Bacheloroppgave i Byggdesign

Tittel:

Self-Compacting Ultra-High-Performance Concrete

Mix design and aptitudes

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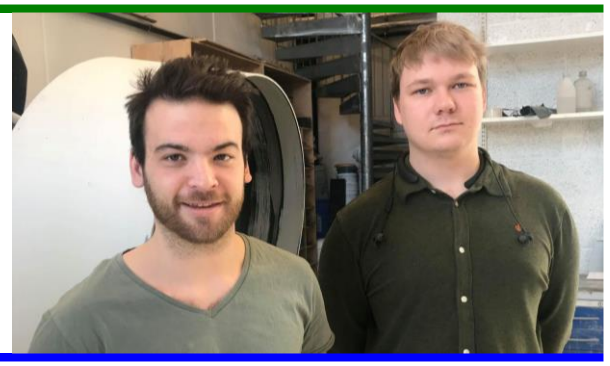


Ultra-High-Performance Concrete (UHPC) Is a material which can withstand over 150 MPa in compressive strength. The concrete is usually made with a Particle Size Distribution (PSD) that ranges from a few µm to 1mm to achieve this. Today, the concrete industry expect that the high-quality natural aggregate deposits will be depleted in the future. As UHPC isn't a widely used material, it is interesting to see if it is possible to produce it with manufactured crushed aggregate that is already being used in the industry today.

The approach for making a concrete mix design that could withstand over 150 MPa, with crushed aggregate from Lauvås, was to look at the self-compacting ability of the fresh state. To improve the mix design, an iterative method was established where several "generations" of mix designs were made, but only the one that showed the most promising result was further developed into the next "generation."

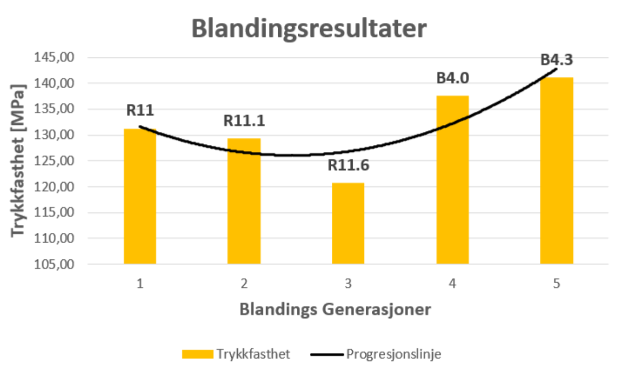
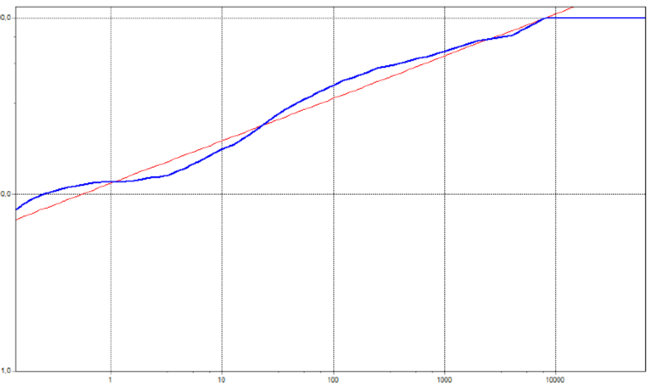


Figure 1: Result from our mixing generation

Over the mixing generations, there was developed several attempts to improve the workability of the concrete to see if it could enhance the compressive strength. Two main improvement was to add more superplasticizer to reduce the water-cement ratio and using EMMA, a program developed by Elkem, to improve the combined PSD of all dry particles in the mix.



Material Name	Density	Quantity	Vol %	Price	Version	CO2/kg	KJ/kg
Aalborg Rapid	3,10	641,60	25,46			0,00	0,00
Mikrosilika	2,20	120,00	6,71			0,00	0,00
4-8 knust	2,71	517,00	23,47			0,00	0,00
0-2 ny	2,71	977,00	44,35			0,00	0,00

Figure 3: Graphical representation of mix designs PSD

When using EMMA to improve the PSD, the Q-value in the program were set to 0.22 as a constant. It showed a considerable improvement from earlier designs, which led to the next step that was to lower the water-cement ratio and to increase the superplasticizer-binder ratio.

