CONCRETE, MORTAR AND CEMENT BASED REPAIR MATERIALS:
QUALITY CONTROL OF FRESH SELF-COMPACTING CONCRETE –
WORKABILITY, AIR CONTENT, DENSITY AND CASTING OF TEST SPECIMENS

Key words: Concrete, self-compacting concrete, J-ring, slump flow, workability, air content, density, test specimen

1 SCOPE

This procedure is for the quality control of the of fresh self-compacting concrete.

With respect to air content, density and casting of test specimens this method is in accordance with EN 12350-6, and EN 12350-7 shall be used except for the sections given in the present document. These sections are superior to EN-12350.

2 FIELD OF APPLICATION

The method is applicable to self-compacting concrete with a slump flow of 500 mm or higher as determined by the method described in this procedure without J-ring.

3 REFERENCES


4 DEFINITIONS

Workability: The filling properties of fresh concrete in relation to the behaviour of the concrete in the production process, described in the terms of filling ability, passing ability and resistance to segregation.
Filling ability: The ability of the fresh concrete to flow under gravitation, or under pressure (e.g. pumping) and totally fill formwork and enclose reinforcement.
Passing ability: The ability of the fresh concrete to pass confined section of the formwork, dense reinforcement, etc., without the aggregate blocking.
Resistance to segregation: The ability of the fresh concrete to retain its homogeneity during the casting process and when the concrete has come to rest.
5 TEST METHODS

It is of outmost importance that the concrete tested is representative. When sampling concrete from a truck 0.3 m³ should be emptied before taking the sample for testing.

5.1 Workability

5.1.1 Principle

The test aims at evaluating the workability of fresh SCC. The slump flow without J-ring indicates the free, unrestricted deformability of SCC (filling ability), while the slump flow with J-ring indicates the restricted deformability of SCC due to blocking effect of reinforcement bars (passing ability). The flow-time T50 indicates the rate of deformation within a defined flow distance. The difference in test results from different sampling indicates the inhomogeneity of SCC due to e.g. segregation.

If there is a requirement to passing ability, the test of slump flow with J-ring can be used.

On the suspicion that segregation might occur, two tests of slump flow with J-ring can be carried out, one with the fresh SCC from the upper portion of the sample in a bucket and another with the fresh SCC from the lower portion of the sample in the same bucket.

5.1.2 Apparatus

- Base plate of size at least 900 × 900 mm, made of impermeable and rigid material (steel or plywood [Note 1]) with smooth and plane test surface (deviation of the flatness not exceed 3 mm [Note 2]), and clearly marked with circles of Ø200 mm and Ø500 mm at the centre, as shown in Annex 1.
- Abrams cone with the internal upper/lower diameter equal to 100/200 mm and the height of 300 mm.
- J-ring (dimensions as shown in Annex 2).
- Weight ring (> 9 kg, to keep Abrams cone in place during sample filling. An example of its dimensions is given in Annex 3). Alternatively, a cast iron cone may be used as long as the weight of the cone exceeds 10 kg. As a second alternative the cone may be kept in position by hand no weight ring is needed.
- Cleaning rag.
- Stopwatch with the accuracy of 0.1 second.
- Straight rod with for example triangular cross section with a length of about 400 mm and the flexure on at least one flat side < 1 mm.
- Ruler (graduated in mm).
- Clean, wetted and squeezed towel or cloth.
- Bucket, made of rigid plastic or metal with the inside diameter of 300 ± 10 mm and capacity of about 14 litres.

Note 1: Wear or damage of the surface coating of plywood plates may affect the flow of concrete.

Note 2: The deviation of the flatness of the test surface is defined as the greatest difference in height between the highest and the lowest points on that surface, while disregarding any small single cavities in the surface.

5.1.3 Test procedures

5.1.3.1 Sampling

Fill the bucket with about 6 litres of representative fresh SCC. Let the sample stand still for about 1 minute (± 10 seconds).

If the resistance to segregation is to be tested an additional bucket is filled with 12 litres of representative fresh SCC. Let the sample stand still for 2 minutes (± 10 seconds).

