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Review on Experimental Study on Mechanical and Durable Properties of Self Curing Concrete by Using Polyethylene Glycol 600 and Light Weight Fine Aggregate

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Abstract- In the present day's concrete is one of the most rapidly used construction materials in civil engineering due to its high-quality durability and its strength. The durability and strength of concrete will be fulfilled only if it is properly cured. For curing of the concrete large amount of water is required so, in recent year's new technique developed known as self-curing in which cure of concrete done by itself by retaining moisture content in the concrete. This paper represents the methods of self-curing concrete and past work done so far in this area. It was found that various chemical admixtures such as (PEG), (PEA), (PVA), (SAP), etc and naturally available material like lightweight aggregate, light expanded clay, wood powder, etc. were used as a self-curing agent. Hence this paper focuses on chemicals used, physical and mechanical properties such as (Compression strength; Tensile strength; workability; durability) of self-curing concrete. Literature reviewed shows the different techniques used for self-curing concrete. Keywords— self-curing concrete; mechanical properties; physical properties; lightweight aggregate (LWA), (PEG), (PEA), (PVA), (SAP).

Index Terms-Sustainability, Polyethylene glycol, Ceramic, Brick, Self-curing concrete, Durability

I. INTRODUCTION

Today concrete is the most widely used construction material due to its good compressive strength and durability. Self-curing concrete is basically a concrete which is cable of flowing in to the formwork. Concrete is a very strong and flexible moldable construction material. It consists of cement, sand, and aggregate (e.g., gravel or crushed rock) mixed with water. The cement and water form a paste or gel which coats the sand and aggregate. When the cement has chemically reacted with the water (hydrated), it hardens and binds the whole mix together. The initial hardening reaction usually occurs within a few hours. It takes some weeks for concrete to reach full hardness and strength. Concrete can continue to harden and gain strength over many years.

Curing of concrete is defined as providing adequate moisture, temperature and time to allow the concrete to achieve the desired properties for its intended use. Self-curing or internal curing is a technique that can be used to provide additional moisture in concrete for more effective hydration of cement and reduced self-desiccation. Evaporation in the initial stage leads to plastic shrinkage cracking and at the final stage of setting it leads to drying, shrinkage and cracking. Curing temperature is one of the major factors that affect the strength development rate. In addition to the normal concrete mix, some additional compounds in proper dosage and materials such as fly ash are used to increase the durability and strength of concrete mix.

Curing is the name given to the procedures used for promoting the hydration of the cement, and consists of a control of temperature and of moisture movement from and into the concrete. Curing allows continuous hydration of cement and consequently continuous gain in the strength, once curing stops strength gain of the concrete also stops. Proper moisture conditions are critical because the hydration of the cement virtually ceases when the relative humidity within the capillaries drops below 80%. Proper curing of concrete structures is important to meet performance and durability requirements. In conventional curing this is achieved by external curing applied after mixing, placing and finishing. Self-curing or internal curing is a technique that can be used to provide additional moisture in concrete for more effective hydration of cement and reduced self-desiccation. When concrete is exposed to the environment evaporation of water takes place and loss of moisture will reduce the initial water cement ratio which will result in the incomplete hydration of the cement and hence lowering the quality of the concrete.

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Various factors such as wind velocity, relative humidity, atmospheric temperature, water cement ratio of the mix and type of the cement used in the mix. Evaporation in the initial stage leads to plastic shrinkage cracking and at the final stage of setting it leads to drying shrinkage cracking. Curing temperature is one of the major factors that affect the strength development rate. At elevated temperature ordinary concrete losses its strength due to the formation of the cracks between two thermally incompatible ingredients, cement paste and aggregates.

Concrete has been the most versatile material used in the construction industry. It is the second most consumed material in the world due to its high compressive strength and durability, which is the mixture of cement, fine aggregate, coarse aggregate and water needs curing to achieve required strength. When cement is added to water, hydration reaction takes place and this hydration process is necessary for hardening of concrete.

Curing is the process to avoid moisture content deficiency from concrete during the hydration process. Effect from curing has a strong influence on the properties of hardened concrete such as it will increase the durability, strength, volume stability, abrasion resistance, impermeability and resistance to freezing and thawing. If water is not provided then shrinkage of concrete takes place which results in cracking. Furthermore, unexpected shrinkage and temperature cracks can reduce the strength, durability, and serviceability of the concrete.

