Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 45 No. 3 (2024)

A Review on Experimental Study to Optimize Self-Curing Concrete by Using Light-Weight Aggregates

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Abstract:

Self-curing concrete, also known as internal curing concrete, is a significant advancement in concrete technology that enhances hydration and performance by injecting more moisture throughout the curing process. In this study, we will apply self-curing chemicals in M35 grade concrete to attain the same strength as traditionally cured concrete. To assist the concrete in curing on its own, we will employ several self-curing agents such as lightweight aggregates and saturated normal weight aggregates, as well as a specific ingredient known as PEG-4000 superplasticizer. We'll look at how these chemicals impact the concrete's mechanical qualities, such as its capacity to endure pressure, tensile strength, and shrinkage. We will also evaluate the endurance of the concrete using a Rapid Chloride Penetration evaluate (RCPT) by varying the quantity of superplasticizer in this mix. A scanning electron microscope will also be used to analyze the small structure inside the concrete. This will allow us to examine how a certain element in the concrete interacts with the concrete particles. This is useful for projects where traditional curing methods, such as spraying water or coating with wet materials, are difficult or prohibitively expensive. Self-curing concrete is a type of concrete that can retain moisture without the need for external assistance. This allows the cement to mix effectively with water, making the concrete stronger, more durable, and less prone to cracking. We will utilize a step-by-step approach to investigate the areas for improvement identified in our analysis of previous studies. First, we will test all of the materials we have chosen in accordance with industry standards. Next, we shall mix concrete in accordance with IS: 10262-2009 specifications. Then, we'll do preliminary experiments and create concrete samples, test them, and compare the outcomes to regular concrete.

Keywords: Self-curing concrete**,** Internal curing agents**,** Mechanical properties**,** Durability**,** Microstructure analysis.

Introduction

Properly treating concrete structures is important to ensure they work well and last a long time. Normally, this is done by adding water from the outside after mixing, placing, and smoothing the concrete. Self-curing or internal curing is a method that can be used to add extra water inside the concrete for better results. Cement hydration and less self-desiccation. The ACI-308 Code says that "internal curing means the hydration of cement happens because there is extra internal water that wasn't mixed with the water". This extra internal water usually comes from using a small amount of saturated, lightweight, Polyethylene Glycol, super absorbent polymer particles in the concrete. curing concrete involves adding water to it from the outside after it has been mixed, placed, and finished. Proper curing helps the cement in the concrete to hydrate and gain strength continuously. Curing keeps the moisture moving in and out of the concrete. Hydration stops when the relative humidity inside the tiny pores in the concrete drops to 80%. Self-curing or internal curing is a method where the hydration of cement continues with the help of extra internal water, which is not the external water. The internal water is kept in place by adding a self-curing agent called polyethylene glycol, which reduces the loss of water from the concrete, thus increasing its water-holding capacity. The benefits of internal curing include better hydration and strength growth, less shrinkage and cracking, lower permeability, and increased durability.

Benefits of Self-Healing Concrete: Lessens cracking on its own Heals itself Decreases water seepage Boosts cement paste strength and early strength Strong enough to handle stress More efficient use of cement Lower maintenance needs.

Curing and their types:

In concrete curing is the process necessary to keep conditions which are acceptable moisture, temperature & time so that cement hydration can take advantage of this. Proper consolidation is essential in order to obtain the desired properties of concrete, that includes compressive strength and durability as well volume stability of hardened cement paste. When cement is mixed with water, a chemical reaction called hydration takes place to set and cure the concrete.

