Temperature Control Analysis of Mass Concrete and Engineering practice

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Abstract. The problem of controlling the hydration heat of large volume concrete has been paid highly attention by the bridge project. In this paper, the construction process of large volume concrete in the cushion cap of Extradosed Cable-Stayed bridge is monitored in real time and measures of heat preservation are put forward in time: set up the cooling water pipe, strict temperature control and maintenance measures, The rate of temperature change in temperature is recorded in real time and so on, and compared with the relevant regulations of the standard in time. There is no crack after the concrete placement of the cushion cap is completed,, which has reached the desired concrete crack protection requirements. Engineering practice shows that the real time temperature control measures of mass concrete are effective, and the information construction of mass concrete temperature control is realized.

1. Introduction

The release of hydrated heat from mass concrete during the curing process will lead to greater temperature change and contraction, resulting in cracks. In the construction of bridge pier concrete, often because of improper cracking measures, leading to temperature stress exceeds the cracking strength, cause concrete cracking and concrete use. There are the rapid development of Chinese transportation in The Belt and Road Initiative environment, ridge engineering construction scale is increasing unceasingly. The problem of controlling the hydration heat of mass concrete has been paid great attention by the bridge engineering community.

There is the regulation on 《Code for construction of mass concrete》GB50496-2012: The volume of concrete structure with a minimum geometric size is not less than 1m, or a concrete that is expected to cause harmful cracks due to temperature change and shrinkage caused by hydration of cement materials in concrete, is called mass concrete. The American Concrete Institute(ACI) stipulates: "any mass concrete placed on site must be solved to solve the problem of hydration heat and the consequent volume deformation, so as to minimize the cracking.

The object of this paper is the cushion cap and pier structure of a Extradosed Cable-stayed bridge located in Yunnan, China. The cross section size of cushion cap is 26m x 12m x 5m. According to the construction plan, it is divided into 3 layers which are 1.9m, 1.5m and 1.6m height of the casting respectively and the concrete marks are C40. In order to ensure the quality of the construction and increase the temperature monitoring of the second section length 4m of the main pier, the main pier is filled with 4m for each layer, and the concrete mark is C50. The part of the arrowhead as shown in Fig.1.

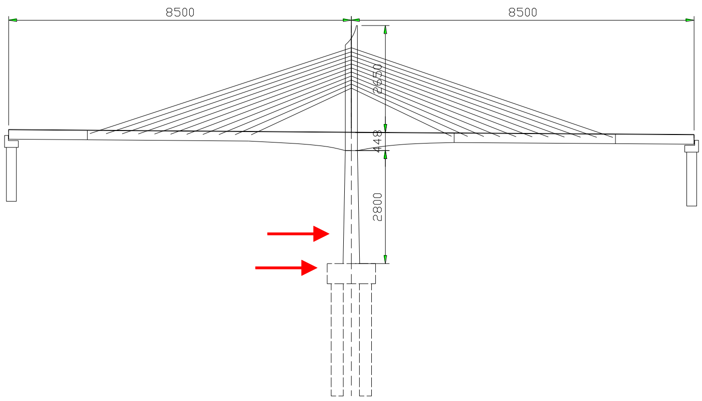


Figure1 Diagram of pier location

In order to master pier mass concrete internal hydration temperature change and development, to avoid the emergence of concrete temperature gradient, which effectively control the temperature cracks in concrete production, setting up a temperature monitoring scheme and the cooling cycle of water pipes to monitor the temperature inside the mass concrete of the platform, so as to realize the control of the mass concrete construction efficiency.

2. Monitoring indicators and their threshold

During the construction of mass concrete, the mould temperature of concrete, central temperature of concrete pouring body, and temperature of concrete surface are monitored to determine the following 4 temperature control values: temperature rising value of concrete pouring body; internal and external temperature difference of concrete pouring body； cooling rate of concrete pouring body; temperature difference between interior and surface of concrete pouring body and atmosphere.

When the temperature control value reaches the following regulations, the supervisor and the constructor are warned to adjust the concrete pouring procedures, cooling measures and maintenance methods in time.

①The temperature of the concrete pouring is more than 50 degrees centigrade on the basis of the mold temperature.

②The temperature difference between the interior and surface of concrete pouring body is greater than 50.

③The cooling rate of concrete pouring body is more than2℃/d.

