EFFECT OF SURFACE LAYER QUALITY OF CONCRETE BY USING DIFFERENT FORMWORK AND CURING PERIOD

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ABSTRACT

The surface quality of concrete is important to ensure the durability of concrete structures. In this study, the relationship between the surface bubbles and the quality of the surface layer was examined. As a result, it was found that the reduction of the surface bubbles of the concrete has little effect on the quality of the surface layer. In addition, it was found that increases in surface bubbles is a factor of lowering the freezing and thawing resistance. Furthermore, by using a handy type lightweight ultrasonic velocity meter, it was shown that the quality of the surface layer of concrete can be evaluated easily.

Keywords: *Surface quality, Surface layer, freezing and thawing resistance, ultrasonic meter*

1. INTRODUCTION

It was thought that concrete structures that were constructed were concrete of uniform quality both in the surface layer and inside. However, in recent years the concrete materials used have changed and the work environment has diversified. Therefore, the initial defect may occur even if the construction of the conventional, there is a problem that deterioration in quality occurs. Also, if the quality declines, the concrete becomes ununiformed, and the quality of the surface layer of the concrete becomes extremely low. Surface quality of concrete is important to ensure durability of concrete structures. The quality of concrete is regarded as important for the durability of concrete structures. On the other hand, Surface bubbles are important to reduce the aesthetic appearance of concrete. The relationship between surface bubbles and quality has not cleared. Previous studies have reported that surface bubbles can be reduced by applying a water repellent or the like to a formwork. The quality of the surface layer of concrete is improved by prolonging the curing period. From this point, in this research we aimed to clear the relationship between the aesthetic appearance of concrete and the quality of this surface layer of concrete. Concrete specimens were prepared by changing the type of formwork and the number of curing days. After clearing the surface bubble ratio and the quality of the surface layer of concrete, we tried to clarify the relationship between the aesthetic appearance and durability of concrete.

Table 1. Mix proportion for this study

W/C (%)	s/a (%)	Unit Amount(kg/m^3)				
		W	OPC	GGBFS	S	G
60	48	170	163	120	870	972

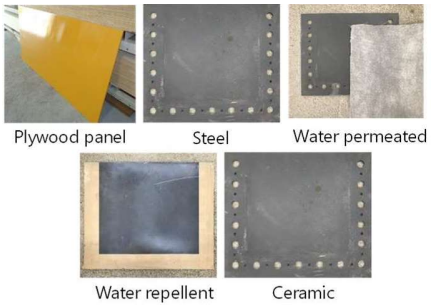


Fig. 1. Formwork used in this study

2. EXPERIMENT

2.1 Experiment apparatus

In this research, blast furnace cement which replaced the ground granulated blast furnace slag by 42.5% was used. Table 1 shows the mix proportion of this study. Water cement ratio was set high so that the influence of

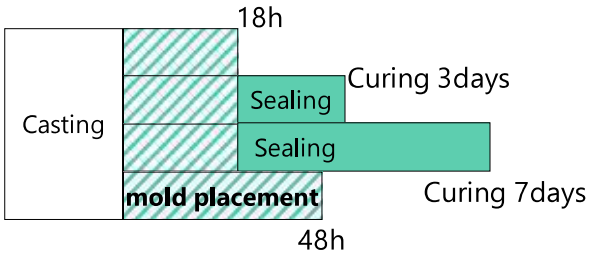


Fig. 2. Demolding and curing time

Table 2. Surface bubble ratio

Mold	Steel	Water permeable	Ceramics	Water repellent	Plywood panel
Surface bubble ratio (%)	3.1	0.3	2.4	0	2.1

curing remarkably appears. There are two types of specimen size, 300×300×150mm and 225×225×55mm. In this research, five types of formworks were used. Fig. 1 shows five types of formworks. It is made of steel, water permeated, ceramic, water repellent, plywood. As the demolding time, the specimen was prepared which had the earliest 18 hours actually carried out in the general tunnel lining concrete construction and the formwork for 2 days. In addition, in order to change the quality of the surface layer concrete, the number of curing days after demolding was changed to 3 days and 7 days. The curing pattern is shown in Fig. 2.

