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To Study the effect of Water and Super Plasticizer on High Performance Concrete

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Abstract - Among the modern construction materials, concrete occupies a unique place. Concrete is a hard, chemically inert particulate material, known as an aggregate (generally made of sand and gravel), that is blended with cement and water. Concrete with significantly higher general performance than normal concrete. This type of concrete is known as High Performance Concrete (HPC). Three of the key attributes of HPC. They are strength, ductility, and durability. HPCs are primarily used to build bridges, dams, flyovers, etc. The material is also used in residential buildings such as skyscrapers and high-rise buildings.

To produce high-performance concrete (HPC), various materials must be used to fill voids in the concrete. Specially formulated high range water reducers are used to reduce the voids and give high strength.

Concrete mix design is the process of choosing the ingredients and determining their relative amounts. In this way, concrete with the desired strength, durability, and workability can be produced as economical as possible.

***Key Words*:** Concrete, Aggregate, Water, HPC

1.INTRODUCTION

Using high performance concrete (HPC) to construct concrete structures can provide several benefits that are not always possible with conventional concrete and normal mixing and curing practices, to achieve better strength and workability. In other words, a HPC is a concrete in which certain characteristics are developed for a particular application and environment, so that it will give excellent performance in the As well as within the structure where it will be placed. This is in the environment to which it will be exposed, and with the loads to which it will be exposed throughout its design life. A concrete that provides significantly improved resistance to environmental influences (durability in service) or substantially increased structural capacity without compromising durability. Additionally, it may include concrete, which can significantly reduce construction time without sacrificing durability. While high strength concrete aims at enhancing strength and consequent advantages owing to improved strength, the term high-performance concrete (HPC) is used to refer to concrete of the required performance for most construction applications.

2. Body of Paper

There are over 100 million cubic meters of concrete consumed annually in India, which makes it one of the most widely used construction materials. Conventional concrete designed based on compressive strength does not adequately meet many functional requirements like impermeability, resistance to frost, and thermal cracking. Conventional Portland cement concrete lacks the following characteristics: -

- ❖ Durability in severe environments
- ❖ Energy absorption capacity
- ❖ Time of construction
- ❖ Repair and retrofitting jobs

HPC successfully meets the above requirement.

Construction of concrete structures can be improved with the use of HPC concrete, a specialized series of concrete with several benefits. These benefits cannot always be achieved routinely using conventional ingredients, mixing, and curing practices. In other words, a HPC is some concrete in which certain characteristics are developed for a particular application and environment, as a result, it will provide excellent performance in the structure in which it will be installed. Due to its environmental conditions and load requirements during its design life, it will be exposed to these conditions. This type of concrete is capable of significantly improving resistance to environmental influences (durability in service) or substantially increasing structural capacity while maintaining adequate durability. In addition to reducing construction time, the use of concrete, which is long-lasting and durable, can also reduce costs.

Traditionally, HPC may be regarded as synonymous with high strength concrete (HSC), which is because lowering the water-to-cement ratio, which is required for high strength, also generally improves other properties. It is now recognized that with the addition of mineral admixtures HPC can be achieved by further lowering the water-to-cement ratio, but without its certain adverse effects on the properties of the material. Therefore, it is essential to understand how concrete performance to its microstructure composition and microstructure. Properties of concrete can be related to performance of concrete. It can mean excellent workability in fresh concrete, or low heat of hydration in case of mass concrete, or very quick setting and spray concrete that is used to repair roads and airfields hardens, and storage vessels with very low imperviousness cannot be used as roads or airfields. Nevertheless, from a structural perspective, HPC is best known for its high strength, high ductility, and high durability. These are the most favorable aspects of being a construction material.

2.1 Composition of HPC

Usually, HPC consists of the composition of water, cement, fine sand, superplasticizer, fly ash and silica fume. Quartz flour and fiber are also sometimes used for HPC due to their high strength and flowability (above 650). The key elements of high-performance concrete can be summarized as follows:

➢ Low water-to-cement ratio,

➢ silica fume and/or other fine mineral powders

➢ Fly ash

➢ Small aggregates and fine sand,

➢ High dosage of super plasticizers.

2.2 Comparison between the Microstructure of HPC & NSC

The use of HPC as a construction material has been increasing in recent years due to its long-term durability, performance, and better rheological and mechanical properties than Normal Strength Concrete (NSC). Compared to NSC, HPC requires a lower water binder (w/b) ratio and higher cement content.

Interrelationships between the microstructure and properties of both HPC and NSC need to be established. The microstructure of concrete can be described in three aspects, namely composition of interfacial transition zone, hydrated cement paste and pore structure. When cement reacts with water, it forms the hydrated cement paste. A concrete's pore structure is composed of gel pores, capillary pores and voids, along with their connections. The interfacial transition zone refers to the boundaries between aggregates and cement paste or particles of admixtures. The NSC composition is relatively simple, which consists of water, cement, and aggregate.

