

Mechanical and thermal analysis of self-curing concrete modified with polyethylene glycol-400

Ruhal Pervez Memon ^{a,*}, Alyas Khan Mandokhail ^b, Jabir Hussain Memon ^c, Muhammad Noor ^d, Irfan Ali ^e, Gohar Nadeem ^d

^a Department of Civil Engineering, Dawood University of Engineering and Technology, Karachi, Pakistan.

^b Department of Civil Engineering, Sir Syed University of Engineering and Technology, Karachi, Pakistan.

^c Department of Civil Engineering, Ziauddin University, Karachi, Pakistan.

^d Department of Civil Engineering, Balochistan University of Engineering and Technology, Khuzdar, Pakistan.

^e Department of Telecommunication Engineering, Dawood University of Engineering and Technology, Karachi, Pakistan.

* Corresponding author: Ruhal Pervez Memon, Email: ruhal.memon@duet.edu.pk

Received: 05 May 2025, Revised: 20 June 2025, Accepted: 30 June 2025, Published: 01 July 2025

KEY WORDS

Self-curing Concrete
Polyethylene Glycol
Workability
Compressive Strength
Temperature Exposure

ABSTRACT

The development of concrete microstructures through curing enhances the material's performance and longevity. As water resources become increasingly scarce, there is an urgent need for research on water conservation in concrete. As a result, efforts have been made to develop self-curing concrete by employing polyethylene glycol 400 (PEG-400) as a self-curing ingredient. Work is frequently conducted in areas with severe water shortages when using purifying water is not financially feasible. The present investigation involves the use of a self-curing agent, PEG-400, at concentrations of 0%, 0.5%, 1%, and 2% by weight of cement. After 28 days of curing, the compressive strength, density, and appearance of conventional and self-cured concrete mixtures of M30 grades were examined. The thermal response of controlled and optimized self-curing concrete was investigated at elevated temperatures of 200°C, 400°C, 600°C, 800°C, and 1000°C, with a Continuous heating duration of 6 hours and after that furnace cooling was adapted, to analyze the density and residual compressive strength of controlled and optimized self-curing concrete. At 0% PEG-400, the baseline strength was 37.35 MPa. The optimal concentration of PEG-400 in M30 grade concrete was found to be 0.5% by weight of cement, which yielded a maximal strength of 47.87 MPa and a workability of 70 mm. The residual compressive strength of optimised self-curing concrete decreases by up to 15.56%, while that of controlled self-curing concrete decreases by up to 38.17% when the temperature is raised to 1000 °C in thermal behaviour analysis. The loss of compressive strength in controlled self-curing concrete is 22.61% higher than that in optimal self-curing concrete. It is determined that the self-curing approach would improve concrete qualities in terms of fire-resistant construction. Concrete sample containing 0.5% PEG-400 exhibited minimal evident evidence of spalling when heated up to 1000°C. Taking all considerations into account, the self-curing concrete containing 0.5% PEG-400 exhibited satisfactory performance, delivering all the required concrete properties.

1. Introduction

Concrete is the principal engineering material used in most civil engineering constructions. Because of its strength, availability, and adaptability, concrete is the most extensively used building material in the world; hence, contemporary construction organizations have requested almost a billion tons of concrete for infrastructure. The cement and concrete materials sector have seen substantial growth in recent years. It will increase from \$419.23 billion in 2024 to \$448.12 billion in 2025, with a compound annual growth rate (CAGR) of 6.9% [1]. Construction booms, industrialization, economic development, population increase, infrastructural spending, and regulatory standards have all contributed to historical growth. Concrete is believed to be modified with diverse components and techniques to enhance its properties and applicability for various construction purposes. Concrete constructions need curing to satisfy performance and durability standards.

