

Technology of reusable assembly power pipe trench and temporary road system

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Abstract. Based on the current situation of the temporary pipelines with disorderly layout and low integration, the temporary roads with time consuming, material consuming and environmentally unfriendly in, construction site, a new type of reusable assembly power pipe trench and temporary road system technology is proposed in this paper. The research background and research ideas of the technology are described; the partition, structure and connection of the system are designed; the stress of the system is checked by finite element method, and the main stress structure is optimized. The system has the advantage of high degree of integration, convenient transportation and installation, and high reusability, and it is in line with the modern construction concept of carbon emission reduction, green construction and civilized construction.

1 Introduction

Temporary pipelines and roads play a very important role in construction projects. An incomplete system make the pipe network disordered, easy to damage, difficult to turnover, frequent faults. And there are even safety accidents caused by pipeline faults. This puts forward higher requirements for the layout of temporary hydropower projects on the construction site, and also promotes the development trend of modernization, technology and intensification[1] of hydropower network.

The hardening degree of the temporary road on the construction site is relatively high, and the construction period is relatively tight[2], so the temporary road will directly affect the construction progress of the project. At present, the main form of temporary roads in China's construction projects is cast-in-place reinforced concrete temporary roads [3]. The prefabricated structure has the characteristics of good product quality, high production efficiency, fast construction speed and highly integrated functions [4]. In North America, Europe, Japan and other developed regions, prefabricated structure has been widely used [5]. In this paper, combined with the idea of prefabricated structure, a reusable assembly power pipe trench and temporary road system is designed to solve the above problems.

2 Design ideas

The design ideas of reusable assembly power pipe trench and temporary road system draws lessons from the ideas of comprehensive pipe gallery, and consider integrating the drainage, water supply, strong and weak current

systems into comprehensive power pipe trench to realize unified management.

3 Material selection

In the construction site, the system needs to meet the requirements of short processing cycle, fast assembly speed, low foundation requirements, good mechanical properties and low comprehensive cost.

3.1. Temporary road system

SP prestressed hollow plate (hereinafter referred to as SP plate) is a kind of large-span prestressed concrete hollow plate[6]. Due to the low requirement of SP plate for foundation, in order to reduce the area of foundation treatment, support will be set up and SP plate will be put on the support. The support adopts the conventional reinforced concrete beam form, and the beam section is selected from the rectangular section, trapezoidal section and triangle shape section (as shown in Figure 1).

3.2. Power pipe trench system

Power pipe trench system includes drainage zoning, water supply zoning, strong and weak current zoning. Combined with the design idea of the comprehensive ditch, the water supply zoning and the strong and weak current zoning are integrated into the small comprehensive ditch, and the function of the drainage zoning is incorporated into the prefabricated drain.

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4 Cross-sectional design

After material selection and preliminary design of each functional zoning, through assembly, the cross-section combination form of reusable assembly power pipe trench and temporary road system can be obtained, as shown in Figure 2. The road zoning is composed of SP plate, support A and support B; the drainage zoning is composed of drain; the water supply zoning and strong and weak current zoning are integrated into comprehensive pipe trench.

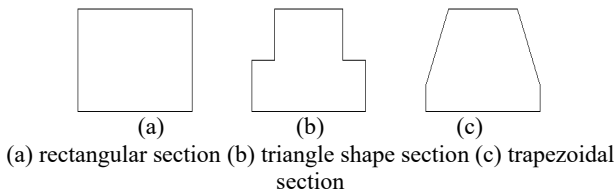


Fig.1. Schematic diagram of support section

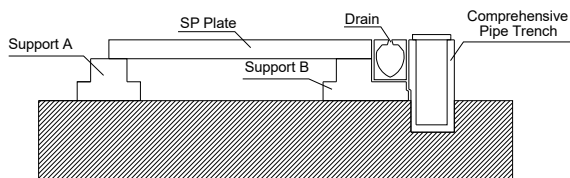


Fig.2. Sectional diagram of reusable assembly power pipe trench and temporary road system

5 Longitudinal design

5.1. Determination of longitudinal modulus

Basic module is the basic unit of dimension in module coordination. If the module is too large, the processing and handling of components is not convenient. If the module is too small, the installation is complex and uneconomic. Therefore, the modulus value should be comprehensively considered and designed in accordance with the Chinese national standard "Standard for modulus coordination of building" [7].

