

August 5, 2007

Hydration heat test

Internal temperature of the concrete mixed with Silica White

Examination results report

Measured from July 5 to July 15, 2007



Silica Japan Laboratory Inc.

Address: 52, 1 chome, Higashi 3 jo, Ryokuendai, Ishikari, Hokkaido, Japan
Postal code: 061-3223



Product Giken, Inc.

Registered construction consulting company authorized by The Ministry of Land,
Infrastructure and Transport
Registration No.: Ken 16-8076



1. General Matters

Outline of the Examination

- ①. Test to measure the internal temperature when the concrete is curing
Plan for the blend of concrete that uses Silica White
- ②. Objectives and contents of the examination
The examination is conducted by creating the basic plan for the blend and measuring compressive strength when Silica White is used as a replacement material for ordinary cement and blast furnace cement, and measuring the internal temperature when the concrete is curing.
- ③. Shape of the sample
Measuring the temperature change in the center of the cube after pouring concrete inside the wooden 1.0m×1.0m×1.0m panel frame

Client requesting the examination

Address: 52, 1 chome, Higashi 3 jo, Ryokuendai, Ishikari, Hokkaido, Japan
Postal code: 061-3223
Silica Japan Laboratory Inc.

Conducted by:

Department of Research and Development, Product Giken, Inc.

Measured from July 5 to July 15, 2007

Test site

Examination building at Product Giken, Inc.

2. Examination and measurement methods

Mixing design/compressive strength

Using ordinary Portland cement and based on the blend (designed strength: 24 N/mm², slump: 15cm), the cement is replaced with Silica White. The same procedure is performed on blast furnace cement, as well. An air-entraining and high-range water-reducing agent is used in order to make concrete properties constant. Blend, compressive strength, and other properties of the fresh concrete are shown below.

Table of Blends

(unit: kg)

Name of the Blends	W	N	B	SW	G	S	AE
24-15-25N	153	283	—	—	1078	762	2.26
24-15-25N-SW	181	268	—	67	1026	686	3.02
24-15-25B-SW	181	—	268	67	1021	683	3.02

W/water • N/ ordinary cement • B/ blast furnace cement • SW/Silica White • G/ Coarse aggregate • S/ Coarse aggregate • AE/AE water reducing agent

Compressive strength, and properties of fresh concrete

Name of the Blends	Measured on:	Compressive strength (age of the material: 28 days)	Mixing temperature	Air volume	Slump
24-15-25N	7/9PM14	27.2	27	4.5	15
24-15-25N-SW	7/5PM14	29.5	25	4.4	15.5
24-15-25B-SW	7/12PM14	28.9	—	4.3	15.5

Unit - compressive strength: mm², temperature:°C, air volume: %, slump: cm

2-2 Method for measuring the internal temperature of the concrete

Using the three types of blended concrete specified in the preceding clause, measure the internal temperature change when the concrete is curing after pouring each type of concrete inside the wooden 1.0m×1.0m×1.0m panel frame in the laboratory where the temperature is kept constant.

Photo ①

Wooden frame

Memory device for temperature measurement
(data logger/ thermocouple)