2.2 Experiment

2.2.1 Measurement of surface bubble ratio

In order to calculate the bubble ratio of the concrete specimen surface, binary processing of the image of the surface of the concrete specimen surface was performed. The threshold value was set at a brightness of 40%.

2.2.2 Freezing and thawing test

The freezing and thawing test was conducted according to ASTM C 672 using a specimen of 225×225 ×55mm. After 28 days of age, banks were prepared using a sealing material and water was put to a height of 6 mm to the test surface. It was frozen in a freezer at -20°C. For 17 hours and then melted in a constant temperature and humidity room (20°C, RH 60%) over 7 hours. This was regarded as one cycle and 30 cycles were carried out. A scaling piece that was peeled off from the test surface was collected and the value obtained by dividing the weight of the sample by the test surface area was taken as the scaling amount per unit area (g/cm^2).

2.2.3 Air permeability test

To evaluate the quality of the concrete surface, the air permeability test was conducted by the Trent method. Measurement was carried out after it was confirmed that the moisture content of the surface of the specimen of 300 ×300×150mm after the age of 28 days was 5% or less. At the central part of the concrete test piece, the air permeability was measured using the Trent method. For

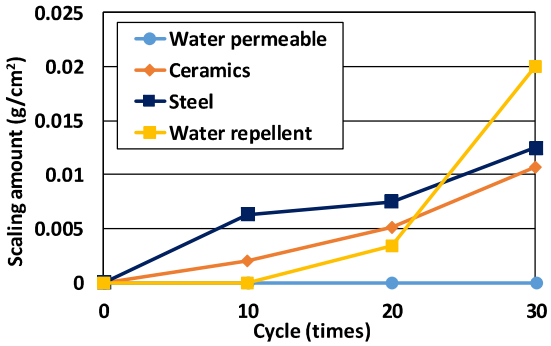


Fig. 3. Result of freezing and thawing test

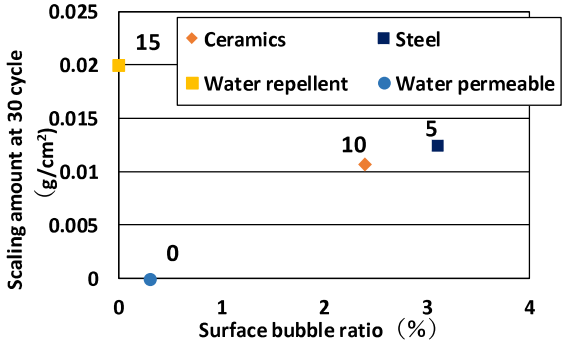


Fig. 4. Relationship between scaling amount at 30cycle and surface bubble ratio

the evaluation, KT value which is the surface permeability coefficient was used.

2.2.4 Water permeability test

Using a test specimen of 300×300×150mm, a permeability test was carried out according to JSCE-K 571-2013 at the center of the specimen. The testing machine was fixed using the sealing material at the center of the test surface and the water permeability was measured every hour. In order to eliminate the influence of the permeation pressure by the position head, water was poured again after each measurement and measurement was carried out for 12 hours.

2.2.5 Measurement of ultrasonic velocity

Using the specimen of 300×300×150mm, the ultrasonic velocity was carried out at the center of the test surface. UK 1401, an ultrasonic velocity measuring instrument manufactured by Nihon Matech Co., Ltd., was used for the test.