5.2. Longitudinal connection

For longitudinal connection, firstly, a connecting hole is set on the upper side of the end of the trench, and the bolt is penetrated into the connecting hole to connect two adjacent sections of the trench, as shown in Figure 3; then, mortar is poured between the fabricated sections. Mortar will change SP plate from one-way board to two-way board to a certain extent, which has a certain gain to the stress of the structural system; at the same time, it is also conducive to the improvement of the waterproof performance of the whole system. The pipe trench integrates the power supply system and water supply system, so we should pay more attention on the waterproof effect.

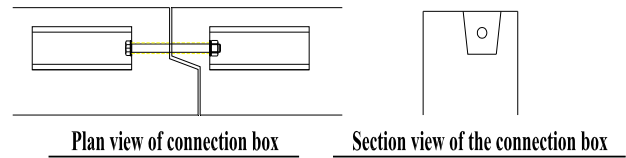


Fig.3. Schematic diagram of bolt connection

6 Finite element analysis

The finite element model of the system is established by ABAQUS software to analyse the overall stress of the system and optimize the main stress structure.

6.1. The establishment of the model

SP plate, the main materials are C45 concrete and prestressed steel strand. C45 concrete is simulated by three-dimensional solid homogeneous element with density of $0.6716 \times 2500 \text{ kg/m}^3$, elastic modulus of $3.25 \times 10^{10} \text{ Pa}$ and Poisson's ratio of 0.2; prestressed steel strand is simulated by one-dimensional truss element with density of 7900 kg/m^3 , elastic model of $1.95 \times 10^{11} \text{ Pa}$ and Poisson's ratio of 0.31. The support is made of C45 concrete. The three-dimensional solid homogeneous element is used to simulate the soil with the elastic modulus of $2.6 \times 10^8 \text{ Pa}$, the Poisson's ratio of 0.42, the density of 1900 kg/m^3 , the cohesion of 19 kPa , the friction angle of 31° and the expansion angle of 29° [8].

In the simulation, vehicle load and prestress are mainly considered. The model refers to the layout of vehicle load in "General specifications for design of highway bridges and culverts" [9]. The front two wheels generate 30 kN load, the four wheels in the middle generate 240 kN load, the rear four wheels generate 280 kN load, and the axle spacing between the two rows of wheels is 1.8 m . In the model, cooling method is used to simulate pretensioned tendons in SP plate. The established finite element model is shown in Figure 4.

6.2. Results of finite element simulation

After the calculation, we found that the maximum deformation occurred in the center of the SP plate. When the width of the SP plate was 8 m , the maximum deflection reached 73.08 mm , which was 0.9135% of the total length of the SP plate. The deflection met the relevant requirements.

The maximum stress appeared in the prestressed reinforcement, and the maximum stress in the concrete structure appeared in the contact area between the SP plate and the support with the initial calculation result of 28.847 MPa . The stress value at this point was large, which indicated that it is necessary to further optimize the design of the support. The maximum stress in the soil was 155.56 kPa , which could meet the stress requirements at the construction site.

7 Optimization for design

From the previous analysis, it can be seen that the support has a large force and needs further optimization design. The support A and B are similar. The only difference is that the support A extends one foot to match the size of the drain to facilitate the installation of the drainage system. Therefore, taking support B as an example, the optimal design is carried out, and support B is shown in Figure 5.

