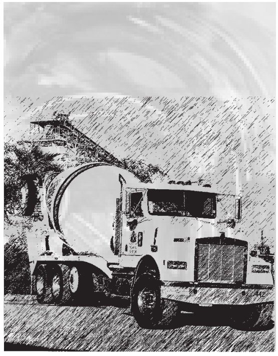


NRMCA

What, Why & How?
High Strength Concrete

CONCRETE IN PRACTICE

CIP 33

WHAT is High Strength Concrete?

It is a type of high performance concrete generally with a specified compressive strength of 6,000 psi (40 MPa) or greater. The compressive strength is measured on 6 × 12 inch (150 × 300 mm) or 4 × 8 inch (100 × 200 mm) test cylinders generally at 56 or 90-days or some other specified age depending upon the application. The production of high strength concrete requires more research and more attention to quality control than conventional concrete.

WHY do we need High Strength Concrete?

A. To put the concrete into service at much earlier age, for example opening the pavement at 3-days.

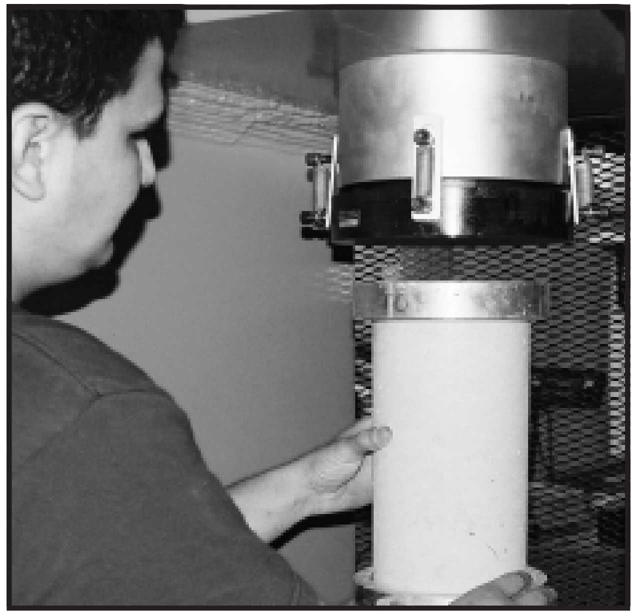
B. To build high-rise buildings by reducing column sizes and increasing available space.

C. To build the superstructures of long-span bridges and to enhance the durability of bridge decks.

D. To satisfy the specific needs of special applications such as durability, modulus of elasticity, and flexural strength. Some of these applications include dams, grandstand roofs, marine foundations, parking garages, and heavy duty industrial floors. (Note that high strength concrete does not guarantee durable concrete.)

HOW to Design High-Strength Concrete Mixtures?

Optimum concrete mixture design results from selecting locally available materials that make the fresh concrete placeable and finishable and that ensure the strength development and other desired properties of hardened concrete as specified by the designer. Some of the basic concepts that need to be understood for high strength concrete are:



Testing High Strength Concrete

1. Aggregates should be strong and durable. They need not necessarily be hard and of high strength but need to be compatible, in terms of stiffness and strength, with the cement paste. Generally smaller maximum size coarse aggregate is used for higher strength concretes. The sand may have to be coarser than that permitted by ASTM C 33 (fineness modulus greater that 3.2) because of the high fines content from the cementitious materials.

2. High strength concrete mixtures will have a high cementitious materials content that increases the heat of hydration and possibly higher shrinkage leading to the potential for cracking. Most mixtures contain one or more

supplementary cementitious materials such as fly ash (Class C or F), ground granulated blast furnace slag, silica fume, metakaolin or natural pozzolanic materials.

3. High strength concrete mixtures generally need to have a low water-cementitious materials ratio (w/cm). W/cm ratios can be in the range of 0.23 to 0.35. These low w/cm ratios are only attainable with quite large doses of high range water reducing admixtures (or superplasticizers) conforming to Type F or G by ASTM C 494. A Type A water reducer may be used in combination.
4. The total cementitious material content will be typically around 700 lbs/yd^3 (415 kg/m^3) but not more than about 1100 lbs/yd^3 (650 kg/m^3).
5. The use of air entrainment in high strength concrete will greatly reduce the strength potential.

More attention and evaluation will be necessary if the job specification sets limits for other concrete properties such as creep, shrinkage, and modulus of elasticity. The engineer may set limits on these properties for the design of the structure. Current research may not provide the required guidance for empirical relationships of these properties from traditional tests and some of these tests are quite specialized and expensive to conduct for mixture evaluation. From theoretical considerations, lower creep and shrinkage, and high modulus of elasticity can be achieved with higher aggregate and lower paste volumes in the concrete. Using the largest size aggregate possible and medium to coarsely graded fine aggregate can attain this. Smaller maximum size aggregate such as 3/8 inch (9.5mm) can be used to produce very high compressive strength but required properties like creep, shrinkage, and modulus of elasticity may be sacrificed. If difficulty is encountered in achieving high strength, simply adding more cementitious material may not increase strength. Factors such as deleterious materials in aggregates, aggregate coatings, coarse aggregate fracture faces, shape and texture, and testing limitations may prevent higher strength from being achieved. Final concrete mixture proportions are determined by trial batches either in the laboratory or by small size field production batches. The production, transportation, placement and finishing of high-strength concrete can differ significantly from procedures used for conventional concrete. For critical projects it is highly recommended that a trial pour and evaluation be conducted and included as a pay item in the contract. Pre-bid and pre-construction meetings are very important to ensure the success of projects using high strength concrete. During construction, extra measures should be taken to protect against plastic shrinkage and thermal cracking in thicker sections. High strength concrete may need longer time before formwork is removed.

High strength concrete test cylinders should be carefully molded, cured, capped, and tested. Extra care and attention to handling of test cylinder specimens at very early age is necessary. Slower setting time of high strength concretes may be experienced. The ASTM Standards are continuously being revised to account for additional special precautions needed when testing high strength concrete. Particular attention should be paid to the type of mold, curing, type of cylinder capping material, and characteristics and load capacity of the testing machine.

References

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