Outline of “New Curing Method Using Water Repellent Sheets for Enhanced Durability of Concrete”

「高撥水性シートを用いた耐久性向上のための新しい養生技術」の概要

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1. Introduction

One of the methods for ensuring the surface quality of concrete structures is curing. The Standard Specifications for Concrete Structures—Materials and Construction of the Japan Society of Civil Engineers specify a wet curing period of 3 to 12 days based on the environmental temperature and cement type, with consideration of the cement hydration rate. Although this is the standard curing period for ensuring quality, in the case of important structures that require an extended service life, it is necessary to make further improvements not only in terms of material and mix proportion but also to enhance the surface quality of the concrete by extending the curing period. Curing in water and curing that suppresses moisture loss are commonly used measures; however, curing in water is often difficult for areas such as the vertical surfaces of walls and the undersurfaces of slabs and beams. In such cases, curing sheets such as bubble wrap are usually attached to the concrete surface after the forms are removed. However, during the time that it takes to attach the sheets, the concrete starts drying. Furthermore, early-age concrete suffers considerable moisture loss because it holds much of the moisture that is not used for the hydration reaction and the surface temperature of the structure increases because of the heat of hydration.

In view of these issues with conventional curing techniques, this paper reports the results of a study on a new curing method that enables rational curing and enhanced durability of concrete.

2. Overview of the Method

To develop a new technique for curing concrete, the authors invented a method in which a highly water-repellent sheet (**Fig. 1**) is attached to the sheathing

Fig. 1 Highly water-repellent sheet

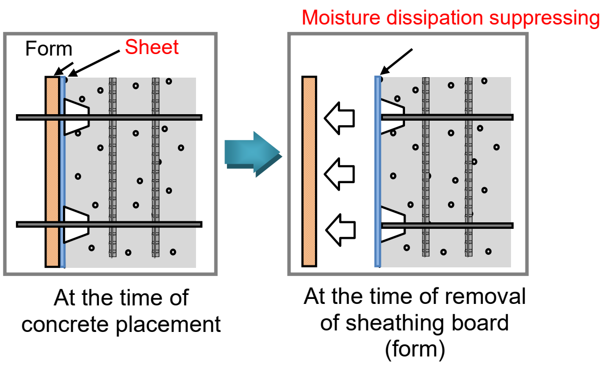

Fig. 2 Overview of sheet curing method

board inside the form, concrete is placed as shown in **Fig. 2**, and the sheet is left there even after the form is removed in order to implement curing (hereinafter, “sheet curing”) for as long as possible. By leaving the sheet in contact with the concrete surface, this curing method provides perfect moisture loss suppression without exposing the concrete surface to ambient air.

3. Effects of the Method

(1) Surface Air Voids

In this method, highly water-repellent sheets are in contact with the fresh concrete. To examine the contact effects, the surface air voids of the concrete were studied. The concrete test specimens were 2.5 m long, 5.2 m wide, and 2.0 m high, and the sheets were attached to the 5.2 m × 2.0 m face using plywood forms. **Figure 3** shows the results of measuring the surface air voids on the large specimens. The area ratios of surface bubbles in the photographed portions were 0.45% for the plywood portion (without sheet curing) and 0.06% for the sheet-cured portion, which indicates that the sheet curing reduced the surface air voids considerably. This surface modification effect is considered to be the result of reduced bleeding near surface air voids due to the high water repellency of the sheet and their easier dissipation from the form interface.

(2) Salt Penetration Tests

Figure 4 shows the relationship between the curing period for each curing method and the total chloride ion content at a depth of up to 8 mm from the specimen surface. With sheet curing, the total chloride ion content decreased as the curing period increased, and with sheet curing for 182 days it decreased to about 60% compared with leaving the plywood formwork on for 7 days. A possible reason for this result is that the texture of the surface concrete was denser in the case of sheet curing because of the progress of hydration at the surface concrete in line with the duration of curing.

4. Application to an Actual Pier

Figure 5 shows an overview of the pier to which the sheet curing method was applied. The pier is part of the Sanriku Coastal Road recovery construction related to the Great East Japan Earthquake. The pier is located in a harsh environment subjected to complex factors including salt coming from the sea, chloride migration due to sprinkling of anti-freeze agent, and freeze–thaw action in winter. The pier is 5.0 m in length, 7.5 m in width, and 22.0 m in height, and it has a hollow section. Sheet curing was applied to lifts 2–7. The forms that were used were as large as 0.9 m × 4.5 m and were made by joining plywood boards, and the sheets were attached to the forms.

Plywood; area ratio of surface air voids = 0.45%

Sheet curing; area ratio of surface air voids = 0.06%

Fig. 3 Suppression of surface air voids by sheet curing

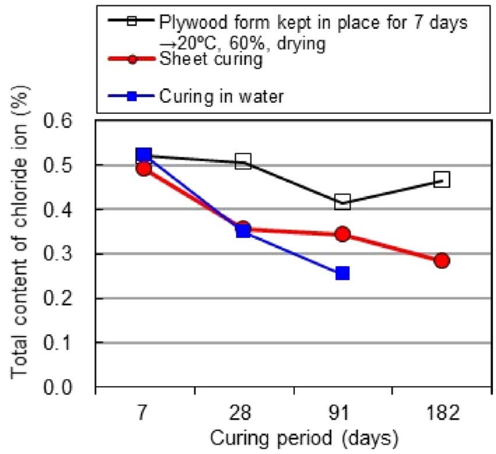

Fig. 4 Results of salt penetration tests[1]

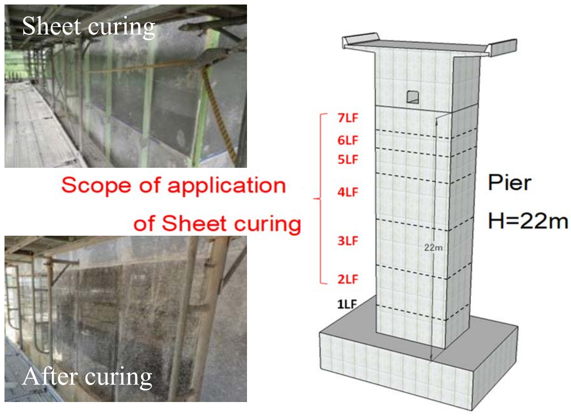

Fig. 5 Overview of pier

5. Conclusion

A long-term curing method using highly water-repellent sheets was invented as a technique to rationally ensure the durability of concrete. Experimental studies confirmed the reduction of surface air bubbles due to the effect of the highly water-repellent sheet and the improvement of salt-blocking properties due to the effect of long-term curing. Furthermore, the authors verified the workability and effectiveness of the method by applying it to a bridge pier that is subject to salt damage.

Reference

[1] T. Ishida et al.: *Developed “ Utsuku-seal method “ to improve surface quality*, Concrete Technology, Vol. 33, No. 12, pp. 9–15, Dec. 2014 (in Japanese).