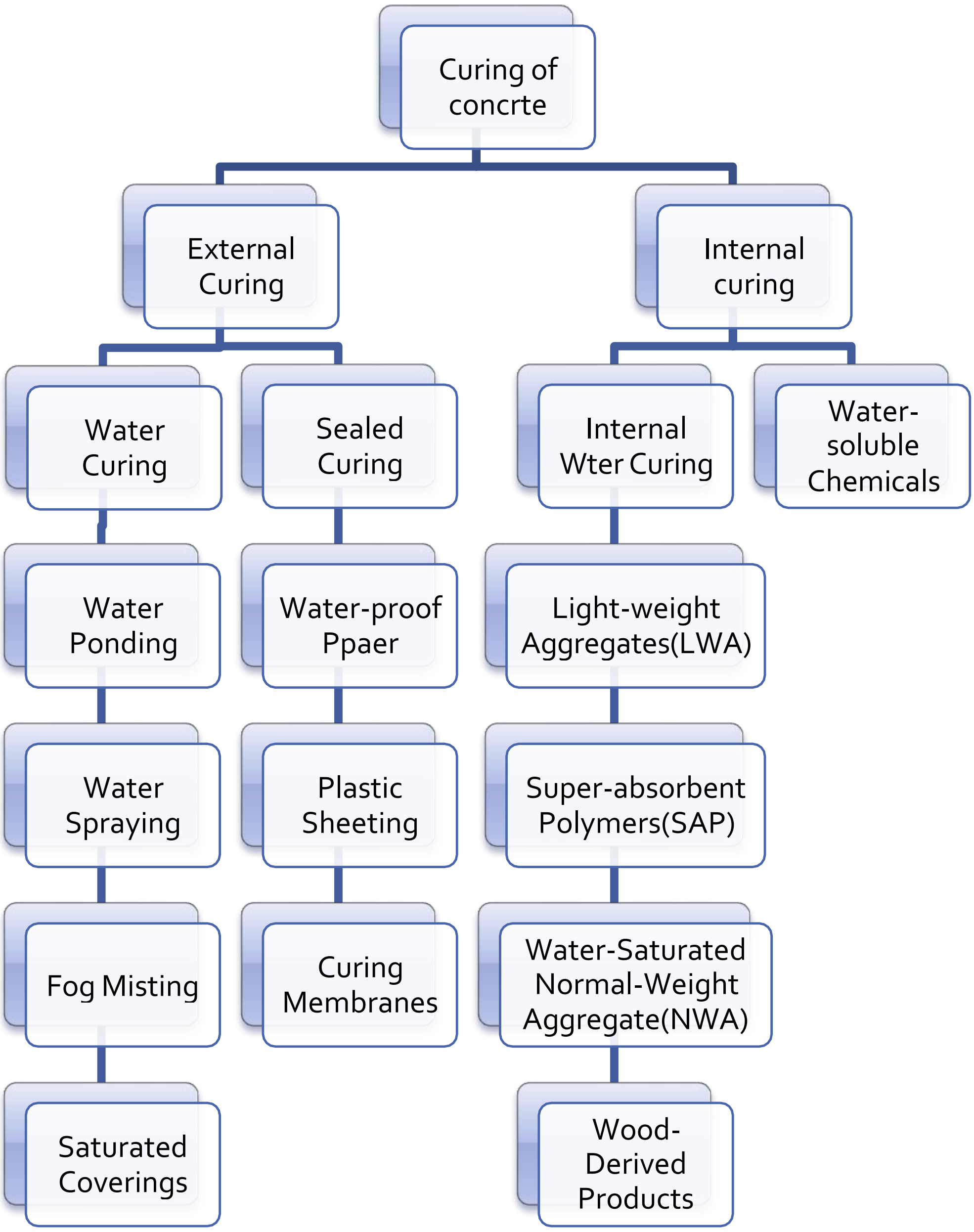

Figure-1. Methods of curing of concrete

Importance of Curing:

Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
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One of the reasons an individual may need to cure concrete is: It ensures conduction of the hydration process, one that is essential in acquiring adequate compressive and tensile strengths for concrete Properly cured cement is stronger and more chemical-resistant, abrasion-resistant, weather-protected and cracks less along the surface. Good curing also diminishes early-age shrinkage and cracking to preserve the volume of concrete as it hardens. Curing prevents the outer layer of concrete from drying out fast and forming weak surface lairs, which in return may also lead to insufficient hydration. In addition, adequate curing produces a denser microstructure with excellent performance characteristics.