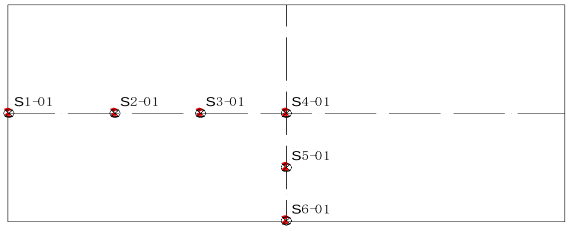
④ The temperature difference between the surface of the concrete pouring body and the atmosphere is greater than 20

Frequency of monitoring：The result of inspection by the supervisor for the temperature of the concrete entering the mould.4 times per day of central temperature, surface temperature, and ambient temperature of concrete pouring body.

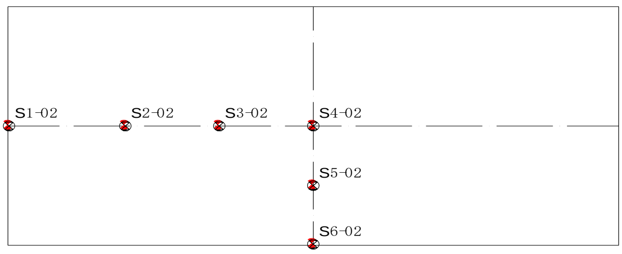
The temperature monitoring of the concrete pouring body's central，surface and environment，which is from the beginning of the concrete pouring day, until the last layer of concrete pouring is completed and maintained for 4~7 days.

3. Measuring point layout

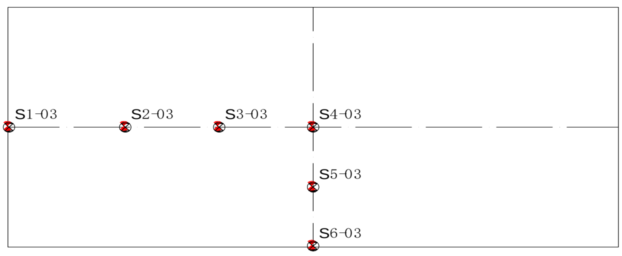
According to the construction plan, the concrete of the bearing platform is completed by 3 layers of pouring. Based on the construction plan and the regulation of《Code for construction of mass concrete》GB50496-2012, monitoring points of concrete pouring temperature and the surface temperature of the body center is arranged in the half symmetry axis of each layer on the concrete. The temperature measurement points for the first placement of the platform are arranged in Fig.2, the second and the third of the pouring layer by analogy; the temperature measurement points of the second layers of main pier are arranged in Fig.3.



2-A Layout of bottom temperature measurement point

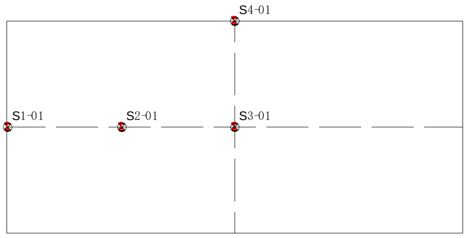


2-B Layout of mesosphere temperature measurement point

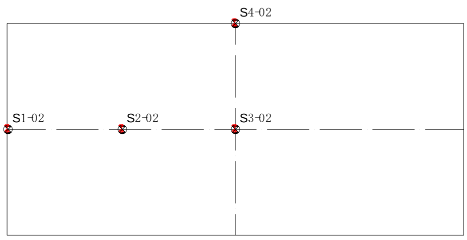


2-C Layout of top temperature measurement point

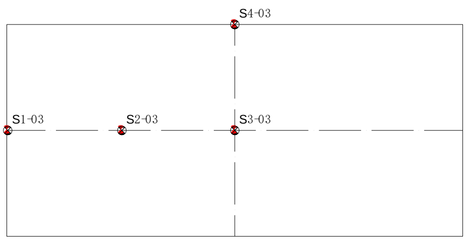
Figure 2 Layout of temperature monitoring point of cushion cap



3-A Layout of bottom temperature measurement point



3-B Layout of mesosphere temperature measurement point



3-C Layout of top temperature measurement point

Figure 3 Second layer temperature measuring point layout of bridge pier

4. Monitoring results

The results of the temperature monitoring at the first floor of the cushion cap are shown in Fig.4.