Water is utilized extensively in the construction industry for curing. Soon, the entire construction sector will need to transition to an alternative curing system to promote both indoor and outdoor construction activities. Even in remote areas with few water resources, water is saved for the sustainable development of the environment [2]. The construction sector is expanding daily, especially in the desert and rural areas. Even Pakistan, India, and other nations struggle to provide their inhabitants with clean drinking water. As a result, the building industry is required to investigate alternative concrete curing techniques [3]. In several instances, inadequate water quality and various other practical obstacles render successful concrete curing unattainable. Proper curing is essential for concrete to get the requisite strength and performance. Normal concrete cures after the completion of the mixing and pouring steps. A technique known as self-curing is employed to supply concrete with adequate moisture, facilitating prolonged hydration. It may also be employed to provide additional moisture to concrete to facilitate the more efficient hydration of cement and prevent self-desiccation[4]. Self-curing agents increase performance, strength, and durability requirements while lowering the amount of self-desiccation in concrete. In conventional curing, this is executed by administering external curing after mixing, placing, and finishing[5]A static case analysis of many collapsed buildings in Nigeria was used to conduct the research [6]. From 1985 to November 2006, 86 building collapses were documented for the case study. Case study statistics show that poor workmanship is the leading source of low-quality

concrete used in building construction, which in turn causes faulty concrete to cure at an early age. Collapses owing to incorrect treatment at an early age occur not only in Nigeria, but also internationally, such as Algeria, Uganda's East African nations, Kenya, Thailand, South Africa, and numerous other African and Asian countries [7].

The technology of concrete has progressed significantly during the previous two decades. Admixtures can be employed to generate a rapid-setting concrete mixture that is superior, utilizing conventional materials. Self-curing materials may be incorporated into concrete to produce internally cured concrete. Consequently, self-curing concrete is a modern method used in the construction industry to mitigate curing-related challenges [8]. In comparison to normal curing concrete, the idea of self-curing chemicals is to enhance the concrete's water retention capacity by decreasing water evaporation. There are currently two main techniques for curing concrete inside. The first method employs saturated porous lightweight aggregate (LWA) to provide an internal water source that compensates for the water lost by chemical shrinkage during cement hydration. The second method utilizes liquid-based additives that reduce water evaporation from the concrete surface and enhance water retention. Natural, recycled polymers, and chemicals are examples of materials employed in the study as self-curing agents. They are not widely accessible and vary depending on the area; also, chemicals containing self-curing ingredients are not environmentally friendly. Present self-curing agents exhibit significant porosity, leading to enhanced concrete voids and reduced compressive strength [9]. The existing self-curing agents depend on natural sources, necessitating industrial processes to achieve their final form, which contributes to increased carbon dioxide emissions. In the context of self-curing concrete, the acquisition of present self-curing substances also hurts natural resources, resulting in non-eco-friendly products.

Polyethylene glycol 400 (PEG-400) is used by several sectors to address challenges in the construction industry. There is currently insufficient research on the use of PEG-400 solutions to improve the performance of self-curing concrete. PEG-400's mechanical and physical characteristics make it a suitable option for self-curing concrete applications. Additionally, it is essential to assess the impact of including PEG-400 as a self-curing agent on the thermal properties of concrete in fire scenarios. The present research seeks to evaluate PEG-400 as a self-curing agent, focusing on its fresh and hardened properties, engineering features, and thermal behavior

of the proposed self-curing concretes containing varying concentrations of PEG-400 solution. For another strong reason to investigate the thermal properties of self-curing concrete, consider the fact that in post-fire circumstances, measuring the remaining mechanical qualities of concrete is critical for determining between structural restoration or destruction. And put back together again because of financial challenges. Due to the construction industry's intent to restore, it is essential to examine the thermal characteristics of concrete. Utilizing these attributes, the industry may evaluate the residual characteristics of self-curing concrete and make an informed choice on renovation or demolition.

2. Materials and Methods

Prior studies used PEG-400 as a self-curing agent in self-consolidating concrete, high-performance concrete, mass concrete, and lightweight concrete [10]. PEG-400 is hardly used in conventional-strength concrete. The self-curing process influences the outcomes of self-curing concrete (SCC) depending on the environmental circumstances of each location. In Pakistan's arid environment, the self-curing method received little attention. [11] This study approach applies only to normal-strength self-curing concrete in dry areas of Pakistan.

2.1 Experimental Materials

To prevent any form of contamination, the cement utilized in this study was procured from a single supplier and maintained in an airtight container. As illustrated in Fig. 1(a), Ordinary Portland Cement from Lucky Cement, according to ASTM C150 specifications for Type I Cement, was used throughout the trial phase [12].

