Research on Deepening Design and Construction of Cross-Sea Tunnel Based on the Principle of Prefabricated Building

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Abstract. With the development of the economy and the rapid progress of the construction level, the construction of the cross-sea tunnel began to gradually promote and further promoted. China gradually ushered in the peak period of undersea tunnel construction, has built xiamen, Qingdao, guangzhou, Shanghai chongming island and other undersea tunnels. However, due to the late start of cross-sea tunnel construction compared with western countries, there is still a lack of certain construction experience, especially in the construction of cross-sea tunnel. The construction of the cross-sea tunnel has put forward higher requirements on the construction level. In terms of the design and construction of the cross-sea tunnel, China is still in the initial stage of exploration and still needs unremitting research. Based on this deepening design and construction of cross-sea tunnel has become the focus of research. Based on the principle of prefabricated building and relevant calculation with the GO method, this paper calculates the reliability and risk of prefabricated building in the construction of cross-sea tunnel, and puts forward the deepening design and construction method of cross-sea tunnel on this basis. On the one hand, it is beneficial to the further development of cross-sea tunnel construction in China. On the other hand, it provides a certain theoretical basis for future research on related aspects.

Keywords: Prefabricated Building, Cross-Harbour Tunnel, Design and Construction, GO Method

1. Introduction
With the continuous improvement of China's economic level and the increasing development of science and technology, China has also started the construction of cross-sea tunnel. In particular, in recent years, China has achieved certain results in the construction of cross-sea tunnel, and China has started to enter the peak period of cross-sea tunnel construction [1-2]. The construction of cross-sea tunnel also requires a high level of science and technology, and at the same time, it needs a lot of manpower and financial resources. However, the completion of the cross-sea tunnel also makes the communication between the two places across the sea closer, making the transportation more convenient to a certain extent and promoting the economic development [3]. However, we must be aware that compared with western developed countries, the construction of cross-sea tunnel in China started relatively late and has insufficient experience. There are still many deficiencies in the design
and construction of cross-sea tunnel and it is still in the initial exploration stage [4-5]. In this case, it is an urgent problem to study the deepening design and construction of cross-sea tunnel. In recent years, as people pay more and more attention to the issue of environmental protection, the construction industry also starts to pursue green and environmental protection. Therefore, prefabricated buildings gradually start to be applied in the construction industry, and are also gradually applied in the design and construction of cross-sea tunnels [6-7]. Because prefabricated building connection is a direct assembly connection, and the technical requirements are relatively low. Moreover, installation and configuration of the building is a kind of environmental protection and energy saving construction. The application of prefabricated buildings in the deepening design and construction of cross-sea tunnel will play an important role in its rapid development [8-9].

However, the development of prefabricated architecture in China is not mature enough, and there are still many problems in its application. At present, Chinese scholars have conducted many studies on the design and construction of prefabricated buildings and cross-sea tunnels [10]. However, few scholars combine the principles of prefabricated architecture with the design and construction of cross-sea tunnel and make in-depth research, which makes the research in this aspect disjointed to some extent and cannot achieve in-depth integration between the two [11-12]. In this respect, there is still a theoretical gap in this field, which is not conducive to the scientific application of prefabricated buildings in cross-sea tunnel construction.

In order to fill this theoretical gap, the scientific application of prefabricated building principle in the construction of cross-sea tunnel is promoted, and the safety and reliability of cross-sea tunnel construction are guaranteed. Based on the principle of prefabricated building and relevant calculation with the GO method, this paper calculated the reliability and risk of prefabricated building in the construction of cross-sea tunnel, and proposed the deepening design and construction method of cross-sea tunnel [13-14]. On the one hand, it is beneficial to the further development of cross-sea tunnel construction in China. On the other hand, it provides a certain theoretical basis for future research on relevant aspects [15].

2. Method

2.1 Prefabricated Buildings
Buildings assembled with prefabricated components are called prefabricated buildings. Different from the traditional building form, the prefabricated building embodies great advantages, such as standardized design, factory production, information management, integrated decoration, intelligent application and so on. Because prefabricated building connection is a direct assembly connection, and the technical requirements are relatively low. Moreover, installation and configuration building is an environmentally friendly and energy-saving building method, so people gradually apply this building principle to the design and construction of various buildings. Prefabricated building mainly has the following characteristics: first, the workshop can directly produce prefabricated building materials; Second, the construction period is shorter than the traditional construction method. Third, high security and stability; Fourth, information and standardization design and management; Fifth, in line with the concept of ecological and environmental protection. However, in the process of prefabricated construction, it is necessary to pay attention to the design points of each part, such as graphic design, prefabricated component design, facade design, etc. During the design of each part, specific analysis should be made on its actual situation, so that the construction planning and design scheme can reach the standard and standardization.

