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Effect of Curing Temperature on Early Freeze-thaw Resistance of HVFA Concrete

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Abstract: *This paper studies the effect of curing temperature on the early freezing-thawing resistance of HVFA concrete, and determines the early freezing-thawing resistance of HVFA concrete under different curing temperatures by testing the compressive strength, mass and ultrasonic wave velocity of the specimens. The results show that curing temperature has a certain influence on the early freezing-thawing resistance of HVFA concrete. The decrease rate of the compressive strength of HVFA concrete cured at 40℃ is the least, and the quality of HVFA concrete cured at different curing temperatures firstly increases and then decreases with the increase of the number of freezing-thawing cycles. According to the freeze-thaw damage value defined by wave velocity, curing temperature has a great influence on the freeze-thaw damage of HVFA concrete.*

Keywords: *HVFA Concrete, Freeze-Thaw Cycle, Curing Temperature, Compressive Strength, Quality*

1. Introduction

As a green building material, high content fly ash (HVFA) concrete has been gradually applied in water conservancy, construction and other industries. At present, there have been many different views on the anti-freezing performance of fly ash concrete [1].Xiao Qianhui et al. [2] pointed out that when the fly ash content was less than 30%, the fly ash could improve the frost resistance of concrete. Wang Min et al. [3] believe that concrete with 15% fly ash content has the best frost resistance. However, many researchers believe that the antifreeze performance of concrete material cannot meet the design requirements due to the large amount of fly ash [4][5].When the fly ash content of Hu Bangsheng [6] exceeds 30%, the frost resistance of the material decreases. Zhang Qizhi [7] showed that the optimal content of fly ash had an effect on the frost resistance of concrete, which was about 30%.Wang Peng [8] showed that with the increase of fly ash content, the antifreeze performance of concrete showed a decreasing trend. When the fly ash content was 60%, the antifreeze performance was the best. The freezing resistance of HVFA concrete is improved by the application of air entrain agent [9][10][11].However, few of these studies involved the effect of curing temperature on the early frost resistance of HVFA concrete. Therefore, in this paper, by means of experimental methods in different curing temperature is variable of HVFA concrete freezing-thawing resisting performance influence law studies, a systematic analysis of freeze-thaw cycles under different curing temperature on HVFA the quality loss situation, the compressive strength of concrete and the influence of ultrasonic wave velocity, and qualitative and quantitative analysis of different curing temperature on properties of concrete freezing-thawing resisting HVFA, provide the technical support for improving HVFA concrete freezing-thawing resisting performance.

2. Experimental Method

Table 1 Mix proportion of concrete with large fly ash content

number	flyash/kg	cement/kg	Water /kg	sand/kg	cobblestone/kg	superplasticizer/kg	curing temperature/℃
FT-01	219	219	175	625	1162	2.1	20
FT-02	219	219	175	625	1162	2.1	40
FT-03	219	219	175	625	1162	2.1	60

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3. Result and Analysis

The experimental results of mass, compressive strength and ultrasonic wave velocity of HVFA concrete specimens prepared at different curing temperatures after freeze-thaw cycles are shown in Table 2.Among them, the total number of freeze-thaw cycles of specimens cured at 20℃, 40℃ and 60℃ were 141, 152 and 131 times, respectively.

