Elkem Microsilica®
CONCRETE

HIGH STRENGTH &VERY HIGH STRENGTH CONCRETE, 80 – 100 + Mpa

C5-02 Applications

Experience has shown that the design of high strength and ultra high strength concretes is dependent on many factors, especially the materials used.

Elkem Microsilica® is an essential ingredient for the production of high flow or self-compacting high strength concrete with characteristic strength up to 100MPa and beyond. The high performance concrete made possible by the addition of microsilica is purposefully designed flowable, stable concrete, which flows readily into place, filling formwork with minimal mechanical consolidation and without segregation.

The high strength achievable enables designers and architects to be creative with engineering design with overall construction cost savings and opening up extra rentable floor space in tall buildings.

Experience has found that a combination or, ternary blend of: OP cement, flyash/ground granulated blast furnace slag and silica fume; aggregates with higher crushing strengths and relative density linked with advanced admixture technology produce a very high strength homogeneous composite concrete with a fine-grained ceramic type matrix.

Additionally, the 'E' modulus of the concrete can be specified at values required by the engineer, depending on the aggregate type use, typically a dense microgranite or basalt. E.g. values of 37.0+ GPa have been successfully specified in Hong Kong.

Temperature rise

The use of pozzolanic materials in ternary blends (such as fly ash) can also help regulate the heat evolution despite the high cementitious content of the concrete.

ICC Building Hong Kong
Grade 90 (artists drawing)

Other standard methods of heat regulation can also be used to maintain maximum peak temperatures and temperature gradients that may be specified.

Experience in Japan and Hong Kong has lead the way forward with innovative designs and significant cost advantages in rentable floor space.
In Japan, high strength concretes with a design strength of 100MPa are now used for the construction of high rise buildings. Concretes with compressive strength exceeding 150MPa are also being used on a commercial scale.

City Plaza Tai Koo Shing
Hong Kong

Likewise Hong Kong has several high rise buildings where grades of 80, 90 and 100MPa have been specified and used practically since 1995.

The role of microsilica

This development of high strength concrete has principally been made possible by the availability of Microsilica and high range superplasticisers.

Microsilica is the most reactive of several supplementary cementing materials available for modifying the ordinary Portland cement matrix to provide improved binders. In general, all SCM's have a pozzolanic action – a secondary hydration reaction, or pozzolanicity, with the weaker calcium hydroxide that is produced during the normal hydration of the cement.

At low water/ cement ratios and when used with advanced superplasticisers, Microsilica demonstrates multiple effectiveness. The fine particle size and high content of amorphous silica (by standard greater than 85%) makes the microsilica highly reactive with any alkalis in solution within the first few days and weeks of the hydration process[1].

This provides a homogenous, fine grained, almost ceramic matrix linked with the very low water cement ratio governs the characteristic cube strength of 100 MPa concrete.

- Results in a more homogeneous fine-grained cement structure
- Fine spherical nature of Microsilica provides micropacking density and eliminates microvoids.
- Produces stronger C-S-H matrix.
- Marked changes in transition zone (between cement and aggregates), indicating non-microcracked dense matrix as a result of removal of bleed water.
- Eliminates weak zone enabling a truly composite material in which the aggregate can be utilised as a working component and not just a filler[4].

Comfort Towers,
Tokyo Grade 100

Odakyu Southern Tower, Tokyo, Average strength 135MPa

Elkem

Plastic state benefits:
- Extremely mobile concrete facilitates easy placement
- Reduction in manpower requirement for compaction
- Reduction in manpower requirement for compaction
- Reduction in plant requirement for compaction
- Reduced wear to forms
- Improved working environment
- Environmental benefits for locality
- Architecturally complex shapes possible
- Controlled rheology
- Lower pumping pressures, possibilities to pump vertically to great height

Slump flow of 650mm for self-compacting G100 concrete

Hardened state benefits:
Very high characteristic strength 80 to over 100MPa

Surface finish characteristics can be enhanced

Enhanced durability characteristics due to extremely low porous volume

Contributes to waterproof concrete designs

Economies in design

Higher 'E' modulus

Joint responsibilities
The successful outcome of the design and construction of high strength concrete is only possible with close liaison between, design engineer, contractor, concrete producers, testing agencies and materials suppliers including admixture producers and cement producers.s

Curing
As with all concrete, very high strength concrete requires attention to curing to prevent premature drying.

Reference should be made to specialist literature and standards on the methods to ensure an effective curing regime.

Typical mix design of G100 SCC concrete using crushed granite and natural BS882 medium grade sand	
OP Cement (EN196, 42.5)	435 kg/m^3
Fly Ash (BS3892 Pt 1)	145 kg/m^3
Microsilica (Silica Fume, ASTM C1240)	60 kg/m^3
10mm Aggregate	900 kg/m^3
Sand	740 kg/m^3
Water	150 kg/m^3
PC admixture	7.5 L
W/B Ratio	0.24
Target Mean Strength (28 days)	120 MPa
Target slump flow	650mm
Note: based on Granite RD of 2.72 *Mix designs are based on historical data and subject to trial with local materials*	

Petronas Towers, KL

311 South Wacker Drive in front of Sears Tower

Projects of note

	Grade of concrete	Mean strength MPa
City Plaza, Tai Koo Shing, Hong Kong	G100	130
Comfort Towers, Tokyo	G100	130
Tsing Ma Bridge, Hong Kong	G60	80
Ting Kau Bridge, Hong Kong	G60	80
Supreme Court of Justice, Brasilia	G60	94
CBX Tower, La Defense, Paris	G60	93
JJ Hospital Flyover, Mumbai, India	G75	86
Frankfurt Trianon, Germany	100	125
Nihon Bashi Hamacho Project	100	135
Taisei Corporation	150	170

The list will beupdated from time to time to add to these fabulous structures

1. Mehta P.K. and Aitcin P.C. 'Microstructural basis of selection of materials and mix proportions for high strength concrete'. High Strength Concrete Second International Symposium, Berkeley USA, 1990 ACI SP-121 1990
2. Lee F.M. 'The Chemistry of Cement & Concrete' Third Edition, Edward Arnold Publishers, 1970
3. Neville A.M. 'Properties of Concrete'. Third Edition Pitman Books 1981
4. Read A.S.' From 40-100MPa, A Materials Technology Appreciation of High Strength Concrete for Hong Kong' 1995.
5. Construction records of high-rise buildings: applications of high-strength CFT structures, Taisei Corporation, Japan 2005

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