EFFECT OF CURING CONDITIONS AND EXPOSURE CONDITIONS ON DRYING SHRINKAGE OF CONCRETE

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ABSTRACT: There are several causes to form cracks in concrete tunnel linings. One of the causes is the increasing amount of drying shrinkage due to rapid change of environment in tunnel or the lack of curing. The aim of this study is to clarity the relationship between the amount of drying shrinkage and internal moisture content of concrete. The internal moisture content changes due to curing conditions and the different exposure conditions after curing. The amount of drying shrinkage and the moisture content were measured in different curing conditions and exposure conditions. The curing conditions are drying at early age, water curing, spray curing, sealing curing, and the exposure conditions are constant drying, and cyclic drying and wetting. As a result, a good relationship was found between the moisture content of internal concrete and the amount of drying shrinkage.

1. INTRODUCTION

It was not important for curing on tunnel lining concrete construction because it was constant on tunnel environment during construction and it was not affected by the external environment. But there were some reports which occurred cracks and exfoliation. One of the causes is the decreasing the humidity at the before and after the completion of the tunnel due to rapidly change of environment in tunnel. Therefore, in this study, it is necessary to clearly the relationship between drying shrinkage and humidity.
At first, it was investigated the effect of curing method and exposure conditions on drying shrinkage by Step1. Second, it was investigated the relationship between surface and internal concrete on drying shrinkage by Step2. On Step3, it was measured structure by the results of Step1 and Step2.

2. The Outline of Experiment

2.1 Overview of the concrete specimens

In this research, it was used two kinds of cement, one was N (Ordinary Portland Cement), another was BB (Blast-Furnace Slag with OPC).
Table 1 shows the concrete mix proportion which used in this research. The specimens were prism and size was 100*100*400mm .

Table 1 Mix proportion

W/C (%)	s/a (%)	(kg/m³) W	N	BFS	S	G	Slump (cm)	Air (%)
55	47	172	313		855	982	9.5	3.5
		172	172	141	861	976	12	4.9

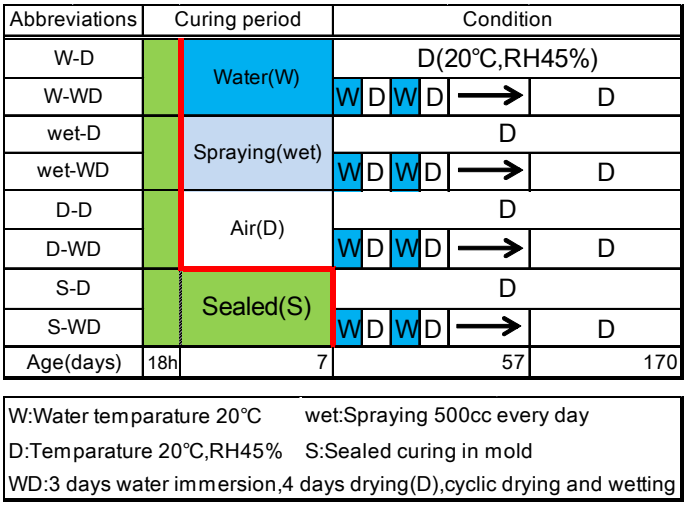

Figure 1 Curing conditions and environmental conditions

2.2 Effect of curing conditions and exposure conditions on drying shrinkage of concrete (Step1)

The curing conditions were water curing, spray curing, sealing curing and the exposure conditions that are constant drying at RH 40%. After curing, the specimens exposed drying condition and cyclic drying and wetting condition. Figure 1 shows the setting for conditions on curing and exposed conditions. The specimens on cyclic drying and wetting condition were moved in drying condition (D) after age of 57days. All specimens were measured until 170 days.
It was measured the drying shrinkage test and moisture content test. The method for drying shrinkage test was used to contact gauge with surface of concrete specimens. Also the method of moisture measurement internal concrete was measured by small sensor for measuring the temperature and relative humidity insert a acrylic pipe in the centre of the specimen.

