CURING EFFECT ON HIGH STRENGTH CONCRETE

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Abstract

This paper includes Need of high strength concrete, its mechanical properties of high strength concrete and effects of curing. The effect of curing on the properties of High strength concrete is reported.

Keywords: Introduction, need, stress-strain behavior, Compressive strength, elastic modulous, tensile strength, curing

INTRODUCTION:-

It is a type of high performance concrete generally with a compressive strength of 6000 psi (40 MPa) or greater. The compressive strength is measured on 6’12” or 4’8” test cylinders generally at 56 or 90 days or some other specified age depending upon the application. The construction of high strength concrete requires more research and more attention to quality control than conventional concrete.

- Concrete is defined as “high-strength concrete” solely on the basis of its compressive strength measured at a given age.
- In the 1970’s, any concrete mixtures that showed 40 MPa or more compressive strength at 28-days were designed as high-strength concrete.
- Later, 60-100 MPa concrete mixtures were commercially developed and used in the construction of high-rise buildings and long-span bridges in many parts of the world.

NEED OF HIGH STRENGTH CONCRETE:-

1. To put the concrete into service at much earlier age, for example opening the pavement at 3 days.
2. To build high rise buildings by reducing column sizes and increasing available space.
3. To build the superstructures of long-span bridges and to enhance the durability of bridge decks.

4. To satisfy the specific needs of special applications such as durability, modulus of elasticity, and flexural strength.

Mechanical Properties of High-Strength Concrete:-

Mechanical properties of High-Strength Concrete (HSC) can be divided in two groups as short-term mechanical properties and long-term mechanical properties. A discussion on short-term mechanical properties of concrete which includes, compressive strength, stress-strain behavior, elastic modulus, Poisson's ratio, tensile strength and modulus of rupture, is presented here. The equations and formulations that are used for normal strength concrete (NSC) cannot always be extended to include HSC, and need to be revisited.

Stress-strain Behavior in Compression

Stress-strain behavior of concrete for different range of compressive strength is shown in Figure 1. The ascending branch of stress-strain is more linear and steeper for HSC. Strain at maximum strength is greater and descending part becomes steeper compared to NSC.

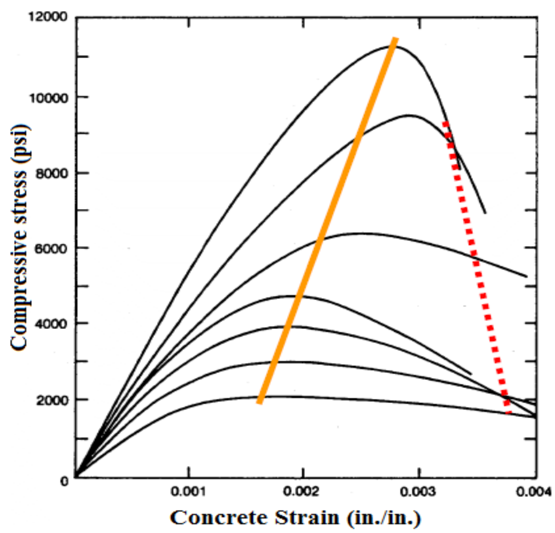

Figure 1: Typical concrete stress-strain curves in concrete (Wight and MacGregor (2009), reproduced from Whittaker (2012))

Stress-strain behavior of HSC depends on material parameters such as aggregate type and experimental parameters that include age at testing, strain rate and interaction between specimen and testing machine. The stress-strain model used for NSC cannot be extended for use in HSC as the nature of loading curve changes significantly. Steeper rise and sudden drop in strength after maximum value presents difficulty in numerical modeling of stress-strain behavior of HSC. Aītcin (1998) suggests that HSC behaves like a real composite material and parallels can be drawn to the stress-strain behavior used in rock mechanics.

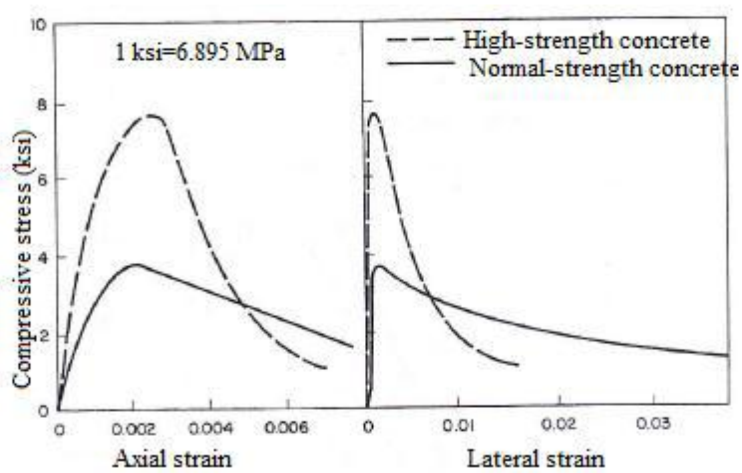

Figure 2: Axial stress vs. axial strain and lateral strain for concrete (from Ahmad and Shah (1982), reproduced from ACI (2010))

Carrasquillo *et al.* (1981) reported that there is less internal micro cracking in HSC than NSC for the same axial strain imposed, as shown in Figure 2. This also implies that HSC experience less lateral strain, and consequently effectiveness of confinement on compressive strength of HSC is often limited compared to NSC.