The natural sand obtained from Fresh Nadi Noriabad Sand, conforming to ASTM C33 Standard for fine aggregates, had a specific gravity of 3.58 and a fineness modulus of 2.84 [13]. By ASTM C117, the sand was cleaned with water before use to diminish silt and other contaminants [14]. The sand was subsequently enclosed in polythene bags to safeguard it from atmospheric moisture following oven-drying, as illustrated in Fig. 1(b).

The coarse aggregate employed in this investigation was sourced from the Hub River. Fig. 1(c) Illustrates air-dried crushed granite, ideal at 10 mm, employed as a coarse aggregate in all mixes. It possesses a specific gravity of 2.7 and a water absorption rate of 0.5%. The aggregates have been

thoroughly cleaned of organic particulates, including crusted soil, leaves, and other hazardous materials.

Tap water that was readily accessible in the vicinity was employed for concrete mixture and curing, as well as for certain specimen testing. The tap water complies with ASTM C1602 specifications. The significance of water quality is essential, since impurities may compromise the integrity of concrete. The PEG used was PEG-400, supplied in a sealed 10-kilogram container, as seen in Fig. 1(d). It is a clear, colorless, viscous liquid at room temperature.

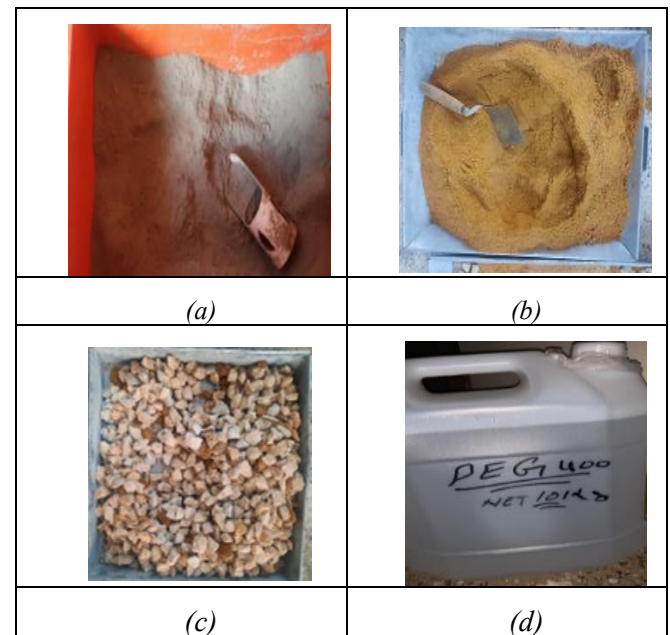


Fig. 1. (a) Cement (b) Sand (c) Stones, (d) PEG-400

2.2 Concrete Mix Design

The DOE approach was used to develop concrete mixes with a target compressive strength of 30 MPa (Grade 30) under the exposure circumstances outlined in BS 8500. In 1997, the Department of the Environment (DOE) released a definitive concrete design methodology that conformed to British regulations [15,16]. BS 8500-1 and 2 were used to categorize the exposure class related to the concrete application to ascertain the mixing ratio required to produce Grade 30 concrete. The concrete mix design ratio was around 1:2:2. The water cement ratio was adjusted at 0.55 to obtain optimal workability in concrete compositions. The targeted mean strength was 43 MPa. Table 1 outlines the quantities of Fine Aggregates (FA) and Coarse Aggregates (CA) in kg/m³ for SCC0.0, indicative of self-curing concrete (SCC) containing 0% PEG-400 in the mixture. SCC0.5, SCC1.0, SCC1.5, and SCC2.0 indicate that the concrete mixture has 0.5%, 1%, 1.5%, and 2% additives, respectively.

Table 1

Self-curing Concrete mixtures of grade 30.