Material to be used:

The different types of materials used in this investigation are given below:

Lightweight aggregate (LWA)

Lightweight aggregate (LWA) is a material used to produce lightweight concrete. These materials are lighter than traditional ones such as sand, gravel, and crushed stone. Lightweight aggregates are designed to make concrete lighter while remaining robust and stable. They are extremely useful in circumstances when making things lighter is crucial. Using lightweight materials in building has many advantages. They are very useful for tall buildings and bridges becausethey make concrete lighter, which means the structures can handle more weight without getting damaged. These materials also help keep the heat and noise out, making the buildings more energy- efficient and quieter. Lightweight concrete is easier to move, work with, and put in place, especially inbig or hard-to-reach areas. Some types even offer better protection against fire. However, using these lightweight materials requires careful planning to make sure the concrete is easy to work with, strong, and lasts a long time. They can absorb more water, which might affect how the concrete hardens and the balance of water and cement. Also, they might cost more than regular materials. To keep the lightweight concrete from soaking up too much water and to make sure it hardens properly, regular- sized stones like gravel or sand are soaked in water before being mixed in.

Types of Lightweight Aggregates:

Natural Lightweight Aggregates: - Pumice is a volcanic rock with microscopic pores, making it ideal for lightweight concrete. Scoria, like pumice, is a volcanic rock, but it has more holes and is slightly heavier. Diatomaceous Earth: This material, composed of microscopic fossils known as diatoms, is incredibly light and is utilized in some forms of lightweight concrete.

Manufactured Lightweight Aggregates: - Expanded clay, shale, and slate: These materials are createdby heating natural substances in a spinning oven, resulting in numerous microscopic holes. Perlite: Perlite is a form of volcanic glass that turns light and porous when heated.

Properties of Lightweight Aggregates:

Light aggregates have a lower weight per cubic meter (300 to 1200 kg/m³) than normal aggregates (2400 to 2900 kg/m³). They have many little gaps within, which makes them lighter. Because of their numerous little spaces, they are effective at keeping things warm. These lightweight materials can improve concrete's ability to absorb sound. Using these lightweight materials may make structures lighter, resulting in smaller foundations and lower material costs.

Water-saturated normal weight aggregate

Water-saturated normal weight aggregate means regular aggregates like gravel, crushed stone, or sandthat have been filled with water before being added to the concrete. These aggregates are not light; they have the usual density and characteristics of typical aggregates used in making concrete. Why Use Water-Saturated Normal Weight Aggregates The main reason for using water-saturated normal weight aggregates is to make sure that these aggregates don't take water away from the concrete mix. This is done to keep the right balance of water and cement and to make sure the cement mixes well with the water. Keeping the right amount of water in concrete is very important for how well it works and how strong it is. The right mix of water and cement makes concrete that is strong and doesn't crack easily. This is really important for big projects like dams and bridges, and for concrete parts made ahead of time. The good things about this are that the concrete is of consistent quality, it's stronger and lasts longer, and it has fewer cracks. But there are problems too. You have to be careful with the concrete and store it right before using it, and it's not easy to keep the right amount of water in it, especially in weather that changes a lot. Also, getting the materials wet before mixing them adds more time and costto making the concrete.

Key Aspects of Water-Saturated Normal Weight Aggregates:

Keeping the Right Water and Cement Balance: Soaking the pebbles and gravel before adding them to the concrete mix ensures that there is enough water for the concrete to set correctly, rather than the rocks depleting the water. This makes the concrete simpler to mix, pour, and smooth out. Soaked rocksprevent concrete from shrinking or breaking because they do not absorb water from the mix Better

Hardening: For concrete to be strong and long-lasting, it must be properly hardened. Soaked rocks ensure there is enough water for this hardening process to occur.

