

Optimization of dam concrete temperature control standard based on concrete thermal cracking test

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Abstract. In this paper, the influence of temperature drop rate at an early age on the thermal cracking risk of concrete was investigated by using concrete thermal cracking test. The temperature drop rates of 1°C/day and 0.5°C/day were set. The test results showed that under the condition of the same temperature drop, the temperature drop rate of 1°C/day can effectively reduce the tensile stress caused by temperature drop, and the cracking temperature can be reduced by more than 8%. The test results verify that the concrete should be cooled to the target temperature as soon as possible provided that the tensile stress is less than tensile strength. This test can effectively optimize the temperature control standard of dam concrete quantitatively and improve the safety of dam construction period.

Keywords: Early age; temperature drop rate; thermal cracking test; cracking temperature.

1. Introduction

Cracking of mass concrete has been a common phenomenon [1]. Cracks not only affect the appearance of concrete, but also accelerate the carbonization of concrete, affect the strength and stability of structure, endanger the normal use of buildings and shorten the service life of buildings. How to effectively prevent the formation of cracks have become the concern of the technicians and this problem is still the key direction to be solved urgently for mass concrete at present [1,2].

By using the concrete thermal cracking test tool (i.e., temperature stress testing machine (TSTM)) [3-5], the concrete cracking process, the characteristics of dam concrete material development and the real constraint condition of concrete can be simultaneously considered; then the optimization of mass concrete temperature control standard can be achieved by obtaining the effect of different temperature drop rates on the thermal cracking of concrete.

2. Experimental program

2.1. Materials

Table 1 shows the mix proportion of concrete.

Table 1. Mix proportion of concrete (kg/m³).

Water	Cement	Fly ash	Sand	Stone	Water reducing admixture	Air entraining admixture
88	60	100	739	1433	1.28	0.56

2.2. Experimental procedure

Temperature difference is a traditional index to control the thermal stress of concrete. However, the temperature drop rate is also an important factor that cannot be ignored. The temperature history data adopted in the thermal stress test were measured from construction site of DG Hydropower station, that is, the temperature data was collected from a thermometer no. Tlr-07 # -3348.65.1 embedded in a concrete block (no. (7-8)#-3347.00). The influence of temperature history at early ages (within 20 days) on the final thermal stress and cracking behavior is emphasized. In order to analyze the influence of temperature drop history on the concrete thermal cracking risk, two different temperature drop rate histories were designed, as shown in Fig. 1.