Batches	Cement	Water	PEG-400	FA	CA
	(kg/m ³)	(kg/m ³)	(%)	(kg/m ³)	(kg/m ³)
SCC0.0	455	250	-	875	815
SCC0.5	455	250	0.5	875	815
SCC1.0	455	250	1.0	875	815
SCC1.5	455	250	1.5	875	815
SCC2.0	455	250	2.0	875	815

2.3 Batching, preparation, mixing, and curing of specimens.

The overall volume of the batch was first evaluated using the necessary proportions for the mixing. To ensure homogeneity, the PEG-400 was combined with mixing water as Additive. Approximately 15% of the projected concrete volume was included during the batching process to account for probable waste during mixing and testing [17]. The specimens were produced by the requirements outlined in the British Standard Bs En 12390-1 [18]. 35 cube specimens will be fabricated with and without polyethylene glycol (PEG-400), and 100x100x100 mm cubes will be employed. The components were combined using a drum mixer to produce homogeneous concrete. To ensure the absence of residual water or concrete mixture, the drum mixer was cleaned and dried one day before the combination of the components. Crushed granite and river sand were combined for three minutes to create the self-curing concrete. Cement binder was then added, and the mixture was mixed for five more minutes to ensure homogeneity. The water-PEG-400 solutions were then carefully added and thoroughly mixed for around five minutes. To standardize the outcomes in the real world and mitigate the influence of weather or other external variables, all concrete mixture specimens were air-cured for 28 days inside the laboratory. The objective of self-curing is to cure concrete without the use of water curing techniques, which is why only air curing is used.

2.4 Tests for Characterization

The assessment of specimens is categorized into two parts. The first phase evaluates the workability, compressive strength, density, and aesthetic qualities of each concrete mixture, as shown in Table 1. The second stage focuses on the thermal behavior of the optimized concrete mixture and the control concrete mixture (SCC0.0) among all mixes, as seen in Table 1. This includes analyzing compressive strength before and after heating. Include the density of both the optimum and control concrete mixtures.

Depending on the equipment available, the tests adhere to several standards, including ASTM, BS, and IS.

2.4.1 Workability

The workability of freshly mixed concrete was evaluated by measuring its slump. To evaluate the workability of freshly mixed concrete and guarantee uniformity between batches, the slump test was conducted. Concrete mixtures free of a superplasticizer (SP) have slump levels ranging from 60 to 180 mm. But PEG-400 may have an impact on slump since it functions as a lubricant or water-retaining agent. The British Standard BS 1881-102 technique is used to assess the slump [19].

2.4.2 Physical Appearance

Standard visual assessment procedure [20] was followed to analysis the visual attributes of concrete, including color and surface quality, were assessed only by direct observation and photography. This attribute was considered because of PEG-400's viscoelasticity, transparency, and clarity. The uniformity of concrete color and the influence of PEG-400 on its color and surface polish were analyzed, with relevant photographs included in the following section. Control and experimental samples were compared with the same background and lighting conditions.

2.4.3 Density

The density of concrete was evaluated using 100x100x100 mm cubes at 1, 7, and 28 days after curing. The specimens were weighed with a precision digital scale (± 0.01 g) after being surface-dried to a saturated surface dry (SSD) state. Mass was divided by the cube's known volume (100 mm³) to determine density. A density measurement conducted in accordance with the British Standard BS 1881-114 [21]. Measurements were made over a period of many days to track the emergence of PEG-400-induced hydration-related density changes. The purpose of this test was to determine how different PEG-400 doses change concrete density as a result of self-curing.

2.4.4 Compressive strength

The compressive strength test is performed on specimens that were cured in water at 20 ± 2 °C for 28 days before testing. The assessment is conducted according to British Standards BS 1881-116 and BS 1881-115 [22, 23]. Three sets of specimens were evaluated at various curing ages. The specimen was properly prepared and placed between the upper and lower metal bearing plates, in compliance with the

applicable standard, throughout testing. The specimen is exposed to a steady loading rate of 5 kN/sec until failure occurs. The purpose of the test was to determine how different PEG-400 concentrations affected the development of compressive strength, a crucial performance indicator for self-curing concrete. Concrete is a construction material used for its compressive strength. The strength characteristic indicates the quality of the concrete.