Literature Survey:

Norhaliza Hamzah, Hamidah Mohd Saman, Mohamm Hajmohammadian, Baghban, Abdul Rahman Mohd Sam, Iman Faridmehr, Muhd Norhasri Muhd Sidek, Omrane Benjeddou, GhasanFahim Huseien., (2022) focuses on establishing a technology for internal curing in high-quality concrete to prevent the cement mixture from drying out and cracking in the completed concrete. Internalcuring is very good for improving the concrete's capacity to resist breaking and bending as it matures, as opposed to merely being compressed. This approach increases the tightness and firmness of the region where various elements meet, making the concrete stronger. This study emphasizes the critical function of curing in promoting chemical processes inside the cement mixture and concrete as they setand harden. Proper curing allows the concrete to improve over time by providing the appropriate quantity of water and warmth, which accelerates the hardening process and protects the concrete from drying up too rapidly. The research also discusses the benefits of employing Porcelanite, a form of ceramic stone, to replace part or all of the sand and gravel in the concrete mix for internal curing purposes. This substitution enhances the overall quality of the concrete, which increases its strength inresisting splitting and bending.

David O. Nduka, John O. Ameh, Opeyemi Joshua, Rapheal Ojelabi., (2018) reviewed benefits of self-curing concrete for Lagos construction professionals. A poll of 115 builders and engineers revealed that 21% were unaware of it, while 43.1% had never utilized it. Experts noted benefits such as reducedwater leakage, better temperature management, and enhanced cement structure. The report recommends greater research into self-curing technologies, particularly for large infrastructure projects and tall structures. Internal curing, which began in the 1950s, employs tiny lightweight components to assist cement set and minimize cracking.

M. Saravanan, R. Gopi, M. Harihanandh., (2021) investigated self-compacting concrete (SCC) constructed using lightweight ingredients such as saturated scoria and fly ash aggregate (FAA) as self- curing agents demonstrates high durability. Scoria (5%-20%) and FAA (15%) are used instead of fine particles to trap moisture inside the concrete, allowing it to cure more effectively. Tests were conductedover various time periods to determine how well the concrete resists salt, changes in volume, and the speed with which sound waves pass through it. The experiments revealed that utilizing presaturated scoria and FAA makes the concrete stronger, more durable, salt-resistant, and better able to manage volume variations and UPV. According to this study, self-curing materials improve the bonding of concrete and extend its lifetime.

Doha M. Al Saffar, Aymen J.K. Al Saad, Bassam A. Tayeh., (2019) studied internal curing in high-performance concrete (HPC) reduces self-desiccation, minimizes fractures, and increases strength and density. Internal curing is more effective at later ages for splitting tensile and flexural strength, which improves the compactness and density of the interfacial transition zones. Using common materials for internal curing increases the density, strength (compressive, splitting tensile, and flexural), shrinkage, andmicrostructure of hydrated cement paste.

İbrahim Türkmen, Abdul Hamit Kantarci., (2006) studied the effects of expanded perlite aggregate(EPA) and different curing conditions on self-compacting concrete (SCC). At a constant binder dose of450 kg/m³ and 2% superplasticizer, EPA enhances capillarity coefficient and porosity while decreasing compressive strength at higher EPA ratios. After 28 days of air curing (CC2), SCC has the maximum porosity and capillarity, but the lowest compressive strength. The study looks at how EPA, curing time, and circumstances influence SCC's compressive strength, porosity, and capillarity.

Pietro Lura, Ole Mejlhede Jensen Z, Shin-Ichi Igarashi., (2006) studied the internal water curing which has a substantial influence on concrete qualities such as strength, shrinkage, cracking, and durability, with a focus on minimizing self-desiccation in lightweight aggregate concrete (LWAC). According to experimental methodologies, internal water curing minimizes autogenous shrinkage and stress while boosting hydration and decreasing porosity, resulting in a refined cement paste. The study

advocates for scientifically rigorous research methodologies to justify and encourage internal water curing in concrete practice.