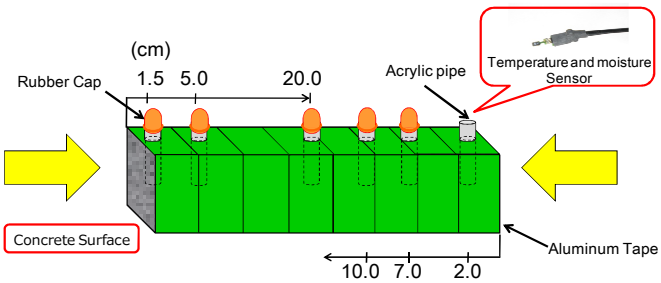

Figure 2 Outline of specimens measured the moisture at each depth

2.3 Relationship between drying shrinkage and the internal and surface structure (Step2)

Figure 2 shows the specimens used for measurement of moisture content at each depth from surface concrete. Both ends of specimens were open, in short exposed drying conditions, and the acrylic pipe set on the depth of 15, 20, 50, 70, 100, 200mm from surface of concrete. Relative humidity in concrete at each depth was measured by small sensor.

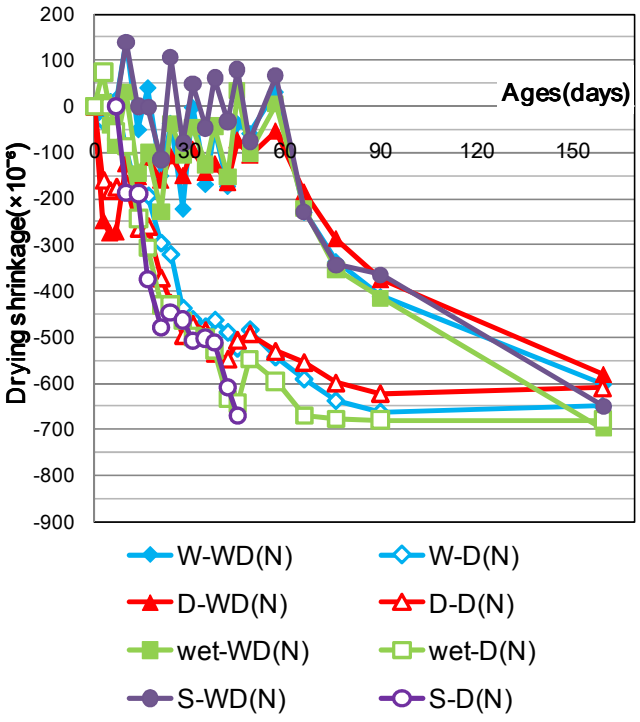

Figure 3 Result of drying shrinkage (N)

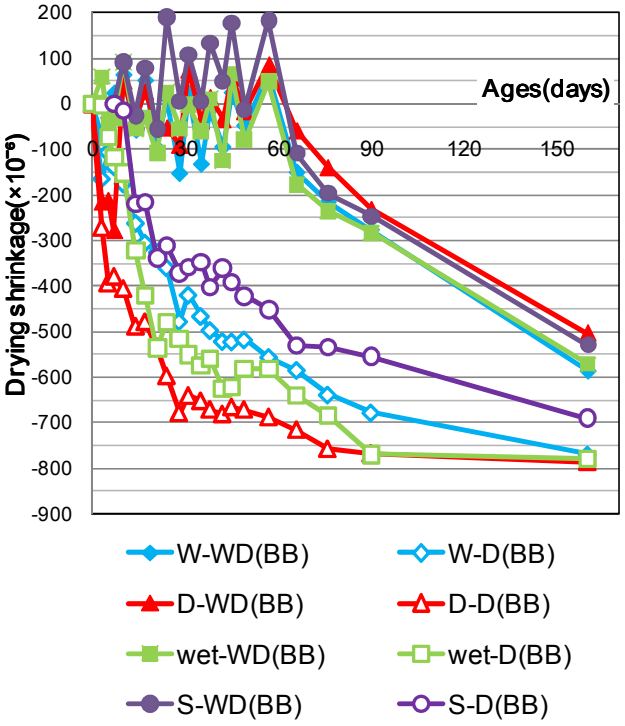

Figure 4 Result of drying shrinkage (BB)