It can be seen from Table 2 that the mass of HVFA concrete test blocks under 20℃, 40℃ and 60℃ curing conditions increased by 0.30%, 0.31% and 0.34% respectively before reaching the freezing-thawing cycle 70 times, 70 times and 60 times. This is because HVFA concrete in the early stage of freeze-thaw cycle due to the strength of concrete itself did not appear slag drop, on the contrary, because of the freeze-thaw cycle caused by the micro-crack water into the concrete test block, resulting in improved quality, and with the increase of curing temperature, the test block mass increased. When the freeze-thaw cycle was carried out for a certain number of times, the HVFA concrete test blocks began to drop slag. According to the data in Table 2, the mass loss rate and compressive strength decline rate of HVFA concrete with the change of freeze-thaw cycles under different curing temperatures were calculated, as shown in Figure 1 and Figure 2.It can be seen from Figure 1 that the variation trend of mass loss rate of HVFA concrete cured at three temperatures is basically the same. Among them, the freezing-thawing cycles of HVFA concrete curing at 20℃, 40℃ and 60℃ with a mass loss rate of 5% were 141, 152 and 131 times, respectively. The causes of this phenomenon may be due to 40 ℃ maintenance HVFA gelled material of concrete hydration rate faster, improve hydration degree, material due to the filling of hydration products is more dense, high strength and 60 ℃ curing test block is because higher curing temperature make the internal pore moisture evaporates quickly so as to make the gel material and water of hydration reaction can't be well leading to the decrease of strength of specimens.

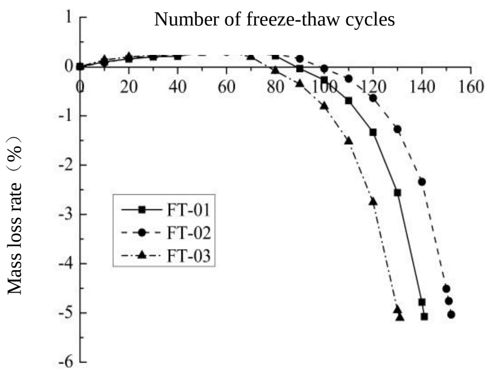

Fig. 1 Mass loss rate of specimens at different curing temperatures

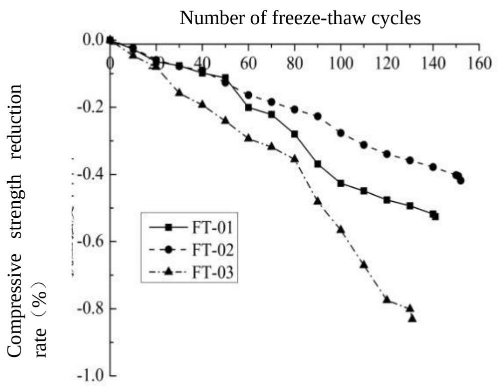

Fig. 2 Compressive strength change rate at different curing temperatures

It can be seen from Fig. 2 that the decline rate of compressive strength of test blocks at three curing temperatures gradually increases with the increase of the number of freeze-thaw cycles. Before starting the freeze-thaw cycle of 40 ℃ maintenance HVFA highest compressive strength of concrete block, block compressive strength of 20 ℃ maintenance center, 60 ℃ curing test block minimum compressive strength, perhaps because HVFA concrete under 40 ℃ maintenance, due to the increase of temperature increased the gelled material hydration rate and the degree of hydration, and the curing temperature of 60 ℃, due to higher temperature internal pore block, moisture evaporates too fast, and minimum strength. The compressive strength of HVFA concrete cured at 60℃ decreased by 60.18%, the compressive strength of HVFA concrete test blocks cured at 40℃ decreased by 39%, and the compressive strength of HVFA concrete test blocks cured at 60℃ decreased by 49.73%.It shows that curing at 40℃ has the best effect on the compressive strength of HVFA concrete test blocks.

4. Conclusion

(1) The mass of HVFA concrete cured at 20℃, 40℃ and 60℃ firstly increased and then decreased with the increase of the number of freeze-thaw cycles. When the mass loss rate reached 5%, the number of freeze-thaw cycles were 141, 152 and 131 times, respectively.

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(2) The decrease rate of the compressive strength of the three curing temperatures increases gradually with the increase of the number of freeze-thaw cycles, and the decrease rate of the compressive strength of the HVFA concrete cured at 40℃ is the least.

References

[1] GUO C R, SU R W. Study on the optimal content of fly ash to meet the requirements of freezing resistance of concrete with large fly ash content[J]. Inner Mongolia Water Conservancy, 2010(2): 14-15.

[2] XIAO Q H, NIU D T. Study on performance of fly ash concrete in freeze-thaw environment[J]. Concrete, 2012(7):81-82.