Practically good curing of concrete is not achievable in many cases due to unavailability of suitable quality of water and many other practical difficulties. During the last two decades, concrete technology has been undergoing rapid Improvements. With conventional ingredients it is possible to design reasonably good fast track concrete mixture using admixtures. Internally cured concrete can be achieved by adding Self Curing Agents.

1. Methods of Self-Curing

Currently, there are two major methods available for internal curing of concrete. The first method uses saturated porous lightweight aggregate in order to supply an internal source of water, which can replace the water consumed by chemical shrinkage during cement hydration. The second method uses Poly Ethylene Glycol (PEG) which reduces the evaporation of water from the surface of concrete and also helps in water retention.

2. Significance of Self-Curing

When the mineral admixtures react completely in a blended cement system, their demand for curing water (External or Internal) can be much greater than that in a conventional Portland pozzolanic cement concrete. When this water is not readily available, significant autogenous deformation and (early age) cracking may result. Due to the chemical shrinkage occurring during cement hydration, empty pores are created within the cement paste leaving to a reduction in its internal relative humidity and also to shrinkage which cause cracking, internal warping and external deflection.

Concrete is the widely used construction material due to its ability to cast into required shape and size. The most important aspect in usage of concrete is the development of desired strength which mainly depends on hydration of cement mortar. Curing allows continuous hydration of cement and consequently continuous gain in the strength. Curing of concrete can be done in several methods, among them external and internal curing has gained popularity so far. Self-curing or internal curing is a technique that can be employed to provide additional moisture in concrete for more effective hydration of cement and reduced self-desiccation. According to the ACI 308 committee, ''internal curing refers to the process by which the hydration of cement occurs because of the availability of additional internal water that is not part of the mixing water''. It was found that water soluble polymers can be used as self-curing agents in concrete. Concrete incorporating self-curing agents will represent a new trend in concrete construction in the new millennium. Results proved that the concrete with polyethylene-glycol as self-curing agent, attained higher values of mechanical properties than with other type of curing agents. Principal and Mechanism of Self Curing

An exposed surface suffers from continuous evaporation of moisture due to the difference in chemical potentials between the vapour and liquid phases. Also when the mineral admixtures react completely in a blended cement system, their demand for curing water can be much greater than that in a conventional ordinary port land cement concrete. When this water is not readily available, significant autogenous deformation and cracking may result. Due to the chemical shrinkage occurring during cement hydration, empty pores are created within the cement paste, leading to a reduction in its internal relative humidity and also to shrinkage which may cause early-age cracking.

It is not possible to provide curing by external supply of water from top surface at the rate required to satisfy the ongoing chemical shrinkage. The polymers added in the mixmainly form hydrogen bonds with water molecules and reduce the chemical potential of the molecules which in turn reduces the vapour pressure [5]. The usage of polyethyleneglycol reduces the evaporation of water from the surface ofthe concrete and thereby providing water retention PEO) or polyoxyethylene (POE), depending on its molecular weight. It is a condensation polymer of ethylene oxide and water. The structure of PEG is commonly expressed as H(OCH2CH2) nOH, where n is the average number of repeating oxyethylene groups typically from 4 to about 180.Polyethylene glycols are available in average molecular weight ranging from 200 to 8000.The low molecular weight compounds up to 700 are colourless, odorless and viscous compounds with a freezing point from -10oC (di-ehylene glycol),while polymerized compounds with high molecular weight more than 1000 are wax like solids with melting point up to 67oC. One common feature of PEG appears to be the water-soluble nature. Polyethylene glycol is non-toxic, odourless, neutral, lubricating, non-volatile and nonirritatingand is used in a variety of pharmaceuticals.

II. MECHANISM OF SELF-CURING

Continuous evaporation of moisture takes place from an exposed surface due to the difference in chemical potentials between the vapours and the liquids phases. The polymers added in the mix mainly form hydrogen bonds with water molecules and reduce the chemical potential of the molecule which in turn reduces the vapours pressure thus reducing the rate of evaporation from the surface.