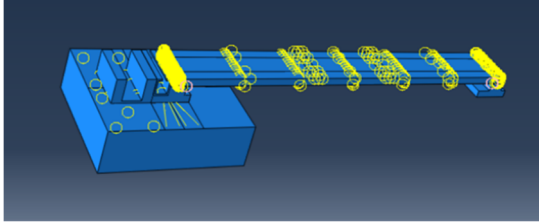


Fig.4. Schematic diagram of finite element model

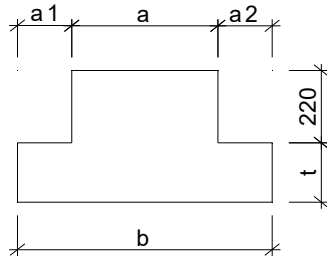


Fig.5. Sectional diagram of support B

The width of the upper edge is a ; the width of the left side is a_1 ; the width of the right side is a_2 ; the width of the lower edge of the support is b ($b=a_1+a_2$); the thickness of the upper part is to match the height of the drain (the thickness of the upper part + the thickness of the SP plate = the thickness of the drain), so it is temporarily set at 220mm; the thickness of the lower part is t . Through the finite element simulation, the maximum stress S_{max} on the support, the stress S_{mid} at the center of the bearing mass center, the stress S_{bot} at the center of the bottom of the support, and the maximum stress coefficient Sv_{max} , the stress coefficient Sv_{mid} at the center of the mass and the stress coefficient Sv_{bot} at the bottom center are recorded, and the cost of the component (volume) is considered in the stress coefficient.

7.1. The influence of thickness t

According to the simulation results (see Fig. 6), the thickness t of the lower part has little effect on the maximum stress value S_{max} ; in the range of 0-180mm, t has a significant effect on S_{mid} ; in the range of 40-140mm, t has a significant effect on S_{bot} . After considering the component cost, Sv_{max} and thickness t are positively correlated; Sv_{mid} and thickness t have a certain cubic function relationship in the range of t on 40-220mm, and have an extreme value around 180mm; Sv_{bot} and thickness t have an exponential function relationship in the range of t on 40-220mm, and the influence of thickness t on Sv_{bot} is not obvious when t exceeds 160mm. Based on the above stress analysis, and considering the structural

requirements and processing convenience, the value of t can be 160-180mm.

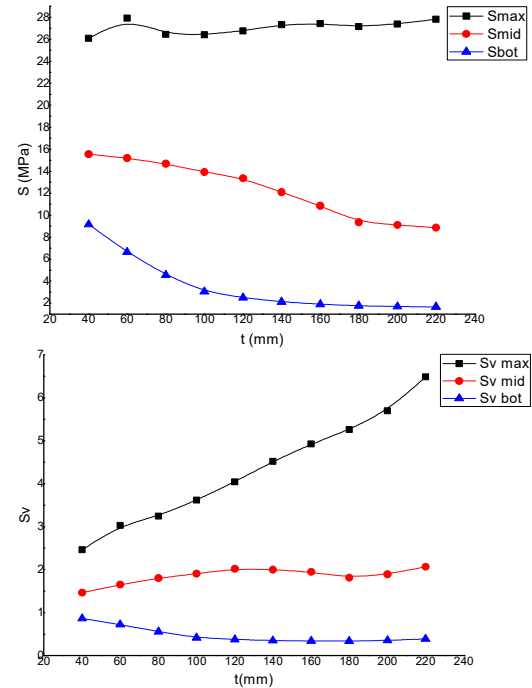


Fig.6. Relationship between thickness t and stress S

(The left figure does not consider the component cost, while the right figure does)

7.2. The influence of width a_1

It can be seen from Figure 7 that the width a_1 has a certain influence on the stress value in the range of 305-390mm, but it is not obvious; after considering the cost factor, a_1 has a small linear relationship with Sv_{max} , and a_1 has no obvious influence on Sv_{mid} and Sv_{bot} . Considering material saving, the range of 305-315mm is preferred for a_1 .

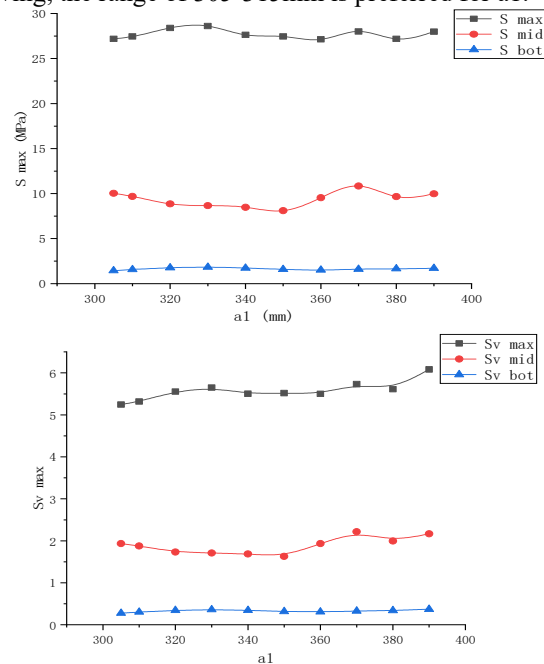


Fig.7. Relationship between width a_1 and stress S

(The left figure does not consider the component cost, while the right figure does)

