Review Paper on Experimental Investigation on Effect of Ultra Fine Material on High Strength Concrete

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ABSTRACT

This paper presents the use of ultra-fine materials in High Strength Concrete (HSC) as a novel approach to enhance its mechanical and durability properties. This report focuses on he utilization of Ultra-fine Ground Granulated Blast Furnace Slag (UFGGBS) as an SCM in concrete while GGBS have been widely used as a partial replacement for cement ,limited research has been conducted on the effect of ultra-fine GGBS. This experimental investigation explores the incorporation of ultra-fine materials, specifically nanoparticles, into HSC Mixtures to achieve superior performance characteristics. The study focuses on assessing the impact of various types and dosages of ultra-fine materials on the compressive strength, Flexural strength and durability properties of HSC. In this research , ultra-fine materials including river sand , GGBFS,stone dust and super plasticizes are incorporated into HSC Mixture at different proportions. Ultra - fine GGBS can enhance the strength and durability of concrete while reducing its carbon foot print. Concrete mixes of M60 Grade were formulated with varying percentages (5%, 10% , 20%,25%, 30%) of ultra-fine GGBS replacing cement. The finding of this study provide valuable insight into the effectiveness of incorporating ultra-fine materials in HSC mixtures. The findings show that incorporating ultra-fine materials considerably enhances the mechanical strength and durability of high-strength concrete (HSC). Additionally, the research determines the most effective amounts and combinations of these materials to optimize performance, providing useful insights for their practical use in HSC manufacturing. Overall this research contributes to advancing the understanding of utilizing ultra-fine materials in HSC mixtures, paving the way for the development of high performance and sustainable concrete materials for various construction applications.

Keywords :- Ultra-fine materials, High strength concrete, Ground Granulated Blast Furnace Slag, Super plasticizers.

I. INTRODUCTION

High strength concrete is typically defined as the concrete with a compressive strength exceeding 50 Mpa (7,000 psi), offers enhanced durability and structural performance enabling slimmer more durable structures and reduced material usage compared to conventional concrete. This impressive strength is the result of choosing the right materials, using exact mixing ratios, and following careful curing methods. The superior strength of high-strength concrete (HSC) makes it possible to build slimmer and lighter structures, which helps increase the amount of usable space. In high-rise buildings, HSC is commonly used to construct thinner columns and beams, allowing for more open and functional floor areas. HSC is used in the bridge construction to allow for the longer span and reduced girder size. The durability and strength of high-strength concrete (HSC) make it ideal for use in tough marine conditions where structures are exposed to saltwater, moisture, and harsh weather.

Key component to achieve high strength concrete are given as below.

Cement:-Using high quality cement with low water- to- cement ratios is typically used to increase strength

Aggregates :- The type and quality of aggregates, both fine(sand)and coarse (gravel/ crushed stone), play a vital role, using a high quality, well graded aggregates contributes to the overall strength and durability.

Admixtures :-Admixtures, such as super plasticizers can improve workability and allow for lower water content , leading to higher strength and durability.

Key Factor to achieve high strength concrete are given as below.

Water -to -cement ratio :-A lower water cement ratio is essential for achieving high strength. Less water allow for denser, more compact concrete matrix, leading to increased strength and reduced permeability.

Compaction :-Proper compaction during placement and finishing is crucial for eliminating voids and ensuring a dense , strong concrete structure.

Curing:-Adequate curing , maintaining moisture and temperature, is vital for the hydration process of cement, which is essential for developing strength and durability.

Temperature :-Maintaining the temperature of concrete during the curing process is important as higher temperatures accelerate hydration and strength development.

Age:-Concrete gain strength over time , so the age of concrete is an important factor in its strength and durability

Technology:-Technological advancement in concrete mix design and production are also playing a crucial role in the development of high strength concrete.

Raw material quality :-The quality of the raw materials used to make concrete s a crucial factor that affects the final strength and durability of the concrete.

