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Comparison between Normal Concrete and Ultra High Performance Concrete

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Abstract: Over the last twenty years, remarkable advances have taken place in the research and application of ultra-high performance concrete (UHPC), which exhibits excellent rheological behaviour's that include workability, self-placing and self-densifying properties, improved in mechanical and durability performance with very high compressive strength, and non-brittleness behaviour.
It is the 'future' material with the potential to be a viable solution for improving the sustainability of buildings and other infrastructure components. This paper will give an overview of UHPC focusing on its fundamental introduction, design, applications and challenges.
After several decades of development, a wide range of commercial UHPC formulations have been developed worldwide to cover an increasing number of applications and the rising demand of quality construction materials.
UHPC has several advantages over conventional concrete but the use of it is limited due to the high cost and limited design codes. This paper also aims to help designers, engineers, architects, and infrastructure owners to expand the awareness of UHPC for better acceptance.

I. INTRODUCTION

Joints are one of the most critical components of bridge elements and are often considered the weakest link in structures. In continuous span structure, joints are often designed where they are less moment or near the inflection points (zero moment). Failure of any structure begins with the failure of connections since they are not designed to withstand the substantial amount of loads to which a structure is subjected to throughout its service life. Joints are responsible for transferring loads from different components of super structure to sub-structure which keeps the chain of load-transfer intact. However not much importance is given to design of these elements which bear such an important role.In pre-cast prestressed bridges, joints are filled with High-strength Self Consolidating Concrete (HS-SCC) usually 6 to 10 ksi (41 to 69 MPa), while in reinforced cast-in-place (CIP) bridges, joints are often cast with conventional concrete (CC) which are not designed to be very strong (3 to 5 ksi /21 to 35 MPa) or durable. Ultra-High Strength Concrete (UHSC) is relatively a new material which has been eye of many researchers in the recent past. UHSC might just be the solution to look for in case of joints.

1) What is silica fume?

Silica fume is also known as micro silica; (CAS number 69012-64-2and EINECS number 273-761-1) is an amorphous (non-crystalline) polymorph of silicon dioxide, silica. It is an ultrafine powder collected as a byproduct of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150mm. The main field of application is as pozzolanic material for high performance concrete.
It is sometimes confused with fumed silica (also known as pyrogenic silica, CAS number 112945-52-5).

2) Chemical Composition Of Silica Fume

Chemical composition of silica fume will mostly depend upon composition of the principle product being made by furnace. Additionally, the composition is also influenced by the furnace design; generally a furnace with a heat recovery system produces silica fume with lower ignition loss the SiO2 content of silica fume varies with the silica content of alloy being producer unlike other by product pozzolans such as fly ash, silica fume from a single source is little or no variation in chemical composition from one day to another.

3) History of Silica Fume

The first testing of silica fume in Portland- cement -based concrete was carried out in 1952. The biggest drawback to exploring the properties of silica fume was a lack of material with which to experiment. Early research used an expensive additive called fumed silica, an amorphous form of silica made by combustion of silicon tetrachloride in a hydrogen-oxygen flame. Silica fume on the other hand, is a very fine pozzolanic, amorphous material, a by-product of the production of elemental silicon or ferrosilicon alloys in electric arc furnaces. Before the late 1960s in Europe and the mid-1970s in the United States, silica fumes were simply vented into the atmosphere material. Silica fume provide high strength to concrete. Silica fume is used to replace 0% to 15% of cement by weight at increment of 5% for cube

4) Production of silica fume

Silica fume is a by-product in the carbothermic reduction of high purity quartz with carbonaceous materials like coal, coke, wood-chips, in electric arc furnaces in the production of silicon and ferrosilicon alloys.

5) Properties of silica fume

The diameter of the silica fume particle ranges from 0.1 micron to 0.2 micron. The surface area about 30000 m^2/kg. Density varies from 150 to 700 kg/m^3 but when it is about 550 kg/m^3, it is best suited as a concrete additive.