Compressive Strength

Decreasing w/c ratio increases the strength of concrete. However, this trend follows only where strength of hydrated cement is low compared to the strength of coarse aggregates. When these two strengths become comparable, decreasing w/c ratio doesn't increase the strength significantly, and to further increase the strength of HSC, strength and quality of coarse aggregates need to be increased, in addition to other factors. Typically, w/c ratios between 0.2-0.4 are used for HSC. Low w/c ratio decreases the workability. Super plasticizers are added to increase the workability in HSC. Shape, texture and maximum size of coarse aggregate affect the compressive strength of HSC. Smooth river gravel produces weaker concrete. Smallest size of coarse aggregate produces highest strength concrete owing to its high specific surface area. Addition of silica fume decreases the requirement of low w/c to achieve high compressive strength. Iravani (1996) noted that effect of silica fume on strength development of HSC is most prominent during 7 to 28 days after mixing.

Elastic Modulus

Numerous equations have been proposed for estimating the modulus of elasticity of HSC; however, due to large variations, most of the equations are representative of only the selected data for that particular expression. Moreover, ACI-363 (ACI, 2010) recommends that a design engineer should verify the elastic modulus through a trial field batching or by documented performance.

Analytical expressions are also available for calculation of elastic modulus that make use of two-phase models involving aggregates and cement paste. Simplest of these models assume either constant stress or strain in both phase. In order to use these expressions, elastic modulus of aggregates and hydrated cement paste are required, making it an unpopular choice.

Tensile Strength

Tensile strength of concrete is measured by direct and indirect tensile tests. Direct tensile tests, which include testing HSC specimen under pure tension, are difficult to perform due to testing limitations. Indirect tests include flexure and split-cylinder tests, and are used popularly to measure tensile strength of concrete.

Poisson's Ratio

Poisson's ratio is a ratio between the lateral and axial strains of an axially and/or flexurally loaded structural element. The normal method in determining Poisson's ratio is by a static test in which a specimen is subjected to compressive forces and simultaneous measurements of both the longitudinal and lateral strains are made. If the material does not obey the Hooke's law, and the stress strain relationship is curved, then static value of Poisson's ratio will depend on the stress, unless the relationship of lateral strain to longitudinal stress is similar to that of longitudinal strain.

Curing

Curing is the maintenance of satisfactory moisture content and temperature in concrete for a period of time immediately following placing and finishing so that the desired properties may develop. The need for adequate curing of concrete cannot be overemphasized. Curing has a strong influence on the properties of hardened concrete; proper curing will increase durability, strength, water tightness, abrasion resistance, volume stability, and resistance to freezing and thawing and deicers. Exposed slab surfaces are especially sensitive to curing as strength development and freeze-thaw resistance of the top surface of a slab can be reduced significantly when curing is defective.

CURING METHODS AND MATERIALS

Concrete can be kept moist (and in some cases at a favorable temperature) by three curing methods:

1. Methods that maintain the presence of mixing water in the concrete during the early hardening period. These include ponding or immersion, spraying or fogging, and saturated wet coverings. These methods afford some cooling through evaporation, which is beneficial in hot weather.

2. Methods that reduce the loss of mixing water from the surface of the concrete. This can be done by covering the concrete with impervious paper or plastic sheets, or by applying membrane-forming curing compounds.

3. Methods that accelerate strength gain by supplying heat and additional moisture to the concrete. This is usually accomplished with live steam, heating coils, or electrically heated forms or pads.

The method or combination of methods chosen depends on factors such as availability of curing materials, size, shape, and age of concrete, production facilities (in place or in a plant), esthetic appearance, and economics. As a result, curing often involves a series of procedures used at a particular time as the concrete ages. For example, fog spraying or plastic covered wet burlap can precede application of a curing compound. The timing of each procedure depends on the degree of hardening of the concrete needed to prevent the particular procedure from damaging the concrete surface.

Effects of Curing

When portland cement is mixed with water, a chemicalreaction called hydration takes place. The extent to whichthis reaction is completed influences the strength and durabilityof the concrete. Freshly mixed concrete normally containsmore water than is required for hydration of the cement;however, excessive loss of water by evaporation candelay or prevent adequate hydration. The surface is particularlysusceptible to insufficient hydration because it driesfirst. If temperatures are favorable, hydration is relativelyrapid the first few days after concrete is placed; however, itis important for water to be retained in the concrete duringthis period, that is, for evaporation to be prevented or substantially reduced.

With proper curing, concrete becomes stronger, moreimpermeable, and more resistant to stress, abrasion, andfreezing and thawing. The improvement is rapid at earlyages but continues more slowly thereafter for an indefiniteperiod. Fig. 12-2 shows the strength gain of concrete withage for different moist curing periods and Fig. 12-3 showsthe relative strength gain of concrete cured at different temperatures.

Conclusions:

Based on the experimental investigation, the following conclusions are drawn.

- The higher strength was obtained from water cured specimens for all types of alkali contents. The optimum alkali content (K_2O + Na_2O) was found to be 10.41 % with a $SiO_2/(K_2O+Na_2O)$ ratio of 0 .76. The maximum strength of 50.20 MPa was obtained from water cured sample having 10.41 % alkali content.

- The oven curing is more sensitive for alkali activated slag. The micro cracks were observed on the surface of the specimens as observed in the SEM image.

- Curing conditions had a significant effect on the mechanical behavior in the hardened state of alkali activated slag paste. The compressive strength of the alkali activated blast furnace slag paste can be controlled by judiciously choosing the curing conditions.

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