Experiences from Vertical Full Scale Castings with SCC

Lars Nyholm Thrane
Danish Technological Institute, Concrete Centre
Overall objective:
To improve the productivity and the working environment of the concrete industry
Outline

Introduction

Test setup

Results
- Form filling
- Segregation/Blocking
- Form pressure
- Surface finish
- Frost resistance
- Air void structure

Fresh state

Hardened state
Introduction

The use of SCC in vertical castings is still much lower than the use of SCC use in horizontal castings such as floors.

The aim of the full scale wall castings is to obtain experience on i.e.

• the relation between the fresh concrete workability, casting technique and the form filling behavior
• form pressure
• surface finish
• air void structure and frost resistance
## Test Setup

<table>
<thead>
<tr>
<th>Wall ID</th>
<th>V1</th>
<th>V2</th>
<th>V3</th>
<th>V4</th>
<th>V5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions</td>
<td>H * W * L = 4m * 0.5m * 5m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete Type</td>
<td>A35</td>
<td>A35</td>
<td>A35</td>
<td>M30</td>
<td>M30</td>
</tr>
</tbody>
</table>
Test Setup

Inlet

V1 and V4

V2 and V5

V3

Concrete surface
Test Setup
Test Setup

![Graph showing temperature (Temp [°C]) over time (Tid [min]). The graph displays a steady increase in temperature starting from 2°C and reaching a plateau before rising sharply in the last 1-2 minutes. The x-axis represents time in minutes, and the y-axis represents temperature in °C.](image-url)
## Test Setup

<table>
<thead>
<tr>
<th>Test</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slump Flow, Annex U i DS 2426</td>
<td>Compressive strength</td>
</tr>
<tr>
<td>Slump Flow, 4C Auto-slump</td>
<td>Heat development</td>
</tr>
<tr>
<td>J-ring</td>
<td>Finish</td>
</tr>
<tr>
<td>Air content</td>
<td>Macro analysis</td>
</tr>
<tr>
<td>Air void distribution: Air-Void-meter</td>
<td>Air void structure: EN 480-11</td>
</tr>
<tr>
<td>Form pressure</td>
<td>Frost Resistance: SS 13 72 44</td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
</tr>
</tbody>
</table>
Monitor – one click and the analysis will proceed automatically

B/W Video camera

Lifting device – Ball screw ensures accurate lifting speed of 7 cm/s

Base plate in hardened sand blasted glass on adjustable rubber feet

Everything mounted on "rollers"

Upright Abrams slump cone with weight ring

4C Automatic Slump Flow

Nordic Concrete Day
2005
4C Automatic Slump Flow

Concept:

Field of view 232 x 172mm – 640 x 480 pixels

Spread as a function of time is determined – 30 images per second

Raw image

Binary image – only black and white pixels

Nordic Concrete Day
2005
4C Automatic Slump Flow

Concept:

- Field of view: 232 x 172 mm – 640 x 480 pixels
- Raw image
- Binary image – only black and white pixels

Yield stress:
\[ \tau_0 = 45 \text{ Pa} \]

Plastic viscosity:
\[ \eta_{pl} = 30 \text{ Pa s} \]
## Results

<table>
<thead>
<tr>
<th></th>
<th>V1</th>
<th>V2</th>
<th>V3</th>
<th>V4</th>
<th>V5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air [%]</td>
<td>5</td>
<td>6.6</td>
<td>5.1</td>
<td>8.5</td>
<td>7.1</td>
</tr>
<tr>
<td>SF [mm]</td>
<td>640</td>
<td>660</td>
<td>670</td>
<td>550</td>
<td>570</td>
</tr>
<tr>
<td>$\tau_0$ [Pa]</td>
<td></td>
<td>20</td>
<td></td>
<td>60</td>
<td>45</td>
</tr>
<tr>
<td>$\eta_{pl}$ [Pa·s]</td>
<td>60</td>
<td></td>
<td>34</td>
<td></td>
<td>34</td>
</tr>
</tbody>
</table>
Results

Time [min] vs Height [m]

- V1
- V2
- V3
- V4
- V5
Results

Complete form filling was obtained. Depending on the rheological properties it was necessary to move the inlet to level the concrete surface.

Form geometry and reinforcement configuration do not prevent high casting rates of up to 25 m/hour. However, may have to lower due to e.g. finish and form pressure.
Results

V1 (~ 2 cm)

V4 (~ 10 cm)
Results

Blocking was not observed during form filling.
Dynamic segregation very dependent on the casting technique and the rheological properties.
Dynamic segregation very dependent on the casting technique and the rheological properties.
Dynamic segregation very dependent on the casting technique and the rheological properties.
Results

Hydrostatic pressure is obtained (> 18 m/hour)

\[
\begin{align*}
0.93 \text{ m} & : 21 \text{ kN/m}^2 \\
0.84 \text{ m} & : 41 \text{ kN/m}^2 \\
1.10 \text{ m} & : 66 \text{ kN/m}^2 \\
1.11 \text{ m} & : 92 \text{ kN/m}^2
\end{align*}
\]
Results

2 types of form oil:
- Bricon Unislip 9-12, mineral oil
- Emulfix LL, vegetable formolie

Visuel inspection showed no difference in surface finish.
Results

Finish is evaluated by counting pores according to:


For each wall four sections are chosen of 1x1 m². The sections represent
Results

5 m

4 m

5 m
The surface finish is very dependent on the casting technique and the rheological properties.
Results

According to annex F in DS 2426 concrete in exposure class XF2, XF3 og XF4 (A, A and E in DS 481), which is exposed to a combination of salt and frost should obtain:

- Air void content in hardened concrete (DS/EN 480-11) > 3,5%
- Spacing factor is < 0.20.

It is observed that all the tested samples fulfil these requirements except for the three core samples in the bottom of V1 where the total air void content is 3.4%.
Results

According to annex F in DS 2426 concrete in exposure class XF2, XF3 and XF4 (A, A and E in DS 481), should obtain the result good in a frost/thaw test (SS 13 72 44).

The results show that a satisfactory frost resistance is obtained.