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High performance concrete and fundamentals

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Abstract
Concrete is considered as durable and strong material. Reinforced concrete is one of the most popular materials used for construction around the world. Reinforced concrete is exposed to deterioration in some regions especially in coastal regions. Therefore researchers around the world are directing their efforts towards developing a new material to overcome this problem.

Keywords: concrete, strong material

Introduction

Invention of large construction plants and equipment around the world added to the increased use of material. This scenario leads to the use of additive materials to improve the quality of concrete. As an outcome of the experiments and researches, cement based concrete which meets special performance with respect to workability, strength and durability known as" High Performance Concrete" was developed. High Performance Concrete can be designed to give optimized performance characteristics for a given set of load, usage and exposure conditions consistent with the requirements of cost, service life and durability. The high performance concrete does not require special equipment except careful design and production. High performance concrete has several advantages like improved durability characteristics and much lesser micro cracking than normal strength concrete.

Objectives

- To put the concrete in to service at much earlier age, for example opening the pavement at 3-days.
- To build high-rise buildings by reducing column sizes and increasing available space.
- To build the superstructures 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 these applications include dams, grandstand roofs, marine foundations, parking garages, and heavy industrial floors.

Fig 1

General Characteristics

- High-performance concrete characteristics are developed for particular applications and environments; some of the properties that may be required include:
- High strength
- High early strength
- High modulus of elasticity
- High abrasion resistance
- High durability and long life in severe environments
- Low permeability and diffusion
- Resistance to chemical attack
- High resistance to frost and deicer scaling damage

- Toughness and impact resistance
- Volume stability
- Ease of placement
- Compaction without segregation
- Inhibition of bacterial and mold growth

Advantages of High Performance Concrete

The advantages of using high strength high performance concretes often balance the increase in material cost. The following are the major advantages that can be accomplished.

Reduction in member size, resulting in increase in plinth area/useable area and direct savings in the concrete volume saved.

1. Reduction in the self-weight and super-imposed dead load with the accompanying saving due to smaller foundations.
2. Reduction in form-work area and cost with the accompanying reduction in shoring and stripping time due to high early-age gain in strength.
3. Construction of High –rise buildings with the accompanying savings in real-estate costs in congested areas.
4. Longer spans and fewer beams for the same magnitude of loading.
5. Reduced axial shortening of compression supporting members.
6. Reduction in the number of supports and the supporting foundations due to the increase in spans.
7. Reduction in the thickness of floor slabs and supporting beam sections which are a major component of the weight and cost of the majority of structures.
8. Superior long-term service performance under static, dynamic and fatigue loading.
9. Low creep and shrinkage.
10. Greater stiffness as a result of a higher modulus of elasticity
11. Higher resistance to freezing and thawing, chemical attack, and significantly improved long-term durability and crack propagation.
12. Reduced maintenance and repairs.
13. Smaller depreciation as a fixed cost.

Comparison between the Microstructure of HPC and NSC

What makes HPC to be different from NSC? In order to answer this question, the microstructure of the material should be studied. Interrelationships between 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 hydrated cement paste, Pore structure and interfacial transition zone. The hydrated cement paste is in fact the hydration products when cement is reacted with water. The pore structure refers to the gel pores, capillary pores and voids, as well as their connections within the Hardened concrete. The interfacial transition zone refers to the boundaries between the cement pastes and aggregates or particles of admixtures. The composition of NSC is relatively simple, which consists of cement, aggregate and water. Figure shows the microstructure of NSC. The composition of high performance concrete (HPC) are almost same as those of Conventional Cement Concretes (CCC). But, because of lower Water Cement Ratio, presence of Pozzolans and chemical admixtures etc., the HPCs usually have many features which distinguish them from CCCs

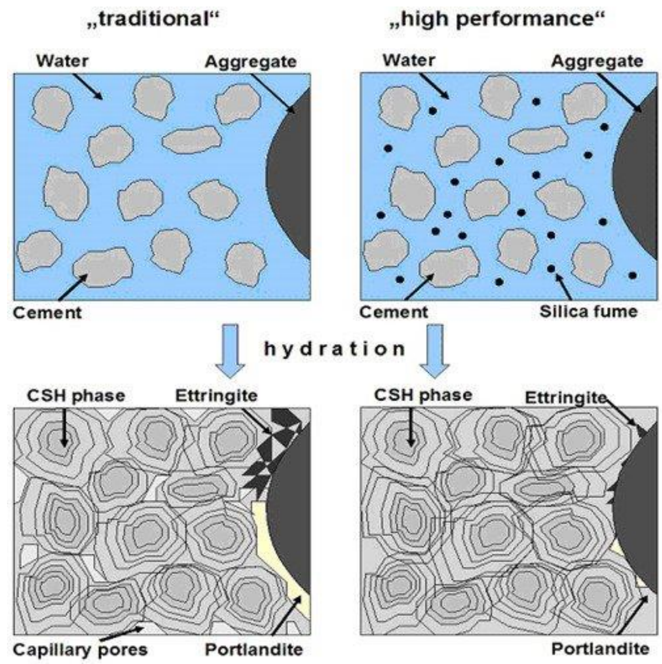

Fig 2

Composition of HPC

The most common composition of high performance concrete as supplementing cementitious materials or mineral admixtures is:

1. Silica Fume
2. Fly Ash
3. GGBFS (Ground granulated blast furnace slag)

Key Features of High Performance Concrete (HPC)

1. Compressive strength > 80 MPa, even upto 800 MPa
2. Water-binder ratio =0.25-0.35, therefore very little free water
3. Reduced flocculation of cement grains
4. Wide range of grain sizes
5. Densified cement paste
6. No bleeding – homogeneous mix
7. Less capillary porosity
8. Discontinuous pores
9. Stronger transition zone at the interface between cement paste and aggregate
10. Low free lime content
11. Endogenous shrinkage
12. Powerful confinement of aggregates
13. Little micro-cracking until about 65-70% of fck
14. Smooth fracture surface

Advantages

1. High-strength concrete resists loads that cannot be resisted by normal-strength concrete.
2. Not only does high strength concrete allow for more applications, it also increases the strength per unit cost, per unit weight, and per unit volume as well.
3. These concrete mixes typically have an increased modulus

of elasticity, which increases stability and reduces deflections.

Disadvantages
Along with the inherent advantages of high-strength concrete, several less clearly defined disadvantages can materialize. Most of these disadvantages are due to a lack of adequate research under field conditions, although many of the issues are currently being alleviated though the use of improved admixtures.

1. Increased quality control is needed in order to maintain the special properties desired. High-strength concrete must meet high-performance standards consistently in order for it to be effective.
2. Careful materials selection is necessary. High quality materials must be used. These materials may cost more than materials of lower quality.
3. Allowable stress design discourages the use of high-strength concrete. One solution is to use load factor and resistance design when using high-strength concrete.
4. Minimum cover over reinforcement or minimum thickness of members may restrict the realization of maximum benefits.
5. Available prestress force in a member may be inadequate to achieve maximum strength.
6. Low water to cementitious materials ratios require special curing requirements.

Conclusion
1. The design of HPC is met when materials are optimized to produce a strong durable concrete.
2. The water, cementitious materials, aggregates and chemical admixtures all need to be proportioned effectively to deliver the mix with the most desirable properties for placement, finishing, curing, and hardened condition.
3. The designs are not cook book and in most cases require that the mix be trial batched to compare the fresh and hardened properties.
4. As mentioned earlier in this section, the designer needs to be innovative with his materials and the proportioning of these materials.
5. Once the mix has been designed and prepared, ensure that enough material is available to make additional tests for durability.

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