Outline chart

Section where the temperature was measured

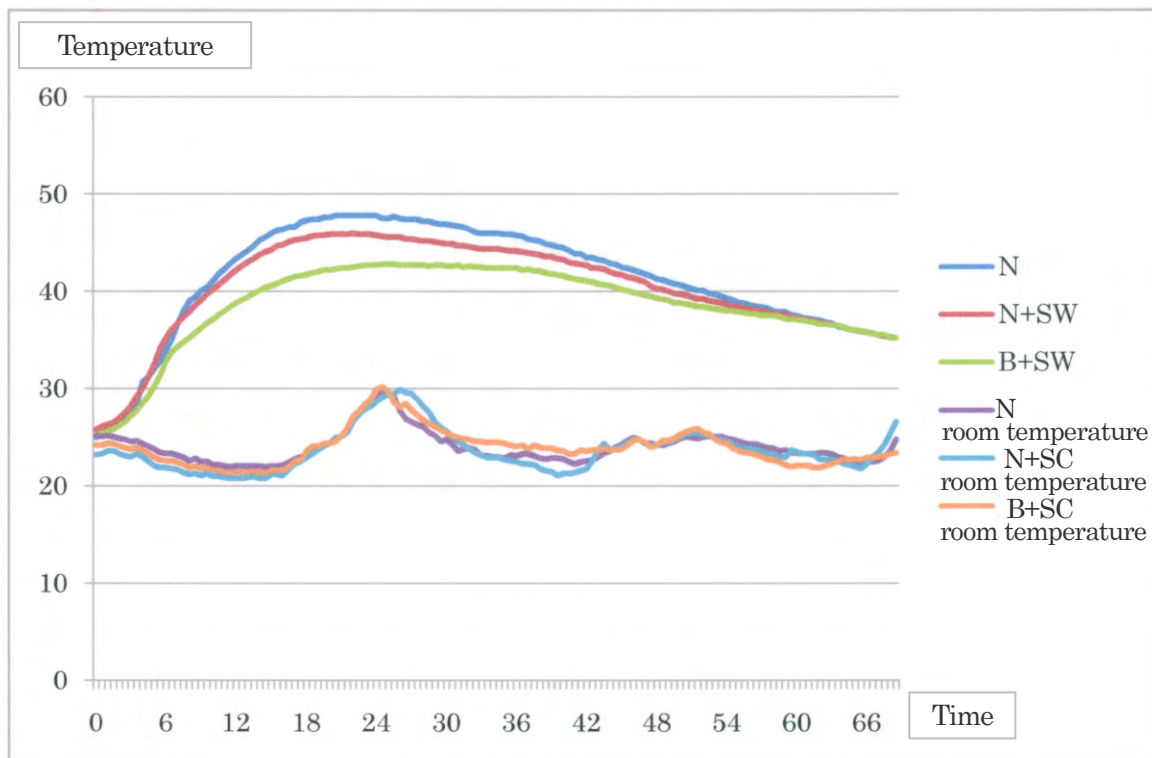
The temperature of the center part of the sample

3. Test Results

After measuring the internal temperature changes that occurred in the three types of blended concrete (see the graph below and attached measurement data), it was revealed that it was possible to lower the curing temperature by replacing cement blended with Silica White. Moreover, during the curing process, the temperature gradient decreased when BB cement and Silica White were blended in. It can be assumed that this happened because the curing temperature lowered the amount of mixed cement per 1 m³, which was reduced by the cement replacement with the blast furnace slab and Silica White.

However, the compressive strength did not decrease even when the amount of cement per square meter decreased. Although the cause cannot be determined unless more detailed tests are conducted in the future, it seems that this was probably due to the close-packed structure resulting in the closest packing possible (by micro-filler effect, etc.) and because the strength was enhanced due to the secondary curing reaction (by pozzolanic action, etc.)







Temperature change



N/24-15-25N · N+SW/24-15-25N-SW · B+SW/24-15-25B-SW

	N	N+SW	B+SW
The highest internal temperature	47.8	46.0	42.8
The maximum temperature difference between the air outside	24.3	23.7	19.5

