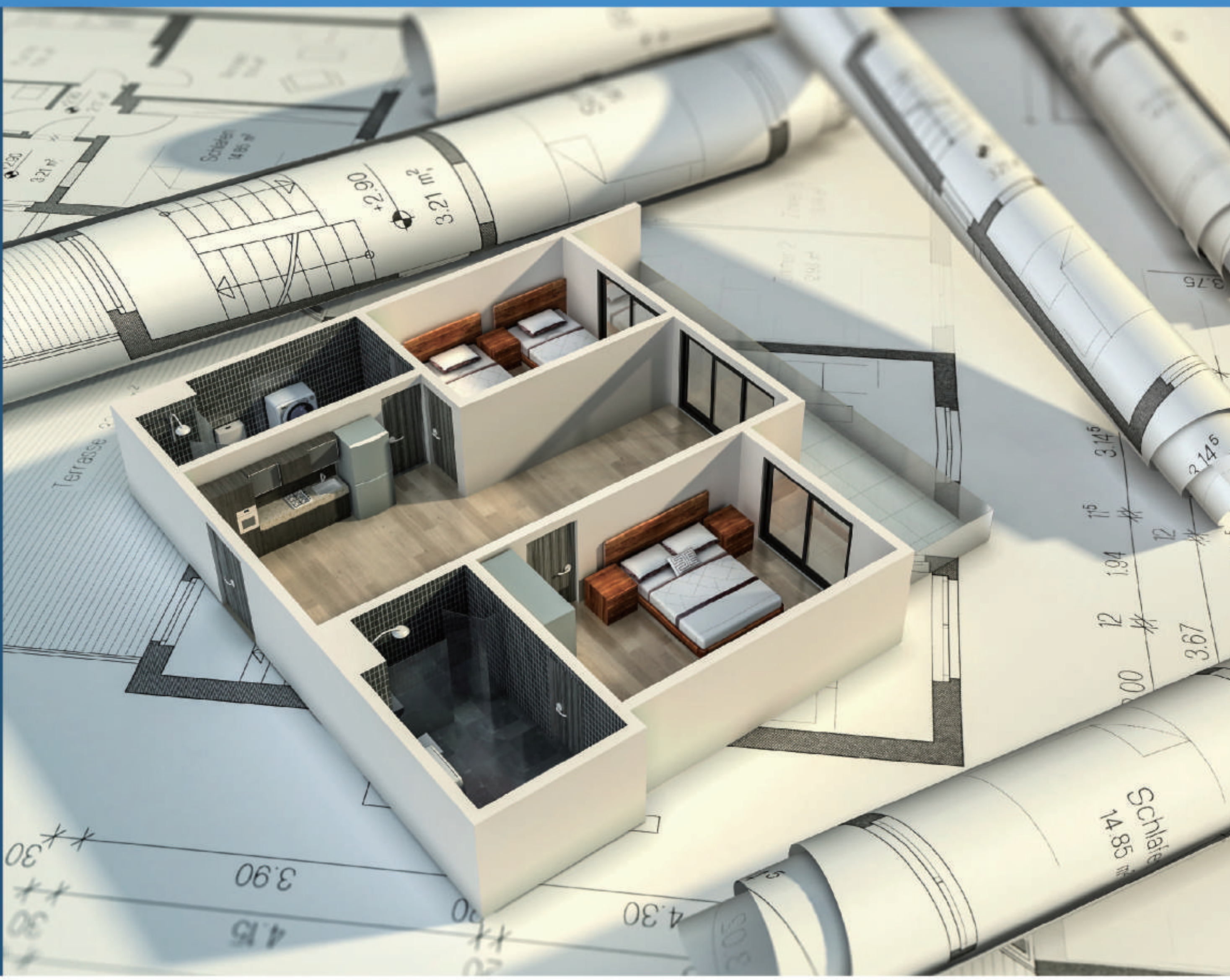
Frontiers Research of Architecture and Engineering

Volume 3 Issue 2 · April 2020 · ISSN 2591-7587 (print) 2591-7595 (online)



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Volume 03 Issue 02 • April 2020
ISSN 2591-7587 (Print) 2591-7595 (Online)

Frontiers Research of Architecture and Engineering

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ARTICLE

Research on Government Compensation for Toll Road Public-Private Partnerships (PPP) Projects

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ARTICLE INFO

Article history
Received: 19 March 2020
Revised: 26 March 2020
Accepted: 24 April 2020
Published Online: 30 April 2020

Keywords:
Project management
Subsidies
Monte Carlo
Toll road
Public-Private-Partnership

ABSTRACT

With the continuous implementation of the PPP projects, due to the imperfection of relevant policies, the blindness of government subsidy is constantly emerging. Thus, it is important to put forward a practical approach for valuing the subsidies and risk. In this paper, the revenue subsidies model and traffic subsidies model are established. Then combined with practical cases, Monte Carlo simulation is used to get the value and probability of government subsidies under different compensation ways. On this basis, the influence of initial traffic volume and traffic growth rate on government subsidies and net present value of investors is analyzed. The research findings can provide theoretical guidance for the government to choose a reasonable way of subsidies, balance the risk of compensation, and formulate subsidies policies.

1. Introduction

Nowadays, China vigorously advocates PPP mode to relieve financial pressure and effectively introduce market competition. Most of the projects built by PPP mode are infrastructure projects, which usually have high investment amount, long payback period and low return rate. In order to attract investment, the government often provides some compensation to share the project risk. The government has been plagued by many problems, such as how much should compensate for these projects, how to compensate, and how to evaluate the risk of project compensation. Wibowo (2004) studied the impact of government compensation on project value[1]. Cheah and Liu (2005) used Monte Carlo method to simulate the appropriate amount of subsidy for a highway bridge project in Malaysia[2]. Brandao and Saraiva (2008) estimated the value of minimum traffic guarantee and its cost-benefit[3]. Galera and Soliño (2010) evaluated the value of minimum revenue guarantee based on real option[4]. Jun (2010) analyzed the government payment and the net present value of concessionaire when implementing the minimum traffic guarantee in BOT projects[5]. Liou and Huang (2012) take a high-speed railway project in southern Taiwan as an example to illustrate the government compensation amount and risk of infeasible projects in financial evaluation[6]. Ashuri and kashani (2012) use the risk neutral pricing theory to study the minimum revenue guarantee for highway BOT projects[7]. Chiara and Kokkaew(2013) analyzed the impact of minimum revenue

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Fund Project:
Soft Science Project of Science and Technology Department of Sichuan Province (20RKX0728).

DOI: https://doi.org/10.30564/frae.v3i2.1797

guarantee using Monte Carlo simulation[8]. Feng and Shuai (2015) discussed the impact of government compensation on toll rate, road quality and road capacity from the perspective of private investors[9].

These studies have a good role in promoting the government to clarify the compensation ideas and establish a perfect compensation policy, but there are still some shortcomings. First, most of the models are theoretical models with poor feasibility, which are difficult to be applied in practical projects. Next, application scope and conditions of different compensation methods are not clear. Finally, the willingness of both government and investors to participate in investment under different compensation limits is ignored. In this paper, two compensation methods, revenue compensation and traffic compensation, are selected to study. The government compensation model is established based on the real option theory. Combined with the actual case and Monte Carlo simulation, the compensation times, average value and net present value of project are analyzed. The research findings are to provide theoretical guidance for the government to choose compensation methods, weigh compensation risks and formulate reasonable compensation policies.

2. Model Building

2.1 Revenue Compensation Model

If the annual revenue R_{aj} is less than a% of the expected revenue R_{pj}, the government compensates the private sectors an equivalent amount. The guarantee is available in concession period. The value of revenue compensation in year j AS_j^R and government total subsidies in concession period TS^R is given by

$$AS_j^R = \begin{cases} 0 \quad if\ R_{aj} \ge a \times R_{pj} \\ a \times R_{pj} - R_{aj} \quad otherwise \end{cases} \tag{1}$$

$$TS^R = \sum_{j=1}^{T} \frac{AS_j^R}{(1+r)^j} \tag{2}$$

$$R_{aj} = Q_{aj} \times P \tag{3}$$

$$Q_{aj} = Q_{aj-1} \times (1+\alpha) \tag{4}$$

Where P = toll rate, Q_{aj} = annual operating traffic volume in year j, α = growth rate of traffic volume, r = discount rate.