Mechanism and Significance of Self Curing Concrete Continuous evaporation of moisture takes place from an exposed surface due to the difference in chemical potentials (Free energy) between the vapour and liquid phases. The polymers added in the mix mainly form hydrogen bonds with water molecules and reduce the chemical potential of the molecules which in turn reduces the vapour pressure, thus reducing the rate of evaporation from the surface. When the mineral admixtures react completely in a blended cement system, their demand for curing water (external or internal) can be much greater than that in a conventional ordinary Portland cement concrete. When this water is not readily available, significant autogenous deformation and (early-age) cracking may result. Due to the chemical shrinkage occurring during cement hydration, empty pores are created within the cement paste, leading to a reduction in its internal relative humidity and also to shrinkage which may cause early-age cracking.

III. NEED AND SCOPE OF STUDY

Curing of concrete is maintaining satisfactory moisture content in concrete during its early stages in order to develop the desired properties. However good curing is not always practical in many cases. The aim of this investigation is to evaluate the use of water-soluble polymeric glycol as self-curing agents. The use of self curing admixture curing admixtures is very important from the point of view that the water resources are getting valuable every day. The benefit of self -curing admixtures is more significant in desert areas where water is not adequately available .In this study the mechanical properties of self-curing at different percentages of poly ethylene glycol will be evaluated and compared with conventional concrete specimen. Scope of the study is to identify the effect of polyethylene glycol (PEG) on strength characteristics of self-curing concrete and also to evaluate influence of poly ethylene glycol on mechanical properties which are experimentally investigated.

1. Problem Statement
When concrete is not cured properly, its durability, strength and abrasive resistance are affected. Due to inadequate curing, concrete develops plastic shrinkage cracks, thermal cracks, along with a considerable loss in the strength of the surface layer. When the surface of the concrete is not kept moist within the first 24 hours after the casting, the evaporation from the exposed horizontal surface results in plastic shrinkage cracks and a weak and dusty surface. An excessive temperature difference between the outer and the inner layers of the concrete results in thermal cracking due to restraint to contraction of the cooling outer layers from the warmer inner concrete. When concrete is allowed to freeze before a minimum degree of hardening is achieved after casting, the concrete gets permanently damaged due to the expansion of water within the concrete as it freezes. This results in irretrievable strength loss and makes concrete porous.

2. Justification of The Project
Today concrete is the most generally utilized development material in the world due to its strength and sturdiness properties. To attain good strength, the curing of concrete is important so we introduce the concept of self-curing concrete rather than immersion or sprinkle curing to avoid water scarcity. It was observed that water-soluble polymers can be utilized as a self-curing agent. Polyethylene Glycol400(PEG-400) The polymers added in the mix mainly form hydrogen bonds with water molecules and reduce the chemical potential of the molecules of water which in turn reduces the vapor pressure, thus reducing the rate of evaporation from the surface.

IV. LITERATURE REVIEW

1. **Khushpreetsingh, Mechanical Properties of Self Curing Concrete Studied Using Polyethylene Glycol-400**
A-review: The global practice regarding concrete technology is experiencing rapid development. Different methods are available to handle this problem while confronting a shortage of water. Self-desiccation may cause by improper curing, and it can seriously affect the strength and durability of the concrete. Earlier, many studies were conducted to distinguish internal curing agents to reduce self-desiccation and enhance concrete strength characteristics. Recently, applying Polyethylene Glycol-400 (PEG) as a chemical agent in self-curing concrete will help to reduce self-desiccation and improve mechanical characteristics. PEG-400 retains the internal water for proper hydration of cement in concrete as compared to conventional concrete. The present paper introduces an overview of various published research on the usage of PEG-400 as the self - curing concrete. The current paper also studied the effect of adding PEG-400 on the mechanical properties of self-curing concrete.

