Experimental Study on Preventive Measures of Plastic Shrinkage Cracking of Cement Concrete

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Abstract

This article is aimed at finding the feasible measures to reduce the early plastic crack of cement concrete, by means of field test and simulating test from laboratory. This essay discusses the advantages and disadvantages of various conservation measures (Including spray all kinds of curing agent; Coverage; Early spray; Secondary cement-plastering), Distinguishes effective control measures. According to the test results this paper puts forward effective construction method and construction material of timely maintenance of new concrete, provides reference ideas for the future engineering construction.

Keywords: Cement concrete; Early plastic Shrinkage crack; Preventive measures; Effect evaluation

1. Preface

In recent years, cement concrete road has been increasing year after year. Cement concrete pavement has a lot of advantages, such as larger carrying capacity, better stability, longer service life and lower daily maintenance cost. Cement concrete is one of the highly recommended types of roads which have the high grade and heavy traffic in China. But at the same time there are some problems need to be solved, the early plastic crack is one of these problems.

Plastic shrinkage cracking appears when the cement concrete (or the paste) in the plastic state with shorter duration about 1 to 2 hours. It started when the concrete surface luster disappears and ends when the concrete sets. This kind of crack was caused by plastic shrinkage is so called “Plastic shrinkage cracking”.

The cement concrete pavement crack occurred in the early of the unset stage of the cement. It is hard to repair and scraping the whole block and placing wasting too much of time and money. The difficulties make it into a challenge for researchers how to prevent it effectively, though many studies have concluded the causes of cracks.
2. The theory and method of the test

Early plastic shrinkage includes drying shrinkage and autogenous shrinkage. Drying shrinkage is mainly attributed to the influence of the environmental conditions while autogenous shrinkage is due to materials’ hydration reaction. Drying shrinkage and autogenous shrinkage both work during the moment of the concrete shaped and solidification (about 2 h). This period is called the plastic shrinkage period. Crack appears during the plastic shrinkage period if the tensile strength of the new concrete is not enough to resist the stress of contraction. This crack is called the plastic shrinkage crack. The crack occurs first and would last for a long time.

The test include spray all kinds of curing agent; coverage; Early spray and secondary cement-plastering. The test uses the same experimental material and mix on different measures. A test group and a control group would be set simultaneously in consideration of the changes in the environment.

The material of cement specimen and the mix proportion are shown in the table below:

| C2 concrete | water   | manufactured sand | natural sand | water-cement ratio |
|-------------|---------|-------------------|--------------|-------------------|
| 648         | 324     | 606.528           | 657.072      | 0.50              |

Different maintenance measures were simulated in the same kind of external environment. We put two xenon lamps beyond the sample in order to simulate solar radiation, and provide heat. Industrial fan is used to produce wind (Figure 1).
3. Analysis and Evaluation of the maintenance effect

3.1. Spray curing agent

These data indicate that the Evaporation rate of experimental groups is higher than the control groups. These two kinds of curing agent both have poor effects because of the crack appeared in the test. According to the result, some test about the effect of curing agents should be done before the starting of the practical projects.

3.2. Coverage

1. Plastic film

No cracks appeared in the group of single thin film. The weight of the test groups keeping with fixed values. This shows that there is no moisture evaporation. But when take the plastic film away, we find cement haven’t completely solidification. The film need to be covered continuously. Cement was completely solidification 3 hours later without any cracks. Impermeability of the plastic film is the key factor of the result because it keeps moisture not be deprived to environment. The conclusion is that plastic film is a more effective maintenance way, just taking for a longer time.

2. General wet linen
Fig. 3. Evaporation rate control chart of Covering wet linen and not covering.

Fig. 4. Total evaporation capacity control chart of Covering wet linen and not covering.

Fig. 5. Surface temperature control chart of Covering wet linen and not covering.
From figure 3 to figure 5 we can see that: the measure of covering general wet linen can reduce the evaporation rate and surface temperature. It can be attributed to several reasons. First, wet linen can prevent sample from being blow. Second, wet linen can keep out of light partly, decreases the influence of temperature. Third, wet linen makes the sample at a high humidity environment, and humid condition takes advantage to the maintenance. Therefore, this article suggested that covering wet linen on the concrete pavement and keeping it wet in practical engineering.

