Humidity Comparative Study of New Maintenance Method in Airport Pavement Concrete of China

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Abstract: Through comparing actual projects this paper presents and discusses the effects of curing film and geotextile on humidity of airport pavement concrete during maintaining process. The results show that, compared with the maintenance of geotextile, the curing film can ensure sufficient humidity, and it has very significant uniformity and continuity.

1. Introduction

As a serious drought and water shortage country China's per capita water resources are only 2,300 cubic meters, which is only 1/4 of the world average level, ranking 88th among 153 countries counted by the World Bank. At present, China has 16 provinces whose per capita water resources (excluding transit water) are below the serious water shortage line and 6 provinces whose per capita water resources amount is below 500 cubic meters[1-3].

In the field of airport construction, by 2020 China will build about 500 general airports[4], and by 2030, 2058 general airports will be built and 190 new civil transport airports will be added, of which a considerable part of the civil transport airports under construction and to be built are located in water-scarce areas[5]. Hence, based on the engineering application, it is of great significance to make a comparative study of different curing technologies and determine the actual impact of different curing systems on concrete.

2. Experimental procedure

2.1 Technical proposal

Maintenance tests were carried out on the airport pavement concrete structure with curing film and traditional geotextile. The difference between curing effect of curing film maintenance (covering 14 days) and that of geotextile maintenance (watering three times a day, covering 14 days)[6,7] was tested and analyzed.

Flow chart of curing film laying is shown in Fig.2 and its requirements are as follows: 1) demoulding after 24 hours of pouring concrete, removing impurities such as floating mortar and sand on the surface of concrete to ensure that there is no dirt on the surface of concrete; 2) Continuous and uniform watering on concrete surface 5 minutes in advance before formal laying, so as to keep the surface of concrete wet, re-pouring when the formal laying, to ensure the water absorption and expansion of granular polymer material in curing film to the thickness of 3mm-5mm, and the curing film clings to the surface of concrete. When overlap occurs between the two curing film, the overlap width should be controlled to be about 100 mm; 3) After watering, sand bags were used to compact
the interface and cover the curing film for 14 days. During this period, the temperature and humidity of geotextile, curing film and external air were tested five times a day.

Figure 1. Flow chart of curing film laying

Geotextile maintenance is the traditional way of airport pavement maintenance[6,8]. The total area of geotextile maintenance in this project is about 20,000 m2. After 24 hours of concrete pouring, the surface of concrete is covered with geotextile. The watering time is three times a day, approximately 6:00-8:00, 13:30-14:30, 17:00-18:00, until the prescribed age.

2.2 Mix proportion
The concrete raw materials used in the test are: Portland cement P.O42.5; two-zone medium sand with a fineness modulus of 2.7; 5-20 mm and 20-40 mm gravel. The proportion of airport pavement engineering application is shown in table1.

Table 1. Mixing ratio parameter

| Cement/kg | Sand/kg | Gravel/kg | Water/kg | Weibull consistency/s |
|-----------|---------|-----------|----------|-----------------------|
| 320       | 615.7   | 502.7     | 933.7    | 128                   |
|           |         | 5mm~20mm  | 20mm~40mm| 19                    |

3. Results and analysis

3.1 Stage 1: 0-7d
The humidity change of concrete covered by curing film during the curing period from 0 to 7 days can be seen in figure 1. With the increase of age, the humidity decreases to a certain extent, but the decrease is not significant. The fitting curve is shown as:

\[ y = 145.78 \exp\left(-\frac{x}{253.01}\right) - 48.74, R^2=0.94 \quad (1) \]

The figure shows that the humidity is in the range of 97%-95% within curing age of 0-3 d. Although it decreases slowly, the humidity is greater than 95%. Within curing age of 4-7 d, the humidity continues to decrease but still in the range of 93%-95%. After curing age of 7 d, compared with the initial curing age, the humidity decreases only about 3.1%.

Therefore, when the concrete is cured by the curing film within 0-7d, the concrete is in a relatively saturated and relatively stable curing condition, which is beneficial to the cement hydration.
During the period of 0-7 d, the humidity variation of concrete surface cured by the geotextile and external environment can be seen in figure 2.

With the increase of curing age, the humidity of concrete surface covered by geotextile exhibits very similar and significant fluctuation in a day-cycle. During the curing period of 0-7 d, the data of humidity are roughly distributed between 70% and 90%, wherein the data value with the humidity being 70%-80%, 80%-90% and 90%-100% is 48.6%, 37.1% and 14.3%, respectively, that is, the humidity data of nearly half is less than 80%.

For the external environmental humidity, within 0-7 d it’s in the range of 52%-70% and fluctuating remarkably due to the possible factors such as temperature and transpiration. Within the period of 0-1 d, the humidity decreases with a drop of 22.6%. During the curing period of 6-7 d, the humidity decreases with a drop of 23.2%, and within the same day it shows a trend of rapid increase first and then sharp decline.