4. Examination Results

	
<p>Silica White charging process</p>	<p>Wooden Panel Frame</p>
	
<p>Cement pouring process</p>	<p>Preparation for Measuring the Temperature</p>
	
<p>Length of measurement</p>	<p>Shape of the sample</p>

(1) Detailed temperature data

	N	N+SW	B+SW	①	②	③
0.0	25.0	25.8	25.2	25.2	23.2	24.2
0.5	25.5	26.1	25.4	25.1	23.3	24.2
1.0	25.7	26.3	25.6	25.2	23.6	24.4
1.5	25.9	26.5	25.9	25.1	23.6	24.3
2.0	26.4	27.0	26.2	24.9	23.3	24.1
2.5	27.5	27.5	26.6	24.8	23.1	24.0
3.0	27.7	28.2	27.2	24.6	23.0	23.8
3.5	28.5	29.2	27.7	24.7	23.3	24.0
4.0	30.7	30.0	28.5	24.4	23.0	23.7
4.5	31.2	31.2	29.2	24.1	22.5	23.3
5.0	32.0	32.5	30.2	23.8	22.1	23.0
5.5	32.8	34.1	31.3	23.5	21.9	22.7
6.0	34.0	35.2	32.8	23.4	21.9	22.6
6.5	35.1	36.1	33.8	23.4	21.8	22.6
7.0	36.7	36.7	34.3	23.2	21.7	22.4
7.5	38.0	37.4	34.8	23.0	21.4	22.2
8.0	39.0	37.9	35.2	22.6	21.2	21.9
8.5	39.4	38.6	35.7	22.9	21.3	22.1
9.0	40.1	39.1	36.2	22.5	21.1	21.8
9.5	40.4	39.7	36.7	22.6	21.3	21.9
10.0	41.1	40.2	37.1	22.2	21.0	21.6
10.5	41.8	40.7	37.6	22.2	21.0	21.6
11.0	42.3	41.2	38.0	22.1	20.9	21.5
11.5	42.9	41.7	38.4	22.0	20.8	21.4
12.0	43.4	42.2	38.8	22.1	20.8	21.5
12.5	43.8	42.6	39.1	22.1	20.8	21.4
13.0	44.2	43.0	39.4	22.1	20.9	21.5
13.5	44.7	43.4	39.8	22.1	21.0	21.5
14.0	45.3	43.8	40.1	22.1	20.8	21.4
14.5	45.6	44.1	40.4	22.0	20.8	21.4
15.0	46.0	44.3	40.6	22.1	21.2	21.6
15.5	46.3	44.7	40.8	22.1	21.2	21.6
16.0	46.4	44.8	41.1	22.2	21.1	21.6
16.5	46.6	45.1	41.3	22.5	21.7	22.1
17.0	46.6	45.3	41.5	22.8	22.3	22.6
17.5	47.1	45.4	41.6	23.0	22.5	22.8
18.0	47.3	45.5	41.7	23.3	22.9	23.6
18.5	47.4	45.7	41.9	23.7	23.3	24.1
19.0	47.4	45.8	42.0	23.9	23.7	24.1
19.5	47.6	45.8	42.2	24.3	24.1	24.4
20.0	47.6	45.9	42.2	24.4	24.4	24.4
20.5	47.8	45.9	42.3	24.8	25.0	24.6
21.0	47.8	45.9	42.4	25.2	25.1	25.2
21.5	47.8	45.9	42.4	25.8	25.5	26.0
22.0	47.8	46.0	42.5	27.0	26.7	27.2
22.5	47.8	45.9	42.6	27.6	27.4	27.7
23.0	47.8	45.9	42.7	28.2	27.9	28.4
23.5	47.8	45.9	42.7	28.6	28.2	28.9
24.0	47.8	45.8	42.7	29.3	28.7	29.9

※ ①N room temperature ②N+SW room temperature ③B+SW room temperature

(2) Detailed temperature data

	N	N+SW	B+SW	①	②	③
24.5	47.5	45.7	42.8	29.7	29.1	30.2
25.0	47.5	45.6	42.8	29.6	29.4	29.7
25.5	47.7	45.6	42.8	29.1	29.5	28.6
26.0	47.5	45.6	42.7	27.7	29.9	28.1
26.5	47.4	45.4	42.7	26.9	29.6	28.5
27.0	47.4	45.4	42.7	26.6	29.5	27.8
27.5	47.4	45.3	42.7	26.3	28.9	27.3
28.0	47.2	45.2	42.7	26.1	28.2	26.8
28.5	47.2	45.2	42.6	25.5	27.6	26.4
29.0	47.0	45.1	42.7	25.2	26.5	26.1
29.5	46.9	45.0	42.7	24.6	26.0	25.8
30.0	46.9	44.9	42.6	24.8	25.6	25.5
30.5	46.8	44.9	42.6	24.3	25.1	25.2
31.0	46.7	44.7	42.7	23.6	24.6	25.0
31.5	46.6	44.7	42.5	23.8	24.2	24.9
32.0	46.4	44.6	42.6	23.9	23.8	24.8
32.5	46.1	44.5	42.5	23.7	23.4	24.6
33.0	46.0	44.4	42.5	23.1	23.2	24.6
33.5	46.0	44.4	42.4	23.1	22.9	24.5
34.0	46.0	44.4	42.4	23.0	22.9	24.5
34.5	46.0	44.4	42.4	23.0	22.9	24.5
35.0	45.9	44.3	42.4	22.9	22.7	24.4
35.5	45.9	44.2	42.4	23.2	22.6	24.2
36.0	45.8	44.2	42.4	23.1	22.5	24.1
36.5	45.7	44.1	42.2	23.3	22.3	24.2
37.0	45.4	44.0	42.3	23.3	22.3	23.8
37.5	45.3	43.9	42.1	23.1	22.2	24.2
38.0	45.2	43.8	42.1	22.9	21.8	24.0
38.5	44.9	43.6	41.9	22.8	21.6	23.9
39.0	44.8	43.6	41.8	22.9	21.5	23.9
39.5	44.6	43.4	41.7	22.9	21.1	23.7
40.0	44.5	43.3	41.6	22.8	21.3	23.6
40.5	44.2	43.0	41.4	22.5	21.3	23.3
41.0	43.9	42.9	41.3	22.3	21.4	23.3
41.5	43.9	42.8	41.2	22.5	21.6	23.7
42.0	43.5	42.7	41.1	22.6	21.8	23.6
42.5	43.5	42.4	41.0	22.7	22.6	23.7
43.0	43.3	42.4	40.8	23.0	23.7	23.7
43.5	43.2	42.3	40.7	23.4	24.4	23.9
44.0	42.9	42.0	40.6	23.6	23.7	23.7
44.5	42.8	41.8	40.4	24.0	23.9	23.7
45.0	42.5	41.7	40.2	24.3	24.1	23.8
45.5	42.4	41.5	40.1	24.7	24.5	24.2
46.0	42.2	41.4	39.9	25.0	24.9	24.7
46.5	42.0	41.2	39.8	24.8	24.8	24.8
47.0	41.8	41.0	39.6	24.4	24.5	24.5
47.5	41.6	40.6	39.5	24.4	24.2	24.0
48.0	41.3	40.3	39.3	24.2	24.2	24.2