Ultra fine Materials :-

Ultra-fine Materials such as , nanoparticles or nanoscales additives, can enhance there properties of high strength concrete.This Material are typically used to Improve the strength, durability and other characteristics of concrete. Common ultra fine materials used in a high strength concrete include: GGBS, Fly ash, Nano silica (nanao-Sio2) ,Nano Alumina (nano-Al2O3), carbon Nano tubes (CNTs), Graphene Oxide (GO), Nanaofibres, Nano- Clay, being an extremely fine material, is usually added in small amounts. To achieve the desired concrete properties, it is important that the clay is evenly distributed throughout the mix and that it blends well with the other components. Incorporating these materials can result in high-strength concrete with improved performance characteristics.

Advantages of High strength concrete :-

i. High durability (e.g. abrasion and carbonation resistance)

ii. High resistance to weight ratio, particularly for lightweight HSC

iii. High early strength allows faster construction and form work reuse.

iv. Longer span and fever beams for the same magnitude of loading.

v. Reduced axial shortening of compression supporting members.

vi. Low creep and Shrinkage.

vii. Greater stiffness as a result of a higher Modulus of EC.

viii. Reduced maintenance and repairs.

ix. Smaller depreciation as a fixed cost.

I. Disadvantages of High strength concrete :-

i. Using Ultra-fine Material like GGBS in high strength concrete can lead to disadvantages such as Slower early - age strength development.

ii. Potential issues with workability, and increased cost, although it also offers benefits like improved durability.

iii. While GGBS - blended concrete exhibits improved strength at later ages (56 days and beyond), the initial Strength development can be a slower compared to ordinary Portland cement concrete.

iv. This can be concern for project requiring rapid construction or early form work removal.

v. The high fineness of GGBS can lead to increased water demand and potentially reduced workability , especially at higher replacement levels.

vi. This can make the concrete more difficult to place and compact, requiring adjustments to mix design and construction techniques

vii. Ultra- fine GGBS may be a more expensive than standard GGBS, contributing to the overall cost of the concrete mix.

viii. However the the long term benefits of improved durability and reduced cement usage can offset these costs in some cases.

ix. The high fineness and reactivity of ultra-fine GGBS can lead to increased drying shrinkage , potentially resulting in cracking m especially in structures exposed to rapid drying conditions.

x. Ultra-fine GGBS may not be readily available in all regions or for Smaller scales concrete production, which can pose logistical Challenges.

xi. The supply of GGBS itself is also becoming limited as blast oxygen furnaces (BOFs) are phased out.

II. MATERIALS USED

The components used in high-strength concrete include cement, fine aggregates (like sand), coarse aggregates (such as gravel or crushed stone), and water. Additionally, admixtures can be added to improve specific characteristics of the concrete. For example, Ground Granulated Blast Furnace Slag (GGBS) is often used to enhance durability and strength.

Cement :- Cement is a binding material in construction, used to bind the sand and gravel (aggregate) together, forming concrete.OPC "53 Grade" indicates that the cement reaches a minimum compressive strength of 53 MPa after being cured for 28 days. The cement has a specific gravity of 3.15, meaning it's 3.15 times heavier than water. Its initial setting time is 45 minutes, which refers to the time it takes for the cement to start hardening after water is added.

2. Fine Aggregate (River sand):- River sand serves as the fine aggregate in the concrete mix. It has a specific gravity of 2.68, meaning it is 2.68 times denser than water. Water absorption by fine aggregate is 0.8%. Based on the sieve analysis, the fineness modulus of the fine aggregate is found to be 3.13. This value gives an indication of the average size of the particles in the sand, with a higher value suggesting coarser material.. of zone ll .

3. Coarse Aggregate :-

Coarse aggregates are a vital part of high-strength concrete. They are usually made up of crushed stone, gravel, or a mix of both. These aggregates add volume and help stabilize the concrete mix, improving its overall strength and durability. The size and shape of the coarse aggregates also affect how easy the concrete is to work with and influence its mechanical performance.. Properly graded and well shaped coarse aggregates help to reduce voids and improve the packing of particles, resulting in higher strength and better performance of the concrete mix. Specific gravity of the coarse aggregate is 2.86. Water absorption by them is 0.40%. Size of coarse aggregate is taken as 38% of 10mm size aggregate and 62% of 20mm.

4. Water :-

Water plays a crucial role in the concrete mix, including high-strength concrete. It is essential for the chemical reaction with cement (hydration) and helps in making the mix workable and easy to place. It activates the cement by hydration process, allowing cement particles to react and bind together with aggregates, forming a solid matrix. Using the correct amount of water is very important because too much water can reduce the strength of the concrete and make it less durable. Maintaining the proper water-to-cement ratio is key to producing high-strength concrete with the desired performance and quality.