It can be seen from figure 3 that during the curing period of 0-7d, the difference between the humidity of geotextile-cured concrete and the ambient humidity is controlled between 30–40%, that is, the geotextile maintenance is adopted in the summer environment, the surface humidity of concrete is greatly affected by the environmental humidity. At the same time, the geotextile maintenance measures can be roughly considered to increase the humidity of concrete surface by about 30-40% based on the ambient humidity.
3.2 Stage 2: 7-14d
The humidity of dry-hard concrete using the curing film to maintain at the age of 7-14d is presented in figure 4.

With the increase of age, the decreasing trend of humidity in the curing film tends to gradually flatten, that is, the greater the age, the smaller the change of humidity, and finally stabilizes. At 14d age, the humidity is the lowest, but still greater than 83%. The fitting curve is shown as:

\[ y = 186.72 \exp(-x/2.47) + 83.71, \quad R^2 = 0.95 \]  

During the curing period of 7-14d, the humidity decreases from 93% to 83%, and the absolute value of humidity decreases by 10%. Among them, during the period of 7-11d, the decline is faster, and the humidity value decreases by about 7%. Then it gradually slows down and decreases by about 3% in the end.

Combined with figure 1 and figure 4 it is showed a downward trend of inverse proportional index during the period of 0-14 d age, and the decreasing trend gradually slows down with the extension of the curing age. In 0-7d, although the polymer material in the curing film releases the water stored therein, the cement hydration reaction consumes a large amount of water inside the film, so the humidity in the curing film still shows a decreasing rate; in 7-14d, according to existing research, the cement hydration reaction has become less severe, reducing the water consumption in the curing film, which combined effect makes the humidity of curing film decrease, but the decline rate shows a gradual decrease. Hence during the 7-14 days of curing age, with the airport pavement concrete being cured with curing film, the overall performance is that the humidity in the concrete can still be maintained at a pretty higher level.

![Figure 5.](image)

**Figure 5.** Variation of surface humidity of dry-hard concrete in 7~14d curing age (%)

Figure 5 shows that the humidity variation law of the environment and concrete surface cured by geotextile in the period of 7-14 d. The surface humidity of concrete in geotextile fluctuates apparently with the increase of curing age in the period of 7-14 days, which is similar to that in the period of 0-7 days. During the 7-14 d, the data of humidity in geotextile (refer to table 2.) are still mainly distributed in range of 65%-90%, of which the data proportion of humidity less than 70%, 70%-80%, 80%-90% and 90%-100% is 22.9%, 42.9%, 22.9% and 8.5%, respectively, that is, the data with humidity less than 80% exceeds 65%. On the other hand, compared with 0-7 days, the discreteness of humidity data in this stage is further increased. The difference between maximum and minimum humidity is almost 20% on the same day. At 12-13 d age, the humidity difference between the maximum of 93% and the minimum of 66% is even as high as 27%.

It can be seen from figure 6 that during the curing period of 7~14d, the data distribution of humidity difference between the geotextile and environment is increased, the data with humidity difference (refer to table 3.) less than 10%, 10-20%, 20-30% and more than 30% accounted for 5.7%, 51.4%, 22.9% and 20.0% respectively, that is, the data is mainly distributed in 10%~30%. Compared
with the curing period of 0-7d, it mainly distributes in the range of 30%-40%. This indicates that the effect of geotextile on humidity retention is further weakened at this stage, and the adverse fluctuation of humidity cured by geotextile is more deeply affected by the external environment.

![Figure 6. Humidity of geotextile maintenance and environment in 7~14d curing age (%)](image1)

![Figure 7. Difference Humidity between geotextile and environment in 7-14 day (%)](image2)

**Table 2.** Data distribution of surface humidity of concrete cured by geotextile (%)

| Curing age | <70% | 70%~80% | 80%~90% | 90%~100% |
|------------|------|---------|---------|----------|
| 0~7d       | 0    | 48.6    | 37.1    | 14.3     |
| 7~14d      | 22.9 | 42.9    | 22.9    | 8.5      |

**Table 3.** Data distribution of humidity difference between geotextile and environment (%)

| Curing age | <10% | 10~20% | 20~30% | 30~40% | 40~50% |
|------------|------|--------|--------|--------|--------|
| 0~7d       | 0.0  | 0.0    | 11.4   | 60.0   | 28.6   |
| 7~14d      | 5.7  | 51.4   | 22.9   | 20.0   | 0.0    |

**4. Conclusions**

For airport pavement concrete maintained by curing film, during the curing period of 0-7d, its humidity is all greater than 93% and the data of humidity over 95% is about 1/2 of the total data, and the concrete is in a condition of relatively saturated and stable humidity maintenance state; during the curing period of 7-14d, the humidity decreases slowly and tends to be stable, with reaching 14d age, the humidity is the smallest but still above 83%, indicating that the moisturizing effect with using the curing film to maintain airport pavement concrete is very significant.

For airport pavement concrete maintained by geotextile, the humidity fluctuates significantly with the increase of curing age. in the 0-7d, the humidity is roughly distributed in range of 70% ~ 90%, nearly half of humidity data are less than 80%. Within 7-14 d, the discreteness of humidity data increases further. At different times of the same day, the difference between the maximum and minimum humidity is almost 20%.
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