3. White pore-closed linen

White emulsioni paint was painted onto normal linen surface in order to prevent the water in the sample from evaporating. In addition, white is helpful to keep out the light and is good for restraining temperature rising. So we can draw the conclusion that white pore-closed linen has better effect than general wet linen. Analyze two sample’s experiment data to confirm that whether the deducing is right.

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![Evaporation rate control chart of Covering white pore-closed linen and not covering](image1)

Fig. 6. Evaporation rate control chart of Covering white pore-closed linen and not covering

![Surface temperature control chart of Covering white pore-closed linen and not covering](image2)

Fig. 7. Surface temperature control chart of Covering white pore-closed linen and not covering
From figures above, we can see that the evaporation rate of white pore-closed linen is much less than the general wet linen. Because of the control standard is different, so the D-value of the test group and control group need to be contrasted. The results are as follows:

Figure 9 shows that the evaporation capacity D-value of white pore-closed linen is bigger than general wet linen. This indicates that white pore-closed linen has better effect on restraining evaporation. It proved that the conjecture before is right—white pore-closed linen has better effect than general wet linen.
From figure 10, we can see that the surface temperature D-value of white pore-closed linen is bigger than general wet linen. But it makes no great difference. This shows that white pore-closed linen has better effect on restraining temperature than general wet linen, but the difference is not obvious.

### 3.3. Early spray

Spray to the sample by the Push sprayer when there is no obvious water stains on the surface. The nozzle and samples should maintain a distance of 30-70cm and the nozzle should be parallel with the sample. Sample should keep wet during the spray process.

From the figure above, we can see that the evaporation capacity of sprayed sample is smaller than which is not sprayed. And the change of evaporation rate is stable. Spraying is good for maintenance because the smaller evaporation capacity is, the better effect would be taken on.
3.4. Secondary cement-plastering

When there is no obvious water stains on the surface of the sample, floating it by a float. When the gloss completely disappeared, float again, a total of two times.

![Evaporation rate of each period](image)

Fig. 12. Evaporation capacity control chart of secondary cement-plastering and not any floating

From the test we can see cracks appeared in the 45 minutes after the start. The effect of secondary cement-plastering is unsatisfactory.

4. Conclusion

The μPFC has evaluated various maintenance measures’ effect. Tell some effective maintenance measures and put forward a new method and material. Specific summarized as the following:

1. Spray curing agent

   We have only set two groups contrast test of curing agent due to time limit. We suggest that some tests should be done before the construction in order to find the proper curing agent.

2. Coverage

   Covering film achieved the purpose for maintenance, but the curing time is too long, and the effect for restraining the influence of the light——— the rise of temperature is not obvious.

   Covering wet linen got a good effect. In actual constructions, it needs to water on the surface of the sample timely. Keeping a certain distance between linen and concrete, covering the closer the better. The linen is easy to obtain in the actual engineering, the feasibility is good in construction.

   White pore-closed linen played a good curing effect. Construction attention is as same as general wet linen. White pore-closed linen has better heat insulation than general wet linen. This lien is a kind of transformed linen, and concrete method is: close the pores by white wall paint. The material is still at the experimental research stage, to achieve better effects, need further development and popularization. Therefore, considering the construction feasibility, using general wet linen is a recommended method.

3. Spray

   Curing effect is desirable, if spray the sample timely. Spray time interval must be strictly controlled otherwise the effect should be directly influenced. Therefore, if the project will not be strictly control about spray time interval, do not recommend using this method.
4. Secondary cement-plastering

Secondary cement-plastering is really effective for reducing evaporation. But the time of second pressure is difficult to master, operation is inconvenience, it is not suggested to be used in engineering.

In general, in actual construction, set ports beyond new pouring cement concrete, and cover coverings (supports can be precast, in order to recycle). Setting support is to prevent covering contacting the surface of new casting pavement, that is good for curing timely. Considering the construction feasibility, the paper suggests covering should choose general wet linen.

References

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