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EVOLUTION OF HIGH STRENGTH CONCRETE OF M80 GRADE

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ABSTACT

The primary difference between high-strength concrete and normal-strength concrete relates to the compressive strength that refers to the maximum resistance of a concrete sample to applied pressure. Although there is no precise point of separation between high-strength concrete and normal-strength concrete, the American Concrete Institute defines high-strength concrete as concrete with a compressive strength greater than 6,000 psi (40N/mm^2). Manufacture of high-strength concrete involves making optimal use of the basic ingredients that constitute normal-strength concrete.

Australia has taken the advantage of the benefits of high-strength concrete through its widespread use on buildings such as 120 Collins Street, Melbourne Central, the Rialto project in Melbourne. The Eureka Tower, which is one of the tallest buildings in Australia was completed in 2006 has utilized HSC up to 100 MPa.

To study the specimen size effect on compressive strength of M 80 grade concrete. To study the effect of age on compressive strength, split tensile strength and flexural strength of M 80 grade concrete. Strength concrete of grade M 80. To study the various mechanical prosperities of M 80 grade concrete.

1. INTRODUCTION

1.1 Introduction

In the last 15 years, concrete of very high strength entered the field of construction, in particular construction of high rise buildings and long span bridges. High strength concrete is the concrete with strength above 50 N/mm^2.High performance concrete is the new definition recently introduced in concrete technology. High performance concrete is defined as the concrete which will satisfy the special requirements that cannot be achieved by normal concrete; these performances can be high strength, low shrinkage, self-compaction, high fire resistance etc.

Concrete is the most widely used construction material in India with annual consumption exceeding 100 million cubic meters. It is well known that conventional concrete designed on the basis of compressive strength does not meet many functional requirements such as impermeability, resistance to frost, thermal cracking adequately. Concrete is generally classified as Normal strength concrete (NSC), high strength concrete (HSC) and ultra high strength concrete (UHSC).

High Strength concrete is required in the following cases

- To put the concrete into service at much earlier age, for example opening the pavement at three days.
- To build high rise buildings by reducing column sizes and increasing the available space.
- To build the super structures of long span bridges and to enhance the durability of bridge decks.
- To satisfy the specific needs of special applications such as durability, modulus of elasticity and flexural strength.
- Some of the applications include dams, grand stand roofs, marine foundations, parking garages and heavy duty industrial stores
- Larger stiffness as a result of a larger value of Young's Modulus of concrete.
- High resistance to crack propagation, chemical attack.
- Reduces maintenance cost.

1.2 Applications of High Strength Concrete

- In the context of tall buildings and large spans bridges, it is clear that use of high strength concrete leads to reduced column sizes and beam depths.
- In addition it results in improved performance in terms of creep, shrinkage and other elastic properties that yield a more favorable deformation pattern for tall buildings.
- The improved elastic properties also limit the sway and reduce elastic shortening and other secondary effects. Hence, high strength concrete has found application in various structures used by industries.
- High-strength concrete is required in engineering project that have concrete components that must resist high compressive loads.
- High-strength concrete is typically used in the erection of high-rise structures.

The American Concrete Committee on HPC includes the following six criteria for material selections, mixing, placing, and curing procedures for concrete.

(1) Ease of placement
(2) Long term mechanical properties
(3) Early-age strength
(4) Toughness
(5) Life in severe environments
(6) Volumetric stability

1.3 Methods for achieving High Performance

Two approaches to achieve durability through different techniques are as follows.

1. Reducing the capillary pore system such that no fluid movement can occur is the first approach. This is very difficult to realize and all concrete will have some interconnected pores.
2. Creating chemically active binding sites which prevent transport of aggressive ions such as chlorides is the second more effective method.

1.4 Salient High-Performance Requirements

1 Compressive strength > 70 MPa

2 Very early strength (4 h) > 17.5 MPa

3 Early strength (24 h) > 35 MPa

4 High degree of impermeability to prevent ingress of water/moisture/CO_2/SO_4/air/oxygen/chloride

5 High resistance to sulphate attack

6 Smooth fractured surface

7 Absence of micro-cracking

8 High level of corrosion resistance

9 High electrical resistivity

10 High chemical resistivity

The parameter to be controlled for achieving the required performance criteria could be any of the following.

(1) Water/ (cement + mineral admixture) ratio, (2) Strength, (3) Densification of cement paste, (4) Elimination of bleeding, (5) Homogeneity of the mix, (6) Particle size distribution, (7) Dispersion of cement in the fresh mix, (8) Stronger transition zone, (9) Low free lime content, (10) Very little free water in hardened concrete.

