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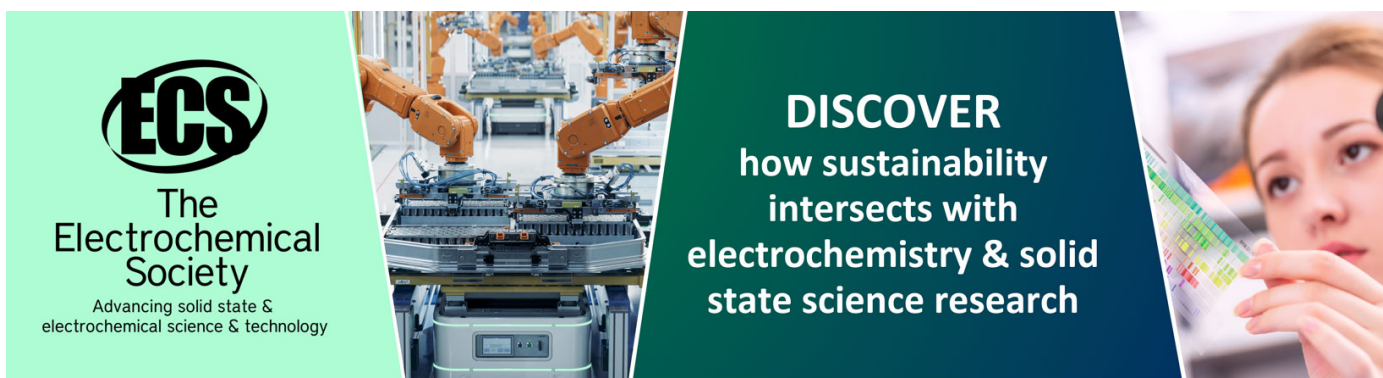
Carbonation and Mechanical property of the Concrete Core Samples from a concrete dam after long-term operation

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Carbonation and Mechanical property of the Concrete Core Samples from a concrete dam after long-term operation

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Abstract. To investigate the ageing characteristics of dam concrete, concrete core samples were obtained from an existing dam. The compressive strength and carbonation depth were determined. The relationship between compressive strength, carbonation depth and operation time were analyzed. The results show that the compressive strength of dam concrete increases with operational time, the increasing rate of compressive strength was gradually decreased, and the compressive strength gradually increases with depth carbonation growth. There was a certain correlation between compressive strength, operational time and depth carbonation. The research results will provide a reference for the safety evaluation of hydraulic concrete structures in service.

1. Introduce

Carbonation was a no-negligible influence factor of hydraulic concrete durability, and is more and more attention. The concrete structure is inevitably attacked by carbon dioxide in the service process, and the concrete will shrink after carbonization, or even crack in severe cases, which seriously affect the durability and mechanics behavior of concrete [1], so carbonation was one of the main factors that lead to the destruction of concrete structure. Carbonation can decrease the flexural strength of concrete, and due to carbonation, water absorption and permeability of concrete were decreased [2]. Carbonation was very unfavorable to concrete for earthquake-resistance and fire-resistance [3]. Carbonation can increase the density of concrete, compressive strength, freeze-thaw, flexure strength, abrasion resistance, may cause corrosion of reinforced concrete, and are no adverse effects to plain concrete [4]. In order to make objective and accurate assessment of the safety of the dam, the study on mechanics property and durability of dam concrete after carbonization in complicated natural environment is very necessary.

Compressive strength was one of the most important properties of concrete, and it was considered as a reference for many other properties, such as the tensile strength and elastic modulus of concrete. Carbonation depth was recognized as one of the main factors to quantitatively assess the carbonation degree of concrete. In this paper, the concrete core sample with a diameter of 100mm was drilled from the different parts of an existing dam after long-term operation. The compressive strength and carbonation depth were investigated by mechanical test and chemical analysis. The correlation between compressive strength, carbonation depth and operation time was discussed based on the experimental results.



2. Experimental research

A concrete dam is located on the Han Jiang River, which is 18 km west of AK City. The height of the dam is 120 m, with a crest of 500 m in length and 12.0 m in width. This dam began to establish after 1978, and the main concrete construction had been completed in February 1998. In the 22 years running, the whole dam is functioning properly. However, some ageing diseases are emerging in the dam, such as crack and calcium dissolution in Figure.1. Some core samples were obtained from the dam in order to evaluate the ageing characteristics of the hydraulic concrete.



Fig 1. The calcium dissolution in the gallery

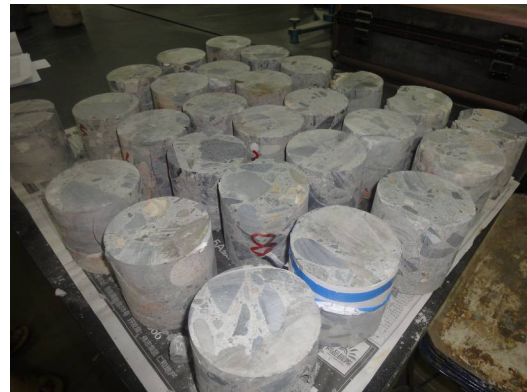


Fig 2. The concrete core samples

The core samples were drilled with a new type of thin-wall diamond core drill bit, the location, design concrete grade and construction date of the core samples were given in Table 1.