5. Admixture:-

Admixtures are additives used in small quantities to modify various properties of concrete, Like strength, durability, workability, to increase or decrease setting time etc. Here Ultra-fine, GGBS is used as an admixtures It's grey in colour.

6. Super plasticizer:-

Super-plasticizers are commonly used in high strength concrete to improve workability without sacrificing strength. They are typically high range water reducers that allow for significant reduction in water content while maintaining the desired slumps or flow characteristics. These additives enable the production of high strength concrete with lower to water cement ratios, resulting in enhanced strength , durability and overall performance.

Parameters	**Observation**
Product Name	CAC -Hyperfluid plus H7
Appearance	Light Brown Liquid
Base Material	Poly Carboxylic Ether Polymer
Specific gravity @25℃	1.116
PH	7.39

Ultrafine GGBS:-

Ultra-fine Ground Granulated Blast Furnace Slag (GGBS) is highly reactive, low calcium silicate mineral- based additives, used in concrete to enhance strength, durability and workability, and is produced by quenching molten iron slag from a blast furnace. Ultra-fine GGBS has a controlled particles size distribution ,resulting in high reactivity and enhanced hydration processes. It's a hydraulic additive, meaning it reacts with water to form cementitious compounds. Enhances concrete's strength and durability, especially in harsh environments. Helps to reduce the water- to-binder ratio in concrete mixes, leading to denser and more durable concrete.It's help to reduce shrinkage cracking in concrete.

III.

Physical Analysis	Value obtain	Limit as per IS 16715 - 2018
Partical size µm D50 D95	 3.95 14.16	 5,Max 15, Max
Fineness, m^2/kg (BET Method)	1667	1500, Min
Slag Activity Index % 7 days 28 days	 95 109	 85, Min 100, Min
Specific Gravity	2.89	

LITTÉRATURE REVIEW

i. Shradhanand Tiwari and A.K. Tiwari, (June 2024), Ultra-fine GGBS and ultra-fine fly ash as a cement replacement to mitigate the environmental impact of concrete.

This research paper investigate maximizing cement replacement in concrete with ultra-fine fly ash and GGBS to create more sustainable concrete without sacrificing mechanical properties. It comprehensively reviews concrete's environmental impacts, analyzes Strategies for reduction (including CCU, recycled materials and alternative materials,)and identifies future research opportunities in sustainable concrete production.

ii. J.Brooks, M.A.Megat Johari, M. Mazloom (April 2000) effect of admixture on the setting time of high strength concrete.

The effect of Silica fume (SF), Meta-kaolin (MK), Fly ash (FA), and Ground granulated blast furnace slag (GGBS)on the setting of high- strength concrete was investigates using the penetration resistance method (ASTM C 403). Additionally the effect of a shrinkage reducing admixture (SRA) on the setting time of normal ad high strength concrete was studied The following conclusions were drawn:

iii. A.Oner , S.Akyuz (July 2007) An experimental study on optimum usage of GGBS for the compressive strength of concrete.

This Paper investigates the effect of adding ground granulated blast furnace slag (GGBS) on the compressive strength of concrete. A total of 32 different mixtures were created, where Ground Granulated Blast Furnace Slag (GGBS) was used to replace between 0% and 110% of the cement, across four groups with varying amounts of total binder content. Control mixtures with varying cement amounts were used to calculate Bolomey and ferret coefficients. Concrete samples were allowed to harden and were then tested for how much pressure they could withstand at different stages. The tests revealed that the concrete's strength increased as more GGBS (Ground Granulated Blast Furnace Slag) was added, reaching its highest strength when about 55% of the total binder was made up of GGBS. Beyond this point, the strength did not improve further due to unreacted GGBS acting as filler.

iv. Susanto teng, Tze Yang Darren Lim, Bahador Sabet Divsholi (November 2012) Durability and Mechanical properties of high strength concrete incorporating ultra fine Ground Granulated Blast Furnace Slag.