2.2 The GO Method
GO method is a technique for systematic probability analysis, which is based on probability analysis. With the help of the analysis of the system, the flow chart of the system is converted into the GO diagram, and then the system probability is calculated on this basis. The GO method is often used to analyze the risk probability of the system under different states and time points. Operators and signal
streams are two important elements that make up a GO diagram. On the basis of the GO method and the characteristics of the fabricated building itself, the relevant GO diagram can be established. When the flow chart of the assembly building is converted to GO diagram, relevant calculation can be carried out with the help of its algorithm, and the state probability of the system signal flow can be derived. Because GO system is a two-state system, which is accident state and success state respectively, it is necessary to calculate the probability of these two states respectively. PR represents the success probability derived from the GO method signal, and PI represents the risk probability derived from the signal, so the specific calculation formula is as follows:

\[ P_I = 1 - P_R \]  

Where, PR represents the success probability derived from the GO method signal, and PI represents the risk probability derived from the signal. In order to obtain the risk probability and accurately estimate the risks of the assembled building, it is necessary to calculate PR. The specific calculation formula is as follows:

\[
    P_\theta = \sum_{K=1}^{1} \sum_{K_2=0}^{1} \ldots \sum_{K_M=0}^{1} P_{K1K_2\ldots KM} \prod_{n=1}^{M} \left[ (1 - P_{\text{sm}})(1 - k_n) + P_{\text{sm}}K_n \right]
\]

Type, PRK1K2…KM represents the success probability of the derived signal in the case of a total of M signal combinations. KM represents the correction factor of the MTH signal stream. With the help of the above formula, the success rate and risk of cross-sea tunnel design and construction under the principle of prefabricated building can be accurately predicted, so as to better promote the design and construction of cross-sea tunnel.

3. Experiment
First, the selection and determination of experimental samples; Select the cross-sea tunnel that has been constructed as the sample, and consult relevant materials to obtain the construction data of each structure in the process of cross-sea tunnel construction;

Second, risk calculation; According to the selected experimental samples, GO method is used to calculate the risk of traditional cross-sea tunnel construction based on the specific construction data. Secondly, consult relevant materials, collect specific structural data of the prefabricated building, and use GO method to calculate the risk of cross-sea tunnel under the principle of prefabricated building. And accurately record the calculated data;

The third step is the comparison and analysis of data. Through the above calculation, the data are compared and analyzed, mainly to analyze the current risks of prefabricated buildings and the comparison between them and traditional buildings, so as to obtain the advantages of prefabricated buildings intuitively and understand their disadvantages. Record the analysis process and conclusion.

The fourth step is to propose the deepening design and construction countermeasures of the cross-sea tunnel. On the basis of the above analysis, the paper puts forward some concrete methods for the design and construction of the cross-sea tunnel.

4. Discuss
4.1 Analysis of Experimental Results
From the above experiments and calculations, it can be seen that the risk of cross-sea tunnel construction is reduced by the prefabricated construction, and there are many advantages compared with the traditional construction. The specific experimental data are shown in figure 1 and table 1, and the data are sorted out by the author.
Figure 1. Comparison between traditional architecture and prefabricated architecture

Table 1. State probability table of prefabricated building system

| Signal Stream Number | Probability of Success | Risk Probability |
|----------------------|------------------------|------------------|
| 1                    | 0.890                  | 0.110            |
| 2                    | 0.697                  | 0.303            |
| 3                    | 0.840                  | 0.160            |
| 4                    | 0.8824                 | 0.1176           |
| 5                    | 0.646                  | 0.354            |
| 6                    | 0.653                  | 0.347            |
| 7                    | 0.628                  | 0.372            |
| 8                    | 0.731                  | 0.269            |
| 9                    | 0.756                  | 0.244            |
| 10                   | 0.905                  | 0.095            |
| 11                   | 0.734                  | 0.266            |
| 12                   | 0.912                  | 0.088            |
| 13                   | 0.600                  | 0.400            |
| 14                   | 0.651                  | 0.349            |

