

Exercise 7: Analysis of mixing test results, performance prediction

The two tables below give the quantities used to carry out two mixing tests with a material volume of around 25 liters. The first test was carried out using a self-compacting concrete (SCC) formulation with rolled aggregates (the percentage of fines in the sand used was around 9% by mass). The second test was carried out with a thixotropic UHPFRC (Ultra High-Performance Fiber reinforced Concrete) mix for slope castings.

1. SCC

Component	ρ [kg/m ³]	Mass [kg]
Cement CEM II/A-LL 42.5 N	3050	9.3
Flying Ash	2200	2.5
Limestone filler	2700	1.25
Water	1000	4.18
Sand 0/4 mm	2680	21.3
Fine gravel 4/8 mm	2690	8.5
Gravel 8/16 mm	2690	12.8
Admixture	1100	0.113
Dry extract 40 %		
60% water		
Total		59.94

2. UHPFRC

Component	ρ [kg/m ³]	Mass [kg]
CEM II/A-M (D-LL) 52.5 N	3150	15.9
Silica fume	2200	2
Limestone filler	2700	15.9
Water	1000	4.46
Fine sand 0.1/0.4 mm	2680	13.6
Thixotropizer	980	0.127
Fiber 10 / 0.16 mm	7850	8.95
Admixture	1060	1.146
Dry extract 25 %		
75% water		
Total		62.08

Work to be carried out:

Using the test results on fresh materials given in the appendix:

1. Calculate the actual volumes produced in the two batches, then the actual composition for the two materials (dosage of each component in kg/m³ and liters/m³).
2. For SCC: calculate the Water/C_{eq} ratio, the respective percentages of the 3 granular fractions, the respective fines contributions and the total of fines, the total volumetric % of paste (fines + water + admixture + air), and the average cylinder compressive strength estimated at 28 days. What are the slump flow class and the apparent viscosity class according to SN EN 206: 2013 + A1 (2021)?
3. For UHPFRC: calculate the Water/Cement and Water/(Cement + Limestone filler) ratios, the fiber content (kg/m³ and in % by volume), the % by mass and % by volume of silica fume in relation to cement, the admixture content in relation to (cement + limestone filler), in % by mass, and the % by volume of paste (cement + limestone filler + silica fume + water + admixture + air).
4. Discuss and compare the mix-designs and results obtained for the two materials tested.

Appendix

1. SCC

Mixing sequence

- dry aggregates and powders: 3 minutes
- add 80% water, mix for 1 minute
- addition of superplasticizer, then add remaining water
- total mixing time 8 minutes

Airmer volume: 8.11 liters

Concrete without water added to the system: 19,322 g

Concrete with additional water for filling: 19,400 g

Air volume: 1%.

$T_{\text{air}} = 24.8\text{ }^{\circ}\text{C}$

$T_{\text{concrete}} = 26\text{ }^{\circ}\text{C}$

Abrams spread: 750/770 mm

$t_{500} : 8\text{ s}$

2. UHPFRC

Mixing sequence

- Dry sand and powders: 4 minutes
- add 90% water, mix for 1 minute
- addition of superplasticizer, then add remaining of water
- fibers added after 22 minutes (total)
- total mixing time 24 minutes (total)

Airmer volume: 1.011 liters

UHPFRC without water added to the device: 2544 g

UHPFRC with additional water to fill the device: 2566 g

Air volume: 3.3 %

$T_{\text{air}} = 24.8\text{ }^{\circ}\text{C}$

$T_{\text{UHPFRC}} = 31.4\text{ }^{\circ}\text{C}$

Holding test on 6% slope: OK

NB: the total volume of the airmeter is known (8.11 or 1.011 liter). The device is not fully filled with SCC or UHPFRC. As soon as the lid is closed, the remaining empty volume is filled with water until water is seen flowing out of the device, from the vent. The volume of the airmeter minus the volume of added water gives the real SCC or UHPFRC volume. The mass of SCC or UHPFRC over its volume gives its specific weight.

The air content of the SCC or UHPFRC is determined according to the Boyle-Mariotte law $PV=RT$. Air is put under pressure in the lid of the device, by means of a hand pump. As soon as the water has been added, the vents are closed. The empty space in the airmeter has been filled with water and the only compressible phase is the air contained in the fresh SCC or UHPFRC. The built-up pressure in the lid is put into contact with the content of the airmeter by pressing on the green button, after having set the zero by pressing on the black button. The air in the SCC or UHPFRC and the air under pressure in the lid will then equilibrate. As the volume of air in the lid is known, the volume of air in the SCC or UHPFRC can be determined. The calibrated scale on the device directly represents the volume of air in the fresh material (inverted manometer scale). If the fresh materials contain no air, there will be no pressure drop and the index will remain on zero. If the pot contains something compressible, the air pressure will drop, and the needle will come to the position corresponding to the air content in the fresh material.

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