If the annual revenue R_{aj} is more than b% of expected revenue R_{pj}, the private sector provide the c% of excess profit to government. The annual excess profit sharing AP_j^R and total excess profit sharing TP^R are shown as below

$$AP_j^R = \begin{cases} 0 \quad if\ R_{aj} \le (1+b) \times R_{pj} \\ (R_{aj} - (1+b) \times R_{pj}) \times c \quad otherwise \end{cases} \tag{5}$$

$$TP^R = \sum_{j=1}^{T} \frac{AP_j}{(1+r)^j} \tag{6}$$

Expected revenue R_{pj} is calculated according to the method proposed by the Ministry of Finance[10], in which the construction cost I, operation cost C, and rate of reasonable profit β are considered.

$$R_{pj} = \left[\frac{I \times (1+r)^j}{T} + C_j \right] \times (1+\beta) \tag{7}$$

2.2 Traffic Compensation Model

If the annual traffic Q_{aj} is less than d% of the expected traffic Q_{pj}, the government compensates the private sectors an equivalent amount. The guarantee is available in concession period. The value of traffic compensation in year j AS_j^T is given by

$$AS_j^T = \begin{cases} 0 \quad if\ Q_{aj} \ge d \times Q_{pj} \\ (d \times Q_{pj} - Q_{aj}) \times P_j \quad otherwise \end{cases} \tag{8}$$

Similarly, if the annual traffic Q_{aj} is more than e% of expected traffic Q_{pj}, the private sector provide the f% of excess profit to government. The annual excess profit sharing in traffic compensation AP_j^T is expressed by

$$AP_j^T = \begin{cases} 0 \quad if\ Q_{aj} \le (1+e) \times Q_{pj} \\ (Q_{aj} - (1+e) \times Q_{pj}) \times P \times f \quad otherwise \end{cases} \tag{9}$$

2.3 Investment Willingness of Government and Private Sectors

The net present value (NPV) of project is net profit of private sector, which is shown as

$$NPV_p = \sum_{j=1}^{T} NPV_j - I = \sum_{j=0}^{T} \frac{R_{aj} + AS_j - C_j}{(1+r)^j} - I \tag{10}$$

Where NPV_p = NPV of project, T = concession period, I = investment value of private sector.

  DOI: https://doi.org/10.30564/frae.v3i2.1797

The NPV of government NPV_g should consider the social benefits and net government payment, as in (11).

$$NPV_g = \sum_{j=1}^{T} \frac{G_j - AS_j + AP_j}{(1+r)^j} \tag{11}$$

Here, G_j = social benefit of the project in year j.

The social benefits of expressways are mainly reflected in the pulling effect of the construction period of Expressways on the construction industry and the operation period on the gross national product (GDP) of the transportation industry [13].

$$G_j = \left[\frac{\mu \times I \times (1+r)^j}{T}\right] + \delta \times Q_j \tag{12}$$

In (12), $\left[\frac{\mu \times I \times (1+r)^j}{T}\right]$ describes the construction of toll road promotes the development of construction industry, which average discount to each year of concession period, while $\delta \times Q_j$ is the driving effect of the project operation period on the transportation industry. μ and δ are constant and greater than zero.

The effect of government compensation is simulated by Monte Carlo Simulation. The simulation process is show as Fig. 1.

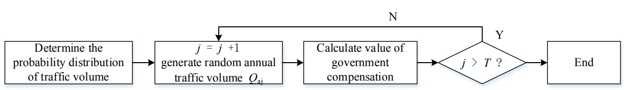

Figure 1. The simulation process

3. Case Study

3.1 Project Background and Simulation Parameters

A toll road will be built in a province, public bidding will be carried out by PPP mode, and construction will start in 2009, with a construction period of three years and 30 years operation period. At the end of the concession period, the private sector should deliver the project to government for free. According to the contract, the toll rate of the project is 0.48 yuan / vehicle · km.

The construction period *n* is 3 years, discount rate *r* is 10%. According to the *Annual Report of Highway Traffic Investigation and Statistics* issued by the Highway Bureau of Sichuan Provincial Department, the parameters in equation (12) are fitted, $\mu = 0.27$, $\delta = 27.95$. The cost of toll road operation period is mainly composed of operation management fee and daily maintenance fee, which is increased every year according to different usage. The value is calculated by the feasibility study report of the project. The initial traffic volume is 3.4204 million vehicles / year. The traffic growth rate is divided into two stages: short term (2012-2026) and long term (2027-2041). The corresponding traffic growth rate is 12% and 6%. The probability distribution of initial traffic and growth rate of traffic are listed in Table 1.

Table 1. Probability Distribution of Non-fixed Parameters

Parameters	Probability Distribution	
Initial traffic	Normal distribution,	Mean value: 3.4204 million, std.:0.34
Growth rate of traffic	Normal distribution	In short term, mean value 12, std.: 4
		In long term, mean value 6, std.: 2

3.2 Simulation of the Model

3.2.1 Discussing about Revenue Compensation

According to the above revenue compensation model, assuming that when the annual revenue is lower than 90% of the expected revenue, start the revenue compensation, using MATLAB (R2015a version) for simulation, and the number of simulation is set as 20000 times.

Figure 2 shows that during the 30-year concession period of the project, the government needs to provide 11.83 times of revenue compensation on average, with a standard deviation of 8.35. Figure 3 shows the probability of providing revenue compensation each year during the operation period. In the short term, due to the relatively high traffic growth rate, the revenue increases gradually, and the government's compensation probability decreases gradually. With the passage of time, the growth rate of traffic volume will decrease. When the increase of revenue cannot cover the increase of cost, the government's compensation probability increases gradually.

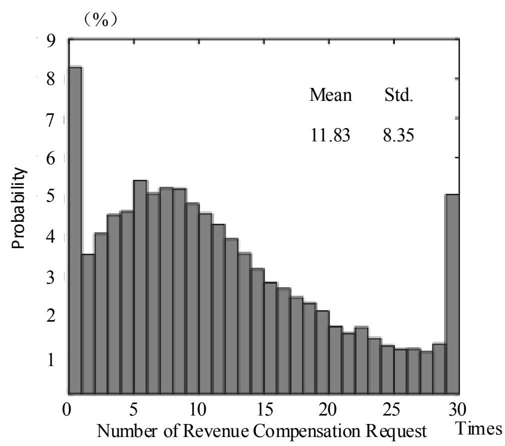

Figure 2. Probability distribution of number of revenue compensation

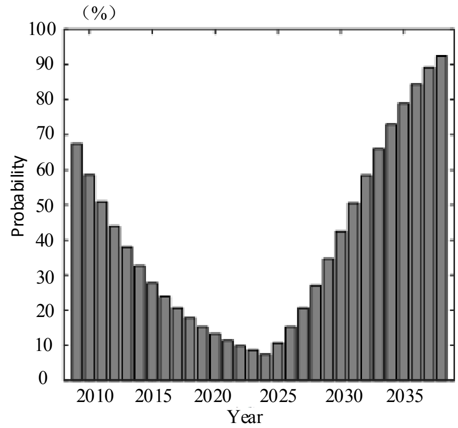

Figure 3. Probability of revenue compensation provided in each year

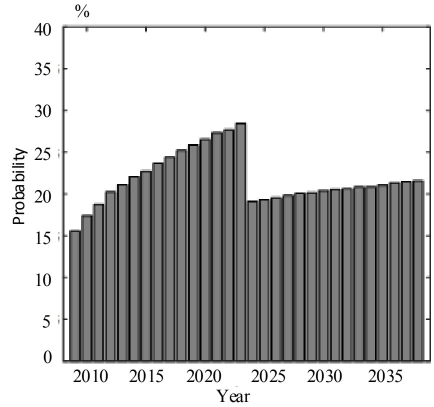

Figure 5. Probability of traffic compensation provided in each year

3.2.2 Discussing about Traffic Compensation

According to the traffic compensation model, if the traffic volume is less than 90% of the expected traffic volume, the traffic compensation is started, and the simulation times are 20000. Compared with the revenue compensation, the number of traffic compensation request are relatively low. The average number of compensation in a concession period is 6.54 (as shown in Fig. 4). Figure 5 shows the probability of compensation for each year of the concession period under traffic compensation. Traffic compensation is only related to the change of traffic volume. Therefore, in the short term of the project, due to the large fluctuation of traffic volume, the probability of compensation is high and increases year by year. In the long term of operation, the traffic volume tends to be stable, and the probability of compensation is relatively low. There is a big change difference in the figure 5, which is caused by different traffic growth rates and volatility in the short-term and long-term stages of operation.

