A SURVEY ON HIGH PERFORMANCE CONCRETE USING MINERAL ADMIXTURES (FLY ASH AND SILICA FUME)

[1]Vipin Kumar Kannaujiya
Department of Civil Engineering,
Madan Mohan Malviya University of Technology, Gorakhpur, India
Email: vipin.civil56@gmail.com

[2]Rajesh Kumar Bharti, [3]Chandan Rao
Department of Civil Engineering,
Madan Mohan Malviya University of Technology, Gorakhpur, India
Email: chandan.rao16@gmail.com, bharti.rajesh13@gmail.com

ABSTRACT: This study presents the effect of incorporating silica fume and fly ash (SF, FA) on the mechanical and durability properties of high strength concrete for a constant water/binder ratio of 0.3. Silica fume and fly ash mixtures with cement replacement of 5, 10, 15, 20 and 25% were designed for target strength and slump of 58.25 MPa and 100 ± 25 mm. various percentages of Silica Fume (SF) and Fly Ash (FA) were added at different water/cementitious (w/cm) ratios. Concrete specimens were tested and compared with plain concrete specimens at different ages. Optimum replacement percentage is not a constant one but depends on the w/cm ratio of the mix. SF contributed to both short and long-term properties of concrete, whereas, FA showed its beneficial effect in a relatively longer time. Adding of both SF and FA did not increase compressive strength in the short-term, but improvements were noticed in the long-term. Compared with compressive strength, flexural strength of SF concretes has exhibited greater improvements. Relationships between the 28-day flexural and compressive strengths have been developed using statistical methods. It is concluded that local concrete materials, in combination with mineral admixtures, can be utilized in making High Strength Concrete in India and such concrete can be effectively used in structural applications.

KEYWORDS: High strength concrete, Silica fume, Fly ash, Compressive and flexural strengths.

INTRODUCTION

HPC is a concrete designed to meet a performance specification. Many definitions of HPC have been proposed over the past 15–20 years; one to note is the definition proposed by Good speed and later expanded by Russell and Ozyildirim that offers a series of strength and durability-related performance characteristics.(1,2) It recommends that the desired performance of the concrete should be considered and that the performance characteristics should then be set accordingly. Example performance characteristics toward which concrete properties may be focused include chloride penetration, shrinkage, compressive strength, and freeze/ thaw deterioration resistance.

- The definition of high-performance concrete is more controversial.

Civil Engineering Research Foundation (CERP)

High performance construction materials and systems: An essential program for American and infrastructure. HPC is a concrete in which some or all of the following properties have been enhanced

(a) Ease of placement
(b) Long term mechanical properties
(c) Early age strength
(d) Toughness

(e) Volume stability
(f) Extended service life in severe environments.

- Mehta and Aitcin used the term, **highperformance concrete (HPC)** for concrete mixtures possessing high workability, high durability and high ultimate strength.

High Strength Concrete (HSC) is one of the most significant new materials available to the public to utilize in new construction and in rehabilitation of buildings, highways and bridges. The demand for HSC has increased in Jordan due to the booming of high-rise buildings and towers. Benefits of using HSC are: 1) to put the concrete into service at much earlier age; 2) to build high-rise buildings by reducing column sizes and increasing available space; 3) to build superstructures of long-span bridges; and 4) to satisfy the specific needs of special applications such as durability, modulus of elasticity and flexural strength. Factors influencing the strength of HSC are the amount and type of cement, w/cm ratio, aggregate type and
grading, workability of fresh concrete, mineral admixtures, chemical additives, curing conditions and age of concrete. HSC has been produced and is widely used in the US and Europe. Despite the positive successes reported from field and laboratory-based studies, this concrete has not been widely applied in practice in Jordan and, sometimes, its use has been discouraged by some professionals. The overriding obstacle preventing the use of HSC in Jordan lies in the absence of a locally accepted design technique that accounts for the variables believed to contribute to its performance. So, in order to effectively use HSC in Jordan, there is a need to accurately predict its compressive strength, which is used as an essential parameter in structural design. Therefore, the 20 and 25) of FA and three percentages (10-10, 10-15 and 10-20) of SF-FA combination. Three w/cm ratios of 0.30, 0.35 and 0.40 were used in the mixes to objectives of this investigation are: 1) to explore the possibilities of producing HSC with mineral admixtures and locally
available concrete materials in Jordan; and 2) to determine how SF and FA influence the compressive and flexural strengths of concrete as well as the optimum percentages of those mineral admixtures.