2. Akram Z. Yehia, Mechanical Properties of Self-Curing *Concrete (SCUC)*

The mechanical properties of concrete containing self-curing agents are investigated in this paper. In this study, two materials were selected as self-curing agents with different amounts, and the addition of silica fume was studied. The self-curing agents were, pre-soaked lightweight aggregate (Leca); 0.0%, 10%, 15%, and 20% of volume of sand; or polyethylene-glycol (Ch.); 1%, 2%, and 3% by weight of cement. To carry out this study the cement content of 300, 400, 500 kg/m^3, water/cement ratio of 0.5, 0.4, 0.3 and 0.0%, 15% silica fume of weight of cement as an additive were used in concrete mixes. The mechanical properties were evaluated while the concrete specimens were subjected to air curing regime (in the laboratory environment with 25 °C, 65% R.H.) during the experiment. The results show that, the use of self-curing agents in concrete effectively improved the mechanical properties. The concrete used polyethylene-glycol as self-curing agent, attained higher values of mechanical properties than concrete with saturated Leca. In all cases, either 2% Ch. or 15% Leca was the optimum ratio compared with the other ratios. Higher cement content and/or lower water/cement ratio lead(s) to more efficient performance of self-curing agents in concrete. Incorporation of silica fume into self-curing concrete mixture enhanced all mechanical properties, not only due to its pozzolanic reaction, but also due to its ability to retain water inside concrete.

3. Ahmed H. Abdel-Reheem, Physical Properties of Self-Curing *Concrete (SCUC)*

In this study the effect of two different curing-agents has been examined in order to compare them for optimizing the performance of concrete. The first used type is the Pre-soaked lightweight aggregate (leca) with different ratios; 0.0%, 10%, 15% and 20% of volume of sand, and the second type is a chemical agent of polyethylene-glycol (Ch.) with different percentages; 1%, 2% and 3% of weight of cement. In the test programme performed in this study, three cement content; 300, 400 and 500 kg/m^3, three different water-cement ratios; 0.5, 0.4, and 0.3, and two magnitudes of silica fume as a pozzolanic additive; 0.0% and 15% of cement weight, were used. The physical properties of concrete were evaluated at different ages, up to 28 days. The concrete specimens are subjected to dry-air curing regime (25 °c) during the experiment.

The results show that the use of self-curing agent (Ch.) in concrete effectively improves the physical properties compared with conventional concrete. On the other hand, up to 15% saturated leca was effective while 20% saturated leca was effective for permeability and mass loss but adversely affects the sorptivity and volumetric water absorption. Self-curing agent Ch. was more effective than self-curing agent leca. In all cases, both 2% Ch. and 15% leca were the optimum values. Higher cement content and/or lower water–cement ratio leads to more effective results of self-curing agents in concrete. Incorporation of silica fume into concrete mixtures enhances all physical properties.

4. Rapheal Ojelabi, Awareness and Benefits of Self-Curing Concrete in Construction Projects: Builders and Civil Engineers Perceptions

Self-cured concrete is a type of concrete with a special ability to reduce autogenous shrinkage responsible for early-stage cracking. It is useful generally for the construction of high rise buildings and bridges. The application and use of this technique of curing concrete, however, depends on the level of awareness among stakeholders regarding the application of the technique and its benefits among other factors. This study, therefore, sets out to investigate the level of awareness of selected construction professionals regarding the self-curing concrete technique in addition to the benefits. A cross-sectional survey design method was embraced by giving out 115 questionnaires to builders and engineers in Lagos who were purposely selected. The data was subjected to descriptive statistics. The results indicate that about 21% of selected builders and civil engineers practicing in Lagos are not aware and familiar with the concept of self-curing technology while about 43.1% of the professionals who have the knowledge of SCT have never used it in their professional practice. In addition, lower permeability, reduced coefficients of thermal expansion, and improved microstructures of cementitious paste were perceived as the dominant benefits of the self-curing concrete method. The implication of this study to construction professionals in Nigeria is in developing capacities on innovation practices in high-strength concrete technologies that will make them strike a balance with international counterparts.

5. Alaa Ali Bashandy, Recycled Aggregate Self-curing High-strength Concrete

The use of recycled aggregates from demolished constructions as coarse aggregates for concrete becomes a need to reduce the negative effects on the environment. Internal curing is a technique that can be used to provide additional moisture in concrete for more effective hydration of cement to reduce the water evaporation from concrete, increase the water retention capacity of concrete compared to the conventionally cured concrete. High strength concrete as a special concrete type has a high strength with extra properties compared to conventional concrete. In this research, the combination of previous three concrete types to obtain self-curing high-strength concrete cast using coarse recycled aggregates is studied. The effect of varying water reducer admixture and curing agent dosages on both the fresh and hardened concrete properties is studied. The fresh properties are discussed in terms of slump values. The hardened concrete properties are discussed in terms of compressive, splitting tensile, flexure and bond strengths. The obtained results show that, the using of water reducer admixture enhances the main fresh and hardened properties of self-curing high-strength concrete cast using recycled aggregate. Also, using the suggested chemical curing agent increased the strength compared to conventional concrete without curing.