2. Materials

2.1 Material Selection

The main ingredients of HPC are almost the same as that of conventional concrete.

These are

2.1.1 Cement

2.1.2 Fine aggregate

2.1.3 Coarse aggregate

2.1.4 Water

2.1.5 Mineral admixtures (fine filler and/or pozzolonic supplementary cementitious materials)

2.1.6 Chemical admixtures (plasticizers, super plasticizers, retarders, air-entraining agent)

2.1.1 Cement:

It consists of a mixture of oxides of calcium, silica and aluminum. Portland material and similar materials are made by heating lime stone(a source of calcium)with clay and grinding this product(called clinker)with a source of sulphate (most commonly gypsum).

2.1.2 Fine aggregate:

Sand with fineness modulus exceeding 3.2 is unsuitable for making satisfactory concrete. Fine and coarse aggregates make up the bulk of a concrete mixture. Sand, natural gravel and crushed stone are used mainly for this purpose.

2.1.3. Coarse aggregate

The aggregate is generally stronger than the paste, its strength is not a major factor for normal strength concrete. However, the aggregate strength becomes important in the case of high performance concrete. Surface texture and mineralogy affect the bond between the aggregate, sand the paste as well as the stress level at which micro cracking begins.

2.1.4. Water

Water is the most important but the least expensive ingredient of concrete. A part of mixing water is utilized in the hydration of cement to form the binding matrix and the remaining water acts as a lubricant to make the concrete readily placeable. The water in excess of that quantity required for cement hydration i.e. $3/10^{th}$ of the cement weight requires to be kept to minimum, since too much water reduces the strength of the concrete.

2.1.5. Mineral admixtures

Mineral admixtures form an essential part of the high-performance concrete mix. More than the chemical composition, mineralogical and granulometric characteristics determine the influence of mineral admixture's role in enhancing properties of concrete. The fly ash (FA), the ground granulated blast furnace slag (GGBS) and the silica fume (SF) has been used widely as supplementary cementitious materials in high performance concrete. Using both silica fume and fly ash, the strength at 12 hours has been found to improve suddenly over similar mixes with silica fume alone. This phenomenon has been attributed to the liberation of soluble alkalis from the surface of the fly ash.

2.1.6. Super plasticizer or HRWR

The super plasticizers are extensively used in HPCs with very low water cementitious material ratios. In addition to deflocculation of cement grains and increase in the fluidity.

The main objectives for using super plasticizers are the following:

To produce highly dense concrete and to ensure very low permeability with adequate resistance to freezing-thawing. To minimize the effect of heat of hydration by lowering the cement content. To produce concrete with low air content and high workability to ensure high bond strength. To lower the water-cement ratio in order to keep the effect of creep and shrinkage to a minimum. To produce concrete of lowest possible porosity to protect it against external attacks. To keep alkali content low enough for protection against alkali-aggregate reaction and to keep sulphate and chloride contents as low as possible for prevention of reinforcement corrosion. To produce pump able yet non-segregating type concrete.

The following types of super plasticizers are used.

- Naphthalene-based
- Melamine-based
- Lignosulfonates-based
- Polycarboxylate-based
- Combinations of above

2.2 Advantages and Disadvantages of High-Strength Concrete:

The main advantages of using high strength concrete are the following:

- Reduction in member size, resulting in an increase in the usable floor space.
- Reduction in the quantity of concrete, and a consequent reduction in construction time.
- Reduction in self-weight and a consequent reduction in the foundation cost.
- Reduction in axial shortening effects in columns.
- Reduction in floor thickness and beam height.
- Elimination of a few footings because of adoption of larger spans.
- Larger stiffness as a result of a larger value of Young's modulus of concrete.
- Reduced maintenance costs.

The disadvantages of using high strength concrete are the following:

- Due to lack of adequate research under field condition, many of the issues are currently being alleviated through the use of improved admixtures.
- High quality materials are used so they may cost more.

- Allowable stress design discourages the use of high strength concrete, solution is to use load factor and resistance design, when using high strength concrete.

2.3 Methods of Mix Design:

The main objective of concrete mix design is to select the optimum proportions of the various ingredients of the concrete, which will yield fresh concrete of desirable workability, and hardened concrete possessing the specified characteristic compressive strength, durability and economical too.

