Research on Cracking Control of Immersed Tube Tunnels Concrete by Pre-heating treatment

Fang Yu^{1,*}, Chunlin Deng¹, Zhibo Sheng¹, Kangchen Wang² and Shenyou Song²

¹ Key Laboratory of Durability Technology for Harbor and Marine Structure, Ministry of Communications, China

² Shenzhen-Zhongshan Link Administration Center, Zhongshan, 528400, China.

Abstract. Herein, the pre-heating treatments are researched. With diversity of zone and temperature, highest average temperature of the section 10cm below surface was 14.7°C, which is lower than that of the concrete block. And the distance of 20cm and 40cm to surface of section, the temperature is 11.8°C and 9.8°C, respectively. When the heating water of 60°C, the increase of 48h to 72h, the highest temperature is about 47.2°C and 49.6°C.

1 Introduction

With the development of marine structures, especially in China. The Immersed tubes have been built in sea-crossing projects. However, tubes that casted onsite or prefabricated with full-section casting are facing a problem of cracking control in constructions. The concrete blocks are pouring adopted, it is less impacted by climate and better curing condition, but concrete easily presented cracks in the old-new interfacial region during the construction, of which cracks occurred longitudinally and transversely were illustrated in Figure 1.

Fig. 1. Cracks occurred in interfacial region

The cracks caused by the external restrain of old sections, in new sections, and the shrinkage of tubes mainly stem from shrinkage of concrete cooling and drying shrinkage. Moreover, the shrinkage of concrete after 14d continues to be happened, the temperature of concrete dropped and contraction unfinished. According to the simulations and literatures, the cracks caused by temperature difference onto surface is less, but the possibility of cracking caused by constraint of new and old concrete is greater.

Therefore, the old concrete should be heated, and when the temperature of the new concrete rises to the peak, the two should be cooled at the same time to achieve the

synergistic shrinkage effect. It is important to study on the distribution of pipe and heating range of pipe, toward to the implementation of heating measures for immersed tubes and development of countermeasures.

2 Experiment

2.1 Preparation of Concrete block

One concrete section with size of 5.0m×3.0m×1.5m block is to be poured. The temperature and deformation of the internal section of concrete are to be monitored to analyse the distribution and varied volume of internal temperature field, and verify the performance of concrete. Temperature monitori shall be carried out after the concrete section 1 is poured. When the concrete drops to normal temperature, pre-heating tests shall be carried out in three areas (A, B and C zone), to study the variation trend of internal temperature field and deformation amount under the pre-heating condition.

Fig. 2. Schematic diagram of concrete block

Before casting, Temperature sensors embedded in the formwork monitor, of which monitor the specific location including: upper surface (5~10cm from the upper surface

* Corresponding author: yfang1@cccc4.com

of concrete), lower surface (5~10cm from the lower surface of concrete), component center, geometric center of water pipe section, etc. And Water pipes and temperature monitoring points in zone are shown in the figure 3.

region A is about 21cm, and the distance between the measuring point 1-07 and the water pipe is further. From the two points temperature monitoring results, the temperature variation trend and magnitude of the measuring points 1-07 and 1-33 are similar. The distance between 1-07 and the heating water pipe is relatively far, but the number of heating water pipes makes up for the disadvantage of the distance. 1-09 is located in the middle of two water pipes at the bottom of concrete. Although the rising trend of temperature is similar to that of the measuring point 1-33, the concrete has good heat dissipation due to its contact with the ground. When the temperature tends to be stable, the maximum temperature is 6°C lower than that of 1-33.

Table 1. Temperature in different points

No.	Distance to pipe/cm	Stable time/h	Stable temperature/°C
1-08	3	54	58
1-33	21	60	56
1-07	32	60	56
1-09	32	84	50

Fig. 5. Temperature variations of different points in concrete

3.2.2 influence range of heating by pipe

The heating stability time and temperature at different horizontal positions from the heating pipe are shown in Table 2, and the concrete temperature monitoring is shown in Figure 6. According to the temperature monitoring results, the closer the distance is to the water pipe, the shorter the time needed for the heating temperature to reach the temperature. When the distance exceeds 45cm, the time for the heating temperature to reach the stability will not increase with the increase of the distance. After heating, the surrounding concrete is heated, and the temperature distribution of the heated concrete has a certain gradient. The temperature gradient of concrete is linearly distributed within 15~90cm from the horizontal position of water pipe. When the distance exceeds 90cm, the heating pipe has no obvious thermal effect on the concrete, the temperature of different points is illustrated in table 2.

Table 2. Temperature in different points

No.	Distance to pipe/cm	Stable time/h	Stable temperature/°C
1-27	15	76	52
1-11	30	83	48
1-28	45	91	46
1-29	60	91	43
1-30	75	92	42
1-31	90	92	40

Fig. 6. Temperature variations of different points in concrete

The temperature field distribution at different locations of pipes with different heating times are shown in fig 6. After the temperature stabilizes, the temperature field distribution is shown in fig 7. When heated for 12h and 24h, the concrete isotherm at 50 °C was 10cm away from the water pipe; when heated for 48h, the range of 50 °C began to expand to 15cm; when heated for 72h, the isotherm at 50 °C stabilized to 20cm. When heated for 12h, the isotherm at 45°C was 22cm away from the water pipes. With the heating time of 24h, 48h and 72h, the isotherm expanded to 30cm, 44cm and 50cm, respectively, start to stabilize. The range of isotherm was not significantly expanded after further heating. When heating for 12h, the isotherm at 40 °C was 42cm from the water pipe, and when heating for 24h, 48h and 72h, the isotherm was expanded to 79cm, 80cm and 89cm respectively, and the range of the isotherm was further expanded to a small extent. From the change of temperature field, the temperature range of 50°C and above after concrete heating is the smallest, and with the extension of heating time, the expansion area is the smallest, but the actual stable temperature is the shortest. The temperature range of 40~45°C is the largest. After heating for 24h, the influence range will be larger, but the influence range of further heating will not increase much. The influence range of 45~50°C is between them. With the extension of heating time, the expanded area also increases greatly. From the perspective of heating effect, the influence of hot water on the thermal range of concrete can be maximized by heating for 24h. In the heating stage, the temperature field of concrete shows exponential distribution within the range of 0~90cm from water pipe. When the heating is stable, the concrete temperature field

shows a linear distribution within the range of 15~90cm from the water pipe.

Fig. 7. Temperature variations of different points in range

4 Conclusions

The highest average temperature of the section 10cm to the left was 14.7°C lower than that of the block. The highest average temperature of the section 10cm to the left was 14.7°C lower than that of the plain concrete section; the lowest average temperature was 11.8°C lower than that of the template 20cm; the lowest average temperature was 9.8°C lower than that of the template 40cm; the concrete temperature within 50cm at the end was significantly lower than the internal temperature. Therefore, appropriate curing conditions, such as heat preservation, can be taken into consideration in the actual construction of immersed pipe joint to maintain the original temperature field of old concrete and reduce the risk of restricted cracking.

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