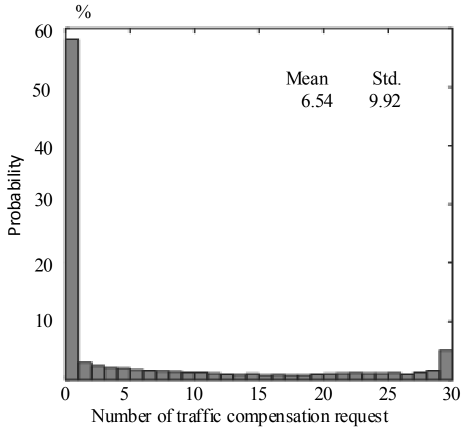

Figure 4. Probability distribution of number of traffic compensation

3.2.3 Comparison of Simulation Results

The simulation results of revenue compensation and traffic compensation are compared as shown in Table 2. The revenue compensation shares the revenue risk of the project, while the traffic compensation only shares the traffic risk. Therefore, compared with the traffic compensation, the frequency and amount of the revenue compensation provided by the government are higher, and the value of the shared excess profit is lower, which makes the government's financial net present value lower. But at this time, the project's profit is considerable, and the rate of return is 11.63%, which is higher than the profit of the transportation project, private sectors have a higher willingness to invest. When considering the social benefits of the project, the government's NPV is higher, indicating that the project has a higher construction value, and the government has a certain willingness to compensate, while the government's NPV is low, which requires a lot of expenditure. Traffic

Table 2. Comparative Analysis of Simulation Results

Items	Revenue compensation	Traffic compensation
Mean value of number of compensation	11.83 times	6.54 times
Mean value of annual compensation	97.518 millions	18.057 millions
Mean value of total compensation	1183.597 millions	81.772 millions
Excess profit sharing	1.446 millions	101.025 millions
NPV of private sector	595.348 millions	397.932 millions
Rate of return	11.63 (%)	7.77 (%)
NPV of government (including social benefits)	3998.502 millions	4185.340 millions
Financial NPV of government (excluding social benefits)	-1182.145 millions	19.253 millions

DOI: https://doi.org/10.30564/frae.v3i2.1797

compensation mainly shares the traffic volume risk of the project, with fewer number of compensation request and relatively low amount of compensation. The government has certain financial revenue to participate in the project, good social benefits and high willingness to participate. On the other hand, the investor's return on investment is basically the same as the return on investment of other transportation projects. The investor is willing to invest, but the enthusiasm for investment is less than the project under revenue compensation.

4. Conclusion

Monte Carlo simulation is used to analyze the actual case, and the compensation provided by the government and the net present value of private sectors under revenue compensation and traffic compensation are obtained. The results show that under revenue compensation, the number and amount of compensation provided by the government are higher than that of traffic volume compensation, but the private sectors have better return on investment and stronger willingness to invest. Therefore, revenue compensation is more suitable for projects with better financial situation of the government, which need to attract investors to invest, or projects with high social benefits. Under the mode of traffic compensation, the number of times of compensation is small and the amount of compensation is relatively low, which can share the traffic volume risk of the project to some extent. Thus, the traffic compensation is applicable to the government with poor financial situation and project has high traffic risk, which can guarantee the investors' income to a certain extent. In addition, the uncertainty of initial traffic volume and traffic growth rate affect the NPV of private sectors, and the greater the uncertainty, the greater the NPV of private sectors. The NPV of private sectors under revenue compensation is always greater than that under traffic compensation, so it is more appropriate to adopt traffic compensation when the traffic risk is large. The conclusions of this study can provide guidance for the government to choose compensation methods, make compensation scheme decisions, and formulate and improve relevant policies of PPP projects.

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ARTICLE

Application of Prefabrication and Assembly to Hong Kong-Zhuhai-Macao Bridge

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ARTICLE INFO

Article history
Received: 2 April 2020
Revised: 9 March 2020
Accepted: 24 April 2020
Published Online: 30 April 2020

Keywords:
Mega project
Prefabrication
Assembly
Technology
Construction concept

ABSTRACT

The Hong Kong-Zhuhai-Macao Bridge (HZMB) project, which has just been opened to traffic in 2018. The special location, construction conditions, quality requirements and multiple functions of HZMB brought many challenges, such as management, technology, safety and environmental protection. To meet these challenges and ensure the achievement of high quality and 120 years design service life, the HZMB project first introduced the completely new concept of "Large size, Factory production, Standardization and Assembly", which was fundamental to the design and construction. This was developed in consideration of the difficulties of the offshore environment.
The core idea was Prefabrication and Assembly, which was to change this HZMB project into onshore work as much as possible by cutting this mega sea-crossing into large sized components, which could be prefabricated on land and then transported to the offshore site for assembly. The success of the HZMB undoubtedly has led the technology of prefabrication and assembly to a new height and recognized scale. This paper describes the implementation process of the concept; "Large size, Factory production, Standardization and Assembly" (LFSA) to the HZMB.

1. Project Introduction

The Hong Kong-Zhuhai-Macao Bridge (HZMB) is a 55km long project crossing the wide Pearl River Estuary of South China, connecting the Hong Kong Special Administrative Region (SAR) with Guangdong (Zhuhai) and the Macao Special Administrative Region. It is also a mega infrastructure project and the first to be constructed under the political concept of one country, two systems. HZMB forms an important part of the Pearl River Delta and national highway networks of China.

With a total investment of over 12 billion Yuan (approximately 1.7 billion dollars), the HZMB project includes three parts; the first is the main work in the sea and this section was constructed and managed by the Three Goverments; the second is the Boundary Crossing Facilities, and the third is the local links to Hong Kong, Zhuhai and Macau.

The main work includes: 22.9km of marine viaducts; three navigation channel bridges; two artificial islands,

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DOI: https://doi.org/10.30564/frae.v3i2.1792

and a 6.7km immersed highway tunnel (figure 1).

Figure 1. Layout of the completed Hong Kong-Zhuhai-Macao Bridge

A project on this scale can never exist in isolation, and a key factor influencing all aspects of the HZMB was that it exists within a critical, committed, and highly diverse environment spanning three judicial districts.

As the landmark project of the Greater Bay Area, HZMB attracted much more attention from the governments and the public. Most of the project's technical decision-making was based on the principle of 'selecting the highest not the lowest' when conflicts occurred.

As a result, this project was expected to be accomplished safely, economically, innovatively, be environment friendly, achieve high quality and be completed within a tight schedule. All this brought the greatest challenges to the engineers.

2. General Introduce

HZMB has a total length of 55 km. Though it is called a bridge, actually it is a mega sea-crossing project which integrates bridges, islands and tunnels. As the longest sea-crossing in China, it used over 20km of steel box girder and over 2,600,000 m^3 of concrete. HZMB has many unique features which differentiate it from other projects, such as; being located in the preservation area for the Chinese White Dolphin (a rare marine mammal); having 120 years design service life; incorporating the deepest (-45m below sea level) immersed highway tunnel, and the longest sea-crossing bridge (over 30 km). Without doubt, there were many challenges and difficulties which needed to be solved in the design and construction process of this project. HZMB is regarded as the most complicated and difficult sea crossing project in China transport engineering.

Despite the main challenges mentioned above of the mega size, high technical standards, unique location, sensitive environment and so on, one point that should be stressed particularly is that it is a completely off-shore project, which meant that the previous experience of bridges and tunnels in China were not sufficient.

After studying worldwide projects, a construction concept was developed in the design phase, which was called large size, Factory production, Standardization and Assembly (LFSA). The core idea of this concept is to change the offshore works into onshore works and this was realized in the following way.

Firstly, the project was divided into many sections made up of standardized structural components which could be prefabricated on land. These components were then transported to site and assembled by machinery or equipment piece by piece. Through this, the project was realized in an industrial way, using production line methods with a minimized workforce.

Using this concept minimized the offshore construction work and improved the quality and safety, as well as shortening the construction time.

As a result, this project was realized by assembling the various components offshore, as if the engineers were playing a super building block game.

3. Application of Prefabrication and Assembly

The key points of LFSA are prefabrication and assembly. Large-size and standardization of components were two key features applied to prefabrication and assembly. To fully demonstrate the application of prefabrication and assembly, details of LFSA are described in the following four sections, according to the concept headings.

3.1 Large-size

The HZMB has a total length of 55 km, including over 30km of sea-crossing bridges, a 5.7 km long immersed tunnel (which is the longest immersed highway tunnel), and nearly 20km of local link highways. Based on these data, it is really a Super Project in the engineering industry.