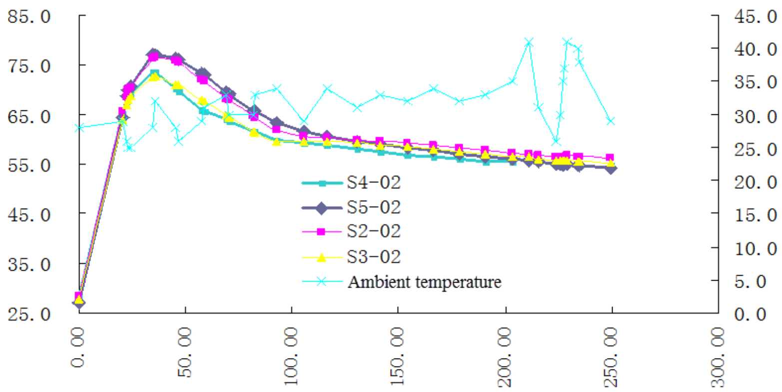


Figure4 The internal temperature change curve of the first layer of the cushion cap

Note: x-axis represents time/h, Left Y-axis The internal temperature of concrete/℃, Right Y-axis Ambient temperature/℃

① The maximum internal temperature of all monitoring points is 77℃, and the highest temperature appears at 14H after full storehouse.

②The maximum value of the internal and external temperature difference is 34.2℃， and appears at 3H after full storehouse. The time range of the internal and external temperature difference over 25℃ from 19:00 to 10:00 in August 25th to August 28th, the total time is 63H.

③The maximum temperature of cooling rate is 12.0℃/d, the maximum temperature of cooling rate appears at 51H after full storehouse, the time range of cooling rate exceeding 2℃/d is at August 26th 20:00~ August 29th 09:00, the total time is 61H.

The results of the temperature monitoring of the second layers of the cushion cap are shown in Fig. 5.

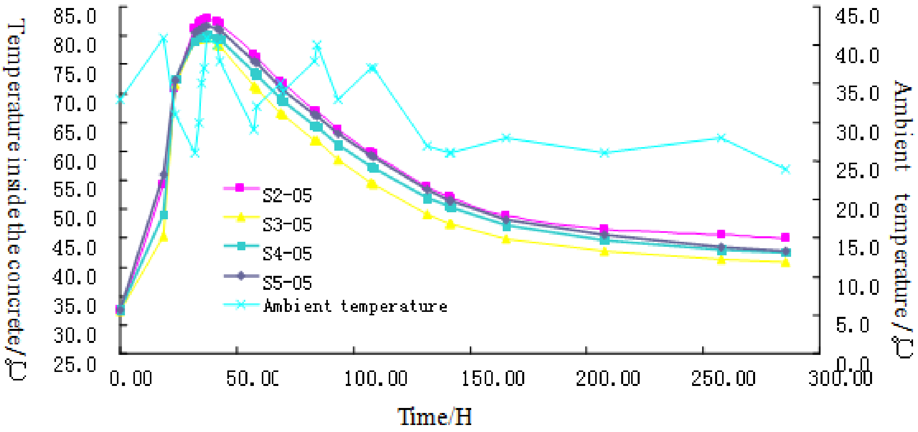


Figure5 Temperature monitoring results of second layers of cushion caps

① The internal maximum temperature of the monitoring point is 82.8℃, and the highest temperature appears at 19H after the full storehouse

②The maximum value of the internal and external temperature difference is 32.3℃, and appears at 65H after full storehouse; the time range of the internal and external temperature difference over 25℃ is from September 2nd 22:00 to 12:00 in September 6th. The total time length is 86H.

③The maximum temperature of cooling rate is 11.4℃/d, and appears at 40H after full storehouse. The time range of cooling rate exceeding 2℃/d is from September 3rd16:00 to 22:00 in September 8th, and the total time length is 198H.

The results of the third layer temperature monitoring of the cushion cap are shown in Figure 6.

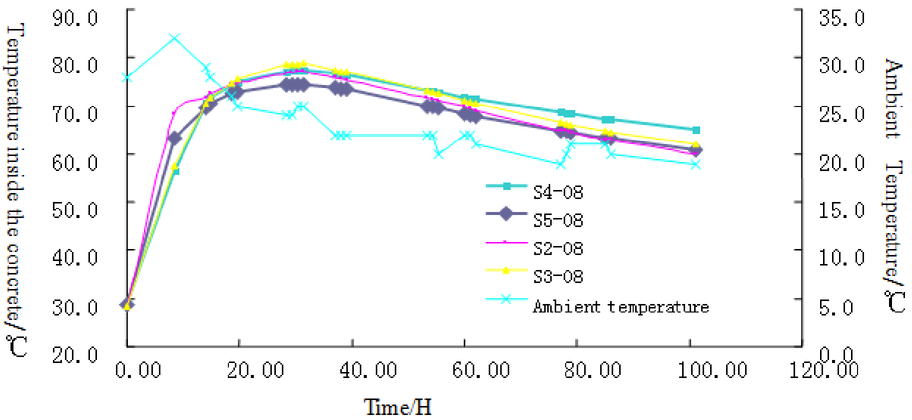


Figure6 Temperature monitoring results of third layers of cushion caps

①The internal maximum temperature of the monitoring is 78.8℃, and appears at 23H after full storehouse

②The maximum value of the internal and external temperature difference is 42.4℃, and appears at 47H after full storehouse; the time range of the internal and external temperature difference over 25 degrees centigrade from September 16th 16:00 to 11:00 in September 21st, the total time length is 115H.