6. Mohamedabd Elrahman, Combined Effect of Fine Fly Ash and Packing Density on the Properties of High Performance Concrete

An experimental approach: High performance concrete often contains large amount of cement which makes ecological, economical and technical problems. This study provides a new approach to optimize high performance concrete with low cementitious materials content. The ideal grading curve according to Fuller has been used in concrete mix design to ensure high packing density of concrete mixtures and to reduce the required binder content. Several systems comprising various pozzolanic materials (silica fume, fly ash and fine fly ash) have been prepared and tested. The role of fine fly ash on concrete performance has been estimated by measuring the concrete mechanical properties, porosity and durability. The mechanical properties were assessed from compressive strength and modulus of elasticity, whilst the durability characteristics were investigated in terms of water permeability, water absorption and chloride diffusion. The results showed that fine fly ash performed better than normal fly ash for the strength development and durability aspects. The ternary system containing slag cement, fine fly ash and silica fume with low w/b ratio performed the best amongst all the systems regarding concrete mechanical properties and durability. Combination of fine fly ash and silica fume with OPC or with slag cement resulted in a significant reduction in concrete porosity. All mixes containing fine fly ash exhibited high performance concrete with excellent durability properties.

7. Raffaele Cioffi, Preparation and Characterization of New Geopolymer-Epoxy Resin Hybrid Mortars

The preparation and characterization of metakaolin-based geopolymer mortars containing an organic epoxy resin are presented here for the first time. The specimens have been prepared by means of an innovative *in situ* co-reticulation process, in mild conditions, of commercial epoxy based organic resins and geopolymeric slurry. In this way, geopolymer based hybrid mortars characterized by a different content of normalized sand (up to 66% in weight) and by a homogeneous dispersion of the organic resin have been obtained. Once hardened, these new materials show improved compressive strength and toughness in respect to both the neat geopolymer and the hybrid pastes since the organic polymer provides a more cohesive microstructure, with a reduced amount of microcracks. The microstructural characterization allows to point out the presence of an Interfacial Transition Zone similar to that observed in cement based mortars and concretes. A correlation between microstructural features and mechanical properties has been studied too.

8. Dale P. Bentz, Internal Curing: A 2010 State-of-the Art Review

The American Concrete Institute in 2010 defined internal curing as “supplying water throughout a freshly placed cementitious mixture using reservoirs, via pre-wetted lightweight aggregates, that readily release water as needed for hydration or to replace moisture lost through evaporation or self-desiccation” (American Concrete Institute, 2010). While internal curing has been inadvertently included in many lightweight concretes produced within the past 100 years, it is only within the first decade of the 21st century that this technology has been intentionally incorporated into concrete mixtures at the proportioning stage, using a variety of materials including pre-wetted lightweight aggregates, pre-wetted crushed returned concrete fines, superabsorbent polymers, and pre-wetted wood fibers. This report provides a state-of-the-art review of the subject of internal curing, first addressing its history and theory, and then proceeding to summarize published guidance on implementing internal curing in practice and published research on its influence on the performance properties of concrete. The ongoing exploration of extensions of the internal curing concept that employ the internal reservoirs to contain materials other than water are reviewed. Finally, the critical issue of sustainability is addressed. An extensive internal curing bibliography that is also available over the Internet is included in an appendix. The report is mainly focused on the utilization of pre-wetted lightweight aggregates as the internal reservoirs due to this being the current established practice within the U.S.

9. Magda I.Mousa, Self-Curing Concrete Types; Water Retention and Durability

Internal curing of concrete by the use of pre-saturated lightweight aggregates or polyethylene-glycol is well established method of counteracting self-desiccation and autogenous shrinkage.