[3] ZHANG M, ZHANG Y. Experimental study on frost resistance of fly ash to concrete[J]. Journal of Hunan Institute of Science and Technology: Natural Science Edition, 2018, 31(1): 58-63.

[4] Zhang P , Li Q F . Freezing-thawing durability of fly ash concrete composites containing silica fume and polypropylene fiber[J]. Proceedings of the Institution of Mechanical Engineers, Part L: Journal of Materials: Design and Applications, 2014, 228(3):241-246.

[5] XU C D, XIE J L et al. Study on the decaying law of dynamic elastic modulus of fly ash air-discharged concrete under freeze-thaw action[J]. Water conservancy and hydroelectric technology. 2017,48(03):113-118

[6] HU B S. Study on frost resistance of concrete with large amount fly ash in high cold area[D]. Chongqing Jiaotong University,2017.

[7] ZHANG Q Z. Experimental study on freezing resistance of fly ash concrete under freeze-thaw cycles[J]. Fly Ash Comprehensive Utilization, 2018(01):28-30+34.

[8] WANG P, DU Y J. Study on impermeability and frost resistance durability of concrete with large amount of fly ash[J]. Concrete, 2011(12):76-78.

[9] LIU P H, XU Z M, YING B. Experimental study on high performance concrete with high content fly ash [J]. Journal of Yangzhou University (Natural Science Edition) , 2007, 10(1):67-71.

[10] YAN H D, SUN W, LI G. Study on bubble parameters and frost resistance of hydraulic concrete with large amount fly ash[J]. Industrial Architecture, 31(8):46~48.

[11] LU J F. Study on mechanical properties of concrete with large fly ash content under freeze-thaw cycles[D]. Northwest Agriculture & Forestry University.

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Table 2 Experimental results of concrete specimens with large fly ash content

Number of freeze-thaw cycles	quality/kg	compressive strength /Mpa	wave velocity/Km/s	Number of freeze-thaw cycles	quality /kg	compressive strength /Mpa	wave velocity /Km/s	Number of freeze-thaw cycles	quality /kg	compressive strength /Mpa	wave velocity /Km/s
0	2.355	38.2	3.72	0	2.263	43.1	4.11	0	2.332	34.8	3.47
10	2.357	37.2	3.7	10	2.265	42.1	4.1	10	2.336	33.1	3.46
20	2.358	35.8	3.68	20	2.267	40.6	4.02	20	2.337	32.0	3.5
30	2.359	35.3	3.61	30	2.268	39.8	4.01	30	2.338	29.3	3.54
40	2.360	34.5	3.57	40	2.268	39.2	3.97	40	2.339	28.0	3.56
50	2.362	33.9	3.56	50	2.270	37.7	3.92	50	2.339	26.4	4.19
60	2.362	30.5	3.32	60	2.270	36.1	3.56	60	2.340	24.6	4.11
70	2.362	29.7	3.25	70	2.270	35.2	3.45	70	2.337	23.7	4.07
80	2.360	27.5	3.21	80	2.269	34.2	3.39	80	2.330	22.4	4.01
90	2.354	24.1	3.01	90	2.266	33.3	3.31	90	2.324	18.0	3.76
100	2.348	21.9	2.95	100	2.262	31.2	3.02	100	2.314	15.1	3.57
110	2.338	21.0	2.83	110	2.257	29.7	2.97	110	2.297	11.4	3.37
120	2.323	20.0	2.76	120	2.248	28.5	2.86	120	2.268	7.8	3.07
130	2.249	19.4	2.72	130	2.234	27.7	2.82	130	2.217	6.9	2.68
140	2.242	18.4	2.56	140	2.210	26.8	2.77	131	2.213	5.9	2.5
141	2.235	18.1	2.49	150	2.161	25.8	2.74	-	-	-	-
-	-	-	-	151	2.155	25.7	2.68	-	-	-	-
-	-	-	-	152	2.149	25.1	2.6	-	-	-	-