A. Objectives

1) To improve the properties of concrete by using silica fume.
2) To increase a high compressive strength of concrete.
3) To improve high durability of the concrete.
4) To find the optimum percentage of silica fume in cement. So that we can achieve maximum strength.
5) To reduces segregation and bleeding in concrete.

B. Advantages

1) Reduced material usage
2) Increased life span
3) Improved sustainability
4) Reduced permeability

C. Disadvantages

1) High material cost
2) Increase labor cost
3) Specialized equipment required
4) Difficulty in achieving proper curing

II. METHODOLOGY

A. Material Selection

1) Cement =High strength cement with low alkali content is typically used.
2) Aggregate=Fine aggregate is used to improve bonding.
3) Silica fume=it is used in replacement of sand (20% of sand).

B. Mixed Design

1) Proportioning= Materials are proportioned to achieve optimal packing density and paste aggregate bonding.
2) Water cement ratio= Low water cement ratio (typically < 0.25) is used to minimize porosity and improve strength

C. Mixing and Processing

1) Temperature Control = Mixing and casting are typically done at controlled temperature (eg. 20-25°C).
2) Casting And Finishing = UHPC is cast into molds and forms and finished using specialized techniques.

D. Curing and Testing

1) Curing = UHPC is typically cured at controlled temperature and humidity levels to optimize hydration and strength development.
2) Testing = Mechanical properties compressive strength.

III. COMPRESSION STRENGTH TEST RESULT OF NORMAL CONCRETE

Sr No.	Sample	Loads (KN)	Area (mm^2)	Strength (N/mm^2)
1.	7 days	(a) 427.4	150x150	18.99
		(b) 450	150x150	20.64
		(c)464.0	150x150	20.62
2.	14 days	(a) 460.4	150x150	20.46
		(b) 470	150x150	24.40
		(c)496.0	150x150	22.04
3	28 days	(a) 550.0	150x150	24.44
		(b) 575.0	150x150	25.55
		(c) 598.0	150x150	26.58

IV. COMPRESSION STRENGTH TEST RESULT OF UHPC CONCRETE

Sr No.	Sample	Loads (KN)	Area (mm^2)	Strength (N/mm^2)
1.	7 days	(a) 472.3	150x150	20.99
		(b) 484.4	150x150	14.94
`		(c) 478	150x150	21.24
2.	14 days	(a) 585.7	150x150	26.03
		(b) 575	150x150	22.54
		(c) 581	150x150	25.82
3	28 days	(a) 620.0	150x150	27.55
		(b) 675	150x150	30
		(c) 660	150x150	29.33

V. DIFFERENCE BETWEEN NORMAL AND UHPC CONCRETE

NORMAL CONCRETE	UHPC CONCRETE
A mixture of cement, water, aggregates (sand, gravel, or crushed stone), and admixtures.	A combination of cement, silica fume, fine aggregates, water, and admixtures a low water-to-cement ratio.
Relatively inexpensive and widely available.	More expensive due to the high-quality materials and specialized production process.
Has a significant environmental impact due to cement production and transportation.	Offers improved sustainability due to its:1. Reduced cement content. 2. Lower water consumption.
Suitable for general construction, such as buildings, roads, and bridges.	Ideal for high-performance applications, including: 1. High-rise buildings and skyscrapers. 2. Long-span bridges and structural components.
May deteriorate over time due to environmental factors.	Exhibits exceptional durability and resistance to degradation.

VI. CONCLUSION

Ultra-High Performance Concrete (UHPC) has demonstrated exceptional mechanical and durability properties, making it an ideal material for various structural applications. With its unique combination of high strength, toughness, and sustainability, UHPC offers numerous benefits over traditional concrete, including:

1) Enhanced structural integrity and safety
2) Reduced material usage and environmental impact
3) Improved durability and lifespan
4) Increased design flexibility and architectural possibilities

VII. FUTURE WORK

While Ultra-High-Performance Concrete (UHPC) has demonstrated remarkable mechanical strength, durability, and sustainability, further research is needed to enhance its practicality and widespread adoption. The following areas are recommended for future investigation like :- Cost Optimization, Sustainability & Environmental Impact, Structural Applications, Durability Under Extreme Conditions, Advanced Manufacturing Techniques, Hybrid Composites & Reinforcement, Numerical Modeling & AI Integration

