Influence of Water Reducer on Concrete Compressive Strength under Wind Erosion

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Abstract. In this paper, using flow sand jet erosion, erosion tests were performed on concrete samples of the same strength grade with standard and retardation type water reducing agent respectively, study the erosion rate and the impact of compressive strength of concrete samples with erosion time and wind speed during erosion.

1. Introduction  
China's desertification land area accounts for more than a quarter of the country's land area. The desertification of the land will produce a large amount of desertification land, providing abundant material conditions for sandstorms. Sandstorm occur mostly in the northwestern part of China and the northern part of North China. The disaster caused by sandstorms of medium and above is not to be underestimated. It will not only cause great damage to the natural environment, but also cause great damage to the surface of the building.

At present, many scholars at home and abroad have studied the erosion of concrete under blown sand environment. For example, WANG Yanping [1] studied the erosion rate of different strength grades of concrete, mortar and cement under blown sand environment. FAN Jincheng [2] studied the erosion rate of concrete under the erosion of freeze-thaw cycles and different salts.

Although the above research results can analyze the phenomenon of concrete erosion rate change under blown sand environment, the above research mostly focuses on the change of concrete erosion rate under different strengths and different external conditions, but there is no research for changes in erosion rate and changes in compressive strength of concrete with different admixtures.

Based on the previous research results, this experiment uses the C30 concrete sample with two different types of water reducing agents commonly used in construction as the test material, and uses the air blast tester to simulate the sandstorm and simulate the erosion test. Because WANG Yanping [1] has studied impact angle on erosion, the erosion rate of brittle material is the largest when impact angle on erosion is 90°, so the impact angle on erosion of this test choose 90°. Study the erosion rate and compressive strength loss of C30 concrete sample with Standard and retardation type water reducing agent and analyse the mechanism of different erosion rate and compressive strength loss.
2. Test raw materials and test methods

2.1. Test materials

According to JGJ55-2011 *Specification for mix proportion design of ordinary concrete*, the design is based on Table 1. The ordinary portland cement selected from Hongshi Holding Group Co., Ltd with a strength grade of P·O42.5; The fine aggregate is washing sand and medium sand (fineness modulus is 2.9); The coarse aggregate is made of gravel and the grain composition is between 5~31.5mm.; The admixture is JW-2 poly carboxylic acid water reducing agent (standard type, retardation type); Water is edible water; C30 concrete sample with two different types of water reducing agents were prepared. The cube sample size was 100mm*100mm*100mm and was maintained to 28d under normal curing condition quantity. The 28d compressive strength of the two different types of concrete samples is shown in Table 1.

| Water Reducing Agents | Compressive Strength /MPa | Cement /(kg/m^3) | Fly Ash /(kg/m^3) | Sand /(kg/m^3) | Gravel /(kg/m^3) | Water /(kg/m^3) | Water Reducer /(kg/m^3) |
|-----------------------|---------------------------|------------------|------------------|---------------|-----------------|-----------------|------------------------|
| standard type         | 37.84                      | 300              | 76               | 840           | 1027            | 170             | 7.5                    |
| retardation type      | 38.60                      | 300              | 76               | 840           | 1027            | 170             | 7.5                    |

2.2. Test instrument

The instrument used in this experiment are air compressor that provides pressure, sandblasting machine for sand supply, and test spaces (placement samples). The air compressor provide a certain pressure, and the yellow sand in the sandblasting machine is taken out. The nozzle forms a two-phase flow of gas and particles mixed, and the surface of the concrete sample is eroded at a certain speed, and the erosion speed can be changed by adjusting the output pressure of sandblasting machine. In this experiment, yellow sand was used as the abrasives. The physical diagram of the test instrument is shown in Figure 1.
2.3. Test methods
In this experiment, the control variable method was used to test, the sand flux was 98.54g/min, the abrasive was yellow sand, and the impact angle on erosion was 90°. Test 1 studied different wind speeds (same time) on the erosion rate of concrete samples with two different types of water reducing agents. By adjusting the output pressure of the sandblasting machine to 0.1MPa, 0.16MPa, and 0.22MPa respectively, the corresponding two-phase flowair speeds are 17 m/s, 22 m/s and 25 m/s. Test 2 studied the effects of different time (same wind speed) on the erosion rate and the effect of changes in compressive strength loss of concrete samples with two different types of water reducing agents. The output pressure of the sandblasting machine was fixed to 0.16 MPa, and the erosion time was adjusted to 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5 and 7 min.

2.4. Test result processing
The concrete samples were eroded in the sandblasting machine in a group of three. The weighing tool use an electronic balance with a range of 3 kg and a precision of 0.01 g. The mass before and after the erosion was measured. The compression testing machine tests the compressive strength of the samples before and after erosion, and calculates the compressive strength according to GB50107-2010 Standard for evaluation of concrete compressive strength.

The formula for calculating the erosion rate is as follows:

$$E = \frac{\Delta m}{m}$$  \hspace{1cm} (1)

Where: $\Delta m$ is the mass reduction of concrete sample before and after erosion, g; $m$ is the mass of concrete sample before erosion, g.

The formula for calculating the percentage of compressive strength loss is as follows:

$$S = \frac{\Delta f_{cu,k}}{f_{cu,k}}$$  \hspace{1cm} (2)

Where: $S$ is the percentage of compressive strength loss; $\Delta f_{cu,k}$ is the absolute value of the difference between the pressure of the concrete sample before and after erosion, MPa; $f_{cu,k}$ is the average value of compressive strength of the concrete sample before erosion, MPa.