The hydrated cement paste is referred to as cementitious calcium silicate hydrate (C-S-H) gel which is the main product of the hydration of cement and water. The hydrated cement paste of NSC is dominated by an amorphous C-S-H gel which is intrinsically porous. Concrete is porous due to gel pores, micropores, and voids. Hence, C-S-H gel is a low-density phase, which is space filling, but strength limiting. For concrete with strength below 60MPa, the increase in strength is primarily attained by decreasing the capillary porosity alone. However, reducing capillary porosity is not enough to generate a concrete strength higher than 60MPa. Capillary pores and gel porosity should be reduced together to substantially reduce the total porosity of concrete. to convert C-S-H to more crystalline phases further reductions in gel porosity requires, which leads to the production of HPC.

While the total porosity of the cement paste matrix has a significant influence on the strength of concrete, the porous structure and its connectivity have a significant impact on permeability. Since concrete's inner parts are more easily attacked by chemicals in the surrounding environment, high permeability is usually a sign of low durability. Using a proper curing process, however, high permeability concrete can achieve a higher early strength. This is because the hydration process can be completed continuously with the flow of water within the pores. Due to the absence of fine particles, NSC usually has higher porosity and pore connectivity than HPC.

To improve concrete performance, three aspects are considered.

(a) It is necessary to strengthen the hydrated cement paste,

(b) The porosity of concrete should be reduced, and

(c) Enhance the interfacial transition zone.

These aspects are evaluated one by one. Firstly, it is necessary to strengthen the hydrated cement paste by reducing the gel porosity inside the hydrated cement paste. In comparison to amorphous C-S-H gel, crystalline C-S-H gel has a lower gel porosity. By adding suitable admixture (e.g. silica fume), crystalline C-S-H gel can be achieved. Secondly, the porosity in concrete can be reduced by mixing suitable fine admixtures with the concrete to fill up the empty spaces. In HPC, very fine admixture, such as silica fume or fly ash, is included in the design mix so that the empty space inside concrete can be reduced significantly.
At the same time, the pore connectivity is reduced because the very fine particles effectively block the capillary network. Thirdly, the interfacial transition zone can be toughened by lowering the locally high water-to-cement ratio and by optimizing the particle packing in this zone. Superplasticizer is included in concrete mix so that a very low water-to-cement ratio (less than 0.2) can be adopted. Fine admixtures, like silica fume or fly ash, are also included to enhance particle packing in the interfacial transition zone. Admixtures must be added to the design mix in order to generate high performance concrete (HPC).

2.3 Advantages of HPC

At present, high performance concrete (HPC) can be classified as an advanced construction material. The following are the major advantages that can be achieved: -

➢Reduction in the size of the columns

➢Faster construction times.

➢Lower overall costs.

➢More economical than steel concrete composite columns

➢Reduced depth of floor system and decrease in overall building height

➢Higher seismic resistance, lower wind sway and drift.

➢Wearing resistance, abrasion resistance

➢Improved durability in an aggressive environment

➢Durability against chloride attack

➢Increased durability in the marine environment

➢Greater Freedom in Design.

➢Low shrinkage and high strength

➢Service life more than 100 years

➢Reduction in the thickness of floor slabs and supporting beam sections which are a major component of the weight and cost of most structures.

➢ Reduced maintenance and repairs.

➢Construction of high-rise buildings easily.

2.4 Applications of HPC

Major applications of HPC have been in the areas of high-rise buildings, long-span bridges, dams and pavements.

➢High Rise buildings or Skyscrapers
➢Bridges
➢Box culvert
➢Concrete filled steel columns
➢Tunnel
➢Dam
➢Concrete products (blocks, culverts, wall, water tank, slab, and segment)
➢Diaphragm wall
➢Tank

3. CONCLUSIONS

Based on all these findings it can be concluded that, in general, a flat slab structure may undergo progressive failures because of a sudden column loss. However, this is only likely to occur if the punching shear stress around the adjacent columns exceeds the capacity, because of the redistribution of loading and the dynamic effects. Provided that the slab contains continuous flexural reinforcement throughout the entire span, total flexural failures are unlikely to occur. Related to this, the extent of damage sustained in most cases remains small and does not pose an immediate risk to the structure. As a result of this, inclusion of the full nonlinear behavior of the slab elements may not be required in assessing its potential for progressive failure or collapse. However, dynamic effects caused by the inertia of the moving slab after a sudden removal can play a significant role. Although the value of the DAF depends on the layout and design of the structure, with particular focus on the extent of damage that occurs because of a column loss, the factor was always below 1.62. As GSA (2013) recommends a value of 2.0, this indicates that following such guidelines may result in over conservative designs, especially for punching shear capacity.

Below are the main conclusions of this study.

• Reinforced Concrete (RC) flat slab structures are robust and can resist progressive collapse provided brittle failures, such as by punching shear, are prevented.

• For common structural designs, the extent of material nonlinearity depends on the design of the slab. During dynamic analysis, displacements up to 3.31 times the yield displacement were measured. However, geometric nonlinearity was not significant in assessing the response of the structure.

• Dynamic factors, primarily the increase in deflections and shear forces due to inertial effects, can be significant, with a Dynamic Amplification Factor (DAF) up to 1.62 calculated. This factor decreases with higher nonlinearity in the structural response.

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ABBREVIATION

HPC - High Performance Concrete
NSC - Normal Strength Concrete
HSC - High Strength Concrete
RC - Reinforced Concrete
GSA - General Services Administration
DAF - Dynamic Amplification Factor