Advanced Nanoparticle Technology

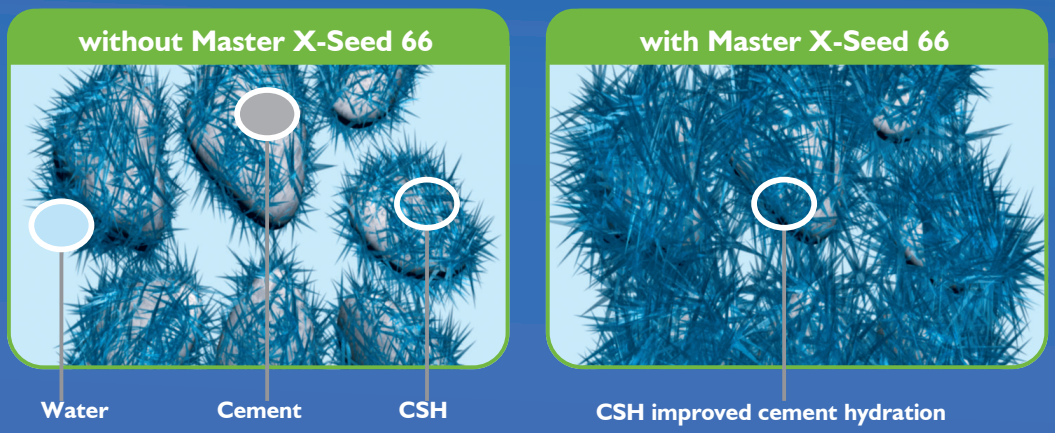

Figure 1 – *Illustration shows increased CSH crystal growth with Master X-Seed 66 admixture*

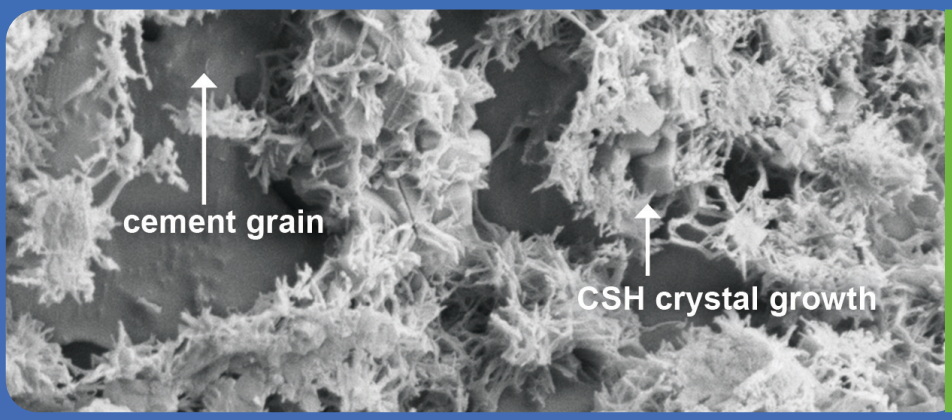

Figure 2 – *Image from CryoSEM with portland cement paste treated with Master X-Seed 66 admixture shows active crystal growth between the cement grains*

CSH Seeding Technology

Master Builders Solutions Master X-Seed technology was first introduced in Europe and Asia, and has been utilized in strength-enhancing applications since 2009. This patented technology to improve the quality of hardened cement paste was used to develop the Master X-Seed 66 strength-enhancing admixture for North America.

Master X-Seed 66 admixture is a stable suspension of synthetically-produced crystalline calcium silicate hydrate (CSH) nanoparticles. These nanoparticles facilitate the growth of CSH crystals between cement grains and improve overall hydration of portland cement (Fig. 1 and 2), thereby increasing early- and late-age strength development.

About Master Builders Solutions

Master Builders Solutions is a leading global manufacturer of concrete admixtures, as well as other sustainable solutions for the construction industry, focussed on delivering its vision: **Inspiring people to build better**. Master Builders Solutions provides value-added technology and market-leading R&D capabilities to improve the performance of construction materials and to enable the reduction of CO2 emissions in the production of concrete. Founded in 1909, Master Builders Solutions has ca. 1600 employees operating 35 production sites globally, supporting their customers in mastering their building challenges of today – for a decarbonised future.

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MASTER® BUILDERS SOLUTIONS

Master X-Seed® 66

The Solution for Carbon Reduction in Concrete

Improve Strength and Sustainability

Increase Concrete Strength

Master X-Seed 66 is a water-reducing and strength-enhancing admixture that improves both early- and late-age strength development in concrete. This unique technology improves cement hydration, providing the ability to reduce cement content of a concrete mixture, without decreasing the water-cementitious materials ratio (w/cm).

This strength-enhancing technology provides the flexibility to expand the performance space of a given concrete mixture and offers an increased strength safety factor. In addition, Master X-Seed 66 admixture increases both early- and late-age strength development.

Improved Workability

Master X-Seed 66 admixture includes polycarboxylate technology that helps produce concrete mixtures with different levels of workability. Master X-Seed 66 increases slump by 0.25 to 2 inches (5-50 mm) depending on the dosage and mixture design.

Master X-Seed 66

Enhanced Durability

With the addition of Master X-Seed 66 admixture, a concrete mixture can include higher levels of supplementary cementitious materials (SCM), which improve the durability characteristics and support the overall life cycle of the concrete.