HZMB is located in the Pearl River Delta, crossing Lingdingyang where there is an ecologically sensitive area and habitat of the endangered pink dolphins. Least disturbance in the water during construction and minimum obstruction to water flow were primary considerations in the design and construction.

For environmental considerations, 85-110m spans with single pier columns to support either two separate decks or a single wide deck have been used for the marine viaducts in HZMB, with pile caps for the bridge piers recessed below the seabed, so as to provide the least obstruction to water flow.

As mentioned above, in order to minimize the works insitu, the engineers divided the project into sections of large components. The bridge elements insists of pile cap and pier, steel box girder, steel-concrete composite box girder and steel pylon, all of which were fabricated in var-

DOI: https://doi.org/10.30564/frae.v3i2.1792

ious precast yards or fabrication yards.

The pile caps and piers were prefabricated as complete units. The tallest of such kind of pile cap and pier unit was about 50 meters high and weighed over 3000t (figure 2).

Figure 2. Precast pile-cap and pier units

Long spans of steel box girder were assembled and erected. The longest piece was 152.6 m long, weighed 350t and was erected onto the piers by a large floating crane with a lifting capacity of 4000t (figure 3).

Figure 3. Erection of a full span steel box girder

The 5.7 km long immersed tunnel was divided into 33 elements, each of which has a length of 180m and a width of 38m. Each element is still a big block, with a weight of 76000t (figure 4).

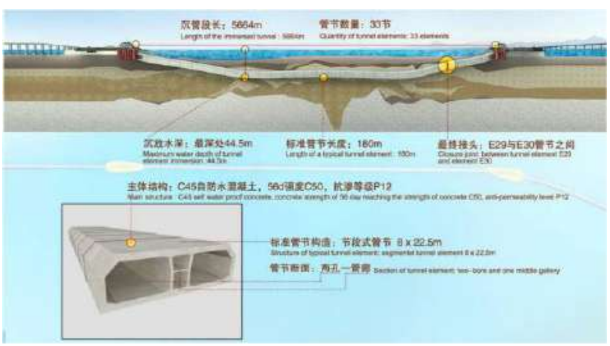

Figure 4. Longitudinal profile of immersed tunnel elements

The body of the two artificial islands was formed using other big elements; steel cylinders with a height of 45m and each weighing over 500t were used to enclose these sand-filled reclamations (figure 5).

Figure 5. Steel cylinder for drilling into the ground to form island

Based on the above structural components, the whole construction of HZMB was realized by assembling by production line methods, which greatly reduced the work offshore, minimized the risks for safety, the environment, quality and cost, and greatly shortened the construction time. Of course, such methods largely changed the offshore work of HZMB into onshore work. As a result, this encouraged a system to promote technology development for the construction methods, equipment and management.

3.2 Factory Production

As mentioned above, the HZMB is very long and the quantity of work was huge. The various standard components which were prefabricated in factories were very large size. All these components were produced in various dedicated factories surrounding the assembling sites. In order to save work time, each fabrication factory set up a linear flow production line, which was similar to the systems used by the mature industrial manufacturing industry.

It is not the first time tunnel or bridge elements have been produced in an industrial manner at ground level, under controlled factory-type conditions. However, it is the largest and widest application due to the scale of HZMB.

The typical factory for HZMB components can be classified into three main kinds; prefabrication facility for the immersed tunnel; steel girder fabrication facilities, and pile-cap and pier prefabrication facilities. These are described in more detail below.

3.2.1 Factory for Tunnel Elements

The immersed tunnel of HZMB has 33 elements, of which

DOI: https://doi.org/10.30564/frae.v3i2.1792

28 are a standard size and 5 are curved elements. Each standard element is 180m long and has a weight of over 76000t. It was the first time for China to prefabricate such huge tunnel elements. Even worldwide, it is only the second time immersed tunnel elements have been prodiced in a factory type manner.

Considering the transportation distance and convenience for the immersion, a specialized prefabrication facility was set up on Niutou Island, which is only 7 miles by sea away from the immersed tunnel location. The total area of this facility was about 40000 m^2. It was divided into four zones; material zone; concrete mixing zone; element production zone, and the dock zone (figure 6).

Figure 6. Layout of fabrication factory for tunnel elements

The tunnel element production zone was set up with a linear work flow arrangement. Each 180m element was made up from 8 equal segments of 22.5m, which were concreted using 3400m^3 concrete in one continuous operation. The factory had two production lines which could be working at the same time and overall, the facility had the capability to produce two elements every two months.

The production process of a tunnel segment was as follows; fix the reinforcement for bottom slab, side wall, interior wall and top slab; slide the reinforcement cage into the formwork (bottom form, inner form and side form); place concrete using a pumping system (the temperature of concrete before placing was controlled to be below 25℃), and curing, which was conducted after the forms had been stripped. The internal and external temperature of the concrete during curing was monitored using a digital monitoring system.

After curing for 72 hours, the segments could be pushed forward 22.5m, to clear the bed, ready for the next one。Each segment was match cast and the launching cycle was repeated 8 times until all the segments of one element had been completed. The entire element was then pushed forward into the shallow dock for outfitting.

The hydraulic system for launching the elements into the outfitting area was controlled by the computer to ensure balanced support and directional control. After the outfitting of a pair of elements had been finished, the sliding dock gate between the dock and the production line was closed and the dock flooded to the highest level to float the elements. The floating elements were then moved sideways into the deep wet dock area for storage. When required, the floating elements were moved out of the wet dock and towed to site for installation.

3.2.2 Steel Girder Production Factory

HZMB is also the largest and longest steel box girder bridge. It is calculated that over 400,000 tons of steel have been used for the steel box girder. To deal with such a huge amount of steel girder, the contractors set up 4 steel panel fabrication factories in different places of China, such as Shanhaiguan, Wuhan, Yangzhou and Nantong. At the same time, three steel box girder assembly line factories were set up in the Zhongshan area, near to the bridge site. The production flow is shown in figure 7.

The plates and stiffeners were cut and welded using CNC systems. The stiffened panels were then transported to the assembly factories in Zhongshan and assembled into span-long sections. All the processes were set-up and controlled as linear flow production lines. The completed steel box sections were transferred to special blasting and painting enclosures, after which the span-long sections were transported on special barges to the installation site and erected by very large floating cranes.

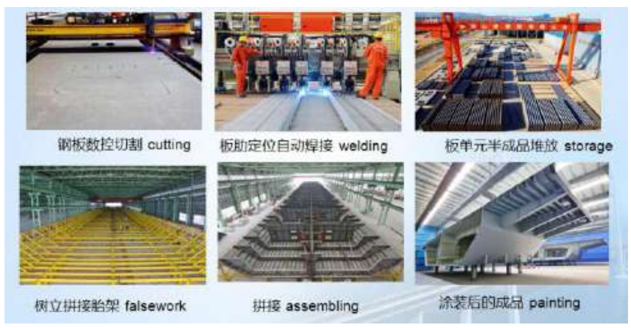

Figure 7. Production process for steel box girder

3.2.3 Pile Cap and Pier Production Factory

To meet the requirement raised by the marine authorities for a limit to the water flow obstruction rate, HZMB adopted pile caps for the piers that were recessed below the seabed. All the pile-caps and piers were prefabricated as units and the piers were divided into one to three sections, depending on the capability of the contractors' cranes. All the pile-cap and lower pier sections was made

DOI: https://doi.org/10.30564/frae.v3i2.1792

as one unit, with all site joints for the piers made above sea level.

An innovation was developed to make the connections between piles and some of the pile-caps (figure 8). A steel cofferdam on the pile cap was lowered over the piles so that work could be done in the dry. The precast pile cap with stub columns had oversize holes in them with shear keys. The pile cap was lowered onto the flanges off the piles. A gasket type water seal closed the gap between the bottom of the soffit of the pile cap and the pile, and then the hole was concreted (figure 9).

Figure 8. Steel cofferdam for connection between pile cap and pile

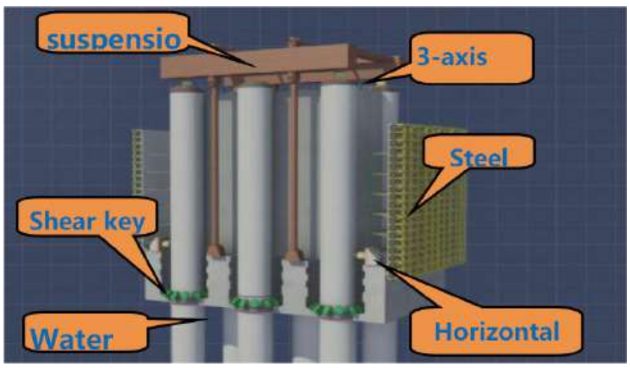

Figure 9. Inside view of steel cofferdam

All the pile-cap and piers were prefabricated in the land factories and assembled at the offshore site. The whole prefabrication process is shown in the figure 10.