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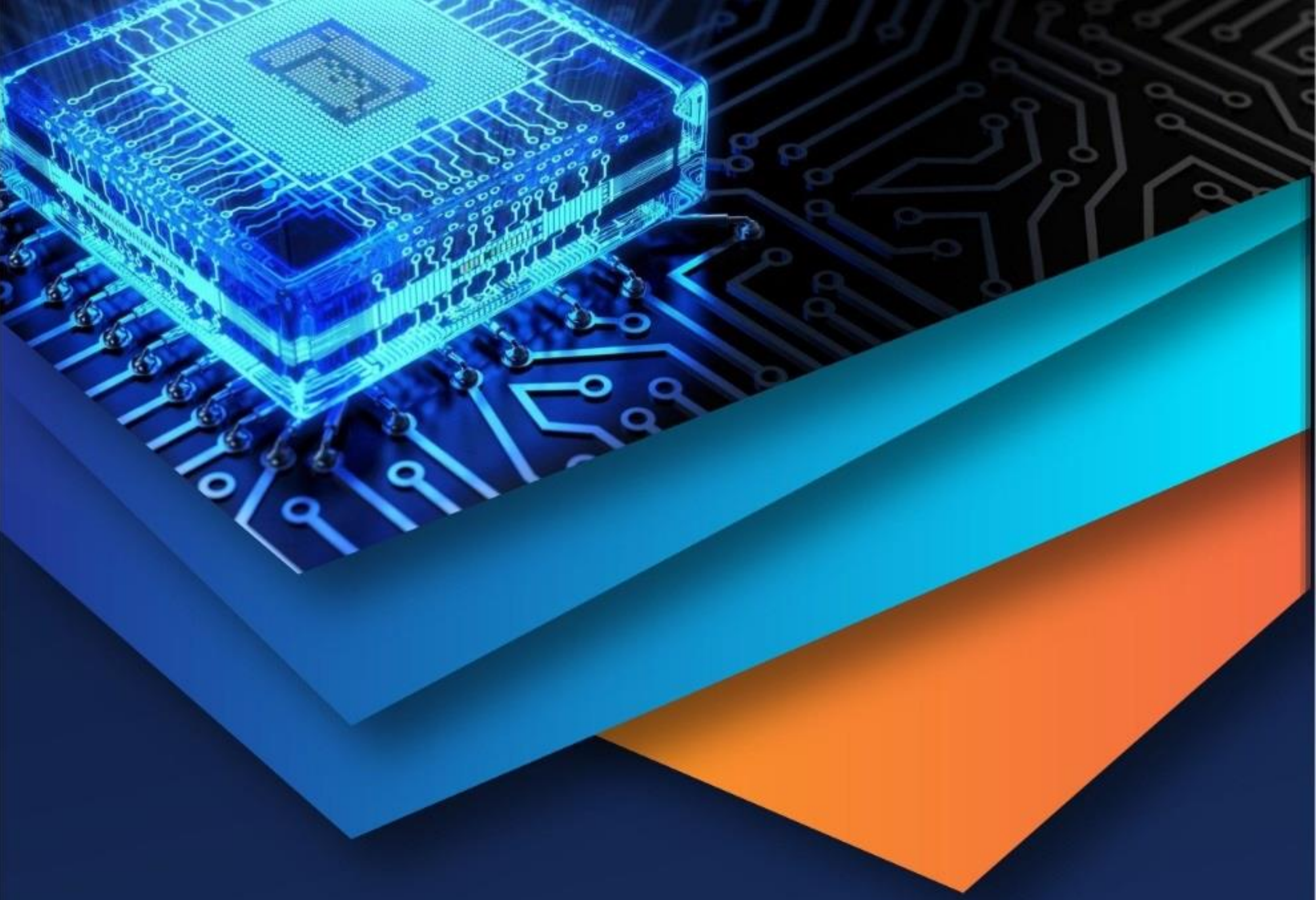

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