Study on the Reasonable Spacing of Post-pouring Zone for 50m Long Inverted-T Type Concrete Structure on Soft Foundation

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Abstract. There are a large number of inverted-T type concrete structures on soft soil foundation in the Yangtze River Delta area of China. Setting post-pouring belt is one of the effective methods to reduce the cracking of such structures during construction. However, there is still a lack of reference standard on how to quantify the interval between the post-pouring belts under different conditions. For this kind of structure, natural silo positions in three pouring seasons are considered, and the post-pouring belts with different spacing are set up in the base plate and pier wall. The stress development during the construction period of the concrete under different combination conditions are simulated by finite element method (FEM). The results show that under the condition of load during the construction period, the pouring blocks of the base plate on the soft foundation do not need to be provided with a post-pouring belt. While the pier wall is constrained by the base plate, the maximum tensile stress of the pier wall has a positive correlation with the maximum temperature of concrete.

1. Introduction

When the plane dimensions of building structures exceed the maximum spacing of expansion joints specified in the concrete code, consideration should be given to increase the expansion joint spacing by using the method of construction post-pouring belt. The post-pouring belt can effectively solve the problem of self-shrinkage of concrete during construction [1].

Based on the analysis of the displacement of isolation bearing and the deflection of beam in construction stage under the most unfavorable temperature difference [2], it is found that the influence of post-pouring belt on the force deformation of isolated structure during construction is obvious. Setting the post-pouring belt "mainly by releasing" can effectively release the early shrinkage stress of concrete, and the effect of post-pouring belt closure is very obvious, which can be used as an important measure to effectively solve the effect of temperature difference shrinkage of super-long structure [3].

The reinforcement, width and spacing of the post-pouring belt are the important factors affecting the function of the post-pouring belt. The results of literature [4] show that the connection condition
of steel bar has a significant effect on the function of post-pouring belt. In the range of width and spacing of common post-pouring belt, the influence of post-pouring belt width on post-pouring belt is very small, so it can be determined according to the construction requirements. Literature [5] summarizes and analyzes the calculation theory of the interval between the post-pouring belts of basement structure. Reference by controlling the temperature of pouring settlement, designing and monitoring the post-pouring belt steel to better play the role of post-pouring belt [6]. At present, there are many researches on the reinforcement, pouring, width and layout of the post-pouring belt, but there is little research on the effect of the spacing of the post-pouring belt on the soft foundation on the stress of concrete during the construction period, so this paper carries out the research and analysis from this aspect.

2. Simulation model and parameters
The pier wall is 50 m in length, 2 m in width and 8 m in height. The base plate is 50 m in length, 50 m in width and 2 m in thickness. The cushion is 0.2 m in thickness. The soft soil foundation is 30 m in thickness of and the rock foundation is 20 m in thickness. There are pile foundations in the soft soil foundation under the base plate and cushion, and the foundation extends 50 m along each side of the upper and lower reaches. The overall finite element model is shown in Fig. 2-1, and the layout of the different post-pouring belts is shown in Fig. 2-2. Different finite element models are established according to the spacing of the post-pouring belt. The coordinate origin is located on the right bank of the base plate. The Z axis is vertical upward, the X axis is horizontal river direction from the right bank to the left bank, and the Y axis is the reverse flow direction.

![Fig 2-1. Structural finite element model.](image)

![Fig 2-2. The finite element model of base plate and pier wall with different spacing.](image)

The foundation material below the base plate of this structure is mainly silty clay. C30 concrete is used in pile foundation structure and C25 concrete is used in cushion structure. The concrete strength grade of inverted-T structure is C 30. The thermodynamic parameters of various materials are shown in Table 2-1.
In order to be easy to calculate, the monthly mean temperature of many years is fitted into a cosine curve.

\[ T_\text{a}(\tau) = 17.1 + 12 \times \cos \left( \frac{\pi}{6} (\tau - 7.2) \right) \]  

(1)

In the form:  
\( \tau \) Time (month).

In the simulation of the temperature field, the surrounding and bottom surface of the foundation is adiabatic boundary, and the upper surface is the heat dissipation boundary. The other surfaces are heat dissipation boundaries.