The prefabrication of the pile-cap and pier units was modernized. The factories were equipped with automatic CNC cutting and bending equipment for the steel reinforcement bars. All prepared reinforcement was moved to an assigned position after inspection. The reinforcement was assembled into preformed reinforcement cages and then the cages were slid or lifted on to the fixed casting beds. After the forms had been positioned, the concrete was cast in one continuous operation without construction joints. The forms were stripped away after the concrete reached sufficient strength to allow the pile-cap and pier unit to be pushed forward to clear the casting bed, which could then be prepared for the next unit.

Figure 10. Production process of pile cap and pier unit

3.3 Standardization

Standardization of components was deliberately chosen and implemented. Moreover, the components were designed to be the largest practical size to minimize the offshore assembly work. Standardized components were the basis for implementing subsequent construction by prefabrication and assembly. The typical key components were; immersed tunnel element; pile-cap and pier unit, and steel box girder. As well as the design of standardized components, the construction management system for the project called for Centralized Standards to be implemented in all the production and fabrication plans to ensure proper control of the production management for concrete, steel and other components.

During the whole construction period, there were; nineteen concrete mixing plants (figure 11); three steel box girder production factories; three pile-cap and pier production factories (figure 12); one tunnel element production factory, and several small component factories, which produced the necessary sub-components (such as dolos or cover slabs) for HZMB.

The extensive use of industrial type production under factory conditions in HZMB had many advantages. These industrial type factories centralized all the factors and processes for production of the structural components and allowed standardized management systems to be implemented. Under the centralised control of the factory type production line, the workforce, materials and working time were all greatly reduced, and the working environment was much improved. These arrangements also promoted mechanized and automatic production. Efficiency, quality and safety were promoted as well. It is believed that all these represented modern engineering methods and trends.

  DOI: https://doi.org/10.30564/frae.v3i2.1792

Figure 11. Concrete batching plant

Figure 12. Layout of production factory of pile cap and pier units

3.4 Assembly

As mentioned above, the large size components and factory production were designed to implement offshore assembly, so that the blocks of components could be built up. However, the offshore assembly also needed big and suitable equipment. Fortunately, by learning from other countries and projects, the HZMB contractors were able to develop a lot of new equipment.

During the construction period for the immersed tunnel, the largest gravel bed placing and levelling barge was made by the Chinese contractor and this was the core equipment for placing gravel on the sea bed in deep water to form the foundation for the immersed tunnel elements. The immersed tunnel contractor also developed a set of automatic operation systems for immersion and monitoring the tunnel immersion process.

Actually, many other large machines and equipment were developed for use in the construction of HZMB to realize the offshore assembly concept, such as for installing sand compaction piles to greater depths, a 4000t gantry crane for load out of steel box girder elements, 4000t floating cranes for offshore installation (figure 13, figure 14), and so on.

In China, if a company cannot invent or make the necessary equipment, they will search for cooperation with foreign companies or import the equipment directly. For instance, in order to realize automation of the production lines for the steel box girders, CNC systems with cutting and welding robots were introduced and locally developed. For the bridge deck paving work, blasting machines and asphalt mixing plants were purchased from Europe directly.

Some equipment was developed by the contractors to meet the requirements of the local environment. Examples were the automatic spraying line for the MMA waterproofing in the steel deck paving work, and the aggregate production plant for crushing, screening and packing the coarse and fine aggregates for the deck paving mastic asphalt.

The development, optimization and automation of such advanced equipment was greatly promoted in this project, and this has been a critical aspect in achieving the increased efficiency and quality. These measures had a great influence on pushing forward the HZMB project and also in upgrading the construction industry in China. This progress is very significant for the development and strength of Chinese construction.

Figure 13. 4000t Floating crane for erecting girders

Figure 14. 12000t Floating crane for installing tunnel closure element

4. Benefit

The concept of Large Size, Factory Production, Standardization and Assembly (LFSA) successfully changed offshore work into onshore work and realized the benefits of industrial production in the bridge construction industry. In the HZMB project, the large structural components have been prefabricated in factories, transported and erected by large capacity, automated cranes. All of the 23km long bridges have been built from modules and standard-

DOI: https://doi.org/10.30564/frae.v3i2.1792

ized components. 190 no. pile-caps and piers were prefabricated and embedded in the seabed. 420,000 tons of steel box girders were produced on automatic production lines, and then erected in span-long sections.

It has been calculated that the implementation of LFSA has saved a lot of work time. For instance, for the bridge portions, when using the method of casting on site, one pile-cap and pier would need 165 days. Now, HZMB required just 53 days to finish the whole precasting and installation. When it comes to the case of the steel deck box girders, HZMB needed just 57 days to finish all the production for a 130m long girder and 1 day to install it.

The two artificial offshore islands needed just 210 days to finish the core of each island using large diameter steel cylinders for the enclosurers, which is 2 years faster than the traditional way of dredging and fill reclamation. The closure joint for the immersed tunnel needed just 1 day to install using a prefabrication and assembly method and a 12000 tons crane.

It can be seen that the concept of LFSA has greatly reduced the work time, improved the work efficiency and ensured quality and safety as well.

5. Conclusion

The HZMB Project is the first to adopt the concept of LFSA in China. During the construction process, various enclosed factories were set up to prefabricate immersed tunnel and bridge elements.

The extensive investment required for temporary installations and custom tailored equipment were justified by the extraordinary size of the project and the high quality it produced to the full satisfaction of the owner and governments.

After a hesitating start-up, the concept of LFSA was eventually shown to be viable. The diligence and perseverance of the engineering crews and staff made it possible to catch up lost time by constantly improving production rates and finally, to complete the whole project in 8 years, as expected.

6. Expectation

The core idea of LFSA is prefabrication and assembly. The essence is based on the accumulative achievements of China's 30 years of reform and development, which combines advanced research and manufacturing competence and then transfers this into the construction engineering industry.

Nowadays it is obvious that the prefabrication and assembly method is a future trend for the buildings and bridges. With the accomplishment of the HZMB, the technology and equipment for assembly of bridges have been improved and promoted. HZMB has set a successful example. The experience, methods and research results are useful for future design and construction. Of course, the prefabrication and assembly of big bridges is just at the initial stages, and the experience, concepts and technology need to be promoted widely and greatly. Design, equipment, production line, supply train and so on, all need to be considered in more detail in the future.

Overall, prefabrication and assembly is an irresistible trend in construction engineering. The opportunities and challenges are both great. The successful will always be those who are aware of and prepare for this.

Acknowledgement

The authors would like to acknowledge the help of Su Quanke and Zhang Jinwen, the project director of the HZMB.

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REVIEW

Research on the Factors Influencing the Premium Rate of the Inherent Defects Insurance

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ARTICLE INFO

Article history
Received: 17 March 2020
Revised: 24 March 2020
Accepted: 24 April 2020
Published Online: 30 April 2020

Keywords:
Inherent Defects Insurance
Rate
Influencing factors

ABSTRACT

This paper introduces the composition of the premium rate of Inherent Defects Insurance, and analyzes the factors influencing the premium rate of the Inherent Defects Insurance.

1. Introduction

In 2004, in order to solve the potential defects of construction quality caused by the rapid development of the construction industry, the Chinese government began to study the Inherent Defects Insurance (IDI) system, and issued many documents to implement in recent years. However, in China, the development of IDI has been restricted by the small proportion of insurance, the small social impact and the low degree of recognition of all parties. There are many reasons for this phenomenon. It is an important problem that the premium rate is difficult to be determined scientifically.

Premium rate is of great significance for the implementation of iodizing the process of implementing IDI, due to the lack of uniform standards, there are often problems that different insurance companies determine different rates for the same project. The high premium rate results in the low enthusiasm of the policyholder, and the low premium rate results in the loss of the insurance company, which is unwilling to underwrite. Therefore, scientific and reasonable premium rate is of great significance for the implementation of IDI.

