REVIEW PAPER ON SELF-CURING CONCRETE USING BIO-ADMIXTURES

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ABSTRACT:

In the present scenario of water scarcity in the construction field, self-curing agents are being introduced and used to reduce the water requirement for curing of concrete. The research aims to investigate the effects of using Spinacia oleracea as a self-curing agent in concrete, in order to address the crisis of water scarcity in the construction industry.

The self-curing agent will be added in varying dosages by mass of cement, and will be compared to conventionally cured concrete. The specimens were cured for different time periods. The goal is to analyze the behaviour (compressive strength, split tensile strength and flexural strength) and durability properties of the resulting concrete. In addition to strength, durability is also an important factor in the performance of concrete structures. The durability of the self-cured concrete will be evaluated by assessing the water absorption, sea water resistance and acid resistance of the specimens.

The self-curing agent is expected to reduce water evaporation from the concrete, leading to increased water retention capacity compared to conventionally cured concrete. This, in turn, could potentially save a significant amount of water during the construction process. The results of the study could provide insights into the effectiveness of Spinacia oleracea as a self-curing agent and its potential for reducing water consumption in the construction industry.

KEYWORDS: Self-curing concrete, Conventional concrete, Spinacia oleracea, Behaviour, Durability, Water retention, Water evaporation.

1. INTRODUCTION

GENERAL:

Concrete is a widely used building material due to its durability, ease of manufacturing, and long service life. It is made by mixing cement, aggregates, and water together to form a hard matrix that binds the material into a stone-like substance. Different shapes can be achieved by using formworks, and there are two types of concrete mixes: nominal and design mix. Design mix is more economical as it is based on lab tests to determine the optimal mix proportions for achieving the required strength. The strength of the mix is denoted by M5, M10, M15, etc. The performance of concrete is a critical factor in the life of a structure, especially as construction continues to rapidly increase. One of the most important parameters affecting the performance of concrete is curing. According to the IS 456:2000 code clause (13.5), curing is the process of maintaining a satisfactory temperature regime while preventing the loss of moisture from the concrete.

1.2 CURING:

Curing is a critical period during which sufficient moisture content must be maintained to ensure that the cement particles continue to hydrate until the desired properties are developed in the concrete. The process of cement hydration is a long-term, continuous process that occurs at a decreasing rate over time. Curing allows for the continuous hydration of cement and the resulting continuous gain in strength. If curing stops, the gain in strength also stops.

Concrete must be kept moist during curing to achieve optimal strength and durability. Over 90% of a mix's final strength is typically achieved within four weeks, with the remaining 10% achieved over years. Inadequate curing can lead to plastic shrinkage cracking in the initial stage of evaporation and drying shrinkage cracking at the final setting stage. Adequate curing is essential for concrete to achieve its required structural and durability properties, making it one of the most important requirements for optimal concrete performance.

Proper curing of concrete structures is crucial to meet performance and durability requirements. Properly cured concrete leads to increased strength, lower permeability, and fewer cracks. Even if a mix contains enough water, any loss of moisture from the concrete will reduce the initial water-cement ratio, resulting in incomplete hydration of cement, particularly in mixes with a low water-cement ratio. This can result in poor-quality concrete.

1.3 SELF-CURING CONCRETE:

In the construction industry, curing concrete requires a significant amount of water, which can pose a challenge for sustainability efforts and construction in remote areas with limited water resources. To address these issues, self-curing concrete has emerged as a viable alternative to traditional curing methods.

Self-curing concrete is a specialized solution that can address insufficient curing caused by human negligence, water scarcity, and difficult terrains. Self-curing agents such as water-soluble polymers and water retention polymers can be added to concrete to reduce water evaporation and increase water retention capacity. This eliminates the need for manual labor to provide water or external curing, while producing concrete with comparable or even superior properties to conventionally cured concrete.

Using self-curing admixtures is crucial as water resources become increasingly valuable, with curing operations being a critical factor in developing the micro-structure and pore structure of concrete for improved durability and performance. Excessive evaporation of water from fresh concrete can lower the degree of cement hydration and result in unsatisfactory properties, so adequate water availability for cement hydration during curing is essential. Self-curing concrete with internal curing agents is an effective way to overcome challenges in ensuring effective curing procedures in construction industry.

1.4 BIO ADMIXTURES:

1) Calatropis gigantean

2) Spinanceaoleracia (Palak)

These bio-materials possess unique properties of retaining and releasing water as and when required, acting as internal reservoirs similar to self-curing agents. Their microstructural properties resemble those of polyethylene glycol. Although the quantity of these bio-materials used in cement is less than 1% by weight, they perform better than PEG and are cost effective. Additionally, there is no requirement for water curing from the day of concreting, and the required strength is achieved.

