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Review of Ultra-High Performance Concrete and Cost Impact of UHPC in Durability Aspects

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***Abstract*:- The development in mineral admixtures and chemical admixtures leads to the development of several types of high quality concrete. These types of concrete typically include high strength concrete, high performance concrete and fiber reinforced concrete. The further advancement in concrete technology has resulted in a new type of concrete called Ultra-High performance concrete(UHPC).UHPC was first known as reactive-powder concrete since it contained only very fine materials. The main objective of this paper is to study the UHPC and its cost efficiency in India. . UHPC is exhibited to possess very high strength, elastic modulus, ductility and brilliant durability properties. The reported results are in the range of: compressive strength > 150 MPa, flexural tensile strength > 25 MPa, modulus of elasticity > 50 GPa. UHPC has many advantages over conventional concrete but is still in limited practice due to limited design codes and high cost As far as the constituents are concerned, steel fibers, finer silica sand and silica sand amounted for nearly half of the total cost. Despite the higher cost of UHPC, it has the advantage of having longer lifespan.**

Keywords: UHPC, Expenditure, Life span

1. INTRODUCTION

Modern Civil Engineering construction tends to progress towards more economic design and construction of structures through gradually improved methods of design and the use of higher strength materials. The application of Ultra-High performance concrete has overcome the limiting features of ordinary reinforced. A Ultra-High performance concrete is a concrete in which certain characteristics are developed for a particular application and environment so that it will give excellent performance in the structure in which it will be replaced, in the environment to which it will be exposed and with the loads to which it will be subjected during its design life. It is a class of concrete defined by its exceptionally high strength and durability. It is a cementitious, concrete material that has a minimum specified compressive strength of 17,000 pounds per square inch with specified durability and toughness requirement.

2. CONTENT

To produce UHPC by the usage of silica fume and steel fiber. The UHPC can be prepared by SF, FAC, GGBS, local river sand, masonry sand, quartz sand, HRWR, steel fiber etc,… of these materials steel fibers are mandatorily used source material in production of UHPC. Straight steel fibers with 0.2 mm diameter and 13 mm length were used to enhance mechanical properties. The tensile strength and elastic modulus of the steel fiber are 1.9 and 203 GPA respectively. This paper studies the UHPC and its cost effectiveness.

2.1Cost Effectiveness

Nowadays, high-performance concrete (HPC) and ultra-high-performance concrete (UHPC) are ranked among advanced concrete technologies. The application of the mentioned advanced technologies may have potential to improve the construction efficiency from several points of view. For instance, reducing of construction time and construction material, construction quality improving, environmental impact minimizing, and increasing of both durability and lifetime of structures as well as reducing of total construction costs may be obtained.

2.1.1 In Rehabilitation

For the last 30 years, most of the concrete structures expose to severe environmental conditions are required for strengthening or rehabilitation. Many of these severe environmental conditions are the result of cold climate conditions such as low temperature, freeze thaw action and exposure to deicing salts etc. Because of this, the environmental durability of the repair materials and methods used in strengthening or rehabilitation applications are of greatest importance, especially in aggressive climates (Emmons 1993). Rehabilitation and strengthening of deteriorated concrete structures is a heavy burden from the socio-economic viewpoint since it also leads to significant user costs During this rehabilitation works, UHPC can be used to stiffen and strengthen the zones where the concrete structures are exposed to severe

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environmental conditions such as deicing salts, marine environment; and high mechanical loading such as regions subject to impact loading, concentrated loads and fatigue loads. All other parts of the concrete structure remain in ordinary structural concrete as these parts are subjected to relatively moderate exposure.

2.1.2 During Construction

Last advances in material engineering permit producing the concrete whose performance is higher than of the HPC. Those are so-called ultra-high-performance concrete (UHPC). Higher strength, durability, and aesthetic value of monolithic and/or precast concrete structures can be achieved by using materials based on advanced concrete technologies (HPC and UHPC). Specific properties of concrete based on mentioned technologies enable designing lighter and thinner elements utilizing material flexibility.