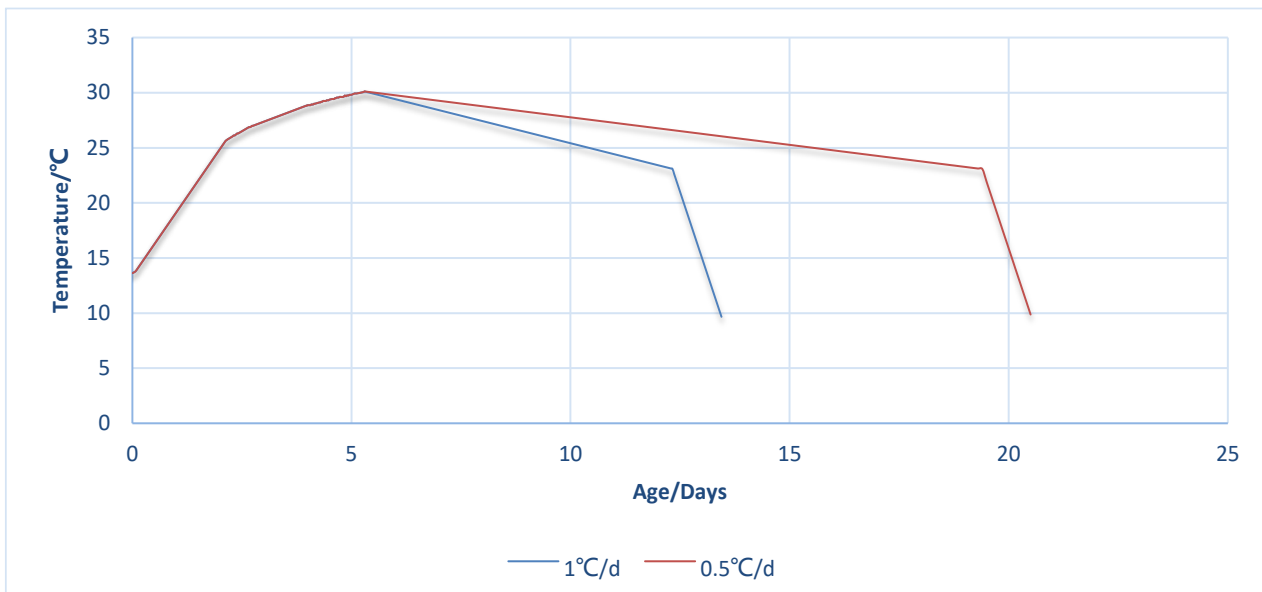


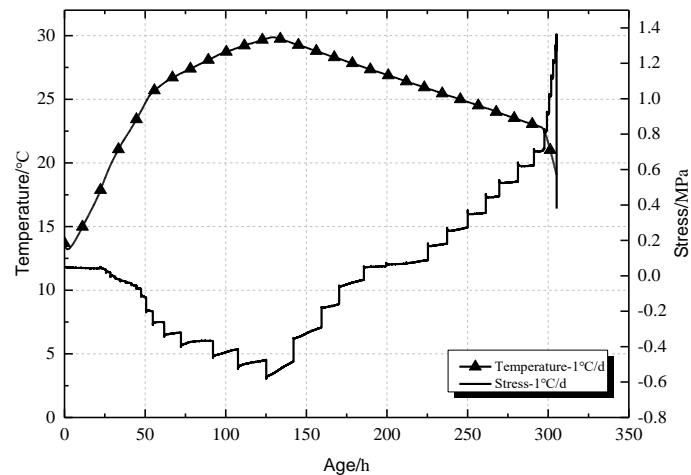
Figure 1. Temperature history of concrete.

The mixed concrete was wet-screened and cast into TSTM molds, then the concrete was well compacted. The same casting temperature was set for each group of concrete. A temperature sensor was installed in the center of the specimen to monitor the concrete temperature change, and a displacement sensor was installed to monitor the concrete displacement change. When the concrete reached the final setting age, the restraint control system was started, and the restraint degree was set at 100% until the concrete cracked.

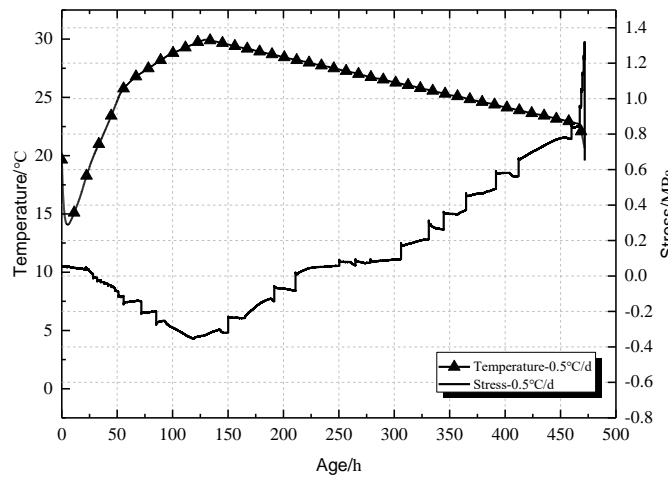
3. Results and discussions

3.1. Thermal stress

Fig. 2(a) and (b) respectively show the concrete temperature and stress curves of concrete under different temperature histories based on TSTM test. The sudden drop of concrete stress curve indicates the occurrence of cracks. With the increase of concrete temperature, the compressive stress of concrete specimen increased. With the decrease of temperature, the deformation of concrete was restrained to lead to continuous growth of tensile stress until cracking. The stress development trend is consistent with the temperature history. It can be seen that the cracking stress of concrete obtained under this test condition is about 1.27MPa.



(a)



(b)

Figure 2. Thermal stress of concrete: (a) 1°C/day and (b) 0.5°C/day.

3.2. Cracking risk

Fig. 3 shows the cracking temperature of concrete under different temperature histories based on TSTM test. It can be seen that the cracking temperature of concrete is 19°C and 20.7°C for the temperature drop rate of 1°C/ day and 0.5°C/ day, respectively. The rapid temperature drop at the early stage reduced the cracking temperature of concrete by 1.7°C with a reduction magnitude of 8.2%. This means that the higher early temperature drop rate can improve the resistance of concrete structure.

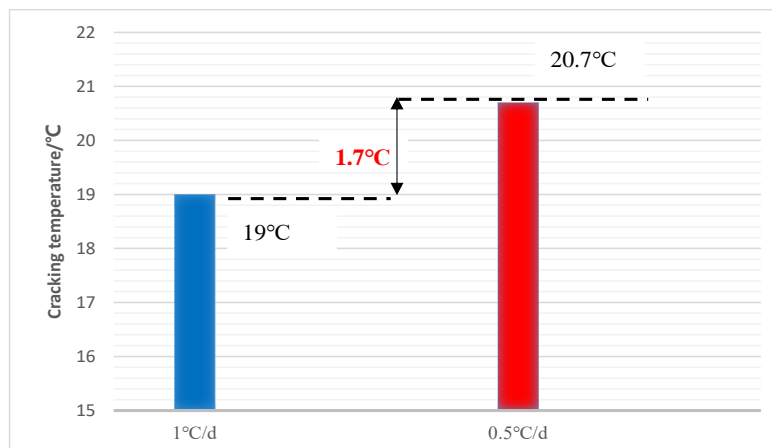


Figure 3. Cracking temperature of concrete.

4. Conclusions

In this paper, the thermal cracking risk of concrete under different temperature drop histories was investigated by using temperature stress testing machine. The test results showed that the cracking temperature of concrete is 19°C at the temperature drop rate of 1°C/ day, and about 20.7°C at the temperature drop rate of 0.5°C/ day. The early rapid temperature drop reduced the cracking temperature of concrete by 1.7°C with a reduction magnitude of 8.2%.

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