3. Test results and analysis

3.1. Effect of Wind Speed on Erosion Rate of Concrete sample
Figure 2 is a graph of the erosion rate of concretes with two different types of water reducing agents on an impact angle on erosion of 90°, an erosion time of 4 min, and a wind speed of 17, 22, 25 m/s. As can be seen from the figure: 1. The erosion rate of both concretes increases with the increase of wind speed. The reason is that as the wind speed increases, the kinetic energy of the abrasives increases, so the impact energy during erosion is greater, this results in a greater erosion rate of the sample. 2. The erosion rate of concrete samples with retardation type water reducing agent at low wind speed is larger, while the erosion rate of samples with standard type water reducer agent is higher at high wind speed due to the addition of retardation type. Compared with the standard type water reducing agent, the composite effect of the water reducing agent will simultaneously amplify the dispersion of the water reducing agent and the retarding effect of the retarder [3], and the dispersion of the water reducing agent will cause the compactness decreases after hardening of concrete. Causing the closed hole to change toward the open hole, and connected pores are formed inside the concrete [4]. At low wind speed, since the kinetic energy carried by the abrasive itself is small, most of the kinetic energy is converted into impact energy when it is washed onto the surface of the sample, and the rebound speed.
is small, does not support the interaction with the abrasive not reach the surface of the sample. But at high wind speed, the kinetic energy carried by the abrasive is large, the rebound speed after erosion to the surface of the sample is large, and the surface compactness of the sample of the retarding type water reducing agent is low, the interconnected pores are more, and the bonding force between the concrete particles is lower. The lost impact energy of the abrasive when impacting the sample is lower than that of the concrete sample with the standard type water reducing agent [5]. So the rebound speed is high, affecting the speed of the abrasive that does not reach the surface of the sample and the impact angle on erosion, reducing the speed of the abrasive, and making the impact angle on erosion less than 90°, results in a lower erosion rate at high wind speeds.

![Figure 2. Erosion rate under different wind speed](image)

3.2. Effect of erosion time on erosion rate of concrete sample

Figure 3 shows that the curve of erosion rate changes when the concrete with two different admixtures have the impact angle on erosion of 90° and a wind speed of 22 m/s, and the erosion times are 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5 and 7 min respectively. As can be seen from the figure: 1. At the same wind speed, the erosion rate of the concrete with retardation type water reducing agent is always greater than that of the concrete with standard type water reducing agent. Because the erosion is performed at the same erosion speed, the abrasives have the same kinetic energy, while the concrete with retardation type water reducing agent has lower compactness and more interconnected pores, the bonding force between concrete particles is lower, so surface is more likely to occur after erosion, results in the mass loss is even greater. 2. The erosion rate of the two concretes generally increases with the increase of erosion time, and the erosion rate remains basically unchanged after 5.5 minutes. The reason is that as time increases, the impact energy converted by the abrasive eroded sample increases, and the degree of damage to the sample is greater. After the erosion time reaches 5.5 min, the coarse aggregate inside the concrete is exposed, and since the selected abrasive is yellow sand, its hardness is less than the hardness of the coarse aggregate, which is not enough to cause large-scale damage and the corrosion rate remains basically unchanged. 3. The difference between the erosion rates of the two samples increases with time, because the concrete surface has a certain roughness, and the impact angle on erosion when the abrasive is washed off to the concrete surface is not necessarily 90°, so the surface of the sample other than the area of the nozzle is eroded, and the compactness of the concrete with retardation type water reducing agent is smaller, so the sample is more susceptible to damage after being washed away by the rebounding abrasive. As time increases, the cumulative loss is greater.
3.3. Effect of erosion time on the change of compressive strength loss of concrete sample

Figure 4 shows the percentage of compressive strength loss for the two admixtures when the impact angle on erosion is 90°, the wind speed is 22 m/s, and the erosion time are 1, 2, 3, 4, 5, and 6 minutes, respectively. As can be seen from the figure: 1. The compressive strength loss rate of the concretes with two different types of water reducing agents increase with time. The reason is that the compressive strength loss of concrete is related to the erosion rate. The greater the erosion rate, the more the loss of fine aggregate on the concrete surface. When the non-erosion surface is used as the compressive surface for compressive test, since the aggregate distribution of the two sides is large, it is more likely to be damaged when subjected to the same pressure, and the compressive strength of the sample is reduced.
4. Conclusion
1. Under the premise of keeping the erosion time constant, the erosion rate of concrete with standard and retardation type water reducing agents increases with the increase of erosion speed. At low wind speed, the erosion rate of the concrete with the retardation type water reducing agent is small, at high wind speed, vice versa.

2. Under the premise of keeping the wind speed constant, the erosion rate of the concretes with standard and retardation type water reducing agents increases with the increase of the erosion time. The erosion rate of the concrete with retardation and retardation type water reducing agent has been large, and the relative difference of the erosion rates of the concrete with two water reducing agents also increases with time.

3. Under the premise of keeping the wind speed constant, the compressive strength loss of the concrete with standard and retardation type water reducing agents increases with time. The compressive strength loss of concrete with retardation type water reducing agents always larger.

4. Both concrete samples entered the incubation period at about 5.5 minutes, and the erosion rate remained unchanged after 5.5 minutes.

5. After the concrete sample enters the incubation period, its compressive strength loss is as high as 19%.

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