2. LITERATURE REVIEW

EI Dieb (2007)[1] Investigated water retention of concrete using water-soluble polymeric glycol as self- curing agent. Concrete weight loss and internal relative humidity measurements with time carried out, in order to evaluate the water retention of self-curing concrete. Water transport through concrete is evaluated by measuring absorption %, permeable voids%, water sorptivity and water permeability. The water transport through self during concrete is evaluated with age. The effect of the concrete mix proportions on the performance of self-curing concrete were investigated, such as cement content and water/cement ratio. In this study water retention and hydration of concrete containing self-curing agent is investigated and compared to conventional concrete. Also, water transport through this concrete is evaluated and compared to conventional concrete continuously moist-cured and air-cured. The dosage was kept constant for all the self-curing concrete mixes. The investigation aimed at studying on concrete with different quantities of cement (350-450Kg/m3) at different water- cement ratios (0.3-0.4) both for self, conventional and air-curing concrete and compare the results for different test.

The study found that the concrete mixes incorporating self-curing agent had higher water retention compared to conventional concrete mixes, as evidenced by the weight loss over time. Additionally, the self-curing concrete suffered less self-desiccation under sealed conditions and resulted in better hydration over time under drying conditions compared to conventional concrete. Water transport through self-curing concrete was also found to be lower than air-cured conventional concrete. Finally, as the self-curing concrete aged, water sorptivity and water permeability values decreased, indicating a lower percentage of permeable pores due to continued cement hydration. Overall, these findings suggest that self-curing agents can enhance the performance of concrete mixes in terms of water retention, hydration, and durability.

Rajesh Kumar (2011)[2] Studied that among the various ways of internal curing for concrete, one of the technique is by using hydrophilic materials in concrete. The use of hydrophilic materials in concrete minimizes the loss of water and also attracts moisture from the atmosphere and help in continuous curing of concrete. The paper discusses the experimental investigation to arrive the optimum dosage of Polyethylene Glycol (PEG) in concrete. The parameters in the study are with two grades of concrete, PEG of two molecular weights, different dosage of PEG and two curing conditions. Two grades of concrete M30 and M40 were considered. Polyethylene Glycol (PEG) was added in dosages 0.1%, 1.0% and 3.05 % by weight of cement. Two types of curing methods indoor curing and conventional curing by immersing the specimens in water were adopted in the study. Concrete cubes of sizes 150mm×150mm×150mm were cast an amount of water retained in concrete under different curing methods and variation of compressive strength were studied.

The findings suggest that, when it comes to self-curing agents for concrete, Polyethylene glycol (PEG) of lower molecular weight performs better than higher molecular weight PEG. Additionally, it was observed that a lower dosage of PEG is more effective in achieving self-curing concrete compared to higher dosages. Therefore, in order to achieve efficient self-curing, it is recommended to use lower molecular weight PEG and administer it in lower doses.

Geetha and Dr. Malathy (2011)[3] In this research they compare the strength and durability properties of different grade concrete by using polymeric materials without use of any external water. During this experimental work grade of concrete selected was M20, M30 and M40. Spinacia oleracea (palak) of 0.6% to 0.8% weight of cement is added as admixture to concrete while preparing concrete. Erukkampal at 0.2% to 0.4% and polyethylene at 0.2% to 0.4% of cement were used as self curing agent. During experimental work split tensile strength, compressive strength, acid resistance, sea water resistance and accelerated corrosion of concrete was observed. The strength as well as durability properties of specimens with palak green was better than other three alternatives and proved be best when compared to external curing. Also the cost of internal curing was cheaper than external curing.

Jagannadha Kumar et al. (2012)[4] In this research paper strength of self curing concrete has been measured using self curing agent PEG-400. This work was carried out for M-20 and M-40 grade of concrete and mechanical strengths of self cured concrete was compared with conventionally cured concrete. Different dosage of PEG-400(0-2%) have been taken of weight of cement. Result shows that optimum dosage of PEG-400 was 1% for M-25 and 0.5% for M-40 grade of concrete. Result also shows that as the percentage of PEG-400 increased slump increased for both M-20 and M-40 grade of concrete. All strength has been increased at its optimum dosage as compared to conventional curing.