Table 1. The concrete core sample from the dam

Sample number	Location	Design concrete grade	Construction date
I#	traffic gallery	R28100S8	1988
II#	grouting gallery	R28100S8	1979
III#	observation gallery	R28100S8	1985
IV#	downstream dam slope	R28150S8D50	1987
V#	Stilling basin	R28150S8D50	1998
VI#	Power house	R28150S8D50	1996
VII#	upstream dam slope	R28300S8D50	1986
VIII#	spillway pier	R28300S8D50	1995
IX#	overflow weir	R28300S8D50	1992

100×100 mm (diameter×height) specimens were made from these core samples. These specimens were cured at acetone solution for one day in order to stop the hydration reaction. All specimens were then placed in dry oven for one day. The temperature of the dry oven varied between 20 to 25°C during the curing. When curing was accomplished, Compression tests were made by a large tonnage static material bending performance test machine, the measuring compressive strength of this device was in the range of 0~3000kN.

The phenolphthalein solution was sprinkled over the fracture surfaces of these specimens to determine carbonation depth. The color of indicator changes to pink with the variation of pH value (more than 8.2). There can appear colored and no-colored areas, which represent noncarbonated and carbonated areas. Carbonation depth was measured based on the non-colored areas. Compressive strength and carbonation depth was provided in Table 2 for all specimens.

Table 2. Compressive strength and carbonation depth for all specimens

Specimen number	Corresponding sample number	Compressive strength/MPa	Carbonation depth /mm
1#	I#	13.8	18.7
2#	II#	15.2	26.5
3#	III#	14.5	20.4
4#	IV#	19.8	17.2
5#	V#	17.1	12.3
6#	VI#	18.7	14.6
7#	VII#	36.4	13.5
8#	VIII#	34.9	10.1
9#	IX#	35.7	11.3

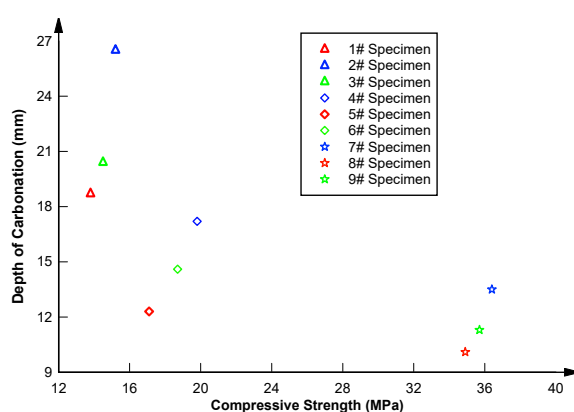


Fig 3. Compressive strength and carbonation depth relationship for specimens

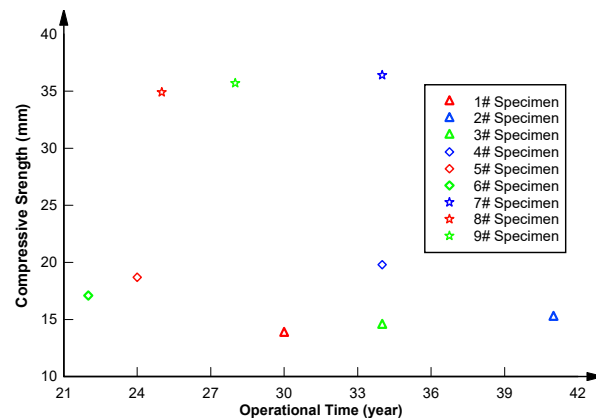


Fig 4. Compressive strength and operational time relationship for specimens

From the experimental results, the carbonation depth of 2# specimen was maximum; the test value was 26.5mm. The carbonation depth of 8# specimen was minimum, the test value was 10.1mm. the compressive strength values of these specimens were greater than the corresponding design strength, and the compressive strength of concrete in the dam was not descending due to carbonization, the compressive strength can increase with operational time.

As shown in Figs.3~4, for specimens with the same design strength, the depth of carbonation increases as the compressive strength increases. This was because carbonation can cause the decrease of the porosity in the dam concrete. For specimens with the different design strength, the depth of carbonation decreases as the compressive strength increases. This was because the concrete with high design strength has less harmful pore structure. The compressive strength increases with operational time, but the increasing rate of compressive strength was gradually decreased. This was because the surface of concrete was dense after carbonization; carbon dioxide is not easy to penetrate [5, 6].

3. Conclusions

Based on the analysis of the results of the experiments, the conclusions were shown as follows:

(1) The experimental results show that there was a certain correlation between compressive strength, operational time and depth carbonation.

(2) The compressive strength of dam concrete was not descending due to carbonization; the compressive strength can increase with operational time.

(3) Carbonation will increase the density of concrete, then improve the mechanical performance and durability of dam concrete.

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References

- [1] NIU Z G, YOU R, WU J T. (2016) Study on relationship between dam concrete material performance evolution and its pore structure. *Water Resources and Hydropower Engineering*, 47:25-28.
- [2] ZHAO B H, FEI Z Y, ZHAO Y, ZHANG S P. (2012) Effect of carbonation on the performance of concrete. *Bulletin of the Chinese Ceramic Society*, 31:1641-1644.
- [3] ZHU B L, XIAO J Z. (1998) The structural behavior of carbonized of concrete. *Industrial Construction*, 28:41-44.
- [4] FANG J, MEI G X, LU C R. (1996) Influence of carbonation on properties of concrete. *Water Resources and Hydropower Engineering*, 2:58-63.
- [5] NIU Z G, YOU R, LI W, et al. (2017) Study on the aging and pore structure of hydraulic concrete. *Advanced Materials Research*, 1142:340-343.
- [6] NIU Z G, YOU R. (2019) Study on evolution of material macroseopical performance of concrete dam. *Dam and Safety*, 3:45-49.