This study was carried out to compare among concretes without or with silica fume (SF) along with chemical type of shrinkage reducing admixture, polyethylene-glycol (Ch), and leca as self-curing agents for water retention even at elevated temperature (50 °C) and their durability. The cement content of 400 kg/m^3, silica fume of 15% by weight of cement, polyethylene-glycol of 2% by weight of cement, pre-saturated lightweight aggregate (leca) 15% by volume of sand and water with Ch/binder ratio of 0.4 were selected in this study. Some of the physical and mechanical properties were determined periodically up to 28 days in case of exposure to air curing in temperature of (25 °C) and (50 °C) while up to 6 months of exposure to 5% of carbon dioxide and wet/dry cycles in 8% of sodium chloride for durability study. The concrete mass loss and the volumetric water absorption were measured, to evaluate the water retention of the investigated concretes. Silica fume concrete either without or with Ch gave the best results under all curing regimes; significant water retention and good durability properties.

10. Shohana Iffat, Durability Performance of Internally Cured Concrete Using Locally Available Low Cost LWA

Curing of concrete is important to ensure both strength and durability. Loss of water through evaporation reduces the hydration rate and eventually results in limited strength and higher permeability. Generally, curing is done by supplying additional water from external sources to prevent the water loss. Such curing requires skilled labor and proper knowledge. However, in a developing country like Bangladesh, it is considered as an additional step and often neglected. Under such scenario, Internal Curing (IC) could be adopted to improve the overall quality of general concreting work. Utilization of locally available burnt clay chip aggregate commonly known as Brick Chips (BC) to produce internally cured concrete can be considered as an effective solution. The pore spaces of these aggregates absorb water during saturation process and later desorb water under favorable conditions of higher temperature and low relative humidity. As a result, no external curing water is needed. This study shows the durability performance of concrete having BC as internal curing medium. Stone chips have been partially replaced by BC since concrete with BC alone produces weaker concrete. Three commonly practiced water cement ratios of 0.4, 0.45 and 0.5 and five curing conditions were selected to simulate inside and outside environmental conditions. Three different percent replacements (10%, 20% and 30%) of stone chips by BC were selected. Control samples with stone chips were also made for comparison. Water permeability test and Rapid Chloride Permeability Test (RCPT) were performed. It is found that durability of internally cured concrete with polythene sheet covering is comparable to the durability of normally cured control concrete. Moreover, under adverse curing conditions with no supply of external water, internally cured concrete performed significantly better than control samples. Therefore, BC can be used as a cost effective internal curing material in Bangladesh to produce durable concrete.

11. Famili, Internal Curing of High Strength Self Consolidating Concrete by Saturated Lightweight Aggregate - Effects on Material Properties

Self-desiccation is the major source of autogenous shrinkage and crack formation in low water-binder ratio (w/b) concretes which can be reduced by internal curing. In this paper performance of high strength self consolidating concrete (HS-SCC) with w/b of 0.28 and 0.33 including autogenous shrinkage, drying shrinkage, compressive strength, and resistance to freezing-thawing was investigated. Then, for the purpose of internal curing, 25% of normal weight coarse aggregate volume was replaced with saturated lightweight aggregate (LWA) of the same size; and its effects on the material properties was studied. Two modes of external curing, moist and sealed, were applied to test specimens after demoulding. Autogenous shrinkage from 30 minutes to 24 hours after mixing was monitored continuously by a laser system. The initial and final setting time were manifested as a change of the slope of the obtained deformation curves. Shrinkage after initial setting was 860 and 685 microstrain (με) for 0.28 and 0.33 w/b mixtures, respectively. The saturated LWA reduced these values to 80 and 295 με, respectively. By LWA Substitution the 28- day compressive strength of 0.28 w/b mixture was reduced from 108 to 89 and 98 to 87 MPa for moist and sealed cured specimen, respectively. The corresponding values for 0.33 w/b mixture was 84 to 80 and 82 to 70 MPa. Shrinkage of 0.28 w/b mixture without LWA after moist and sealed cured specimen dried for 3 weeks was about 400 με. Shrinkage of moist and sealed cured specimen containing LWA was reduced 9% and 25%, respectively. On the contrary for 0.33 w/b mixture an increase was noticed. Freezing-thawing resistance was improved by sealed curing, decreasing w/b and substituting LWA.