2.3.1 ACI Mix Design Method:

This method is based on the fact that for a given maximum size of well shaped aggregate, the workability of concrete controls the water-content (kg/m^3)to be used in a concrete mix, that is it is largely independent of mix proportions. The method further assumes that the optimum ratio of the bulk volume of the coarse aggregate to the total volume of concrete depends only on the maximum size of aggregate and on the grading of the aggregate. The step by step procedure adopted for the selection of mix proportion is as follows

a) The water cement ratio is selected from the below fig1.1 for target strength.
b) The maximum size of coarse aggregate to be used is limited to 12.5 mm.
c) The cement content is calculated from the water content and w/c ratio required for strength and durability.
d) The coarse aggregate content is estimated for the given maximum size of aggregate and fineness modulus of sand.
e) The content of fine aggregate is determined by subtracting the sum of absolute volumes of the coarse aggregates, cement, water and entrapped air from unit volume of concrete.

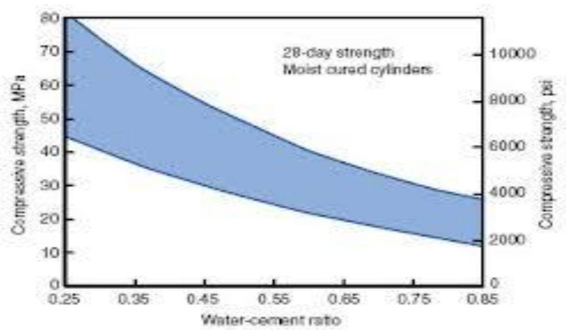


Fig 1.1 Relation between compressive strength and water cement ratio

A series of tests were conducted on concrete specimens to obtain the strength characteristics of M 80grade concrete for application in civil engineering field. From the experimental investigation, the values obtained have been tabulated and represented graphically to show the behavior of concrete with respect to age and also about the optimum dosage of the super plasticizer to be used to gain the high strength performance.

3. Results

3.1. Mechanical properties of M80 concrete:

It is generally understood that the strength of concrete determined using different sizes and shapes of specimens will in general be in an order as follows: 100 mm cubes > 150 mm cubes > cylinders with a diameter of 150 mm and a height of 300 mm.

Table 1.1 Compressive strength of concrete

Age (days)	Compressive strength of 150 mm cubes (N/mm^2)	Compressive strength of 100 mm cubes (N/mm^2)	Compressive strength of 150 mmx300 mm cylinders (N/mm^2)	Cylinder strength / 150 mm cube strength
1	42.22	47	33.33	0.789
3	61.55	65	55.83	0.907
7	85.67	90	76.94	0.898
28	93.33	95	87.86	0.941

3.2 SPECIMEN SIZE –EFFECT:

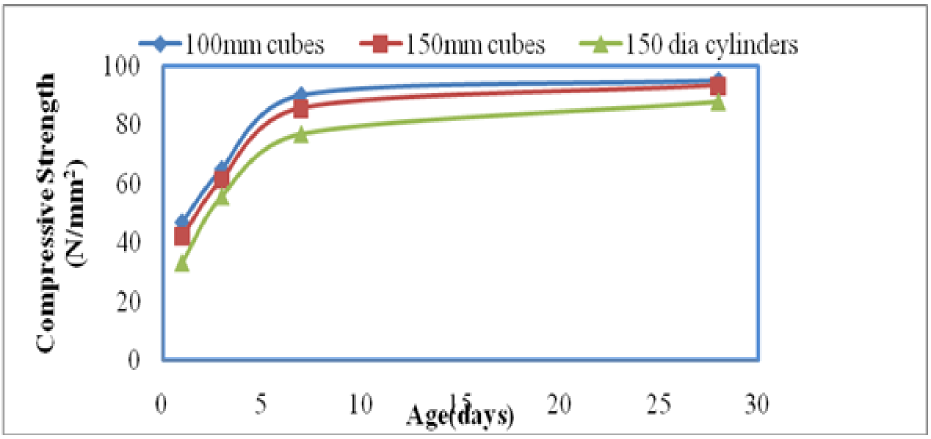
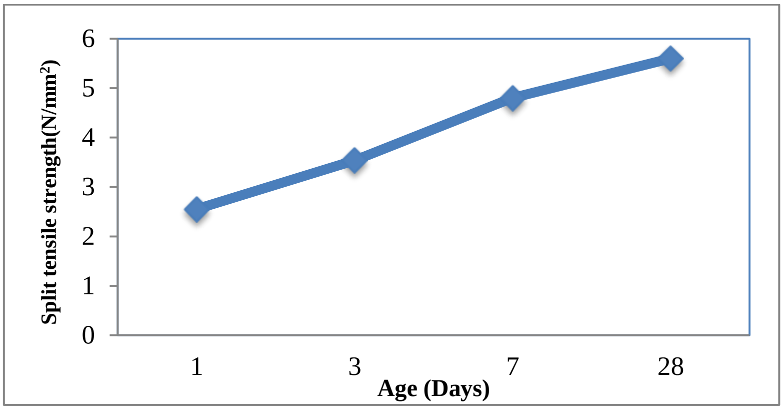