M. Lopez, L. F. Kahn, K.E. Kurtis., (2010) investigated high-strength, self-curing, low-shrinkage concrete for pavements was tested against combinations including pre-wetted lightweight, air-dry lightweight, and conventional weight aggregates. The results reveal that pre-wetted lightweight aggregate enhances hydration and strength while reducing autogenous and drying shrinkage. Lightweight aggregates improve mechanical characteristics while reducing time-dependent deformations. Image study shows that shrinkage occurs mostly in the paste, with less strain at the aggregate/paste contact in high-performance concrete (HPC) due to the lower modulus of lightweight particles. The study finds that HPC with pre-wetted lightweight aggregate improves concrete performance and increases pavement service life.

Vishnu T, Beena B R., (2016) studied the self-curing concrete contains lightweight fine aggregate and polyethylene glycol, eliminating the requirement for external curing. Self-curing concrete increases cement hydration and lowers self-desiccation, resulting in better characteristics. The study compares the compressive, flexural, and split tensile strengths of self-cured and standard concrete. It concludes that hydration reactions and cures are critical to durability and performance. Using lightweight expanded clay aggregate and polyethylene glycol as self-curing chemicals increases strength while decreasing water usage.

Ruhal Pervez Memon, Abdul Rahman Bin Mohd. Sam, Abdullah Zawawi Awang, Ghasan Fahim Huseien, Uroosa Memon., (2018) studied concrete manufacturing consumes a lot of water, causing researchers to look at ways to lessen it. Self-curing technique hydrates the cement inside, preventing self-desiccation and autogenous shrinkage. Self-curing ingredients such as porous lightweight aggregates, chemical admixtures, polymers, natural fibers, and pozzolanic compounds enhance the physical, mechanical, durability, and microstructure qualities of concrete. Expanded shale lightweight aggregates and superabsorbent polymers (SAP) from baby diapers are powerful self-curing agents thatimprove strength and durability. The research focuses on self-curing in high-performance concrete to reduce shrinkage and enhance overall characteristics.

M. Lokeshwari, B.R. Pavan Bandakli, S.R. Tarun., (2020) studied the role of self-curing concrete indecreasing water waste in construction. It investigates the use of superabsorbent polymers (SAP) and polyethylene glycol (PEG) to improve the characteristics of concrete while eliminating the need for external curing. Self-curing concrete reduces shrinkage, increases durability and fracture resistance, andpreserves the reinforcement. Studies reveal that SAP lowers autogenous shrinkage while increasing compressive strength, fracture resistance, and durability. The study emphasizes the potential of self- curing procedures to alleviate water shortages, reduce labour costs, and promote environmentally friendly construction, as well as their revolutionary influence on sustainable building practices.

Joseph P. Rizzuto, Mounir Kamal, Hanaa Elsayad, Alaa Bashandy, Zeinab Etman, Mohamed N. Aboel Roos, Ibrahim G. Shaaban, (2020) investigated that in hot locations where water for curing concrete is scarce and quickly evaporates, self-curing admixtures such as PEG 400 can be useful. This study pitted self-curing concrete (SC) with PEG 400 against conventional concrete (NC) in hot weather. They discovered that SC with PEG 400 had more workability and strength than NC. The improvement was not simply due to water retention; other elements, such as PEG 400's capabilities at higher temperatures and its impact on the structure of the concrete, also played a role. Overall, the PEG 400 self-curing additive is suggested for concrete production in hot weather.

Fareed Ahmed Memon, Muhd Fadhil Nuruddin, Samuel Demie and Nasir Shafiq., (2011) studiedabout the look at how curing time and temperature impact the compressive strength of self-compacting geopolymer concrete prepared using fly ash. Researchers discovered that extended curing durations andtemperatures as high as 70°C enhanced compressive strength when curing conditions ranged from 24-

96 hours and 60-90°C. However, compressive strength reached a plateau after 48 hours, and temperatures over 70°C reduced strength. In conclusion, enhancing curing conditions, particularly at longer durations and moderate temperatures, improves the strength of fly ash-based self-compacting geopolymer concrete.