12. Imanmehdipour, Enhancing the Performance of Calcium Sulfoaluminate Blended Cements with Shrinkage Reducing Admixture or Lightweight Sand

This study investigates the effect of using shrinkage reducing admixture (SRA) or lightweight sand (LWS) on enhancing the performance of calcium sulfoaluminate (CSA) cement in combination with ordinary Portland cement (OPC). Of special interest is the efficacy of the SRA or LWS in modifying the expansion/shrinkage and compressive strength characteristics of OPC-CSA systems in the absence of adequate duration of water curing, which is critical for the expansive reaction of CSA cement and its ability to mitigate shrinkage.

Hydration kinetics ,autogenous and drying deformation, thermogravimetry, and scanning electron microscopy (SEM) are used to evaluate the effect of SRA or LWS on the performance of the OPC-CSA systems. Test results indicate that the OPC-CSA system can exhibit similar drying shrinkage to that of the plain OPC mixture when no moist curing is applied. In the presence of LWS or SRA, the OPC-CSA systems exhibited lower shrinkage or higher extent of expansion compared to the corresponding OPC-CSA mixture alone. This is attributed to delay of the drop in internal relative humidity and promoting hydration of the OPC-CSA system which can enhance the ettringite-generating potential of CSA cement.

The use of LWS was found to be highly effective in enhancing compressive strength of OPC-CSA system. SEM results at 91 days confirm the higher density and lower porosity for the paste surrounding LWS particles compared to the corresponding mixture made without LWS. In the case of inadequate moist curing, the presence of LWS or SRA is shown to enhance the overall performance of OPC-CSA system. For a given overall desirability value of 0.65 determined by multi-objective optimization, the incorporation of 1% SRA or 10% LWS was found to enable the reduction the required period of moist curing from 6 days to 5 and 3 days, respectively.

13. Olawuyi, the Mechanical Behaviour of High-Performance Concrete with Superabsrbent Polymers (SAP)

High performance concrete (HPC) is known to be of low water-binder ratio (W/B) and exhibits high strength, durability and elastic modulus amongst many other properties. HPC is susceptible to autogenous-shrinkage-caused-cracking under restraints while previous research efforts directed at mitigating autogenous-shrinkage in HPC by the introduction of IC agents have reported superabsorbent polymers (SAP) to be the most promising. This study seeks to fill the existing gap on proper understanding of the effect of SAP addition on the mechanical behaviour of HPC. The work studied the mechanical properties of HPC containing SAP as internal curing agent (IC-agent) using two grain sizes of SAP (< 300 μm and < 600 μm) at varied SAP contents (0%; 0.2%; 0.3%; and 0.4% bwob) in four reference HPC mixtures (M1F, M1S, M2 and M3) after 7, 28, 56 and 90 days of curing in water. SAP absorption in cement pore solution (CPS) was determined using the tea-bag test and the 25 g/g absorption in CPS obtained after 10 minutes of immersion was used for provision of additional water in the HPC mixtures. Experimental works were carried to study the impact of SAP addition on the rheology of the HPCs, as well as identify and establish the effect of varying sizes and volume of SAP on rate of cement hydration and strength development. The work involved quantifying and modelling the mechanical behaviour (strength in compression, tension, elastic and fracture properties) of the low W/B (0.2 – 0.3) HPC (C55/67 – C100/115) with SAP. Microstructure and molecular interaction of the internal constituent of the HPC were also investigated using the X-ray computed tomography (CT) scanning and scanning electron microscopy (SEM). The study observed a slight decrease in the compressive strength of HPC as SAP content increases but there is no such effect on the elastic and fracture properties of the concrete. The 25 g/g SAP absorption result of the teabag test over-estimates the actual amount of water used up by SAP in the internal curing of HPC. The 3D void analysis of the HPC via CT scanning revealed that SAP created voids in the HPC is only about half (i.e.12.5 g/g) of the teabag test result of 25 g/g and affirms that the required additional water for SAP's effective internal curing of the low W/B HPC is 12.5 g/g. The study concludes that the optimum additional water for SAP addition in the low W/B HPCs at no negative effect on mechanical properties is 12.5 g/g.

