USE OF SUPERABSORBENT POLYMERS IN INTERNALLY CURED CONCRETE- A REVIEW

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Abstract - *Internal Curing of Concrete has been a topic of considerable interest to researchers in the last couple of years coinciding with the growing demand of high strength concrete (HSC) in construction. In HSC the rate of absorption of water into the concrete microstructure is more than the rate at which water gets absorbed into the concrete matrix. This is a problem which prevents conventional methods of curing of water from being successfully implemented in HSC. Therefore we turn to alternate materials which can absorb, hold and supply water as required, and which also fulfill the role of aggregate such as lightweight aggregate or with the use of superabsorbent polymers (SAP). We could also use shrinkage reducing admixtures like polyethylene-glycol. The water molecules present in these materials are pulled out due to the pressure created in the concrete matrix as water is used up during the curing process. This is also a useful tool for areas where conventional curing is very difficult such as extreme climatic conditions which can lead to excessive evaporation and freezing. Also it will save water losses at sites, which is a growing concern in the construction business as we move towards a more efficient use of our limited resources.*

Key Words: Internal Curing, Superabsorbent polymers, High Strength Concrete, Shrinkage.

1. Introduction

When the mineral admixtures fully react in a blended cement system, the curing water required (external or internal) can be much higher than that which is needed in conventional ordinary Portland cement concrete. When this water is not available, due to depercolation through the capillary porosity, it leads to significant autogenous deformation and (early-age) cracking.

Due to the chemical shrinkage occurring during cement hydration, voids are created within the cement paste, leading to a reduction in its internal relative humidity as well as shrinkage which causes early-age cracking. This condition is increasingly severe in HPC due to its generally higher cement content, reduced water/cement (w/c) ratio and the presence of pozzolanic mineral admixtures (fly ash, silica fume, etc.). The voids created during self-desiccation cause shrinkage stresses and influence the kinetics of cement hydration process, decreasing the final degree of hydration. The strength achieved by IC could be more than that possible under saturated curing conditions.

More often than not, especially in HPC, it is nearly impossible to supply curing water from the top surface at the rate required to satisfy the ongoing chemical shrinkage, due to the extremely low permeability.

ACI-308 Code states that “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.” Conventionally, curing concrete implies achieving such conditions that water is not lost from the surface of concrete i.e., curing is taken to happen ‘from the outside to inside’. In contrast, ‘internal curing’ which is also known as ‘self curing’ is allowing for curing ‘from the inside to outside’ through the internal reservoirs (the likes of saturated lightweight fine aggregates, superabsorbent polymers, saturated wood fibres, etc.) are created.

Some of the advantages found in internal curing of concrete are that it reduces autogenous cracking, reduces permeability, largely eliminates autogenous shrinkage, protects reinforcing steel, increases mortar strength, increases early age strength sufficient to withstand strain, provides greater durability, higher early age (say 3 day) flexural strength, higher early age (say 3 day) compressive strength, lower turnaround time, improved rheology, greater utilization of cement, lower maintenance, use of higher levels of fly ash, higher modulus of elasticity, or through mixture designs, sharper edges, greater curing predictability, higher performance, improves contact zone, does not adversely affect finishability, does not adversely affect pumpability, reduces effect of insufficient external curing.

2. Literature Review

Marianne Tange Hasholt, et al. [1] studied the effect of superabsorbent polymer on the mechanical strength of concrete by optimizing the dosage and internal water added. The authors arrived at the conclusion that "Addition of SAP does not lead to decrease in mechanical strength and while one has to be very patient and careful, it is possible to not only retain the same strength but also to increase it while preventing self-dessication.

M. Manoj Kumar, et al. [2] studied the effects of addition of using different ratios of superabsorbent polymer on the various mechanical properties of concrete, like Compressive Strength, Splitting Tensile Strength and Flexural Strength and compared them to conventional concrete.

Vivek Hareendran, et al. [3] created five different mixes of self- curing concrete and testd them with conventional self cured concrete for mechanical properties of concrete like Compressive Strength, Splitting Tensile Strength and Flexural Strength.

Moayyad Al-Nasra, et al. [4] studied the effect on superabsorbent polymer on fresh and hardened concrete using sodium polyacrylate and conducted some tests on the strength and stability of internally cured concrete.

O. Mejlhede Jensen, et al. [5] tried superabsorbent polymer as a chemical and its effect on concrete with additional silica fume. The autor also outlines the many advantages it brings to concrete such as shrinkage reduction and frost protection.

Alexander Assmann, et al. [6] observed the mechanics behind the internal curing process for superabsorbent polymers and studied the changes it induces to the microstructure of the concrete. The author obtained the results of permeability testing, mercury intrusion porosimetry, compressive strength and drying shrinkage.

C. Chella Gifta, et al. [7] studied the effect of superabsorbent polymer on concrete and compared it to internally cured concrete which used superabsorbent polymer and lightweight aggregate. The researcher observed the advantages superabsorbent polymer has in durability against both lightweight aggregate and conventional concrete in this regard.

Bart Craeye, et al. [8] tested high performance concrete at various dosages of superabsorbent polymer to determine the optimum dosage of superabsorbent polymer which provides the maximum autogenous shrinkage reduction as well as the minimum strength reduction. They also studied thermal stress development due to heat of hydration and the chances of early age cracking are determined using finite element analysis and calculation.

Agnieszka Klemm, et al. [9] in their study observed superabsorbent polymer in cementitious composites and studied the recent advances in the area of SAP modified concrete while providing an idea on what superabsorbent polymer is, how it functions and what are its benefits.

A. Assmann, et al. [10] observed the result of addition of superabsorbent polymer to concrete and its effects to tensile strength, creep and shrinkage.

Ole Mejlhede Jensen, et al. [11] observed the mechanism of superabsorbent polymer and determined how it will affect long term shrinkage and reduces autogenous shrinkage. Also the authors outline the possible problems which are associated with the usage of superabsorbent polymer.

Mohammad J. Zohuriaan-Mehr, et al. [12] reviewed the SAP literature, background, types and chemical structures, physical and chemical properties, testing methods, uses, and applied research works. Also the original usage of SAP in agricultural and healthcare are reviewed.

D. Snoeck, et al. [13] observed the effect of high quantities of superabsorbent polymer in concrete with a high water-cement ratio as well as its effects and some precautions which should be taken when such high addition of the self curing agent are added.

V. Mechtcherine, [14] one of the editors in a report prepared by a technical committee on SAP compiled the reports of researchers from around the world who investigated the mechanism of SAP action in concrete materials and the limitations and advantages of SAP that could solve problems experienced by researchers in the area.

3. CONCLUSIONS

The topic of internal curing is an area that has a tremendous potential for research. It is bound to provide even more intriguing results as more research goes into its usage and benefits.

With the advantages it brings in extreme weather conditions as well as its reduction in water usage on sites, this makes Internal curing a topic which will garner more attention as water usage shoots upwards in the construction industry.

Also with further research one can counter the weakness which are found in this method and move towards a more efficient means of material usage and strength achievement.

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