A BRIEF REVIEW ON HIGH PERFORMANCE CONCRETE

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ABSTRACT
In the recent years, an emerging technology termed “HIGH PERFORMANCE CONCRETE (HPC)” has become highly popular in the construction industry. This paper reviews the performance of concrete mixtures in terms of physical and mechanical properties including its durability aspects. Specifically, this paper aims to provide a brief review of the mechanism of compressive strength. The focus on HPC has immensely increased due to utilization of large quantity of concrete, thereby leading to the development of various infrastructures. HPC is a concrete mixture which possesses high durability and high strength when compared to conventional concrete. It is observed that HPC is a material increasingly utilized in large structural construction.

Key words:- Ground granulated blast furnace slag (GGBS), Silica fume, Fly Ash, Super plasticizer, High Performance Concrete (HPC)

1. INTRODUCTION
High performance concrete (HPC) is a concrete mixture, which possess high strength and high durability when compared to conventional concrete. This concrete contains one or more cementitious materials such as fly ash, Silica fume or ground granulated blast furnace slag and usually a super plasticizer. The use of some mineral and chemical admixtures like Silica fume and Super plasticizer enhance the strength, durability and workability qualities to a very high extent. Use of High Performance concrete in construction enhances the service life of the structure and the structure suffers less damage which would reduce overall costs. The high performance concrete does not require special ingredients or special equipments except careful design and production. Swamy [1] defines that a high performance concrete element is that which is designed to give optimized performance characteristics for a given set of load, usage and exposure conditions, consistent with requirement of cost, service life and durability.

Concrete is the most widely used construction material in India with annual consumption exceeding 100 million cubic metres. Also, the recent earthquakes in different parts of the world have once again revealed the importance of design of structures with high ductility. Conventional Ordinary Portland Cement Concrete which is designed on the basis of compressive strength does not meet many functional requirements as it is found deficient in aggressive environments, and loses its tensile resistance after the formation of multiple cracks. So, there is a need to design high performance concrete which is far superior to conventional concrete, as the ingredients of high performance concrete contribute most efficiently to the various requirements [2,3,4,5].

The attribute “High Performance” implies an optimized combination of structural properties such as strength, toughness, energy absorption capacity, stiffness, durability, multiple cracking and corrosion resistance, taking into account the final cost of the material. Generally speaking, high performance is meant to distinguish structural materials from the conventional materials, and also to optimize a combination of properties in term of its final applications in civil engineering.

HPC concretes are usually designed using materials other than cement alone to achieve these requirements, such as fly ash, ground blast furnace slag, or silica fume. Appropriate amounts of these materials are combined with Portland cement in varying percentages depending on the specific requirements of the HPC to be produced.

The requirements of HPC may involve enhancement of characteristics such as placement and compaction without segregation, long-term mechanical properties, and early age strength or service life in severe environments. Concretes possessing many of these characteristics often achieve high Strength, but High Strength Concrete (HSC) may not necessarily be high performance concrete.
In a high performance concrete, durability of concrete plays an important role in the service life of RCC structures. It can be enhanced by improving its resistance to permeability, resistance to chloride ion diffusion and abrasion resistance. One of the ways to achieving this is by adding superplasticizers and supplementary cementing materials. Also, High Performance Concrete (HPC) can be produced by minimizing the water cement ratio with the help of superplasticizers and carefully selecting supplementary cementitious materials such as fly ash, ground granulated blast furnace slag, metakaoline and silica fume.

2. REVIEW ON HIGH PERFORMANCE CONCRETE
Many researchers have demonstrated the beneficial effects of using GGBS, silica fume and fly ash as cement replacement materials to reduce the rate of penetration of chloride ions reducing the potential of chloride induced corrosion [6,7,8].

Smith Kevin et al., [9] established a testing regime to optimize the strengths and durability characteristics of a wide range of high-performance concrete mixes. One of the prime methods of optimizing the mixtures was to implement supplemental cemenitious materials, at their most advantageous levels. Fly ash, Slag cement, and Micro silica all proved to be highly effective in creating more durable concrete mixes. These materials have also shown to substantially lower chloride ingress, thus extending the initiation phase of corrosion.