2. Definition

Premium: Insurance cost refers to the total monetary expenditure of production factors consumed by insurance companies to provide insurance products. The cost of insurance plus the appropriate management fee, profit, tax and so on constitute the premium, which is usually reflected by the premium rate.

Premium rate: The premium rate refers to the proportion of the expenses paid by the applicant to the insurance company for purchasing the insurance and the insured

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DOI: https://doi.org/10.30564/frae.v3i2.1747

amount. The insured amount refers to the maximum amount of compensation for the project within the contracted scope by the insurance company. The insured amount is the calculation basis for the insurance company to collect the premium.

3. Composition of Premium Rate

Premium rate includes pure insurance rate and additional rate [1].

Pure premium rate is the main component of premium rate, which is determined according to loss probability and loss value.

The premium calculated from the pure premium rate is called the pure premium, which is used to compensate and pay the insurance beneficiary when the events within the insurance scope occur, which is equivalent to the cost of the insurance product.

The additional rate is a secondary component of the insurance rate, including the charge additional rate and the security additional rate. The premium calculated from the charge additional rate is called cost surcharges, which is used for the management expenses, profits and taxes of the insurance company.

The premium calculated by the security additional rate is called the safety surcharge, which is used to reduce the risk of both parties. If the risk is too large in a certain period of time, which exceeds the insurance company's compensation ability and affects the normal operation of both parties, the safety surcharges can reduce the financial risk of the insurance company to a certain extent [2].

4. Principle of premium rate determination

In order to determine the insurance rate scientifically, the following principles should be observed.

4.1 Mathematical Principle

According to the large number theorem and the central limit theorem, the insurance rate of IDI should be equal to the average annual risk loss rate of this kind of project in theory.

4.2 Principle of Giving Consideration to Both Sides

Insurance companies should operate normally, and premium is the main source of income. Premium, in addition to paying compensation when the risk occurs to make up for the loss, must also pay the daily management expenses and other expenses of the insurance company. Too high premium rate of IDI will increase the economic pressure of policyholders, affect the enthusiasm of insurance, and is not conducive to the development of IDI market; too low premium rate will increase the underwriting pressure of insurance companies, and also affect the financial revenue and expenditure of insurance companies, resulting in company turbulence.

4.3 Principle of Justice and Equity

The so-called fair and reasonable is not the so-called absolute average. The insurance rate should be adjusted in time according to the change of risk. The principle of fairness and reasonableness includes two meanings: the fairness between the insurer and the policyholder and the fairness between different policyholders.

The fairness between the insurer and the policyholder means that the premium charged by the insurer should match the risks it underwrites, and the premium paid by the policyholder should match the guarantee obtained by the beneficiary. The fairness between different policyholders refers to the different premiums that should be paid for the insurance subject with different risk levels.

4.4 Principle of Relative Stability

The relative stability of premium rate includes stability and adjustability.

The stability is mainly for the policyholder, which is convenient for the policyholder to estimate the expenditure. Frequent changes in the premium rate will lead to dissatisfaction and affect the policyholder's determination.

Adjustability refers to the fact that the insurance rate needs to be adjusted according to the continuous improvement of statistical data, changes in risk loss and changes in relevant policies and regulations. The premium rate shall be adjusted according to various influencing factors, and the change of future situation shall be estimated to reserve the advance.

4.5 Principle of Legality

The premium of IDI shall be determined in accordance with relevant national laws and regulations.

4.6 Principles of Promoting Disaster Prevention and Loss Prevention

The most important social function of insurance is disaster prevention and loss prevention. Insurance companies should promote the initiative of policy holders through relevant mechanisms to reduce accidents. So, reduce the compensation of insurance companies and the loss of social wealth. For example, the setup of deductible and floating rate follow this principle. Before 1996, there was

DOI: https://doi.org/10.30564/frae.v3i2.1747

no deductible in French housing damage insurance and it was charged at a fixed rate. No matter how small the accident of the subject matter of insurance is, the beneficiary will claim for compensation, the rate of claim remains high, and the false claim is also emerging, forming a "claim culture". After 1996, France began to set up the deductible and adopt the floating rate to give preferential rate to the enterprises with good performance and reputation, which improved the loss prevention awareness of all participants in the project, improved the quality of the project and saved the social cost.

IDI is only a guarantee, and the purpose of insurance is not to compensate, but to urge relevant units to improve the quality of the project and prevent disasters and losses.

5. Factors Influencing the Premium Rate of the Inherent Defects Insurance

Premium rate includes pure insurance rate and additional rate. Then, we study the influencing factors of the two.

5.1 Analysis of the Factors Affecting the Pure Insurance Rate

At present, China adopts the way of differential floating premium. The premium rate is affected by many factors. This paper mainly analyzes the influencing factors of the rate from three aspects: project and insurance, the participants of the project and the quality of the project completion acceptance.

5.1.1 Project and Insurance

The project and insurance mainly includes five aspects: Project soil type, structure type, insurance coverage, historical claim and insurance period.

(1) Chinese buildings are mostly reinforced concrete structures, and the corrosion degree of reinforced concrete is different in different soil. According to the data of China Academy of Building Sciences, the soil in China is mainly divided into four categories: medium alkaline soil, acid soil, inland saline soil and coastal saline soil [3].

Medium alkaline soil is mainly distributed in the Central Plains, North China and Northeast China, with pH value of 7.0-8.5. After 40 years of burial in such soil, the ordinary concrete materials are basically not rusted, and the compressive strength increases by 70% - 138%. This type of soil causes dissolution corrosion to materials, which belongs to weak or medium corrosion soil.

Acid soil is distributed in the soil of brick red, red, red and loess, with pH value of 4.0-6.5. After 40 years of burying in this kind of soil, the compressive strength of ordinary concrete materials increases by 40% - 80%. Soil causes decomposition corrosion to concrete, which belongs to medium corrosion soil.

Inland saline soil is mainly distributed in Xinjiang, Qinghai, Gansu and Inner Mongolia, with pH value of 8.0-9.5. After 40 years of burying in this kind of soil, the compressive strength of ordinary concrete materials is reduced by 40% - 100%. This kind of soil causes expansive corrosion to concrete, which belongs to strong corrosion or extremely strong corrosion soil.

Coastal saline soil is mainly distributed in coastal areas, with pH value of 7.5-8.5. After 8 years of burying in this kind of soil, the ordinary concrete material has been destroyed. This kind of soil causes expansive corrosion to concrete, which belongs to extremely strong corrosion soil.

(2)The main insured IDI is residential project, and its structural type includes structural form and floor height.

The structure forms mainly include brick concrete structure, frame structure, shear wall structure, frame-shear wall structure, and frame-core tube structure. According to the order of structural reliability, the most reliable one is frame-core tube structure, and the next is shear wall structure, frame-shear wall structure, frame structure and brick concrete structure. The brick concrete structure is seldom used at present because of its poor reliability. The floor height is mainly divided into four categories: 1-3 floors are low-rise residential buildings, 4-6 floors are multi-story residential buildings, 7-9 floors are medium and high-rise residential buildings, and more than 10 floors are high-rise residential buildings. Different floor heights correspond to different structural forms, which will not be described here.

(3) Historical claims

The higher the historical claim rate and claim amount of this type of project, the greater the risk of the subject matter of insurance. Through the statistics of historical claim data, we can get the average rate of this kind of insurance, but the time of developing IDI in China is limited and the accumulated data is insufficient, so we need to use other methods to assist the research.

(4) Insurance period

The insurance period of IDI varies from one year, three years, five years and ten years in different countries, with different insurance periods and different rates. The occurrence of quality risk is cyclical, and the rate cannot be determined simply according to the shorter the underwriting time and the lower the rate. The risk of some projects occurs within 3-5 years after the completion of the project, and will not occur within 1 year. For this part of the project, the rates of three years and five years are not much different.

(5) Insurance coverage

Different insurance coverage, insurance companies bear different risks, their rates are also different. For example, the rate of underwriting foundation engineering is higher than that of underwriting seepage prevention engineering.

5.1.2 Comprehensive Strength of Project Participants

People are the direct participants of the project and have an important impact on the quality of the project. The pure insurance rate is mainly affected by the insurance cost, that is, by the project quality. The quality control system of IDI mainly includes the contract issuing unit, survey and design unit, contracting unit, supervision unit, TIS and insurance company.

(1) Contracting unit

The contractor is responsible for the construction of the project, is the most direct participant in the project quality control, and has the most direct impact on the project quality. According to the survey, the impact of the contractor on the IDI rate is mainly reflected in the following aspects: enterprise qualification, financial status, Project Awards.