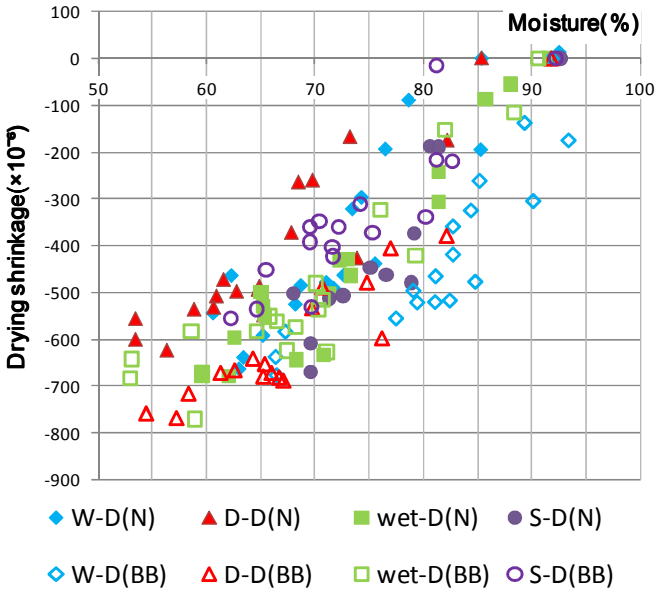

Figure 5 Relationship between drying shrinkage and moisture content of internal concrete

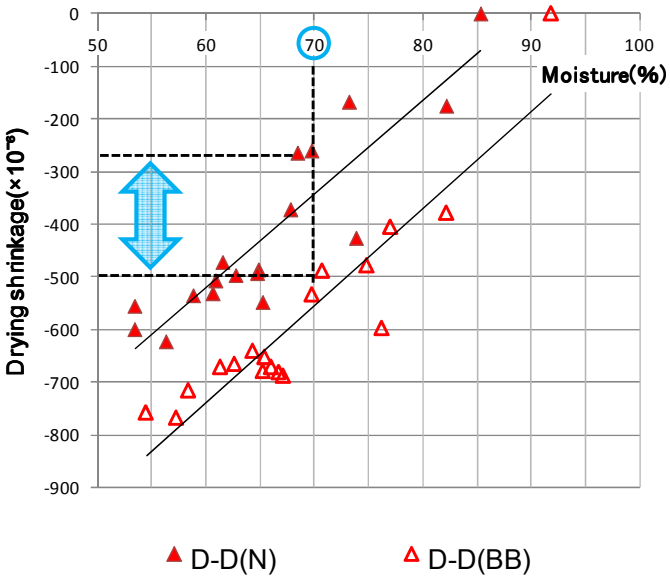

Figure 6 Relationship between drying shrinkage and moisture content of internal concrete
(Focus on only drying condition)

2.4 Measurements of structures (Step3)

There are several causes to form cracks in concrete tunnel linings. One of the causes is the increasing amount of drying shrinkage due to rapid change of environment in tunnel. It was measured the drying shrinkage and relative humidity of internal tunnel at the before and after the completion of the tunnel. Measurement for the drying shrinkage was used by contact gauge. And the measurement of internal relative humidity of tunnel was sensor of temperature and humidity machine. The drying shrinkage was measured on three blocks at different distances from the wellhead of tunnel in the center of the tunnel wall.

3 EXPERIMENTAL RESULTS

3.1 Effect of curing conditions and exposure conditions on drying shrinkage of concrete (Step1)

Figure 3, 4 show the results of drying shrinkage measurement. The value of drying shrinkage is different caused by the different of the curing method in curing. Therefore, the protecting which cracks occurred by drying shrinkage at the initial material age is considered to be important the curing condition. The final value of drying shrinkage at long term period is same, not depend on different curing method, the type of cement, exposed different environment.

3.2 Relationship between drying shrinkage and moisture content of internal concrete (Step1)

Figure 5 shows the relationship between drying shrinkage and moisture content of internal concrete. The value of drying shrinkage tended to increase decreasing in the internal moisture. A good relationship was found between the moisture content of internal concrete and the value of drying shrinkage. Figure 6 shows the relationship between drying shrinkage and moisture content of internal concrete just only drying conditions excerpted from Figure 5. Under the same internal moisture of BB and N cement, the drying shrinkage of BB was tended to larger than it of N. The difference value of the moisture content on internal concrete effected for the value of drying shrinkage. Therefore, it was planed the experiment which was aimed for the relationship between moisture content of internal concrete and drying shrinkage of concrete in each depth from surface of concrete.