3. RESULTS AND DISCUSSION

3.1 Surface bubble ratio

Table 2 shows the ratio of the surface bubbles to the entire surface using banalization treatment. From the results of the surface bubble percentage, bubbles on the concrete surface could not be detected substantially in the water permeable form and the water repellent form. On

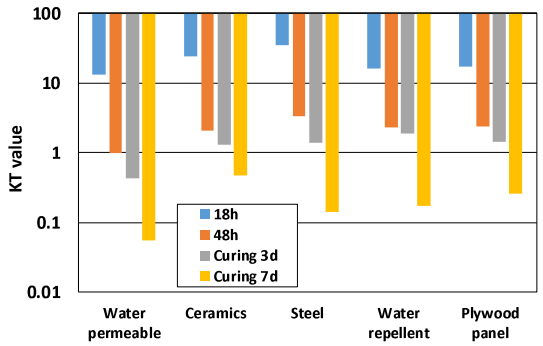


Fig. 5. Result of air permeability test

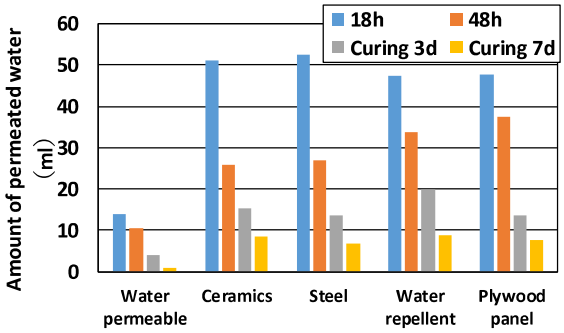


Fig. 6. Result of water permeability test

the other hand, surface bubbles increased on the concrete surface in other forms.

3.2 Freezing and thawing resistance

The results of the scaling by the freezing and thawing test are shown in Fig. 3. A lot of scaling occurred in water repellent, steel and ceramics, and the result was high surface bubble percentage. From this, it can be said that it is effective to select the type of formwork because the bubble ratio on the concrete surface, the aesthetic appearance influences the freezing and thawing resistance. Fig. 4 shows the relationship between the surface bubble ratio and the scaling amount. Even if scaling occurred in steel formwork and ceramic formwork, the amount of scaling was small. Also, the water repellent form took a longer time than other forms until scaling occurred, but once the scaling occurred the surface degradation rate was faster compared to the test bodies made with other forms all right. It is predicted that the water is pushed back by the water repellant, the concrete surface has a thin cement paste film, and in the freezing and thawing test, if cracking occurs from this film, scaling will occur each time the cycle is followed. However, further consideration is necessary for this.

3.3 Air permeability

The results of the air permeability test are shown in Fig. 5. Air permeability of the surface layer of specimen released from formwork release for 18 hours was large in all

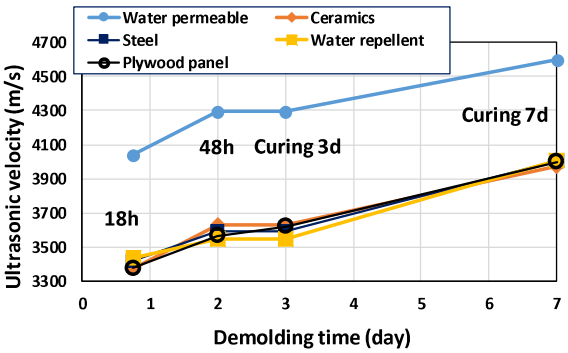


Fig. 7. Result of ultrasonic velocity measurement

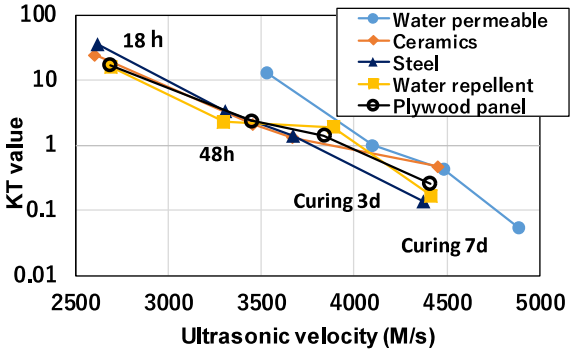
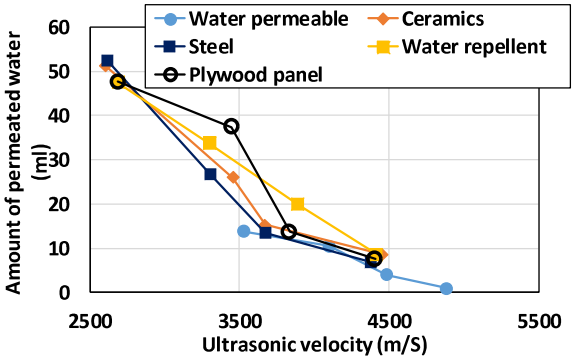