The enterprise qualification of the project contractor is divided into four levels: super level, first level, second level and third level. The super level is the highest qualification. The higher the qualification is, the higher the requirements for the level of the enterprise's employees are, the richer the experience of risk management and control, and the stronger the ability of quality risk control.

The financial situation can reflect the management ability of the enterprise from the side, and then reflect the employee mobility, loyalty and dedication, and then reflect the project quality.

The Project Awards reflect the construction ability of the contractor. China's construction engineering quality awards include three levels: national level, provincial level and municipal level. Each award has strict requirements for the declared engineering quality. The higher the award level, the higher the quality requirements, reflecting the stronger the company's construction capacity.

(2) Contract issuing unit

The contract issuing unit is the manager and controller of the project and is responsible for insuring IDI for the project. The impact of the contract issuing unit on the IDI rate is mainly reflected in the following aspects: enterprise qualification and financial status.

The enterprise qualification of the contract issuing unit is divided into five levels: Level I, level II, level III, level IV and provisional. Level I is the highest level. The higher the qualification is, the higher the professional quality of employees is, and the stronger the ability to control potential risks is.

The financial situation will affect the payment of project funds. If the cooperation with other units is affected due to the payment of project funds, the project quality and progress will be affected.

(3) Reconnoitering and designing work unit

The survey and design unit is responsible for the structural and architectural design of the project, which is the direct basis for construction and plays a decisive role in the project quality. The influence of survey and design units on the IDI rate is mainly reflected in the following aspects: enterprise qualification, financial status, Project Awards.

The enterprise qualification of survey and design units is divided into three levels: Class A, class B and class C. Class A is the highest qualification. The higher the qualification is, the higher the design level of the enterprise staff is, the richer the design experience is, and the stronger the ability to control the potential risk is.

The financial situation can reflect the management ability of the enterprise from the side, and then reflect the dedication of the staff, and affect the potential risks of the project.

The Project Awards reflect the design ability of the design unit. The higher the award level, the stronger the design ability and the lower the potential risk.

(4) Supervision unit

The supervision unit is entrusted by the contract issuing unit to control the construction quality and safety and improve the construction efficiency and level. But the quality of the supervision industry is worrying. It is blinder to follow the project than to supervise the project. In view of the lack of financial data of the supervision unit, the impact of the supervision unit on the IDI rate is mainly reflected in the following aspects: enterprise qualification and Project Award.

The enterprise qualification of the supervision unit is divided into four levels: comprehensive, class A, class B and class C. Comprehensive is the highest qualification. The higher the qualification, the stronger the risk control ability.

The Project Awards reflect the supervision ability of the supervision unit. The higher the award level, the stronger the comprehensive ability of the enterprise and the more accurate the risk control.

(5) TIS

TIS is entrusted by the insurance company to assist the insurance company in the quality risk control of the project, which is highly professional. However, due to the

DOI: https://doi.org/10.30564/frae.v3i2.1747

shortage of talents in China, the professionalism and scale of TIS need to be strengthened. As insurance companies need to refer to the risk assessment report to determine the rate, the level of TIS will directly affect the determination of the rate.

5.1.3 The Quality of the Project Completion Acceptance

The scope covered by IDI mainly covers foundation works and main structure works. In the process of project acceptance, we mainly rely on four aspects of performance test, quality record, allowable deviation and appearance quality to judge the construction quality, and then determine the premium rate of IDI.

(1) Performance testing

Performance testing mainly tests the indicators of the project through automation and other testing tools. Among them, the foundation engineering mainly tests the bearing capacity of the foundation, the bearing capacity of the single pile foundation and the quality inspection of the pile body, the underground leakage inspection and the foundation settlement observation.

The main structure engineering includes concrete structure and masonry structure. The performance test of concrete structure includes concrete strength, thickness of reinforcement protective layer, position and size deviation. The performance test of masonry structure includes mortar strength, concrete strength and verticality of full height masonry.

(2) Quality record

Quality records include material certificate, mobilization acceptance record and retest report, construction record and construction test.

(3) Allowable deviation

In the construction design, the location information of each component is strictly calculated to minimize the quality risk. In actual construction, due to the difference of construction technology and technical level of construction personnel, the construction location will deviate from the design. When the deviation exceeds a certain limit, it will affect the safety of the building.

(4) Appearance quality

The appearance quality directly reflects the external quality of the project, and sometimes reflects the structural quality of the project. Common appearance quality problems include honeycomb, exposed reinforcement, holes, slag inclusion, etc.

5.2 Analysis of the Factors Influencing the Additional Rate

The additional rate consists of charge additional rate and security additional rate. The charge additional rate is mainly related to the management expenses, profits, taxes of the insurance company. Security additional rate are set up to cope with the excessive risk of the insured project. It can be analyzed from the perspective of insurer and society.

From the perspective of the insurer, the better the operating efficiency of the insurer is, the higher the level of capital utilization is. It shows that the insurance company has strong capital accumulation and stable operation. It is conducive to the scientific determination of the rate and the stability of the rate.

From a social perspective, the more suitable the market environment and political environment are for the development of IDI, the more scientific the rate is.

6. Conclusion

This paper mainly studies the factors that affect the premium rate of IDI and provides reference for the determination of premium rate of IDI. Due to the short time of developing IDI in China, it is necessary to conduct in-depth research in order to determine the premium rate scientifically and make IDI work effectively.

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REVIEW

Research on Innovation of Engineering Project Management Mode and Intelligent Management

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ARTICLE INFO

Article history
Received: 5 April 2020
Revised: 12 March 2020
Accepted: 24 April 2020
Published Online: 30 April 2020

Keywords:
Environmental protection engineering
Project management
Management mode
Intelligent management

ABSTRACT

In order to realize the standardization and normalization of environmental protection project management. This paper uses the literature method to study the current status of the existing project management mode, and points out the problems: lack of a sound project management system, insufficient information application of project management, and unclear decentralization in project management; on this basis, this paper proposes optimization strategies from the aspects of perfecting the engineering project management system, clarifying the allocation of project management authority, and strengthening the construction of engineering project management information. And put forward the future development trend of project engineering management, on the basis of two mainstream management modes of BOT (Build-Operate-Transfer) and EPC (Engineering Procurement Construction), build a standardized project management platform to achieve intelligent management. Realize intelligent management of engineering project management to achieve standardization and standardization, greatly improving the efficiency of project management.

1. Introduction

In recent years, the rapid economic development has accelerated the process of urbanization in China, and the problem of environmental pollution has become increasingly serious. In order to promote the sustainable development of social economy, China began to attach importance to environmental governance and protection, and continuously promote environmental protection. Applying project management to environmental protection projects can not only improve the efficiency of project implementation, but also promote the construction of environmental protection in China.[1]

Project management is the systematic overall management of engineering projects, and its connotation mainly includes: the first is project goal orientation, that is, project management should focus on the objectives of project management; the second is the limited nature of project management. Project activities must be carried out under the constraints of human, financial and time constraints; the third is the characteristics of project indicators. For environmental protection projects, the relevant indicators must be met to complete project management during acceptance. Therefore, project management is a series of targeted activities carried out under specific conditions. In order to achieve effective control of project management, it is often necessary to adopt a certain mode to achieve a reasonable allocation of resources, optimize design plans, save project

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  DOI: https://doi.org/10.30564/frae.v3i2.1941

costs, etc., to ensure that the goals are achieved[2].

Although China's engineering project management mode has introduced advanced foreign concepts and project management modes, there are still problems, for example, the low level of project management standardization, the lack of project management compound talents, and unclear responsibilities and other issues have caused strong subjectivity in project management, making it difficult to effectively control project quality, schedule, and investment.[3] In this context, the analysis of the current status of China's engineering project management mode to identify problems and propose corresponding optimization strategies, and the combination of existing management modes and intelligent management, has practical significance for improving project management.

2. Methods

Literature research method: This paper consults the project management related literature and information data in the early stage, sorts out, analyzes, studies, and draws on, through the research on the current situation of the project management mode and points out the problems, explores the innovation of the project management mode.