3.3 Relationship between drying shrinkage and the internal And surface structure (Step2)

Figure 7 shows the relationship between depth from surface of concrete and moisture content of internal concrete. The moisture contents of N and BB were also significantly reduced at the concrete surface. It was cleared that the affected area by drying is 50mm depth from surface of concrete. According to figure 5 and this result, it was able to estimate that the drying shrinkage of surface was larger than it of internal concrete, because of decreasing the moisture content at surface of concrete by drying. Therefore it is able to estimate that the crack will occur by different of drying shrinkage at surface and internal concrete.

3.4 Measurements of structures (Step3)

Figure 8 shows the result of drying shrinkage measurements at each block on tunnel construction site. The value of drying shrinkage was increased toward the portal. The value of drying shrinkage near the portal was affected by the external environment. Figure 9 shows the relationship between drying shrinkage and moisture change. The value of drying shrinkage tended to increase decreasing in the internal moisture. A good relationship was found between the moisture content of internal concrete and the value of drying shrinkage.

3. CONCLUSION

(1)The protecting which cracks occurred by drying shrinkage at the initial material age is considered to be important the curing condition.

(2)The final value of drying shrinkage at long term period is same, not depend on different curing method, the type of cement, and exposed different environment.

(3)It was cleared that the affected area by drying is 50mm depth from surface of concrete.

(4)The value of drying shrinkage was increased toward the portal in tunnel. The value of drying shrinkage near the portal was affected by the external environment.

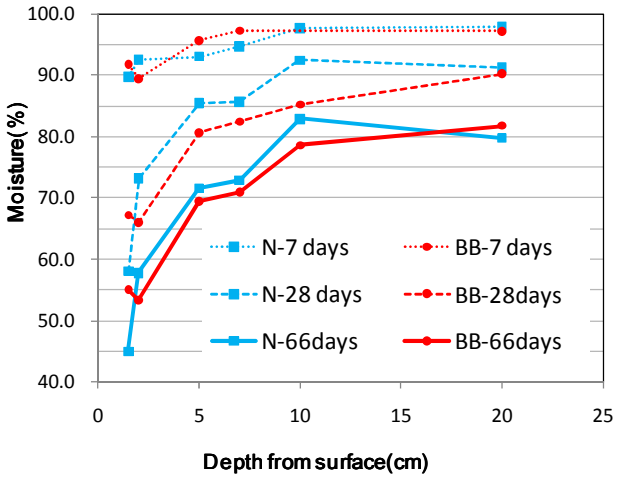

Figure 7 Relation between concrete in depth and moisture content of internal concrete

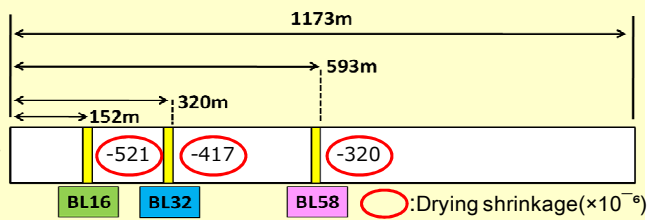

Figure 8 Result of drying shrinkage and measurement position

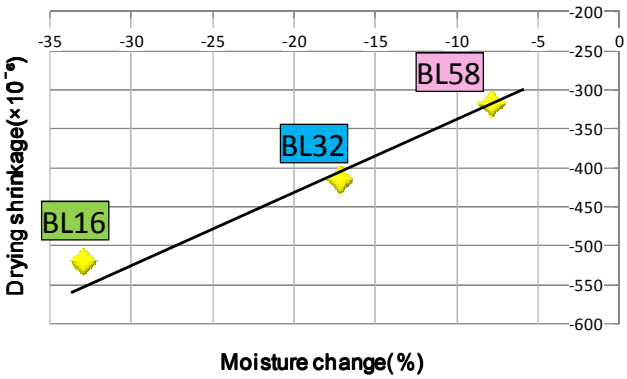

Figure 9 Relationship between drying shrinkage and moisture change