Ultra -Fine Ground Granulated Blast Furnace Slag (UFGGBS)has a large Surface area, enhancing hydration and Pozzolanic reactions. Adding it makes the fresh concrete easier to mix, handle, and place with a more uniform texture." UFFGGBS -blended concrete showed a 12.5% increase in compressive strength at 3 days in mix B compared to control mixes.

v. Dr. P.Muthupriya (August 2013) An experimental investigation on effect of GGBS and glass fibre in high performance concrete.

GGBS - based high performance concrete (HPC) can achieve higher strengths. Experimental results show that GGBS can be used as an alternative to cement, with increased compressive and split tensile strengths as GGBS percentage increases. The increase in strength is mainly because GGBS acts as a filler and glass fibers enhance the concrete's properties. GGBS can serve as a substitute for cement, and test results indicate that replacing 7.5% of cement with GGBS gives good performance. Adding superplasticizer reduces concrete strength due to a chemical reactions with GGBS.

vi. Subhash Thanappan High strength concrete using Ground Granulated Blast Furnace slag (GGBS) July 2014

Concrete tends to be brittle under heavy loads, ljeading to cracks. To enhance its strength and Durability, Ground granulated blast furnace slag (GGBS) is used. GGBS is produced by rapidly cooling molten iron slag, a by product of steel manufacturing, with water or steam. When combined with ordinary Portland cement and /or other Pozzolanic materials, GGBS improves the concretes ultimate strength and durability . Concrete containing GGBS develops higher strength over time, often doubling its 28 days strength after 10 to 212 years , The project aims to compare the compressive strength of concrete made with Portland cement (PCC) versus GGBS , Focusing on how replacing a portion of cement with GGBS affects the concrete performance.

vii. Quaid Johar Bhattiwala Kuldeep Dabhekar (May 2016) Effect of cementitious waste Material (GGBS) on a concrete as a replacement in cement.

Increasing concrete workability typically decreases compressive strength, but strength improves with 40% replacement.

At 7 days concrete with 40% replacement achieved the highest strength , 9% more than control concrete.

At 28 days , strength decreased compared to control concrète, but increased by 6% at 30% replacement.

At 90 days , compressive strength increased up to 40% replacement , then decreased.

Flexural strength increased by 24% at 30% replacement and 28% at 40% replacement, then decreased with higher percentages.

Particles packing theory explain s that the finer particles of GGBS enhance bonding , making 40% GGBS and 60% cement mix stronger due to better particle bonding.

viii. Ardra Mohan , K.M.Mini (20 May 2018) strength and durability studies of SCC incorporatingsilica fume and Ultra fine GGBS .

The studies addresses the high cost and environmental impact associated with self compacting concrete (SCC) due to its use of large amount of cement and Synthetic admixtures. It explore the potential of reducing these drawbacks by using supplementary cementitious material (SCMs) like Silica fume and Ultra fiber Ground Granulated Blast Furnace slag (GGBS). The research involved experimental testing of SCC by varying the proportions of SCMs and adjusting the superplasticizer dosage while maintaining a fixed water- binder ratio. The best results in terms of both mechanical properties and durability were achieved by incorporating 10% silica fumes . A statistical Design of experiments (DOE) approach was used to optimize the mix , determining the ideal combination as 6% silica fume and 8% alccofine with experimental results aligning with DOE predictions.

ix. M. Pradeep Kumar, K.M.Mini, Murali Rangarajan (10 September 2018) Ultra-fine GGBS and Calcium nitrate as concrete admixtures for improved the mechanical properties and corrosion resistance.

This work investigates the enhancement of concrete properties by modifying Ordinary Portland cement with ultra-fine Ground Granulated Blast Furnace Slag (GGBS) and calcium nitrate. Ultra-fine GGBS , with a particle size of 4-6µm, was used to replace 10% of the cement, While calcium nitrate was added at 2% of the cementitious material. The study found that the addition of GGBS increased the silica content in concrete, concerting calcium hydroxide to calcium silicates. This modification improved the compressive strength (by 18%) and bond strength of steel rebar (by 45%), although it reduced workability and water absorption. Adding a calcium nitrate further enhanced these properties , increasing compressive strength by 32% and bond strength by 131% while also reducing water absorption and making the concrete more alkaline. The study also showed a significant reduction in corrosion rates, with corrosion currents in GGBS and nitrate modified concrete decreasing by up to 480 - fold compared to the control. The corrosion potential was affected differently by the two mixtures , with GGBS retarding the cathodic reaction and calcium nitrate promoting the formation of a protective passive film . Scanning electron microscopy revealed reduced pitting and inter granular corrosion due to the admixtures. Overall study demonstrates that using Ultra-fine GGBS and calcium nitrate improves the mechanical and corrosion - resistant properties of concrete.