5.1.3.2 Testing

- Pre-wet the surface of the base plate with water and remove the surplus either by a cleaning rag or by placing the plate vertically.
- Place the cleaned base plate in a stable and level position.
- Place the cone (interior moistened with a towel) in the center of the base plate on the 200 mm circle and put the weight ring on the top of the cone to keep it in place. (If a heavy cone is used, or the cone is kept in position by hand no weight ring is needed).
- Fill the cone with the sample from the bucket without any external compacting action such as rodding or vibrating. The surplus concrete above the top of the cone has to be struck off, and any concrete remaining on the base plate has to be removed.
- Check and make sure that the test surface is neither too wet nor to dry. No dry area on the base plate is allowed and any surplus of the water has to be removed – the moisture state of the plate has to be ‘just wet’.
- If passing ability or resistance to segregation is to be evaluated then place the J-ring around the cone.
- After a short rest (no more than 30 seconds for cleaning and checking the moist state of the test surface), lift the cone perpendicular to the base plate in a single movement, in such a manner that the concrete is allowed to flow out freely without obstruction from the cone. Start the stopwatch the moment the cone lose the contact with the base plate. Stop the stopwatch when the front of the concrete first touches the circle of diameter 500 mm. The stopwatch reading is recorded as the T50 value. The test is completed when the concrete flow has ceased. Do not touch the base plate or otherwise disturb the concrete until the measurements described below are completed.

If the J-ring is used, lay the straight rod with the flat side on the J-ring and measure the relative height differences (as shown in Annex 2) between the lower edge of the straight rod and the concrete surface at the central position (Δh₀).
and at the four portions outside the J-ring, two \((\Delta h_{x1}, \Delta h_{x2})\) in the \(x\)-direction and the other two \((\Delta h_{y1}, \Delta h_{y2})\) in the \(y\)-direction (perpendicular to \(x\)). For non-circular concrete spreads the \(x\)-direction is that of the largest spread diameter. By means of these height differences the value of blocking step \(B_J\) (the difference in height in the centre and outside the ring) can be calculated.

The largest diameter of the flow spread, \(d_{\text{max}}\), and the one perpendicular to it, \(d_{\text{perp}}\), are measured using the ruler (reading to nearest 5 mm). Care should be taken to prevent the ruler from bending.

After testing, the base plate and cone should be cleaned to keep their surface conditions constant.

If resistance to segregation is to be tested, the above procedures should be performed twice using the top half and the bottom half respectively of the 12 litres sample in the bucket as described in 5.1.3.1. The change in the blocking step between the two measurements is an indication of segregation resistance. When the relative change is larger than 50% and the absolute difference in blocking step between the two measurements is larger than its repeatability limit (see Table 1 in 5.1.5.1), there is a risk of segregation.

5.1.4 Expression of the results

- **Flow spread [mm]**: The flow spread \(S\) is the average of diameters \(d_{\text{max}}\) and \(d_{\text{perp}}\), as shown in Equation (1). \(S\) is expressed in mm to the nearest 5 mm. If the J-ring is used, the symbol \(S_J\) can be used to differ from that without J-ring.

\[
S = \frac{(d_{\text{max}} + d_{\text{perp}})}{2} \quad (1)
\]

- **Blocking step \(B_J\) [mm]** (for the test with J-ring): See Equation (2), expressed to the nearest 1 mm.

\[
B_J = \frac{(\Delta h_{x1} + \Delta h_{x2} + \Delta h_{y1} + \Delta h_{y2}) - \Delta h_0}{4} \quad (2)
\]

- **Change in the blocking step \(\delta_{B_J}\)** (for the test of resistance to segregation): See Equation (3), expressed to the nearest 1%.

\[
\delta_{B_J} = \frac{(B_{J2} - B_{J1})}{B_{J1}} \times 100 \quad (3)
\]

where, \(B_{J1}\) and \(B_{J2}\) denote the blocking step from the first and the second measurements, respectively, and \(B_{J1}\) is the mean value of the two measurements.

5.1.5 Accuracy

5.1.5.1 Repeatability

The repeatability \(r\) is defined as a maximal difference between any two values from 20 measurements by the same operator. The values of \(r\) for flow spread, \(T50\) and J-ring blocking step are given in Table 1.

| Table 1. Repeatability values*. |
|-----------------|-----------------|-----------------|
| Flow spread \(S\) [mm] | \(\leq 600\) | 600 ~ 750 | > 750 |
| N.A. | 40 | 20 |
| Flow spread \(S_J\) [mm] | \(\leq 600\) | 600 ~ 750 | > 750 |
| 60 | 45 | 25 |
| \(T50\) [sec] | \(\leq 3.5\) | 3.5 ~ 6 | > 6 |
| 0.70 | 1.20 | N.A. |
| Blocking step \(B_J\) [mm], [Note 3] | < 20 | > 20 |
| 5 | 8 |

* Based on the inter-laboratory test in /2/ with 2 replicates and 8 laboratories. N.A.: Not available.