Manoj kumar and Maruthachalam (2013)[5] In this experimental work carried out to investigate self curing concrete. Work have been carried out for M-40 grade concrete using super absorbent polymers and application of wax based curing compound on de-moulded concrete specimen. Experimental work carried out to measure the effect of variation in strength parameters such as Compressive strength, Split tensile strength and flexural strength. Experimental work carried out for different dosage of SAP (0.2%-0.4% weight of cement) and compared with that conventional cured concrete. A result indicates that internally cured concrete using SAP attains more compressive strength than conventional cured concrete. Both compressive strength and split tensile strength of self cured concrete higher than conventional cured concrete. Optimum dosage to attain maximum strength was 0.3% but at same dosage flexural strength of self cured concrete was lower than water cured concrete. There was gradual increase in strength for dosage from 0.2 to 0.3 % and later gradually reduced.

Aielstein et al. (2013)[6] This research paper was carried out to effect of sulphate resistance of self cured fly ash based concrete. In this research work sulphate attack measurement on self curing concrete was measured at 28 days and 56 days for M-20, M-30, M-40, M-50 grade of concrete. Percentage of weight loss of self cured concrete at 28 days and 56 days was measured. The concrete mix design was carried out for different grade like M-20, M-30, M-40 and M-50. The percentage of fly ash replacements are 10%, 15%, 20%, 25% used. Results indicate that permeability of concrete decreases with increase in replacement of fly ash with cement and in addition of PEG dosage. So penetration of chemicals (Na_2So_4) is decreased with addition of PEG and concrete is safe against sulphate. The percentage of weight loss of the concrete specimens is also decreased for every grade of concrete.

Vinayak et al. (2013)[7] Investigated behaviour of self -cured steel fibre reinforced concrete. Fibres are used in concrete to control cracking due to both plastic and drying shrinkage which reduces the permeability of concrete and bleeding of water. In this study steel fibres are used as an admixture and pumice aggregates as a self-curing agent. The grade of concrete was found to be M30. The steel fibres are added to concrete with 2% by volume fraction and self-curing agent pumice aggregates are replaced by natural aggregates by different percentages 0%, 10%, 20%, 30%, 40% and 50%. The experimental programme involves the sorptivity, water absorption test and strength properties of concrete. In casting programme the cubes are cast by taking the pumice aggregates in 24 hrs water absorption condition and without water absorption condition and the results are compared. The study concluded that when using air curing, a 30% replacement of pumice aggregates with natural aggregates resulted in higher strength in compressive strength, flexural strength, split tensile strength, and shear strength tests. However, increasing the amount of pumice aggregates led to a decrease in strength. On the other hand, when using water curing, using 0% replacement of pumice aggregates with natural aggregates gave the highest strength in all the tests mentioned. Similarly, increasing the dosage of pumice aggregates led to a decrease in strength. Overall, the study suggests that the optimal strength performance is achieved with a moderate replacement of pumice aggregates and a specific curing method, depending on the percentage of replacement used.

Amal and Jino (2013)[8] Investigated on mechanical properties of self-curing concrete. In this shrinkage reducing admixture super absorbent polymer (SAP) is a self-curing compound. The grade of concrete was found to be M40. In this study the self-curing agent is added to concrete with 0%, 0.2%, 0.3%, and 0.4% by weight of cement. The experimental programme involves the compressive, tensile and flexural strength for M40 grade of concrete. The compressive strength, flexural, split tensile results are taken at 3, 7, 28 days of curing and compare the results with air curing it was conclude that, the optimum dosage of SAP for maximum strengths (compressive, flexural, split tensile strength) was found to be 0.3% for M40 grade of concrete.

Chellagifta et al. (2013)[9] Explored the use of Super Absorbent Polymers (SAP) and Light Weight Fine Aggregates as an internal curing material for high performance concrete. Three mixes were used in this study: Mix M1 which is normal concrete without any internal curing material, Mix M2 obtained by adding SAP at 0.1% weight of cement and Mix M3 obtained by replacing 25% of fine aggregate by light weight fine aggregate. Mechanical and durability tests were conducted to determine the properties. To determine compressive strength, specimens of size 150x150x150mm were cast, and cylinders of size 100mm diameter and 300mm height to determine the tensile strength. Beams of size 1200x100x150mm were cast to determine flexural and shear behaviour. Durability tests are conducted on cylindrical specimens of size 100mm diameter and 150mm height while permeability tests were carried out on specimens of size 100mm diameter and 50mm height. The results of this study comparing the strength and durability of different concrete mixes showed that, normal concrete had higher compressive strength at 3 days compared to other mixes, but after 28 days, concrete with lightweight aggregate (LWA) had the highest compressive strength. Concrete mixes containing LWA as an internal curing material also showed higher tensile and flexural strength, although those containing superabsorbent polymers (SAP) were also close. Durability tests revealed that SAP internal curing led to less chloride penetration than LWA specimens. Additionally, mix M2 had the lowest coefficient of permeability among all the mixes tested. These findings suggest that LWA and SAP can be effective internal curing materials for improving the strength and durability of concrete, with each having their unique advantages.