x. Luo Ting , Wang Qiang , Zhuang Shiyu (November 18) Effects of Ground Granulated Blast Furnace slag on initial setting time , Fluidity and rheological properties of cement pastes.

Ultra fine GGBS (UFS) as a substitute for cement accelerates the hydration of the admixtures paste. The initial setting time depends on both dosage and Fineness of UFS . at the same dosage , Finer particles (V2) result in a shorter initial setting time than coarser particles (V1), Electrical resistivity result indicated that UFS does not affect the dissolution period but shortens the induction period, there by reducing the initial setting time of the paste.

xi. Luo Ting , Wang Qiang , Zhuhang Shiyu (1 March 2019) Effect of Ultra-fine Ground Granulated Blast-Furnace slag on initial setting time , Fluidity and rheological properties of cement pastes.

The study investigated the effect of ultra-fine Ground Granulated Blast Furnace Slag (UFS)on the setting time , Fluidity and rheological properties of cement paste systems. The addition of UFS accelerates the initial setting time , with faster setting observed as UFS dosage increases. The Fineness of UFS particle s are also shortens the setting time. However, UFS negatively impact fluidity , with higher dosages reducing the paste's initial fluidity . Despite this, using polycaboxylate superplasticizer (PCE) with UFS can maintain the fluidity due to a Synergistic effect that PCE's dispersing efficiency.

Rheologically , UFS increases both yields stress and plastic viscosity ,making the paste thicker and more resistant to flow . shear stress parameters also rise with higher UFS content .Adding PCE to the UFS - cement system reverses these effects, decreasing shear stress parameters and indicating a positive synergy between UFS and PCE that improves the paste's rheological properties.

xii. Dejian Shen, Yang Jiao, Yan Gao, Shuaishuai Zhu, Guoqing Jiang (April 2020) Influence of Ground granulated blast furnace slag on cracking potential of high performance concrete at early age.

In the present study, tests on the early age cracking potential of high - performance concrete (HPC) under adiabatic conditions at full uniaxial restraint using the Temperature stress Testing Machine (TSTM) were conducted. The influence of ground granulated blast furnace slag (GGBFS) on the temperature history, shrinkage, restrained stress

,stress reserve, and integrated criterion of HPC with different contents of GGBFS (0% ,20% ,35% and 50%) was investigated. The following conclusions were drawn from the obtained results:

Temperature History : GGBFS significantly influences the temperature evolution during the hydration process of HPC.

Shrinkage : The inclusion of GGBFS affects the shrinkage behavior of HPC, with varying content leading to different shrinkage rates.

Restrained stress : The development of Restrained stress in HPC is impacted by the amount of GGBFS, with higher contents typically reducing the restrained stress.

Stress reserve :- The ability of HPC to resist cracking , indicated by the stress reserve, is influenced by the GGBFS content , with optimal levels improving this reserve.

Integrated Criterion :- The overall performance of HPC ,considering factors such as temperature history , Shrinkage , and stress characteristics, is affected by percentage of GGBFS used, with specific contents providing optimal results. These findings highlight the importance of optimizing GGBFS content in HPC to minimize early- age cracking and enhance the material's overall performance.

xiii. Kaliprasanna Sethyl and S Rojalin Nanda (September 2020) Impact of Ultra-fine Ground Granulated Blast Furnace Slag on the properties of High Strength Durable concrete.

Ultra-fine Ground Granulated Blast Furnace slag (UFGGBFS) is an advanced material with excellent Pozzolanic properties that can significantly enhance concrete performance. Its use improves concrete workability, reduces pore connectivity, and lowers permeability, thus enhancing resistance to chloride infiltration. UFGGBFS also reduces the carbon footprint and energy required for concrete production. With a particle size less than 10 micrometers and a high plain surface area (over 600m2/kg),UFGGBFS accelerates hydration and Pozzolanic reactions, providing better filling effects compared to standard GGBFS.