Note 3: SCC of limited filling ability (small flow spreads) may inherently have a blocking step \(B_J\) value higher than 20mm even though no apparent blocking can be visually observed. In such cases \(B_J\) values higher than 20mm reflects the SCC’s inability to pass formwork confinement and reinforcement caused by its low filling ability.

5.1.5.2 Reproducibility

The reproducibility \(R\) is defined as a maximal difference between any two values from 20 measurements by different operators. The values of \(R\) for flow spread, \(T50\) and J-ring blocking step are given in Table 2.

| Table 2. Reproducibility values*. |
|-----------------|-----------------|-----------------|
| Flow spread \(S\) [mm] | \(\leq 600\) | 600 ~ 750 | > 750 |
| N.A. | 40 | 30 |
| Flow spread \(S_J\) [mm] | \(\leq 600\) | 600 ~ 750 | > 750 |
| 65 | 45 | 30 |
| \(T50\) [sec] | \(\leq 3.5\) | 3.5 ~ 6 | > 6 |
| 0.90 | 1.20 | N.A. |
| Blocking step \(B_J\) [mm], [Note 3] | < 20 | > 20 |
| 5 | 8 |

* Based on the inter-laboratory test in /2/ with 2 replicates and 8 laboratories. N.A.: Not available.

5.1.6 Test report

The test report should, if known, include the following information:

a) Reference to this standard
b) Concrete mixture identification
c) Time elapsed from adding the mixing water to sampling
d) Test result as well as individual measurement values
e) Visual observations if any
f) Any deviations from the standard test procedure
g) Composition of the concrete.
5.2 Density and air content

5.2.1 Principle
The method for determination of density and air content of SCC is based on EN 12350.

5.2.2 Apparatus
- Pressurometer of nominal 8L volume. The weight and volume of the container should be known.
- Bucket, made of rigid plastic or metal with the inside diameter of 300 ± 10 mm and capacity of about 14 litres.
- Balance with a maximum reading of minimum 25 kg, and an accuracy of ± 0.020 kg.
- Straight edge.

5.2.3 Test procedures
The test procedure is as follows:
- Fill the bucket with 9–10 litres of representative SCC.
- Place the pressurometer container in a stable and level position.
- Fill the pressurometer by pouring concrete from the bucket without entrapping excess air [Note 4].
- Level the upper surface of the container using the straight edge.
- Measure the weight of the container with concrete and calculate the density to the nearest 10 kg/m³.
- Place the pressurometer lid on the container and measure the air content to the nearest 0.1% as described in EN 12350-7.

Note 4: Another way to fill the pressurometer with concrete is to place an Abrams cone in the pressurometer container with the smallest diameter downwards (inverted position), and fill the cone with concrete from the bucket without any compacting action. Slowly lift the cone to let the concrete flow into the container without entrapping excess air.

5.2.4 Expression of the results
The results are expressed according to EN 12350.

5.2.5 Accuracy
The accuracy is assumed to be equivalent to EN 12350. However, no investigation of accuracy is currently available.

5.2.6 Test report
The test report should be according to EN 12350.

5.3 Test specimens

5.3.1. Principle
Test specimens for e.g. documentation of compressive strength should be cast according to a modified EN 12350.

5.3.2. Apparatus
- Mould/form
- Bucket(s).

5.3.3. Test procedures
The test procedure is as follows:
- The mould/form is filled with representative SCC by pouring from a bucket.
- The upper surface of the mould/form is levelled with the straight edge.
- The mould/form is stored and cured according to EN 12350.
ANNEX 1. DIMENSIONS OF THE BASE PLATE AND ABRAMS CONE
ANNEX 2. DIMENSIONS OF THE J-RING AND POSITIONS FOR MEASUREMENT OF HEIGHT DIFFERENCES

A - A

Explanations:
- Measurement position
- All dimensions in mm
ANNEX 3. EXAMPLE OF WEIGHT RING’S DIMENSIONS AND APPLICATION IN THE J-RING TEST

Material density: 7.8~7.9 g/cm³
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Return address:
Nordic Innovation Centre,
Stensberggata 25
NO-0170 Oslo, Norway