Ferhat Bingöl, Ilhan Tohumcu., (2013) investigated about different curing techniques (air, water, and steam) impact the strength of Self-Compacting Concrete (SCC) containing silica fume (SF) and fly ash (FA). They discovered that mineral additions such as SF and FA increase the characteristics of SCC, with FA demonstrating superior workability. Increased SF concentration increases compressive strength, but increased FA content diminishes it marginally. The greatest results were obtained with 15% SF and 28 days of water curing. Air curing degraded the concrete, but steam curing increased its strength, particularly after 55% FA replacement at 70°C for 16 hours. Overall, employing SF and FA can result in SCC with good characteristics, especially when properly cured.

Brahim Turkmen, Abdulhamit Kantarc, (2006) investigated the effects of incorporating expanded perlite aggregate (EPA) into self-compacting concrete (SCC) on compressive strength, apparentporosity, and capillarity coefficient under various curing conditions, revealing that SCC containing EPA generally exhibits decreased compressive strength, increased capillarity coefficient, and higher apparent porosity than SCC with natural aggregates (NA), particularly under air curing conditions (CC).

Mohamed Amin, Abdullah M. Zeyad, Bassam A. Tayeh, Ibrahim Saad Agwa, (2021) studied the article on the use of self-curing chemicals in concrete to lessen dependency on traditional curing procedures. The study used ingredients such as polyethylene glycol (PEG) and porous ceramic waste aggregate (PCWA) to improve the qualities of both conventional and high-strength concrete. Several experiments were carried out to assess workability, strength development, water permeability, durability, and the impacts of different curing agents. The findings indicated that self-curing regimes improved concrete qualities such as reduced water permeability and increased durability. The study emphasized the potential of self-curing concrete as a sustainable and efficient construction material.

M. Poovizhiselvi1, D. Karthik, (2017) studied the impacts of Polyethylene Glycol-400 (PEG-400) additive on concrete's mechanical qualities, with a focus on self-curing capabilities. Concrete, a commonly used construction material, usually requires external curing to attain the appropriate strengthand durability. Self-curing, an internal curing technology that uses PEG-400, provides an option by adding moisture to the cement to ensure proper hydration. The study looks at different percentages of PEG-400 in M20 and M30 grade concrete mixes and compares compressive strength, split tensile strength, and flexural strength. The results show an ideal dose of 1% PEG-400 for M20 and 0.5% for M30, providing equivalent strength to conventionally cured concrete.

M.M. Kamala, M.A. Safana, A.A. Bashandya, A.M. Khalilb, (2017) investigated the viability of using self-curing self-compacting concrete (SC-SCC) as a solution to difficult concrete compaction andcuring procedures. SC-SCC's self-compacting and self-curing capabilities combine to provide potentialbuilding benefits. The study looks at the effects of different curing agents on the behavior and characteristics of normal and high-strength SC-SCC. Experimental results show that different curing agents influence the workability and flowability of SC-SCC, with PEG600 being more effective for normal-strength SC-SCC and LECA for high-strength SC-SCC. Optimal curing agent doses are found to improve structural performance. Furthermore, reinforced SC-SCC beams have equivalent or better start cracking loads, ultimate loads, and fracture patterns than normal concrete. Overall, SC-SCC provides a feasible solution for structural parts when traditional curing and compaction methods

Pietro Lura, Ole Mejlhede Jensen, Shin-Ichi Igarashi, (2006) studied the article which discusses about the substantial influence of internal water curing on concrete, including hydration, moisture distribution, and qualities such as strength, shrinkage, and durability. It presents experimental methods for studying internal water healing and emphasizes its function in preventing early-age cracks. The emphasis is on understanding the effects of internal water curing, as opposed to those of curing agents such as lightweight aggregates (LWA) and super absorbent polymers (SAP). While the research focuses on purposeful internal water curing, it recognizes past findings in lightweight aggregate concrete (LWAC) where internal water curing was a positive outcome.