14. ZhangJun, Calculation of shrinkage stress in concrete structures with impact of internal curing

This paper presents recent advances in the calculation of shrinkage stress in concrete structures, especially focus on the effect of internal curing. In the modeling, an integrative model for autogenous and drying shrinkage predictions of concrete under drying environments is introduced first. Second, a model taking both cement hydration and moisture diffusion into account synchronously is used to calculate the distribution of internal relative humidity in concrete. Using the above two models, along with the shrinkage stress model for concrete pavement under nonlinear strain along the slab thickness, the development of shrinkage stress in concrete pavements since casting made by low, middle and high strength concrete respectively is calculated. In particular, the effects of internal curing with pre-wetted lightweight aggregates on the progress of shrinkage stress are investigated and discussed. Based on the present study, the following conclusions can be drawn: (1) the progress of shrinkage stress in concrete pavements obeys two-stage mode since concrete casting, a small stress stage (close to zero) in the moisture saturated period and a gradual increasing stage with the relative humidity gradually decreasing in the concrete; (2) the closer to the drying face, the higher the shrinkage stresses; (3) the shrinkage stress is greater in high strength slab than that in low or middle strength slab; (4) internal curing with pre-wetted lightweight aggregate can greatly reduce shrinkage stress in concrete pavement, either in low strength slab or high strength slab.

15. A.S.El-Dieb, Assessment of reinforcement corrosion protection of self-curing concrete

The curing of concrete requires high water demand. In this study reinforcement corrosion protection of self-curing concrete (SC) mixtures incorporating two water-soluble polymers; polyethylene glycol (PEG) and polyacrylamide (PAM) have been evaluated. Durability indices; electrical resistivity, chloride ion penetrability and water permeability, were evaluated and compared to that of control concrete mixture with no self-curing agents under different curing regimes. Reinforcement corrosion monitoring was conducted by exposing reinforced concrete prisms at the age of 28 days to wet-dry cycles for a total period of 96 weeks. In the wetting cycle, the prisms were partially immersed in 5% sodium chloride solution at ambient temperature. The corrosion activity was evaluated by measuring the corrosion potential and corrosion current density. Self-curing concrete mixtures showed better reinforcement protection and durability indices than those of air-cured control mixture. Short water curing period of 3 days significantly improved the reinforcement protection and durability indices of the self-curing concrete mixtures to a level comparable to that of the control mixture that was moist-cured for 28 days. Self-curing concrete represents a step towards a new construction material due to its lower demand for curing water and hence can reserve the limited water resources in many parts of the world.

16. Vaisakh G, an Experimental Study on Properties of M50 Concrete Cured Using PEG 400

Good compressive strength and durability makes concrete the most widely used construction material. Both strength and durability is much dependent on presence of water especially in the stage of curing. Self or Internal curing is the process of hydration of cement using the additional internal water reservoirs, instead of externally applied water as in the case of conventional curing practice. Use of polyethylene glycol (PEG), a shrinkage reducing admixture, in concrete is found to help in self-curing and better hydration thereby improving strength and durability. M50 concrete containing PEG exhibited better curing, strength and durability, with an optimum values for all parameters studied at 1.5% PEG content.

17. Jasgurpreet Singh Chohan, Post-processing of ABS Replicas with Vapour Smoothing for Investment Casting Applications

The need of customized products with tight dimensional tolerances, lower production cost and shorter lead times led to the development of additive manufacturing techniques like fused deposition modelling (FDM). The digitally fabricated ABS patterns prepared on FDM needs to be processed by vapour smoothing (VS) in order to reduce the surface roughness. The post-processing of FDM-based patterns/replicas with VS increases their density, which increases heat input and complexities in ash removal during burnout stage from ceramic shell in investment casting (IC). This study highlights the step-by-step procedure for controlling the density of master patterns/replicas after processing with VS for IC applications.

V. CONCLUSION

As a self-curing agent the polyethylene glycol -400 or polyethylene glycol -600 is a good admixture and by adding of 1% of this admixture for M25 and M20 grade of concrete it had good result but adding 2% of polyethylene glycol decreased strength of concrete.

- From studying of many papers it found that strength of self-curing concrete is more than conventional concrete.
- We can use wood powder as self-curing agent.
- Self-curing concrete is the way for solving the difficulty faced with curing.
- Self-curing concrete is the best answer for desert area where the availability of water is very less or not available.

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