Elkem Microsilica®
CONCRETE

Shotcrete

C5-01
Application

Summary

The use of shotcrete [sprayed concrete and gunite] has increased over the last decades, particularly in tunnel applications, rock stabilisation, repair work and as an alternative construction method. Shotcrete enables construction in difficult areas where in situ casting is not possible or for the creation of thin shell elements and domes.

As the use of shotcrete has increased, so have the demands on the quality and performance of the concrete for spraying: Increased bond, less rebound and dusting, faster setting and hardening, higher strength and increased durability in harsh environments.

Microsilica, or silica fume, is a recommended addition for shotcrete applications in most countries worldwide.

Dry process shotcrete for tunnel support in soft rock conditions.

The addition of Elkem Microsilica improves many properties of shotcrete; strength, bond, impermeability and reduces the amount of rebound and dusting.

The Shotcrete Process

There are two main methods for shotcreting: The 'wet' process and the 'dry' process. In the wet process, readymixed, plastic concrete is pumped to the nozzle and propelled by compressed air. In the dry process, a dry or semi-dry concrete is blown by compressed air to the nozzle where it is mixed with water under pressure and sprayed. Both methods have advantages for different applications. In the main, the wet process is used for larger operations and the dry for smaller, repair style work but this is not a definitive split.

Wet process shotcrete robot in operation. *(Photo: Jacob Mehus)*

Advantages with Elkem Microsilica

Elkem Microsilica will increase the cohesiveness of the fresh concrete, improve the bond of the shotcrete to the surface and reduce the slumping of the freshly sprayed material. Increasing the cohesiveness also reduces the amount of dust created by the spraying action and cuts down on the volume of material that rebounds from the sprayed surface. This latter material is unusable once 'rebounded', and can amount

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to as much as 40% for ordinary shotcrete. The addition of Elkem Microsilica can bring this volume down to less than 5%.

Other advantages are:

Improved pumpability of wet shotcrete, reduced dosage of accelerator, increased thickness of shotcrete layers and, due to the reduced dusting and low rebound, improved working conditions and more efficient production.
Further improvements are obtained in the hardened concrete:
Increased compressive, flexural and tensile strengths; increased bond - to the surface and to reinforcement; reduced permeability; improved frost and chemical resistance.
Tests have shown that compressive strengths of over 100 MPa can be obtained using Elkem Microsilica in 'wet' process shotcrete, and that early age strengths of 1 MPa at only 2 hours can be achieved using accelerators. Because of the improved cohesiveness of microsilica shotcrete it is possible to use lower dosages of accelerators to achieve these results. As can be seen in Figure 1, the high dosages of accelerators normally used for this purpose will reduce the final strength of the shotcrete. In general a dosage of between 8 and 12% Elkem Microsilica is recommended, depending on the type of shotcrete required for a specific project. Higher dosages may be necessary for special applications or very high strengths. As with all concretes, proper curing is necessary to achieve the full potential of the material.

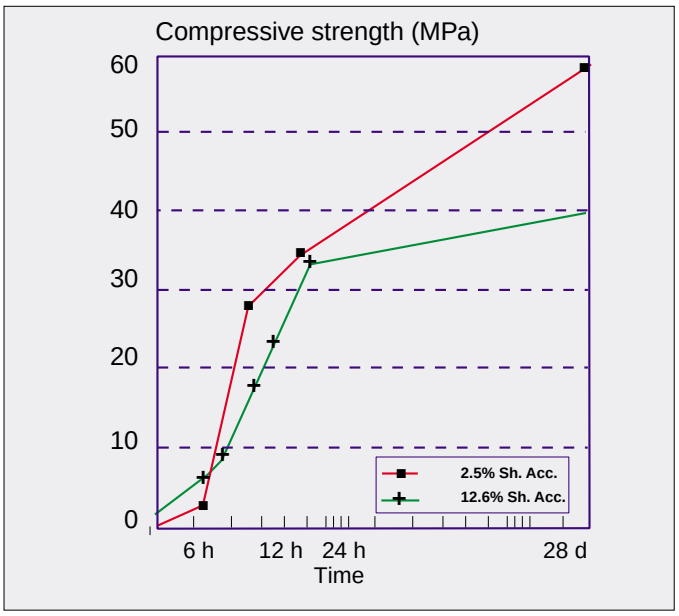

Figure 1 Strength development of shotcrete with accelerator

Fibres

It is now common to add steel fibres to shotcretes in order to increase flexural or tensile properties instead of using mesh reinforcement.
The use of Elkem Microsilica in steel fibre shotcrete has several advantages:
easier mixing of the fibres into the fresh concrete,
reduced pumping problems,
reduced fibre rebound,
and greatly improved fibre/concrete bond.

Gunites

Gunite specifically refers to a sprayed mortar, rather than a concrete. This form of spraying is often used for repair work and small operations. In most applications the gunite, or mortar, is a bagged dry formulated material which is mixed with water on site. These materials are available with wide ranging properties such as: lightweight, rapid set, high build, polymer modified and water resistance, etc.
The majority of formulated gunite materials contain microsilica in order to improve the plastic properties – flow, pumpability, adhesion and cohesion – and the hardened properties – strength, impermeability and durability.

References

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3. Kompen R.: «Stålfiberarmert Sprøytebetong», Journal of Nordic Concrete Research, Vol. 1–1987.
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