3. Results

3.1 Environmental Protection Project Management Mode

At this stage, there are two main modes of environmental project management, namely BOT mode and EPC mode. The BOT mode is a government or government-authorized enterprise that authorizes a project to be built to a private enterprise through a contract, which is a "Build-Operate-Transfer" mode. It is a major mode for private enterprises to participate in government projects. Its process is that firstly the enterprise obtains the authorization of project construction through the form of bidding; secondly, the enterprise obtains funds for the implementation of the project through financing, and after the completion of the project, the enterprise obtains proceeds to repay the bank loan through operation; finally, after the project expires, the enterprise transfers the project to the government. Throughout the process, the government or companies authorized by the government have the right to supervise the project. The advantages of BOT include: solving the problem of insufficient government funds through rational allocation of resources; enterprises can obtain higher returns through projects and achieve a win-win situation.

The EPC mode is a design-procurement-construction management mode. The contractor manages the entire process of the project, including pre-financing, project design, and construction. The contractor focuses on the completion and acceptance of the project. The advantage of this mode is that the contractor first assumes all the responsibilities of the project, manages the project as a whole, and always grasps the implementation progress and quality of the project; secondly, from the perspective of the contract issuer, the EPC mode can avoid its risks and simplify the project management process; finally, it can balance the rights and interests of both parties and achieve a win-win situation[4].

3.2 Current Status and Existing Problems of Project Management

At present, many environmental protection companies use BOT and EPC project management modes. During the project management process, although some companies have formed a certain project management system according to the management mode, there are still some problems.[5]

3.2.1 Lack of Sound Project Management System

The first is the lack of standardization of project management. There is a lack of standardization in project execution in project approval, project cost and schedule control, and engineering inspection and acceptance. Many environmental protection companies rely on project experience summarized by project managers for project management; the second is the lack of a complete project management process system, such as imperfect management systems, unclear key points of the process, and irregular processes; the third is the lack of effective supervision and evaluation in the process of project implementation. For environmental protection projects, the cycle is long, and the supervision function is often ignored in the late stage of project implementation.

3.2.2 Insufficient Information Application of Project Management

At present, the progress management and project quality management of many environmental protection companies in the project management process are still mainly based on manual management, which has greatly restricted the efficiency and progress of project management, which mainly reflects in: first, the multi-project coordination at the same time is difficult and the communication is poor. The communication of the project manager including the implementation personnel depends on WeChat, QQ, etc., which will lead to the lag of project information and is not conducive to multi-project management; second, the lack of information technology support for the implementation of the project has caused the project to lack strict control and supervision in the specific implementation, making it impossible to make correct and reasonable decisions or response measures; third, the project lacks information sharing, information management and other information about project management has not been unified, and a large amount of data is left on the project site. As a result, the data between projects cannot be used for reference and lack decision-making basis, which increases the difficulty and risk of project management to some extent.

3.2.3 Unclear Powers and Responsibilities in Project Management

The projects of many environmental protection companies are scattered throughout the country, which requires the company to be able to coordinate the projects simultaneously within a certain period of time, which also requires matching the corresponding decentralization authorization system. However, at this stage, many environmental protection companies lack a project responsibility system, resulting in unclear rights and responsibilities. Firstly, the procurement rights of each project site are restricted, mainly because the procurement of project materials is mainly concentrated on procurement to reduce their costs. Various projects often have insufficient material procurement or lack of certain materials, but due to the lack of procurement authority, the project implementation progress has been slowed down and the project implementation efficiency has been reduced; secondly, the project manager ’s authority is insufficient, since the company's project management generally adopts centralized management, it also weakens the project manager's authority in procurement, major matters handling, employment, etc., and also affects the project management implementation process to a certain extent.

3.3 Project Management Optimization Strategies

3.3.1 Improve Project Management System

This paper can improve the standardization of project management by formulating a standardized process management manual, mainly including clarifying the scope and target of the process manual; draw a flow chart according to the specific situation of the project, master the process nodes and key nodes of the project process. The second is to improve the project process management system, set project management, cost budgeting, implementation progress, project closure and other management as a first-level process. The project team and the middle and high-level of the company formulate strategic goals, as well as the optimal allocation of resources, decision-making for major projects, monitoring projects and key point decisions, etc., on this basis, a two-level process system is built, and the project supervisor ensures the execution of the task. Next, a three-level process system is built, and grassroots employees conduct specific activities. Finally, refine project management responsibilities. Refine the responsibility of each project, so that the person responsible for each project bears certain responsibilities, which can not only ensure the quality and quantity of management tasks are completed, but also effectively evaluate, supervise and manage the project, laying the foundation for the realization of project management goals.

3.3.2 Strengthen the Information Construction of Engineering Project Management

With the development of science and technology, the informationization of engineering project management has a good momentum of development. The reality is that the project management of many companies is not fully informatized, which limits the efficiency of project implementation. Therefore, in order to improve the efficiency of project management, it is necessary to strengthen the informationization of project management. The first is full network coverage, at the same time, you can use high-tech means or introduce advanced technologies from the world to develop innovative new technologies for environmental protection projects, plan for the engineering situation, use scientific technology and information management methods to strengthen the effectiveness of environmental protection project management, and improve the management level of managers[6]. The second is to realize project management information sharing and build an enterprise project information sharing platform. Through this platform, project personnel can obtain project-related information, mainly including project implementation progress, project budget costs, project quality and other information, which can not only obtain information to help project decision-making, but also find problems in project management in time. The construction of the information system of the project system can realize the real-time monitoring of the cost of project management and the quality of project implementation, and can also obtain detailed information of project management to provide a guarantee for the smooth progress of project management.

3.3.3 Clear Assignment of Project Management Authority

In order to improve the synergy efficiency of multi-proj-

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ect management implementation, environmental protection companies must first clarify the allocation of project management responsibilities. Specifically, it is based on different management issues to determine the operational procedures of authority including proposal, review, meeting review, approval, resolution, and filing. To ensure a reasonable allocation of management authority, first of all, relevant management systems, such as project management system, procurement management, and capital management system, should be improved to ensure that they are carried out in accordance with process specifications. In order to avoid risks in the implementation of the authority operation process specification, enterprises still need to improve the internal management system, adjust project management authority, and respond to risks.[7]

4. Development Trend

The popularity of computers, the Internet, and intelligent technologies in China has provided technical support for the standardization of engineering project management in the environmental protection industry. Environmental protection enterprises can use the original technology and project management experience, and use the Internet technology to connect equipment and management for the characteristics of project management, such as decentralized, technology-intensive, and accumulated experience. At the same time, the project management equipment, capital, manpower, materials, information, technology and other resources are optimized and integrated to simplify the project management process, reduce management costs, improve project management efficiency, and help realize the intelligent management of engineering projects.

In order to realize the intelligent management of the project, Based on the mainstream project management mode, the environmental protection company established a project management intelligent management team to conduct in-depth investigations of the enterprise, and referred to the intelligent production management mode, using Internet technology to combine it with project management to develop a standardized project management platform. The first module in this system is the equipment management module, which takes the equipment ledger as the center and manages the process of equipment purchase, installation, operation, maintenance and scrapping, and connect the equipment coding with operation and maintenance to get the specific data of the equipment operation, and monitor and analyze its operation status and operation change trend in real time. The second module is project implementation management, which mainly includes project initiation, including all types of project incorporation into the system audit, to achieve follow-up adjustment and recording; project plan formulation, adjustment, supplementation, etc.; contract management, including contract creation, review, approval, disclosure, execution, and supplementary functions; construction management, mainly budget, settlement management, on-site management, and completion acceptance management during project implementation; evaluation management, real-time monitoring and evaluation of project progress, quality, cost, safety, etc. The third module is post work platform management, which realizes employees' online office and post management standardization. The fourth module is the financial management module, which realizes the standardization of expense application and reimbursement. The intelligent management of engineering projects based on the Internet and the Internet of Things technology, real-time sharing and updating of engineering management information, data and data, greatly standardizes and simplifies the workflow, and there is a great correlation between system modules to facilitate data, information search, statistics, analysis, etc., to achieve the standardization, standardization and convenience of on-site management process of engineering projects[8].

5. Conclusion

The project management mode of the environmental protection industry generally adopts the BOT and EPC modes. There are still some problems in the process of project management implementation: lack of a sound project management system, insufficient application of project management information, and unclear decentralization in project management, on this basis, this paper proposes corresponding solutions: perfect the project management system, clarify the allocation of project management authority, and strengthen the construction of engineering project management information. It is also proposed that the future development trend of project engineering management is to design a project standardization management system based on the two modes of BOT and EPC, to realize the intelligent management of engineering projects, to make the project site management process more standardized and standardized, and greatly improve the progress and efficiency of project management.

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  DOI: https://doi.org/10.30564/frae.v3i2.1941

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ISSN 2591-7587
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