The study evaluates the early mechanical strength and permeability of High strength concrete incorporating UFGGBFS. Five concrete mixes, each with 180 kg/m2 ordinary Portland cement (OPC) and varying amounts of UFGGBFS (0%, 5%, 10%, 15% and 20%), were tested. A total of 145 samples were analyzed for compressive strength, Flexural strength, modulus of elasticity and water permeability.

xiv. Shaheed Ullah, Jawed Ahmad , Aneel Manan, Muhammad Asim, Rahat Ullaf, Asif Ali, (August 2020) Ground Granulated Blast - Furnace Slag (GGBS) as a binding material in concrete.

In this research , Ground Granulated Blast- Furnace Slag (GGBS) was used as a binding material in varying proportions (0%, 10%, 20%, 30%, 40% and 50%) by weight of cement. GGBS enhances concrete workability, achieving the highest slump at 50% substitution due to its ability to fill voids between sand and coarse aggregate. Strength (compressive, Flexural and tensile increased up to 30% GGBS substitution but decreased beyond this point. The Pozzolanic reaction of Sio2 in GGBS with cement's CH creates additional cementitious components, contributing to strength gain over time, especially and environmentally beneficial for concrete productions.

xv. Dr. G.Maheswaran and Dr. A.Geetha Selvarani (August 2021) Experimental investigation on GGBS added concrete with paper sludge as self curing agent.

Workability :The workability of PRCM with GGBS increased up to 40 % replacement but decreased beyond that, becoming a quite stiff. At 40% GGBS ,flow table test result were 4% higher and Vee - Bee test result were 1second lower than conventional concrete (CC)

The workability of PRCM with PS increased up to 25% replacement but decreased beyond that. At 25% PS, flow table test results were 4% higher and Vee -Bee test results were 2 seconds lower than CC.

The workability of PRCM with a combination of GGBS (up to 25%) and PS (15%) increased , with flow table test results 6% higher and Vee- Bee test 1 second lower than CC.

Compressive Strength :-

The compressive strength of concrete with PRCM by GGBS up to 40% increased compared to control concrete, but decreased beyond 40%.

PRCM with 25% PS showed a maximum compressive strength increase of 17.4% at 28 days of self -curing compared to control concrete.

PRCM with 25% GGBS and 15% PS exhibited higher compressive strength than control concrete and other optimal PRCM mixes at different self curing days, with significant increases in strength percentages.

The increases in compressive strength is attributed to highly active mineral admixtures, pore reduction , and a high rate of dissolution in the reactant solution.

The finding indicate that GGBS , PS, and their combination can be used as alternatives to cement ,reducing cement consumption and pollution.

Split tensile strength :- Specimens with 5% , 10% and 50% PRCM by GGBS showed decreased split tensile strength compared to control concrete.

Specimens with 40% PRCM by GGBS exhibited greater tensile strength than control concrete.

The maximum split tensile strength for PRCM by PS was achieved with 25% PS, which was higher than control concrete.

The Mix with 25% GGBS and15 % PS (Mix ID PG31) achieved the highest split tensile strength among all PRCM by GGBS, PS and control concrete specimens.

xvi. Jin Yang ,Jingyi Zeng , Xingyang He , Huachao Hu, Ying Su, Hang Ba, Hongbo Tan (15 November 2021) Eco-friendly UHPC prepared from high volume wet - grinded ultra-fine GGBS Slurry.

The study develop eco- friendly ultra High performance concrete (UHPC) by using a high amount of wet -Ground Ultra-fine ground granulated blast furnace slag (UGGBS), with UGGBS constituting up to 40% of the cementitious materials. This approach significantly enhanced the mechanical properties, micro-structure and hydration of UHPC. The compressive strength of the UHPC with 20% UGGBS increased by 27% and 15% at 3 and 28 days, respectively, compared to a standard mix , even with reduced cement content.UGGBS improved the pore structure and densified the hardened concrete, while also lowering CO_2 emissions and production costs, thus offering both environmental and economic benefits.

xvii. Seelam Srikanth , Chunchu Bala Rama Krishna , T. Srikanth, K.J.N. Sai Nitesh , V.Swamy Nadh, Sanjeev Kumar , and Subhash Thanappan (27 April 2022) Effect of Nano Ground Granulated Blast Furnace Slag (GGBS)Volume % on mechanical behaviour of High performance concrete.