Mohanraj et al. (2014)[10] Studied on "self-curing concrete incorporated with polyethylene glycol". The compressive strength of cube for Self-cured concrete is higher than of concrete cured by conventional curing method. The split tensile strength of self-cured concrete specimen is higher than that of the conventionally cured specimen. Self-cured concrete is found to have less water absorption values compared with concrete cured by other methods. Self-cured concrete thus have a fewer amount of porous.

Magda et al. (2014)[11] 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%, 10%, 15% and 20% of volume of sand and the second type is a chemical agent polyethylene-glycol with different percentages 1%, 2% and 3% of weight of cement. 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% 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 during the experiment. The results show that the use of self-curing agent (polyethylene-glycol) 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 (polyethylene-glycol) was more effective than self-curing agent leca. In all cases, both 2% (polyethylene-glycol) and 15% leca were the optimum values. Higher cement content or lower water–cement ratio leads to more effective results of self-curing agents in concrete.

Geetha and Dr. Malathy (2017)[12] In their study they compared the strength development of self curing concrete with respect to age using (spinacia oleracea, calatropis gigantea, polyethylene glycol) as admixtures. The dosage of self curing agents in liquid form was added with different water cement ratios of 0.54, 0.49, and 0.39 on M20 grade concrete and their workability and strength properties were studied. From the trail tests it was found that spinacia oleracea at 0.6% calatropis gigantea at 0.25% and polyethylene glycol at 0.3% by weight of cement added to mixes yielded higher results. They concluded that the strength development of self cured concrete is more than the conventionally cured concrete out these three self curing agents (spinacia oleracea, calatropis gigantea, polyethylene glycol), spinacia oleracea is attaining higher strength at early stages when compared to conventionally cured concrete and these bio materials are cost effective and eco friendly and they can be in concrete road pavements without further maintenance of water curing.

Daud Mohamad et al. (2017) [13] Research has studied the use of internal curing agents such as Polyethylene Glycol (PEG400), ceramic, and Super Absorbent Polymer for engineering and construction applications. In this study, new diapers containing super absorbent polymer were used as an internal curing agent in concrete. The polymer becomes a gel-like substance when wet and absorbs water.Concrete cubes with a size of 100 x 100 x 100mm were tested with varying ratios of diapers polymer (0%, 1%, 2%, 3%, 5%, and 10%) at 3, 7, 28, and 90 days.

The results showed that the internal curing process improved the hydration process, preventing early age cracking and promoting cement hydration. The fluid transport coefficients were reduced, and the strength increased. Compared to conventional curing, internal curing allowed water to penetrate uniformly throughout the concrete, minimizing capillary stress and strain development.

Overall, internal curing using baby diapers polymers can be a cost-effective and sustainable solution for areas with water scarcity, contributing to the quality and durability of construction projects.

Vaisakh G et al. (2018)[14] In this experimental study, the use of polyethylene glycol (PEG) as a shrinkage reducing admixture in M50 grade concrete was found to improve self-curing, hydration, strength, and durability. The study found that the optimum PEG content for achieving optimal values in strength and durability(compressive strength, split tensile strength, and modulus of elasticity) is 1.5% and it also exhibited better curing.

Additionally, the study found that resistivity was higher in M50 concrete containing 1.5% PEG, indicating better electrical conductivity and corrosion resistance. Micro-structure studies also revealed improved curing and hydration at the micro-structural level in M50 concrete with 1.5% PEG. Moreover, the use of PEG as a curing agent was found to result in better strength and durability than immersion curing, making it a more effective method for improving the properties of concrete.

In summary, the use of PEG in concrete can lead to significant improvements in strength and durability, with the optimal dosage for M50 concrete being 1.5%. The micro-structure studies also showed improved curing and hydration at the micro-structural level, indicating that PEG is a better curing agent than conventional methods.

Rajasree and Dr. Vincent (2019)[15] This study investigated the strength characteristics of self-curing concrete with silica fume incorporating different chemical curing agents to eliminate the shrinkage effect.The selected grade of concrete was M30, and the self-curing agents were polyethylene glycol-6000 (PEG 6000 of 0.2%, 0.3%, and 0.4%) and Sodium polyacrylate (SAP of 0.2%, 0.3%, and 0.4%) relative to the cement mass. The partial replacement of cement with silica fume (5% and 10%) was also tested to increase the properties of the concrete.