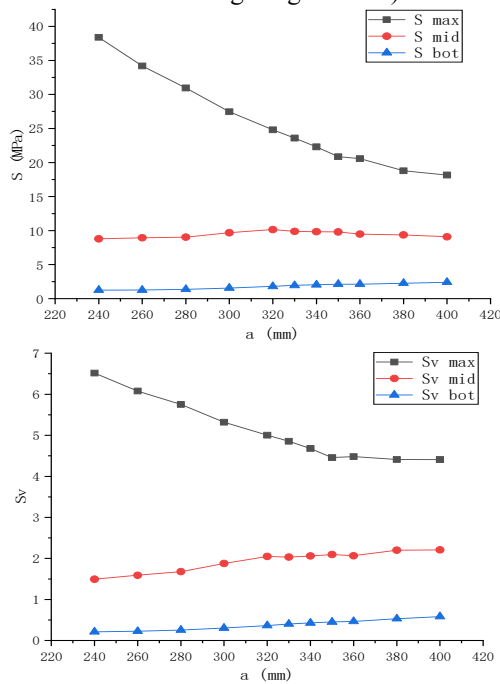


Fig.8.Relationship between width a and stress S

(The left figure does not consider the component cost, while the right figure does)

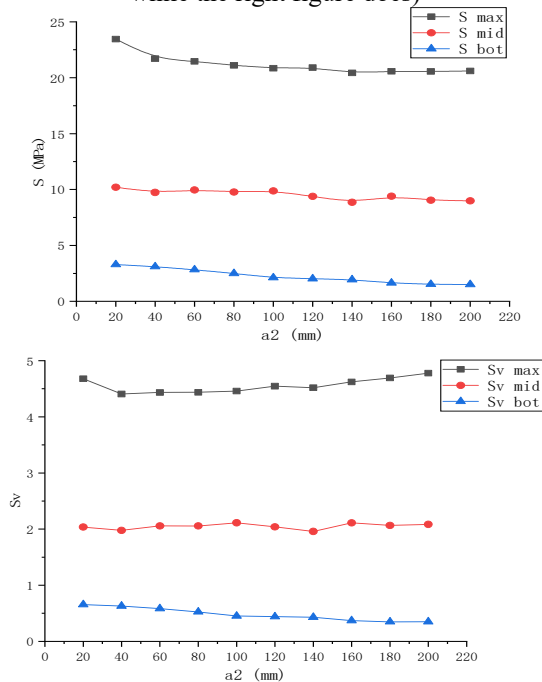


Fig.9.Relationship between width a2 and stress S

(The left figure does not consider the component cost, while the right figure does)

7.3. The influence of width a

It can be seen from Figure 8 that S_{max} decreases with the increase of a in the range of 240-400mm, and the effect of a on S_{mid} is not obvious, showing a weak quadratic

function relationship. The linear growth relationship between a and S_{bot} has a small slope. Considering the cost coefficient, $S_{v_{max}}$ decreases linearly with a when a is 240-350mm, and a has no obvious effect on $S_{v_{max}}$ when a is more than 350mm; $S_{v_{mid}}$ and $S_{v_{bot}}$ increase linearly with a when a is 240-400mm. Considering the obvious effect of a on the maximum stress, the width a can be selected around 350mm.

7.4. The influence of width a2

As can be seen from Figure 9, the effect of parameter a_2 on stress is not significant. By comparison, when a_2 is about 70mm and 130-140mm, there is a lower stress value. And when a_2 is 130-140mm, the maximum stress value is smaller, so a_2 can be selected in this interval.

8 Conclusion

Through the finite element calculation and optimization design, the force of the reusable assembly power pipe trench and temporary road system can meet the stress requirements; the system has high integration, meets the requirements of green construction and civilized construction, has the characteristics of easy operability and turnover. After a single project is completed, it can be used in other projects again, to reduce the use cost. So this system has broad application prospects and value of further investigation.

Acknowledgments

Thanks for the financial support of scientific research projects cscec7b-2019-Z-11 of China Construction Seventh Engineering Division Corp. Ltd..

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