Recent developments in HPC in Europe

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Drivers for development

- Designers are pushing the boundaries

Drivers for development

- Taller buildings

Drivers for development

- Longer lives

Drivers for development

- Higher workability

Drivers for development

- Better durability

Drivers for development

- Sustainability

High strength concrete

Definition

- Concrete with a compressive strength class higher than C50/60 or LC50/55
- EN 206-1 gives compressive strength classes up to C100/115 and LC80/88

Important change

- BS 8110 did not provide design guidance for high strength concrete structures
- EC2 provides design guidance for high strength concrete

Availability

- In general up to about C70/85 available on demand
- Higher strength concrete may need notice

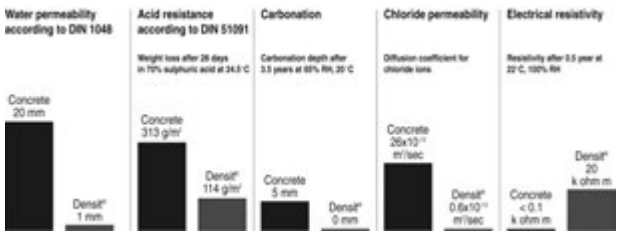
Availability

- Not all normally stocked constituents are suitable for very high strength concrete

Ultra high strength concrete

- Niche markets
- Proprietary concretes

Densit, an ultra high strength concrete



Self -compacting concrete

- Not a single type of concrete, but a family of concretes

SCC characterized by

- Flowability
- Viscosity
- Segregation resistance
- Passing ability

Flowability

- BS EN 12350-8: Slump flow test

- BS EN 206-9 classes

SF1: 550 – 650
SF2: 660 – 750
SF3: 760 - 850

Viscosity

- BS EN 12350-9 V-funnel test

- BS EN 206-9 classes

VF1: <9
VF2: 9 to 25

Viscosity

- BS EN 12350-8 T500 test
- Time to flow to a diameter of 500mm

- BS EN 206-9 classes

VS1: <2

VS2: ≥2

Segregation resistance

- BS EN 12350-11 Sieve segregation test

- BS EN 206-9 classes
- SR1:≤20
- SR2: ≤15

Passing ability

- BS EN 12350-12 J-ring test

- BS EN 206-9

PJ1: ≤10 with 12 bars

PJ2: ≤10 with 16 bars

Passing ability

- BS EN 12350-10 L-box test

- BS EN 206-9 classes

PL1: ≥0.80 with 2 bars

PL2: ≥0.80 with 3 bars

Further guidance

BIBM/CEMBUREAU/ERMCO/EFCA/EFNARC: The European Guidelines for Self-Compacting Concrete – Specification, Production and Use. May 2005

Durability

- For longer working life
- For more aggressive conditions
- For higher reliability

Durability

- A focus in Europe is on the development of tools for HPC
- Service life design
- Equivalent durability procedure

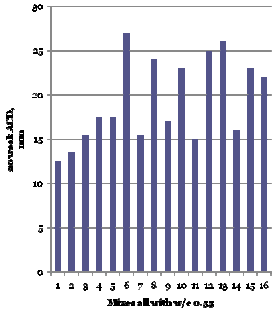
Service life design

- Fib model code published
- ISO drafting a framework standard
- Still many issues related to the use of such tools for the design of new structures

Ageing effects

- Combination of effects of increased concrete maturity and creation of surface layer

Reducing to a traditional specification



- Traditional specifications do not give a consistent performance

HPC with respect to durability

- Either specified by performance
- or, initial testing to develop relationship between performance and mix proportions and then an agreed specification using a combination of performance and prescription

Performance tests

- Are being standardized in Europe

Freeze-thaw tests

- BS TS 12390-9: Scaling tests
- Three methods
- 'Torture' tests
- Often fail concretes that work well in practice
- Less severe test under development

Chloride diffusion test

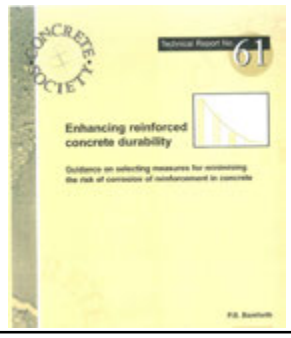
- BS TS 12390-11: Unidirectional diffusion test
- Debate over the need for European standardization of rapid chloride tests

Carbonation tests

- BS TS 12390-10: Relative carbonation test
- BS TS 12390-XX: Accelerated carbonation test

Durability

- Limits to what rebar cover and concrete quality can achieve



Additional measures include

- Change in design
- Design for replacement
- Non-corroding reinforcement
- Protective coatings/barriers

Protective coatings/barriers

- A GRP permanent form will protect the concrete from the environment
- In such situations, what is the correct exposure class for the concrete?
- In theory, X0 or XC1, but damage to the GRP could lead to disproportionate consequences
- Select an exposure class (concrete/cover) such that damage between inspections does not lead to disproportionate consequences

Protective coatings/barriers

- Significant improvements in the materials available for coatings/barriers
- Trend in Europe is to use higher performing materials
- Is silane effective on very high quality concrete?
- The effectiveness of coatings and barriers is highly dependent upon workmanship on site
- Robustness in use (temperature, moisture, cleanliness, impact of curing compound)

High performance concrete requires appropriate

- Design
- Specification
- Materials
- Execution
- Maintenance
- **It is being achieved**

Non-corroding reinforcement

- Zinc-coated rebar rarely (never?) used in Europe
- Due to workmanship issues, trend is away from epoxy-coated rebar
- Current trend is to use stainless steel rebar