※ ①N room temperature ②N+SW room temperature ③B+SW room temperature

(3) Detailed temperature data

	N	N+SW	B+SW	①	②	③
48.5	41.2	40.2	39.2	24.2	24.5	24.7
49.0	41.0	40.1	39.1	24.4	24.6	24.7
49.5	40.8	39.8	38.8	24.6	24.8	24.9
50.0	40.7	39.8	38.8	24.9	25.1	25.3
50.5	40.5	39.6	38.7	25.1	25.4	25.6
51.0	40.3	39.5	38.6	25.0	25.4	25.8
51.5	40.1	39.3	38.4	24.9	25.4	25.9
52.0	40.1	39.3	38.4	25.1	25.3	25.5
52.5	39.8	39.1	38.3	25.1	25.3	25.4
53.0	39.7	39.0	38.2	25.1	25.0	24.8
53.5	39.5	38.8	38.1	25.1	24.8	24.5
54.0	39.3	38.7	38.0	24.9	24.7	24.4
54.5	39.1	38.6	38.0	24.8	24.4	23.9
55.0	38.9	38.4	37.9	24.6	24.1	23.6
55.5	38.8	38.3	37.8	24.4	23.9	23.4
56.0	38.6	38.2	37.7	24.3	23.9	23.4
56.5	38.5	38.1	37.7	24.3	23.8	23.2
57.0	38.4	38.0	37.5	24.1	23.6	23.0
57.5	38.3	37.9	37.5	23.9	23.3	22.7
58.0	38.0	37.8	37.5	23.9	23.3	22.7
58.5	37.9	37.7	37.4	23.6	23.1	22.5
59.0	37.9	37.6	37.2	23.7	23.0	22.2
59.5	37.6	37.4	37.1	23.4	23.7	22.0
60.0	37.5	37.3	37.1	23.4	23.5	22.1
60.5	37.3	37.2	37.0	23.3	23.3	22.1
61.0	37.2	37.1	36.9	23.3	23.3	22.1
61.5	37.1	37.0	36.8	23.3	23.2	21.9
62.0	37.0	36.8	36.6	23.4	22.7	21.9
62.5	36.8	36.7	36.6	23.4	22.7	22.1
63.0	36.7	36.6	36.5	23.3	22.7	22.3
63.5	36.4	36.5	36.5	23.0	22.6	22.5
64.0	36.3	36.3	36.3	22.9	22.3	22.8
64.5	36.1	36.1	36.1	22.6	22.2	22.7
65.0	36.0	36.0	36.0	22.5	22.0	22.8
65.5	35.9	35.9	35.9	22.4	21.8	22.7
66.0	35.8	35.8	35.8	22.5	22.3	22.9
66.5	35.7	35.7	35.6	22.5	23.0	22.9
67.0	35.5	35.5	35.5	22.6	23.5	23.0
67.5	35.4	35.5	35.5	23.0	24.3	23.1
68.0	35.3	35.3	35.2	23.6	25.4	23.3
68.5	35.2	35.2	35.2	24.8	26.6	23.4

※ ①N room temperature ②N+SW room temperature ③B+SW room temperature