Fig. 8. Relationship between KT value and ultrasonic



velocity

Fig. 9. Relationship between amount of permeated water and ultrasonic velocity

formworks. Evaluation at the KT value by the Trent method was an evaluation of "extremely poor" at 18 hours, but in the specimen that had been demolished at 48 hours, the evaluation changed from "extremely poor" to "poor" and further curing. We found that the evaluation improved to "general". From this, it is considered that the longer the curing period, the smaller the KT value, so that the surface layer of the concrete is densified by curing.

3.4 Water permeability test

The results of the water permeability test are shown in Fig. 6. When comparing the results of 18 hours demolding and 48 hours demolding with the amount of water absorption after 12 hours, since the water absorption

of the demolished specimen after 48 hours is reduced, the time during which the formwork is present. It is considered that the quality of the surface layer of concrete was improved. Furthermore, when comparing the specimen that was cured three days and the specimen that was cured for 7 days, the water absorption of the test specimen on the 7 day of curing was reduced, so that the quality of the concrete surface layer was improved by curing. When we look at the amount of water absorption after 12 hours except water permeable form, it turned out that almost the same value was obtained, so it was found that changing the type of frame does not affect the quality of the surface layer of the concrete. In order to improve the quality of the surface layer of concrete, it can be said that there is a need to place the formwork and to subject it to curing.

3.5 Ultrasonic velocity meter

The results of ultrasonic velocity test are shown in Fig. 7. Forms other than the water permeable form were almost equivalent. It was also found that the ultrasonic velocity increases when curing is applied. Moisture was discharged from the water permeable sheet of the formwork as a factor of the increase in the ultrasonic velocity value of the concrete using the water permeable formwork, and the W/C of the surface layer of the concrete test body became smaller, so other forms were used. It is thought that it is dense as compared with the test specimen.

3.6 Estimation of quality of surface layer concrete by ultrasonic velocity

As shown in Fig. 8 and Fig. 9, there was a correlation between ultrasonic velocity and air permeability coefficient, water permeability. From this, it is considered that the material permeability and the quality of the concrete surface layer portion can be evaluated by measuring the ultrasonic velocity. This ultrasonic velocity test conducted this time is lightweight and handy, and easy to carry. In addition, measurement time is as short as 3 to 5 seconds and can be measured. In the air permeation test (Trent method) conducted for the performance evaluation of the surface layer this time, the measurement time is 6 to 12 minutes, and since the testing machine itself has weight, it is troublesome to carry. Furthermore, the measurement time is limited to those whose age is after 28 days. Similarly, in the simple water absorption test conducted in this study, it is necessary to confirm the decrease amount of water depending on human eyes at the time of implementation, and the time of the test is not specified, but measurement at several hours. It is necessary to compare the figures after doing it. From these facts, it is considered useful to conduct the ultrasonic velocity test to evaluate the quality of the surface layer of concrete. We are planning to investigate whether the surface layer quality of concrete can be evaluated by conducting ultrasonic velocity test for concrete with different cement and W/C in the future.

4. SUMMARY

(1) Changing the formwork type has confirmed the effect of reducing the surface bubbles, but it did not affect the quality of the surface layer.
(2) The number of cycles at which scaling due to freezing and thawing occurs can be made longer by reducing the surface bubbles by changing the type of formwork.
(3) The quality of the formwork and the concrete surface layer is irrelevant, it is important to prevent the escape of moisture at the beginning of the age, and the necessity of curing was again shown.
(4) Since the correlation is found between the ultrasonic velocity and the results of the air permeability test and the water permeability test, it is considered that the quality of the surface layer can be evaluated by the ultrasonic method.

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PHOTOS AND INFORMATION

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