Data came from the experimental collation

As can be seen from figure 1, compared with traditional buildings, prefabricated buildings have many advantages in the construction of cross-sea tunnel under the GO method, mainly reflected in construction efficiency, construction quality and economic benefits. From Table 1 risk rate and success rate of the data we found that the risk probability of prefabricated construction is relatively small, but the risk probability is still there, so when using the principle of prefabricated to deepening the research on the design and construction of cross-sea tunnel, made to minimise the risk probability of cross-sea tunnel, improve the security and reliability of cross-sea tunnel.
4.2 Deep Sea Tunnel Deepening Design Based on the Principle of Prefabricated Architecture
(1) Deepen the design of prefabricated components
Most of the deep-sea tunnels are shear wall structure, which mainly consists of the following aspects: floor structure, partition wall and roof structure. The design of the bottom plate structure is usually by means of cast-in-place construction. The other two plump designs are respectively produced in the prefabrication plant according to the design size, and then assembled and reinforced in the construction site. In the design of the partition wall and roof components, it is necessary to strictly follow the characteristics of the structures needed for the deep-sea tunnel and the requirements of the relevant construction methods.

(2) Detailed interface design of prefabricated components
The detailed interface design of prefabricated components mainly includes four parts. The first is the interface design between the partition wall and the cast-in-situ floor. The grouting cylinder can connect the partition wall to the cast-in-place base plate. In the bottom of the building, the vertical reinforcement is set in the part of the dividing wall in advance. When the dividing wall is assembled, the vertical reinforcement is inserted into the interior of the grouting sleeve, and then the grouting is injected into the interior of the sleeve. The second is the longitudinal separation wall indirect mouth design; The two ends of the longitudinal wall cannot be directly joined together, but a certain distance is set to leave a semicircular groove, and mortar is then injected at the interface of the groove, so that the adhesion of the interface is greatly enhanced. And the structure also allows the forces between the walls to be greatly reduced. The third is the interface design of wall and roof. The inverted groove can be formed in zhongjin by means of indirect post-casting belt. At this time, the u-shaped steel bar is reserved at the junction, and the connection at the junction is strengthened by pouring concrete materials. The fourth is the roof indirect mouth design; Cross-sea tunnel has higher requirements on the interface design between the roof, and different interfaces of the roof also need different treatment. For the interface of the bottom plate, the grouting method is used to deal with it, and concrete is poured and filled in the gap between the end of the bottom plate and the second lining structure. As for the interface of the roof, the horizontal way is adopted to combine the dry connection with the sealing rubber strip to ensure the tightness and waterproofing of the cross-sea tunnel to achieve the best results. Furthermore, the safety of the cross-sea tunnel is improved.

4.3 Research on Cross-Sea Tunnel Construction Based on the Principle of Prefabricated Building
In conclusion, on the basis of the assembled principle, the design of each part of the cross-sea tunnel should be deepened. Generally speaking, the basic process of cross-sea tunnel construction is to produce the relevant components according to the structure of the cross-sea tunnel in the prefabricated factory, and to leave the interfaces of the parts in advance. After completion of production, the precast plant will carry out on-site construction and installation, and adopt various methods to ensure the tightness and stability of the cross-sea tunnel, such as structural interlock and high-intensity perfusion. The construction process of the internal components of the cross-sea tunnel structure is as follows: embedded vertical reinforcement in the bottom plate and concrete pouring, etc. → hoisting of prefabricated wall components and grouting under the wall → installation of side span plate → installation of middle span plate, pouring of longitudinal post-pouring belt between board members → grouting of horizontal and vertical interfaces. According to this kind of construction process, the risk of prefabricated construction can be further reduced.

5. Conclusion
The establishment of cross-sea tunnel is the inevitable result of the development of national economy and science and technology. At present, the relevant technology of cross-sea tunnel construction in China is still relatively backward, and the relevant theoretical research is not mature enough. In order to promote the further development of cross-sea tunnel construction in China and improve the safety of cross-sea tunnel construction, this paper, on the basis of the assembly principle and with the help of GO algorithm, estimated the risk of cross-sea tunnel, and based on this, put forward relevant methods
for deepening the design and construction of cross-sea tunnel. Of course, these methods are still not perfect at present, but it also provides reference for future related research.

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