In the past, one of the main reasons for deterioration of concrete is that too much emphasis is placed on compressive strength rather than on the performance criteria. The deterioration of reinforced concrete structures usually involves the transport of aggressive substances from the surrounding environment into the concrete followed by physical and chemical actions in its internal structure. The transport of aggressive substances into concrete depends on its permeation characteristics. As the permeation of concrete decreases its durability performance, in terms of physio-chemical degradation, increases. Therefore, permeation of concrete is one of the most critical parameters in the determination of concrete durability in aggressive environments [10], (VaishaliG Ghorpade and Sudarsana Rao, 2011).

HPC is the key to achieve impermeable, durable and improved protection of embedded steel [11, 12, 13]. Durability of concrete is the ability of concrete to be fully functional over an extended period under prevailing service conditions for the purpose for which it has been designed. The permeability of concrete dictates the rate at which aggressive agents can penetrate to attack the concrete and the steel reinforcement. Corrosion related damage to the concrete structure is a major problem associated with high cost of repairs; sometimes replacement of structure.

Vishal Dhondiram et al., [14] performed an experimental study on properties of concrete supplemented by silica fume and reported that the compressive strength increases with increase in addition of silica fume. The authors attributed the reason to the high pozzolanic nature and void filling ability of the silica fume. Maximum designed compressive strength was obtained at a cement replacement of 10% by silica fume in the study.

Ozawa et al. [15, 16] described a mix of high performance concrete as a concrete with high filling capacity. It can be filled into all the corners of formwork without using any vibrators. The authors conducted a study to investigate the role of chemical admixtures such as superplasticizer and viscosity modifying agents on the deformational and segregation behaviour of fresh concrete. It was found that there exists the suitable viscosity of paste for improving not only the deformability but also the segregation resistance, which is highly dependent on the volume of free water in fresh concrete.

Vijaya Sekhar Reddy et al., [17] performed an experimental study to investigate durability of high performance concrete using rapid chloride permeability tests. The authors concluded that introduction of pozzolanic materials in concrete such as fly ash, silica fume, metakaoline and GGBS improves the pore structure and reduces the permeability. This provides a resistance to chloride ion penetration into the concrete. Mehta and Aitcin [18] suggested that a high performance concrete should possess the following three properties: high-workability, high-strength, and high durability. The authors stated that durability rather than high strength appears to be the principal characteristic for high-performance concrete mixtures being developed for use in hostile environments such as seafloor tunnels, offshore and coastal marine structures, and
confinement for solid and liquid wastes containing hazardous materials. Strength, dimensional stability, impermeability, and high workability are usually the principal characteristics required of high-performance concrete. The authors provided an overview for the basis on which constituent materials can be selected and proportioned. A new step-by-step procedure for mix proportioning was described which was found consistent with the state-of-the-art laboratory and field practice.

Oner et al.,[19] conducted an experimental study on strength development of concrete containing fly ash. The authors also studied the optimum usage of fly ash in concrete. Fly ash was added according to the partial replacement method in mixtures. A total of 28 mixtures with different mix designs were prepared. The authors reported that addition of fly ash to the concrete by replacement generally improves strength and other properties which contributes to the performance of concrete.

3. CONCLUSION

After the brief review of some selected previous studies, the following conclusions can be arrived at:

i. High performance concrete is increasingly becoming popular throughout the world because of its superior properties.

ii. Proper selection and proportioning of constituent materials forms the basis of achieving high performance concrete.

iii. Supplementary cementitious materials such as fly ash, silica fume, and granulated blast furnace slag are introduced to the concrete as a replacement of cement in addition to superplasticizers.

iv. High performance concrete has high strength and superior durability when compared with normal conventional concrete.

v. High performance concrete could be more economical considering the long term benefits through its enhanced strength and properties.

REFERENCES


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