Fig3.1 Variation showing compressive strengths of 100 mm cubes, 150mm cubes and 150 dia. cylinders with respect to Age(days)

3.3 Split tensile strength and Flexural strength

Table 1.2 Split tensile strength and Flexural strength

Age(days)	Split tensile strength (N/mm^2)	Flexural strength (N/mm^2)
1	2.55	5.64
3	3.54	6.18
7	4.8	6.6
28	5.6	7.02



4. Conclusions

1. In the current study, the compressive strength with respect to different mixing times at 7 and 28 days is examined using Conplast SP-430. The 7 day average compressive strength for 3 minute mixing time is 75.60 N/mm^{2}and for 5 minutes mixing time is 78.82 N/mm^2. The 28 day compressive strength for 3 minute mixing time is 84.44 N/mm^2 and for 5 minute mixing time is 93.33 N/mm^2.
2. The compressive strength at 7days varies between 64.59 N/mm^2 to 70.36 N/mm^2 and at 28 days varies from 72 to 84.44 N/mm^2 for different dosage of SP-430 for 3 minutes mixing time.
3. The 7 days compressive strength varied between 70.37 N/mm^2 to 73.48 N/mm^2 and 28 strength from 81.48 N/mm^2 to 89.78 N/mm^2 for % SP dosages between 1% to 2% for 5 minute mixing time.
4. The compressive strength for 3 minutes mixing time at 7 days varies from 64.59 N/mm^2 to 70.36 N/mm^2 with an increase of dosage of Conplast SP-430 from 1.5% to 3% of cementitious material, the compressive strength for 28 days is 72 N/mm^{2}to 78.66 N/mm^2.optimum dosage of sp-430 is taken as 2.5% of cementitious material.
5. The compressive strength for 5 minutes mixing time at 7 days varies from 70.37 N/mm^2 to 73.48 N/mm^2 with an increase of dosage of Conplast SP-430 from 1% to 2% of cementitious material, the compressive strength for 28 days is 81.48 N/mm^{2}to 89.78 N/mm^2.Optimum dosage of sp-430 is taken as 1.5% of cementitious material.
6. With an increase in mixing time, the Compressive strength increases with less dosage of Conplast SP-430.
7. The compressive strength at 7 days varies from 61.23 N/mm^2 to 60.89 N/mm^2 with an increase of dosage of Glenium Ace-30 from 0.5% to 1% of cementitious material, the compressive strength for 28 days is 74.3 N/mm^{2}to

75.6 N/mm^2, with an increase in dosage of Glenium Ace-30. Optimum dosage of Glenium Ace-30 is taken as 0.75% of cementitious material.

8. The Split tensile strength increases with age from 2.55 N/mm^2 to 5.6 N/mm^2.
9. The Flexural tensile strength increases with age from 5.64 N/mm^2 to 7.02 N/mm^2.
10. The compressive strength for 100mm cubes increases with age from 47 to 95 N/mm^2.
11. The compressive strength for 150mm cubes increases with age from 42.22 N/mm^2 to 95 N/mm^2.
12. The compressive strength for 150mmx300mm cylinders increases with age from 33.33 N/mm^2 to 87.86 N/mm^2.
13. The ratio of compressive strength of high strength concrete of 150 mmx300 mm cylinders to 150 mm cubes was 0.964.
14. The ratio of compressive strength of high strength concrete of 100mm cubes to 150 mm cubes was 0.96.
15. The ratio of compressive strength of high strength concrete of 150 mmx300 mm cylinders to 100 mm cubes was 0.923.
16. The ratio of the strength of the cylinder to that of cube increases with an increase in strength for concrete of all ages.
17. The strength of concrete determined by 100 mm cube is greater than that given by 150 mm cube which in turn is greater than that given by 150 mm dia. Cylinder.

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