③The maximum temperature of cooling rate is 9.6℃/d, and appears at 53H after full storehouse. The time range of cooling rate over 2℃/d is from September 17th 16:00 to 11:00 in September 21st, and the total time length is 91H.

The results of the second layer temperature monitoring of the pier are shown in Fig.7.

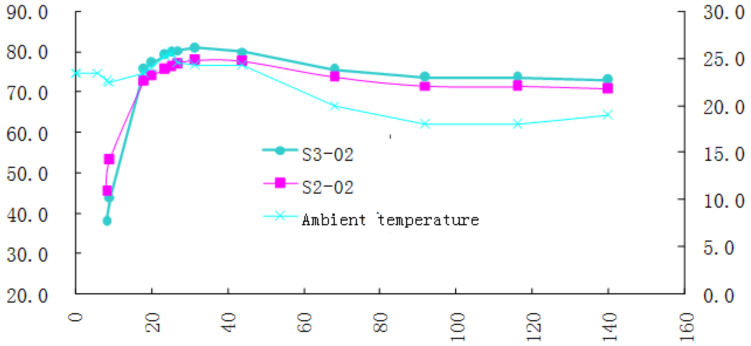


Figure7 Temperature monitoring results of second layers of bridge pier

Note: x-axis Time/h, Left Y-axis The internal temperature of concrete/℃, Right Y-axis Ambient temperature/℃

1) The internal maximum temperature of the monitoring is 80.9℃, and appears at 23H after full storehouse

2）The maximum value of the internal and external temperature difference is 45.7℃, and appears at 84H after full storehouse. The time range of the internal and external temperature difference over 25℃ is from October 12th 8:12 to 10:00 in October 17th, the total time length is 121H.

3）The maximum temperature of cooling rate is 4.4℃/d, and appears at 36H after full storehouse, the time range of cooling rate over 2℃/d is form October 13th 10:00 to October 14th 10:00, the total time length is 36H.

The main cooling measures used in the monitoring process are: When the cumulative temperature is up to 20 C, the cold water begins to pass; when the accumulative temperature continues to rise to 40℃-50℃, the water is fully accelerated to be cooled inside. When the accumulative temperature continues to rise above 50℃, the internal cooling can be accelerated while the external cooling method can be adopted at the same time. slow down the speed of the cooling water until the water temperature is slowly decreasing when the cooling begins. When the temperature difference of the surface is greater than 30℃ during the heating process, the external heat preservation measures can be taken to reduce the temperature difference in the surface.

5. Conclusion

In this paper, the temperature of mass concrete hydration process is monitored in second layers of cushion cap and pier, and real-time understanding of the temperature development and change inside of the concrete. It provides a reliable basis for the constructor to adjust its temperature control measures and maintenance scheme, and also realizes the information construction of the mass concrete. From temperature monitoring:

①The method of adopts cooling water pipe is effective, but the speed and time point of the water should be accurately.

②Real time temperature control measures make the internal and external temperature difference, temperature gradient and maximum temperature of concrete not exceed the standard value, so as to control the internal and external cracks caused by temperature changes of concrete.

③The result of the project shows that there is no temperature crack in the platform, and the temperature control ensures the quality of the project, and provides a guarantee for the construction of the follow-up project.

Acknowledgement

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References

[1] GB50496-2012. *Code for construction of mass concrete*. National standards of People's Republic of China.

[2] Xiaofeng Shang: *Application of Mass Concrete Structure Construction Technology in Civil Engineering Construction.* Atlantis Press2017.

[3] Song Zhao:*Construction quality control of large volume concrete pile cap of Xi-YouDong Bridge.* RAILWAY CONSTRUCTION TECHNOLOGY

[4] F.HollingWorth, D.J.Hooper and J.J.Geringer:*Roller Compacted Concrete Arched Dams, Water Power and Dam Construction*, November, 1989.

[5] T. Belytschko and M.Tabbara: Dynamic Fracture Using Element-free Galerkin Methods .Int, J, Num, Methods in engrg, 1996, 39:923～928.

[6] Kidd Francine, Buttner Clark, Kressel Amy B:*Construction: a model program for infection control compliance.*[J]. American Journal of Infection Control, 2007, 35(5).