Ramalingam Malathy, Ill-Min Chung, Mayakrishnan Prabakaran, (2020) discusses about using natural additives, specifically Spinach and Giant Milkweed, to help concrete stay strong and last longer by keeping it moist from the inside. Using a special tool called FT-IR, we found that these natural

additives have a special part called hydroxyl ether, which helps keep water inside the concrete during the curing process. We tested how well these natural additives and a man-made additive (PEG) could help concrete reach the needed strength without needing to be kept wet. We used different tests like pullout tests, X-ray checks, and a special microscope to see how well the concrete with these additivesheld together and what it looked like. The goal of this research is to find cheaper and better ways to cure concrete without having to keep it wet all the time.

Alireza Ashori and Zaker Bahreini, (2015) investigated Calotropis gigantea, a plant that is not commonly exploited as a source of fibers for composite materials. The fibers from this plant show potential as a substitute for wood fibers, which are increasingly scarce. The study discovered that Calotropis gigantea fibers had qualities similar to other composite fibers and might be a viable sustainable choice. There are some discrepancies in the fibers of the plant's bark and seeds, and additional research is needed.

Raghu M J & Dr. Govardhan Goud, (2017) studied the possibility of employing milkweed fibers as a reinforcing material in epoxy composites. Milkweed fibers are natural fibers that are inexpensive, renewable, and possess good mechanical qualities. The study discovered that milkweed fiber composites have mechanical qualities similar to those created with other natural fibers including sisal, banana, and coconut. The essay also addresses how important it is to alkalize milkweed fibers before utilizing them in composite materials. This treatment increases the adhesion between fibers and epoxy resin, resulting in stronger composites. Overall, the study implies that milkweed fibers might be a feasible alternative to standard synthetic fibers in composite applications.

Sarita Sharma, Devesh Jaysawal, (2018) discuss that standard concrete curing process requires a largeamount of water, which might be problematic in water-scarce places. Self-curing concrete is an option that can help minimize the quantity of water required. This study studies the utilization of high-volume fly ash concrete with self-curing agents, including a synthetic polymer (polyethylene glycol) and a biopolymer (Spinacia oleracea). The study discovered that Spinacia oleracea performed better than polyethylene glycol in terms of workability, compressive strength, and durability.

Research Gaps:

Only a few researchers have explored the autogenous and drying shrinkage of concrete when PEG is utilized, indicating a gap in knowledge regarding the shrinkage properties of PEG-treated concrete. Investigations are needed to understand the long-term effects of different self-curing agents on the mechanical properties, durability, and cracking susceptibility behaviour of high-performance cementitious materials Investigate the durability of SCC with presaturated lightweight aggregates beyond the 90-day period to understand its long-term performance. There is a research gap regarding the optimal dosages and combinations of self-curing agents like SAP and LWA to achieve the best results in terms of strength, durability, and crack resistance. To explore the compatibility of self-curing agents with different types of cement, aggregates, and admixtures to ensure the overall performance and structural integrity of self-curing concrete.

Discussion

It is a type of concrete that has the internal elements or admixtures which help in retaining all content and cures perfectly without external curing practices (water spraying at top). This can help in many ways such as reducing water consumption, contributing to its strength and durability, improving sustainability levels and even easy usability within difficult building contexts. Several researchers are working on different kinds of construction waste materials which could be well used as self-curing concrete know-how in combination with other alternative lightweight aggregates, chemical admixtures, polymers and natural fibers. The molecules work by providing internal water as the concrete cures - while keeping the cement paste wet and preventing cracks from forming. Self-curing concrete is a work in progress, but it holds promise for longer-lasting, more sustainable construction.

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