The findings suggest that the use of PEG 6000 in concrete can have several benefits, including reducing water usage for curing, decreasing evaporation loss, and contributing to the hydration process. It can also help to diminish crack formation and act as a water reservoir for concrete when 10% silica fume is added, which can increase the pozzolanic reaction.The research also found that the finishing surface for both conventional and self-curing beams was almost the same, with a smooth surface without any autogenous cracking. However, the ultimate load carrying capacity of self-curing beams using PEG 6000 (0.2%) and 10% silica fume increased by 7.78% compared to conventional beams. Furthermore, the compressive strength increased by 8.61%, and the split tensile strength increased by 4.62% compared to conventional concrete.

Internal curing agents such as SAP and PEG 6000 had 50 to 110 times water retention capacity from their own weight, and their dosage escalated the degree of the hydration process. Overall, the study suggests that the water scarcity crisis in the construction industry can be overcome by introducing and implementing PEG 6000 with concrete, which can reduce the additional cost of water in scarcity areas by using self-curing agents.

Ahmad and Navinderdeep (2019)[16] The study aimed to develop an economically viable self-curing concrete by using natural and chemical admixtures. Wood powder and polyethylene glycol 400 (PEG400) were used in varying percentages to find the optimum mix for M30 grade concrete in both room temperature (15-20°C) and outdoor conditions (30-35°C). Fourteen trials were conducted using different percentages of wood powder (2-8%) and PEG400 (0.5-2.5%).

The results showed that the use of wood powder and PEG400 had a positive effect on the mechanical properties of concrete compared to conventional concrete. The optimum mix of 6% wood powder with 1.5% PEG400 was found to be effective and economical for M30 grade concrete at room temperature. However, for outdoor temperature, a mix of 6% wood powder with 2.5% PEG400 was found to be optimum. Increasing the self-curing agent beyond the optimum level reduced the compressive strength of the concrete after 7 days.

Using more wood powder decreased the concrete's strength but increased its moisture-absorbing capacity. The use of self-curing agents in concrete increased its strength compared to conventional concrete. The study concluded that an economical self-curing concrete could be developed using readily available wood powder and PEG400, and the results could be used to guide the development of self-curing concrete in other settings.

Avinash and Gajendra (2022)[17] The objective of this experimental investigation was to develop self-curing concrete using light expanded clay aggregate (LECA) to save water in making concrete and construction. The study focused on comparing the strength characteristics of normal strength concrete cast with the self-curing agent LECA and conventionally cured concrete. A trial and error method was adopted for designing the normal strength internal curing concrete of grade M30. The study used replacements of 10%, 20%, and 30% of LECA by volume of aggregate to produce internal-curing concrete. The compressive and flexural strength of the concrete was tested for 7 and 28 days of curing. The results of the study showed that the compressive strength of mix proportion MD2 (Aggregate 90% and LECA 10%) was maximum compared to other mix designs except for MD1 for 7 days of curing. Similarly, the flexural strength of concrete mix proportion MD2 (Aggregate 90% and LECA 10%) attained maximum strength compared to other mix designs except for MD1 for both 7 and 28 days of curing. In conclusion, the use of LECA as a self-curing agent in concrete has the potential to save water in making concrete and construction. The results suggest that, mix proportion MD2 with 10% LECA replacement can provide higher compressive and flexural strength compared to other mix designs. Further research can explore the use of other self-curing agents and their effectiveness in concrete.

3. CONCLUSION

Based on the literature review, it has been observed that previous studies on self-curing concrete have primarily compared it with conventionally cured concrete. Several findings have been reported in this regard:

1) Self-cured concrete using spinacia oleracea, calatropis gigantea, and polyethylene glycol has been found to exhibit higher strength development than conventionally cured concrete. Among these three self-curing agents, spinacia oleracea has been observed to achieve higher strength at early stages. Additionally, these bio materials are considered to be cost-effective and environmentally friendly.

2) The use of spinacia oleracea as an internal curing agent has resulted in concrete specimens with better strength and durability properties than those cured externally. Internal curing using spinacia oleracea has also been found to be more cost-effective than external curing methods.

3) Self-cured concrete has been shown to exhibit lower water absorption values compared to concrete cured by other methods.

4) Water transport through self-curing concrete has been found to be lower than that in air-cured conventional concrete.

In light of these findings, the current study aims to investigate the properties of self-curing concrete using spinacia oleracea as an admixture.

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