To achieve the above objectives, concrete specimens were produced and tested in the laboratory. Cement was replaced, by weight, with five percentages (5, 7.5, 10,
12.5 and 15) of SF, four percentages (10, 15, carry out the 7-day, 28- day and 90-day compressive strength and 28-day flexural strength tests. An equation relating compressive strength to flexural strength has been developed based on experimental evaluation. Moreover, a comparison of this equation with the ACI 363 (1997) formula has also been made. Ultimately, the project aims to provide some guidelines for concrete mix composition that can be used in the formulation of HSC for the Jordanian market [3].

Methods for achieving High Performance

In general, better durability performance has been achieved by using high strength, low w/c ratio concrete. Though in this approach the design is based on strength and the result is better durability, it is desirable that the high performance, namely, the durability, is addressed directly by optimizing critical parameters such as the practical size of the required materials. 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

BACKGROUND

The uses of mineral admixtures have been studied by many researchers. Among many additives, Mineral Admixtures (MAs) were utilized for the production of HSC. It has been possible to produce concrete mixes in laboratory conditions using such MAs that produced a compressive strength which exceeded 180 MPa. The inplace strength in some tall buildings has attained a compressive strength of approximately 125 MPa (Haque and Kayali, 1998). The most often used MAs in the production of HSC are SF and FA. These MAs are either pozzolanic or both pozzolanic and self-cementitious to a degree. Fortunately, most of these MAs are industrial byproducts, so their utilization not only produces economically and technically very superior concrete but also prevents environmental contamination by means of proper waste disposal. SF has a high content of silicon dioxide (SiO2) and consists of very small solid spherical particles. FA can improve concrete properties such as workability, durability and ultimate strength in hardened concrete. FA with high fineness exhibits high pozzolanic activity and can be used to produce HSC (Haque and Kayali, 1998

DISCUSSION:

Workability

From the results of workability tests namely, slump and flow, it is observed that slump and flow values of all the grades of HPC mixes significantly increase with increase in humidity at a constant temperature.

Compressive Strength

From the results of compressive strength test it is observed that the compressive strength of HPC mixes is significantly affected by the variation in temperature and humidity. The results indicate that the compressive strengths of HPC mixes decreases for increased relative humidity levels under a specific constant temperature. This implies that the combined effect of humidity and temperatures on HPC mixes is necessary to be taken into account while proportioning HPC mixes at site, particularly in the context of tropical countries.

PROPOSED MIX DESIGN METHOD FOR HPC

The proposed mix design method for HPC mixes is based on the principles of existing IS Code method of mix design (IS 10262-1982 [12] and IS 10262-2009) [13]. In the development of this proposed method, the basic mix proportions were obtained for making HPC mixes using w/c ratio's worked out by extrapolating the established relationships between free water cement ratio and concrete strength for different cement strengths given in IS Code (IS:10262-1982) [12]. The quantities of fine aggregate and coarse aggregate were determined using the equation given in IS Code method (IS: 10262-1982) [12]. The basic mix proportions thus obtained by following the guidelines of existing IS Code method were used in making trial HPC mixes by incorporating desirable contents of micro silica and SP in view of achieving the desired workability and strength properties. Further, based on experimental observations and results of compressive strengths of various grades of HPC mixes, the curves given in IS Code method are modified so as to arrive at w/b ratios best suited to different grades of HPC mixes (Figure2 to 4). From the experimental observations, the basic mix proportions adopted for making trial HPC mixes were modified by altering coarse aggregate to fine aggregate ratio and incorporating appropriate micro silica and SP contents so as to get desired workability and compressive strengths for different combinations of humidity and temperature.

CONCLUSIONS:

Based on the findings of this study, the following conclusions are made:

• Addition of silica fume and fly ash to concrete can be conveniently achieved with the present day technology. This study has shown that it is possible to produce high strength concrete in Jordan using the locally available materials with proper amount of mineral admixtures. Fly ash and a combination of silica fume and fly ash replacement did not provide as high improvement levels as those provided by silica fume.

• With previously published information as a comparative basis, results indicated that compressive and flexural strengths of silica fume concrete specimens were higher than those of plain concrete specimens at all ages.

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