NANO GGBS in high performance concrete shows promising durability at 30 % replacement. High volume of NANO GGBS reduce permeability but can negatively affect durability. Compressive strength decreases with increasing NANO GGBS content, though the 30% mix Performs similarly to ordinary concrete. Porosity and water absorption decreases at 30% replacement but increases at higher levels. values remain acceptable , while surface absorption rises with NANO GGBS . Evaluating the impact of dual blending on HPC permeability and diffusivity is necessary.

Retardation of setting times: - The setting time of High strength concrete were generally retarded when mineral admixtures replaced the part of cement.

Effect of SRA : While SRA had a negligible effect on the setting times of normal strength concrete, it exhibited a significant retarding effect when used with a superplasticizer in high strength concrete.

Influence of GGBS:The inclusion of GGBS at replacement levels of 40% and grater resulted in significant retardation in setting times.

Replacement levels :- Increasing the replacement levels of mineral admixtures generally led to greater retardation in setting times. However of concrete containing MK, this retardation was only observed up to replacement level of 10%

This findings emphasize the need to carefully consider the type and amount of mineral admixtures and shrinkage - reducing admixtures when designing high strength concrete mixes to control setting time effectively.

xviii. Vishvjeethsinh Dilipsinh Rana, Aakash Rajeshkumar Suthar (Deember 2022) High sttrength concrete using GGBS .

The cement industry significantly contribute to environmental pollution , so finding ways to reduce cement demand is crucial , This study explores how using industrial byproducts - silica fume (SF) and ground granulated blast furnace slag (GGBS) - can help. It examines the combined effect of SF and GGBS on the strength properties of concrete compared to regular cement. The research involves testing various mixture ratios for their impact on compression , shear and bending strength. The goal is to identify the optimal replacement level for cement and to assess how blending SF and GGBS can enhance concrete performance . The study also explores a triple mixing approach that combines cement with both SF and GGBS to leverage their beneficial properties for improved concrete.

xix. Irina Kozlova, Svetlana Samchenko and Olga Zemskova (26 February 2023) Physico - chemical substantiation of obtaining an effective cement composite with Ultra-fine GBS admixture.

This research focuses on enhancing construction materials, by analyzing composites with Nano and ultra-fine admixtures , specifically Ground granulated blast furnace slag (GGBS). the study aimed to understand the Physico - chemical processes during the homogenization and stabilization of cement systems with GGBS components and to access the admixture impacts on composite properties.

xx. Serdar Aydm, Bulent Bardan (February 2014) Effect of activator type and content on properties of alkali-activated slag mortars.

In this research, Ground Granulated Blast-furnace Slag (GGBS) was used in concrete in proportions of 0%, 10%, 20%, 30%, 40%, and 50% by weight of cement. GGBS improved workability, with the highest slump at 50% substitution. Compressive, flexural, and tensile strength increased up to 30% GGBS substitution but decreased beyond that. The Pozzolanic reaction of SiO2 in GGBS with cement's CH enhances strength over time, especially at 28 and 56 days. GGBS can improve mechanical properties and is beneficial for concrete production economically and environmentally.

IV. CONCLUSION

1. From the above experimental study the ultra-fine GGBS can be used as cement replacement material.

2. The use of ultra-fine GGBS in high strength concrete offers significant advantages in terms of strength, durability and workability.

3. Its high fineness enhance the Pozzolanic reaction , leading to a denser and more durable concrete matrix.

4. Using a few quantity of ultra-fine GGBS up to 20% increase in a high strength concrete and give better result.

5. Including low water cement ratios, premium cement, well graded aggregates and the use of advanced mixture such as a superplasticizer, proper proportioning and control are essential to reach the desired properties.

6. As compared to 10 ,20 and 25% of replacing ultra-fine GGBS in high strength concrete 30% not increase its target average compressive strength at 28 days.

7. While there are challenges in mix design and curing , the long term benefits of using ultra-fine GGBS make it essential component in high performance concrete applications , especially in projects where durability and strength are critical.

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