Construction and Building Materials 50 (2014) 560–566

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

The effects of pore size distribution and working techniques on the absorption and water content of concrete floor slab surfaces

Yutaka Yokoyama [a,*], Takeshi Yokoi [b], Jun-ichi Ihara [c]

[a] Dept. of Architecture and Building Eng., Tokyo Institute of Technology, Tokyo, Japan
[b] Dept. of Architecture and Building Eng., Tokai University, Kanagawa, Japan
[c] Graduate School, Tokai University, Kanagawa, Japan

HIGHLIGHTS

- Pore size distribution in the slab surface varies by finishing and curing quality.
- The better the quality is, the less the pores of ca. 10^{-7} to 10^{-6} m in diameter is.
- The better the quality is, the more the pores of ca. 10^{-7} and smaller in diameter is.
- The water absorbency is affected by pores with diameters of ca. 10^{-7} m and larger.
- The water content is affected by pores with diameters of ca. 10^{-8} m and smaller.

ARTICLE INFO

Article history:
Received 11 May 2013
Received in revised form 28 September 2013
Accepted 4 October 2013
Available online 26 October 2013

Keywords:
Floor slab
Pore size distribution
Water absorbency
Water content
Work technique
Quality of surface

ABSTRACT

Pore size distribution in the surface of a concrete floor slab may vary according to the quality of the finishing work, such as trowelling, or with the curing of the concrete. The pore size distribution also influences the water absorbency and water content that modulates the quality of the finished floor. We examined how working techniques, e.g., floor top finishing and curing and the resulting pore distribution on the concrete floor slab surface related to water absorbency and the water content of study specimens. As a result, the more the surface is smoothed, pressing it with a wood or steel trowel (henceforth, *Finishing*) and the longer the surface is moisture-cured, the more the volume of pores ranging from 10^{-7} to 10^{-6} m (100 nm to 1 μm) in diameter is reduced, while the volume of pores with diameters of 10^{-7} m (100 nm) and smaller tended to increase. Furthermore, the study revealed that the quantity of pores exceeding ca. 10^{-7} m (100 nm) in diameter strongly affected the water absorbency, while that of pores smaller than 10^{-8} m (10 nm) in diameter affected the water content. Thus, the above results demonstrate that a working technique of better quality decreases the water absorbency and increases the water content of a concrete floor slab.

1. Introduction

Pore size distribution, or the quantity of pores classified by their diameters, on the surface of a concrete slab differs from that of the inner part. This variability is due to the atmospheric environment during the curing work. The pore size distribution in a cast concrete slab is also affected by the quality of the finishing, such as smoothing and pressing the surface with a (wood or steel) finishing trowel (henceforth, *Finishing*). In view of the effects on the surface finishing material, the water absorbency and water content of a slab are essential quality parameters that strongly depend on the pore distribution of the surface. In this regard, Yuasa et al. carried out accelerated tests to examine the dilation of polymer surface coatings on the top of concrete slabs [1]. They found that the finer the pores are, the less water infiltrates, thus reducing dilation and blisters. However, no literature is available on the relationship between pore distribution and water absorbency and water content that takes into account the surface finishing techniques used on concrete floor slabs.

We therefore assessed the variability of the pore size distribution attributable to surface finishing work, as well as the relationship of the pore distribution on the surface of the concrete floor slab to the water absorbency and the water content.

* Corresponding author. Address: Tokyo Institute of Technology, M1-28, 2-12-1 Oh-okayama, Meguro-ku, Tokyo 152-8552, Japan. Tel./fax: +81 3 5734 3152.
E-mail address: yokoyama@arch.titech.ac.jp (Y. Yokoyama).

0950-0618/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.conbuildmat.2013.10.013

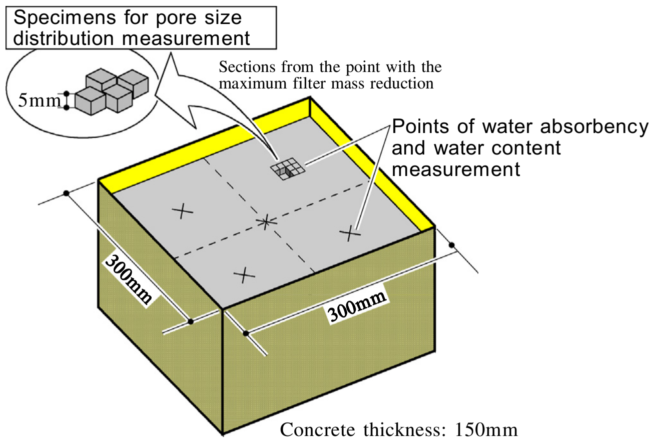

Fig. 1. Overview of samples.