The Solution for Carbon Reduction in Concrete

Reducing portland cement content in a concrete mixture is the best way to reduce embodied carbon. This has the overall effect of reducing the energy demand and emissions associated with the production of portland cement.

Master X-Seed technology is capable of reducing embodied carbon in concrete mixtures by 5 to 20 percent. It's the only stand-alone admixture technology capable of enhancing concrete strength while lowering cement content.

Quantifying Sustainability

You can depend on Master Builders Solutions for expert assistance in quantifying your sustainable concrete solutions, while ensuring they meet performance characteristics based on standard industry guidelines. We can provide Life Cycle Analysis (LCA) documentation via Environmental Product Declarations (EPDs) and Eco-Efficiency Analysis (EEA) reports.

A Health Product Declaration (HPD) for Master X-Seed 66 admixture can be obtained by contacting Master Builders Solutions Technical Support at 800-628-9990 or admixtures@mbcc-group.com.

Performance Results

Enhancement in Compressive Strength

The chart below shows the strength enhancement that can be achieved in a concrete mixture containing Master X-Seed 66 admixture compared to a reference untreated mixture.

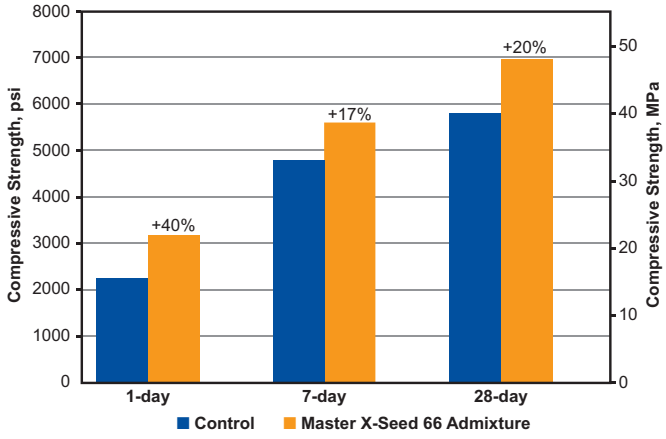


Figure 3 *– Enhancement in Compressive Strength from Addition of Master X-Seed 66 Admixture*

(Nominal cementitious materials content of 564 lb/yd^3 [334 kg/m^3], w/cm of 0.53; Master X-Seed 66 admixture dosage of 10 fl oz/cwt [650 mL/100kg])

Reduced Cement Content

The chart below shows the effect of Master X-Seed 66 admixture on the compressive strength of concrete that can be achieved with reduced cement content compared to a reference untreated concrete mixture.

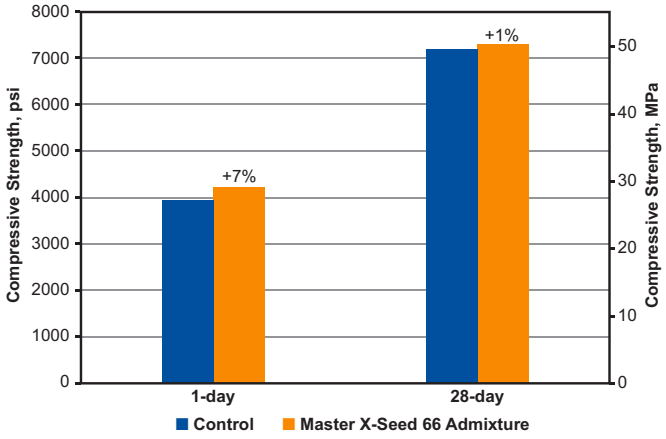
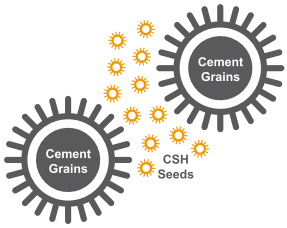


Figure 4 *– Potential for Reducing Cementitious Materials (CM) Content with Master X-Seed 66 Admixture – Mixture's CM content reduced by 47 lb/yd^3 [28 kg/m^3]*

(Control: Nominal cementitious materials content of 658 lb/yd^3 [390 kg/m^3], w/cm of 0.40; Master X-Seed 66 admixture: Dosage of 10 fl oz/cwt [650 mL/100kg]; nominal cementitious materials content of 611 lb/yd^3 [362 kg/m^3],
w/cm of 0.43

Increase Speed and Flexibility



Increase Production Efficiency

The early-age strength enhancement provided by Master X-Seed 66 admixture allows for earlier stripping and reuse of forms, thus increasing production efficiency and speed of construction in both precast and ready-mixed concrete applications.

Flexibility in Design

Increased strength development provides engineering and design flexibility.

Benefits of Master X-Seed 66 Admixture

Seeding technology facilitates growth of CSH crystals and cement hydration

- Provides a unique improvement in the hydration of
  portland cement

Increases strength development (both early- and late-age)

- Increases strength safety factor
- Flexibility to expand the performance space of a concrete mixture
- Permits earlier stripping of forms to improve production efficiency
- Facilitates construction in cast-in-place concrete applications
- Offers opportunity for flexibility in design
- Improves the strength consistency of a concrete mixture even when produced with variable raw materials

Facilitates optimization of the cementitious materials package of a concrete mixture

- Increases replacement levels of supplementary cementitious materials
- Promotes sustainable construction
- Sustainable reporting documents are available to demonstrate environmental transparency.