The technical parameters are typical for a finished structure and are in this case represented by mechanical properties, for example, compressive strength flexure strength, modulus of elasticity, resistance to environment influences (almost zero permeability of the composite), and high durability. The technological parameters characterizing fresh and placed UHPC involve such parameters as high fluidity, ability to flow, fill out the formwork, and flow off the reinforcement, self-levelling, resistance to segregation, and separation. The usage of UHPC has permitted reduction of intersection of the element or reduction of amount of the stringer, herewith fixed load and so cost on material could be reduced. Moreover, time necessary for formwork dismantling, eventually time for structure supporting after formwork dismantling, is reduced.

2.1.3 During life-cycle

The UHPC is characterized by high compressive strength and excellent durability properties resulting in lighter structures and longer life. Different approaches have been adopted by researchers in achieving ultra-high strength and associated other improved performances. As a result, several types of UHPC are available today

One of the significant breakthroughs in concrete technology in the 20th century was the development of ultra-high-performance fibre reinforced concrete (UHP-FRC) or reactive powder concrete (RPC) more commonly known as ultra-high-performance ductile concrete (UHPDC), a cementitious based composite material consisting of the distinctive characteristics of the ultra-high-performance concrete and high tensile strength steel fibres As a new generation of ultra-high-performance sustainable construction material, it is mostly appropriate for use in the fabrication of precast members in civil engineering, structural, and architectural applications. The elimination of the conventional steel reinforcement bars and stirrups can lead to considerable savings in human labors, supervision, and quality control. Therefore, the construction time and labor costs may also be drastically reduced, which will result in saving immediate projects costs. In addition, it will lead to saving considerable maintenance costs and also long-term service costs.

Also, handling, transportation, and installation of UHPDC members are more convenient due to the ultra-light weight property of UHPDC, usually by a factor of two, compared to conventional reinforced concrete or pre-stressed concrete elements. This leads to additional cost savings and increasing safety margins in the construction procedures. On the subject of sustainability, UHPDC technology is a green technology supporting the concept of sustainable development. Using UHPC enables slender sections thereby, using less cement in the concrete and using less concrete in the members. Some preliminary savings in terms of cost, lower embodied energy, and CO_2emissions can be achieved compared to conventional approaches. Its sustainability is even more considerable than other types of concrete with respect to life-cycle

MIX DESIGN

Mix design is one of the most crucial works of UHPC preparation. It aims at perfecting the properties of concrete in fresh and hardened states. The particle packing theory is employed for optimization of the granular density of UHPC. Particle packing theory has been utilized as the important thought for mix design regarding improvement in workability, strength and durability (Schmidt and Fehling, 2005).Materials of varying particle sizes is used to accommodate the near perfect dense mixture. Constituents like nano silica, silica fume, rice husk ash, fly ash, fine aggregate of different sizes and coarse aggregate of well gradation is employed to excel the mixture. Fibres can be into UHPC for improving the ductility and energy absorption capacity of concrete, the term ultra-high performance fibre reinforced concrete (UHPFRC) is then used. Micro fibers and macro fibers are sometimes used. Micro fibers are recorded to improve toughness and control micro cracks. In actuality the modification of the existing UHPC mixtures are calculated by trial and error method and it is very much preferred for UHPC mix design. The triumph of this practice is curbed due to various sources for the employed materials. There are many challenges starting a UHPC design using locally available materials

CONCLUSION

UHPC offers a range of new opportunities for concrete structures. The mix design of UHPC includes large amounts of cement, fillers like nano silica, silica fume, fly ash and admixtures, and a cube strength of 180 N/mm2 can be achieved without any special curing. The preparation of UHPC was ventured by using very fine sand as fine aggregate rather than normal sized aggregate, densified silica fume as highly active pozzolan, and high range water reducing agent, and micro steel fibers and macro steel fibers with very low water/cement ratio (w/c).

Most of the investigators opine that, UHPC is highly expensive than traditional concrete. The price of UHPC develops from its steel fiber reinforcement, so the amount of money spent of the substance is largely due to the cost of this ingredient. Supplementary cost improvements with UHPC above traditional concrete involve decreased

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construction period and improved available floor space or overhead clearance. The application of longer spans with UHPC segments could decrease the estimate of construction schedule. The prophesied longer service life and economical maintenance costs of UHPC could reach to even more cost advantages of UHPC.

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