2. Sample preparation

2.1. Method of preparation

2.1.1. Overview of the samples

Fig. 1 shows an overview of the samples. They simulate commonly used concrete slabs of 150 mm in thickness and 300 mm × 300 mm in surface area. To reproduce working conditions where only the top surface is exposed to the external environment, the samples were left so that only the top surface was exposed and the other 5 air-sealed.

2.1.2. Selection of concrete

Table 1 summarises the different types of concrete used in this study. Fourteen different types of concrete were selected from among those most frequently used in Japan, so as to include various mixtures and various strengths, mainly those of 58 N/mm^2 and lower. Most of the selected concrete types are those used in actual construction work in Japan, while some with specifications deviating from Japanese standards were selected to cover a wider variety of water absorbency and water content.

2.1.3. Working techniques

Table 2 summarises the working techniques used during sample preparation. Four different working techniques, varying the quantity of *Finishing* with wood and steel trowels and the method of curing, were set on the basis of the results obtained by surveys conducted on Japanese construction sites, to cover the different techniques employed in real-life settings. They are characterised as follows:

- Working technique I: the worker in charge of top surface finishing considered the condition as "being the worst amongst what they had experienced or seen/heard of" (Inappropriate condition)
- Working technique II: the worker in charge of top surface finishing considered the condition as being what is "typically used these days" (Typical condition).
- Working technique III: the worker in charge of top surface finishing considered the condition as being "sufficient to obtain a high quality slab surface" (Ideal condition).
- Working technique III': the surface finishing condition is identical to III but with an air curing instead of a 3-day wet curing followed by air curing.

2.2. Sample preparation processes and results

A total of 56 samples, consisting of 14 concrete types that had been worked with 4 techniques, were prepared as described in 2.1.

Concrete placement was performed in a thermostatic and hygrostatic room at 20 °C and 60% humidity. After pouring the mix in the frame, the concrete was compacted with a rod vibrator for ca. 3 s, after which the surface was smoothed with a steel trowel. Then, once the bleeding water receded and the concrete was set sufficiently enough to support human weight (approx. 4 h), the surface was *Finished* with wood and steel trowels as described in Table 2. The same skilled worker performed all trowel *Finishing*.

Table 2
Summary of working techniques.

Condition	Surface finishing work		Curing
	Wood trowel	Steel trowel	
I	Once	Once	Air curing
II	Once	Twice	Air curing
III'	Twice	3 times	Air curing
III	Twice	3 times	Wet (3 days) + air curing

Table 1
Summary of concretes used.

Concrete no.	Binder type[1]	Admixture type[2]	Target compressive strength (N/mm^2)	Target slump (cm)	Target slump flow (cm)	Water-to-binder ratio (%)	Fine aggregate ratio (%)	Water content (kg/m^3)	Admixture dosage[3] (%)	Curing compound added
1	N	AE	21	8	–	63	47	147	1.30	No
2	N	AE	27	12	–	54	46	164	1.10	No
3	N	AE	27	18	–	54	48	178	1.10	No
4	N	HP–AE	36	12	–	45	43	160	0.70	No
5	N	AE	36	18	–	45	46	170	1.35	No
6	N	HP–AE	45	12	–	39	40	160	0.75	Yes[4]
7	N	HP–AE	45	18	–	39	43	170	0.75	No
8	N	AE	45	18	–	39	39	188	0.90	No
9	N	AE	45	21	–	39	41	196	0.90	No
10	N	HP–AE	45	21	–	39	45	175	0.75	Yes[4]
11	M	HP–AE	58	–	55	31	49	165	1.00	No
12	M	HP–AE	58	–	55	31	49	165	1.00	Yes[4]
13	M	HP–AE	58	–	55	31	51	150	1.05	Yes[4]
14	SF	UHP–AE	108	–	55	19	43	155	1.35	Yes[4]

[1] Binder type used. N: normal portland cement; M: moderate heat portland cement; SF: M + 10% expressed in weight-to-weight ratio silica fume.
[2] Admixture type (all admixtures are Category I standard type). AE: air-entraining water reducing agent; HP–AE: high-performance AE water reducing agent; UHP–AE: ultra high-performance AE water reducing agent.
[3] Percentage of admixture to binder, weight-to-weight ratio.
[4] Spraying of paraffin wax curing agent during surface finishing at a standard dosage of 150 mL/m^2.