It also showed signs of the aggregate breaking instead of the Interfacial Transition Zone (ITZ) under compressive load.

Figure 2: a) breaking in ITZ b) breaking in aggregate

The next improvement after 5th generation was to implement 4-8 mm crushed aggregate from Lauvås into the mix design. This implementation led to an expansion of the concrete under the early stage of curing. This expansion correlated both with the compressive strength and buoyancy of the test specimens.

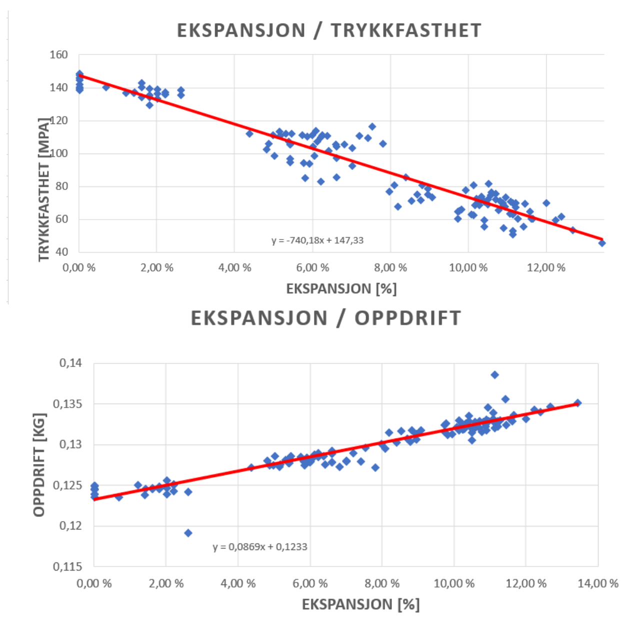


Figure 4: Different correlations to the expansion

There was made a troubleshooting chart of how the expansion could have occurred.

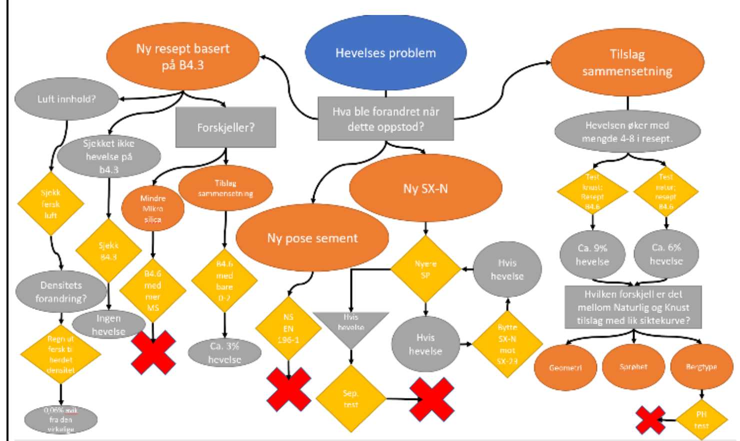


Figure 5: Troubleshooting chart

After all the testing which were done under this thesis, it has been concluded that the crushed aggregate from Lauvås is not suitable to use in concrete that should have a compressive strength of over 150 MPa due to the chance of the aggregate breaking under a compressive load of 140 MPa instead of the ITZ.

It also shows that the expansion which occurred under this thesis might be from the increased amount of entrapped air that is in the fresh concrete when adding 4-8 mm aggregate. Since the crushed aggregate used has a rough geometric shape, texture and linear PSD, both the plastic viscosity and yield stress would be high, and by adding superplasticizer admixture. The yield stress is lower to the point where the collapsed air has enough buoyancy force to slowly drift upwards ripping apart cured layers of the fresh concrete in the early stage of curing, thus leaving behind an expansion.

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