In the simulation of stress field, normal constraint is imposed on the surrounding and bottom surface of the foundation, and the upper surface is free boundary. Other surfaces are free boundaries.

3. Calculation condition and result analysis

3.1 The series of pouring conditions in summer

The base plate is poured in summer, the pouring temperature is 35 °C, and the post-pouring belt is poured after the first pouring block drops to 30℃. The first pouring block of the pier wall is poured after the post-pouring belt of the base plate drops to 30℃, and the post-pouring belt of pier wall is poured after the first pouring block of pier wall drops to 30 ℃. The spacing of the post-pouring belt is 50 m, 25 m, 20 m, 15 m and 8 m respectively.

Limited to space, this paper only gives the stress diachronic curves of the interior characteristic points of the base plate and pier wall.

From the above figure, it can be seen that the optimum pouring length of base plate of the 50m×50m model in summer is 25 m, and the optimum pouring length of pier wall is 8 m.

3.2 The series of pouring conditions in spring

The base plate is poured in spring, the pouring temperature is 25 °C, and the post-pouring belt is poured after the first pouring block drops to 25℃. The first pouring block of the pier wall is poured after the post-pouring belt of the base plate drops to 25℃, and the post-pouring belt of pier wall is poured after first pouring block of pier wall drops to 25℃. The spacing of the post-pouring belt is 50 m, 25 m, 20 m, 15 m and 8 m respectively.
From the above figure, it can be seen that the optimum pouring length of base plate of the 50m×50m model in spring is 50 m, and the optimum pouring length of pier wall is 20 m.

### 3.3 The series of pouring conditions in winter

The base plate is poured in winter, the pouring temperature is 15 °C, and the post-pouring belt is poured after the first pouring block drops to 20°C. The first pouring block of the pier wall is poured after the post-pouring belt of the base plate drops to 20°C, and the post-pouring belt of pier wall is poured after the first pouring block of pier wall drops to 20°C. The spacing of the post-pouring belt is 25 m, 20 m, 15 m and 8 m respectively.

### 4. The relationship between the maximum tensile stress of pier wall and the spacing of post-pouring belt

The relationship between the maximum tensile stress (MPa) and the spacing of the post-pouring belt (m) inside the pier wall is shown in Fig. 4-1.
5. Conclusion

The main results are as follows:

1. From the overall calculation results, under the load condition during the construction period, the base plate on the soft soil pile foundation can be poured into relatively long pouring blocks in any season, and the longest length can be up to 50 m.

2. The maximum tensile stress of the pier wall is greatly constrained by the base plate, and there is a more obvious positive correlation between the maximum tensile stress and the highest internal temperature. To prevent the pier wall from cracking, the reasonable spacing of the joint or the spacing of the post-pouring belt should be chosen. The relationship between the optimum length of pouring block of the pier wall and the maximum temperature inside the pier wall is shown in Fig. 5-1.

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References
[1] Li Yulan. (2005) Design and Construction of concrete Post-pouring Belt. Coal engineering., 12: 35-36.
[2] Du Yongfeng, Zhao Lijie, Zhang Tao, et al. (2015) Study on Construction Mechanics and whole process Monitoring of Super long complex isolated structures. Engineering Mechanics., 32 (7): 1-10.
[3] Fu Xueyi, Wu Bing. (2007) Analysis and calculation of temperature difference shrinkage effect of concrete structure. Journal of Civil Engineering., 40 (10): 50-59.
[4] Zhang Jizhu. (2010) Analysis of the key influencing factors on the effective effect of the post pouring zone of the super long concrete structure. Building Science., 26 (7): 66-71.
[5] Zhang Junlan. (2016) Analysis of the interval between the post pouring bands of the basement structure. Science and Technology Investment in China., 35: 79.
[6] Yin Suhua, Yu Liu, Wu Yanli, Zhao Ying. (2017) The concrete technology of post pouring zone of raft foundation of Hongyun Building B tower. In: 2nd International Conference on Materials Science, Energy Technology and Environmental Engineering (MSETEE), Zhuhai.