2.4.5 Thermal evaluation

The mix of concrete, moisture content, and kind of aggregate significantly influences these qualities. Multiple testing procedures have been created to identify the thermal characteristics of concrete at elevated temperatures [24, 25]. Kodur presents a comprehensive examination of the impact of temperature on the thermal properties of distinct types of concrete [26]. The specimens were produced after the optimization of concrete's strength characteristics, including density, compressive strength, and aesthetics. Cubes sized 100 x 100 x 100 mm were used for testing purposes. Only the control and optimized concrete mix cube specimens were exposed to temperatures of 200 °C, 400 °C, 600 °C, 800 °C, and 1000 °C for six hours each in the heating oven shown in Fig. 2. The mean of the three specimens evaluated at 200 °C, 400 °C, 600 °C, 800 °C, and 1000 °C was used to determine the average outcomes of the residual compressive strength tests for both the control and optimized self-curing concrete mixtures. The heating rate was maintained at 5 °C/min, and the furnace's 6-hour holding period was verified using the cooling procedure, which calls for gradual air cooling to room temperature.



Fig. 2. Heat Oven for thermal analysis.

3. Results and Discussion

3.1 Workability

Fig. 3 is an instance of the experimental findings of the slump test. The addition of PEG-400 to newly poured

concrete increased slump values. The slump depth of the SCC0.0 concrete mix was 50 mm, whereas the SCC0.5, SCC1.0, SCC1.5, and SCC2.0 mixes exceeded the control concrete (SCC0.0), measuring 70 mm, 90 mm, 115 mm, and 140 mm, respectively.

Ethylene oxide and water undergo condensation to produce the highly water-soluble polymer polyethylene glycol. The use of water-soluble polymers, serving as plasticizers and facilitating the flow of new concrete, may be responsible for the increase in slump. PEG-400 may indirectly enhance slump by improved internal lubrication and a delay in moisture loss, as opposed to other plasticizers like Polycarboxylate Superplasticizer (PCE), which reduce surface tension or disperse cement particles. The results align with those of prior research [27].

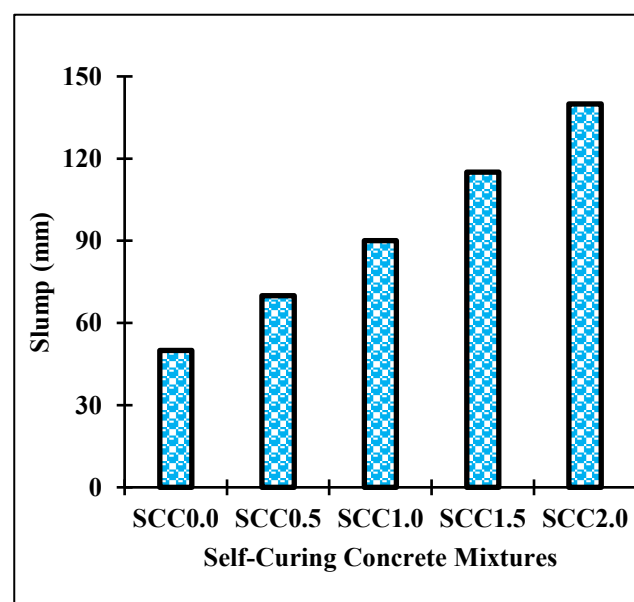


Fig. 3. Workability of fresh self-curing concrete mixtures

3.2 Density of hardened concrete

Fig. 4 illustrates the density of hardened control and self-curing concrete mixtures. The density of SCC0.5, SCC1.0, and SCC1.5 concrete mixes on the first day of concrete age was greater than SCC0.0. However, the density of SCC2.0 is lower than that of any other blend. It is due to excess PEG-400 may function as a soft inclusion, trap air, or even prevent full cement hydration, decreasing density and strength [28]. On the 28th day of concrete. On the 28th day of concrete hardening, an identical scenario followed.

Concrete density is entirely dependent on the density of the binder, particles, and water. The only justification for the density enhancement is the

incorporation of PEG-400. The incorporation of a minimal quantity of water increased the density of the concrete mixture. The increase in density may also be attributed to the molecular structure of PEG-400, which has a significant amount of hydrogen. PEG-400 improves hydration and density in materials such as concrete by preserving internal moisture, enhancing particle packing, and decreasing porosity, all without directly interacting with hydrogen at the atomic level. This results in greater strength and durability [29] [30]. By the 28th day, all concrete mixtures exhibited reduced density relative to the first day of concrete maturation [10].

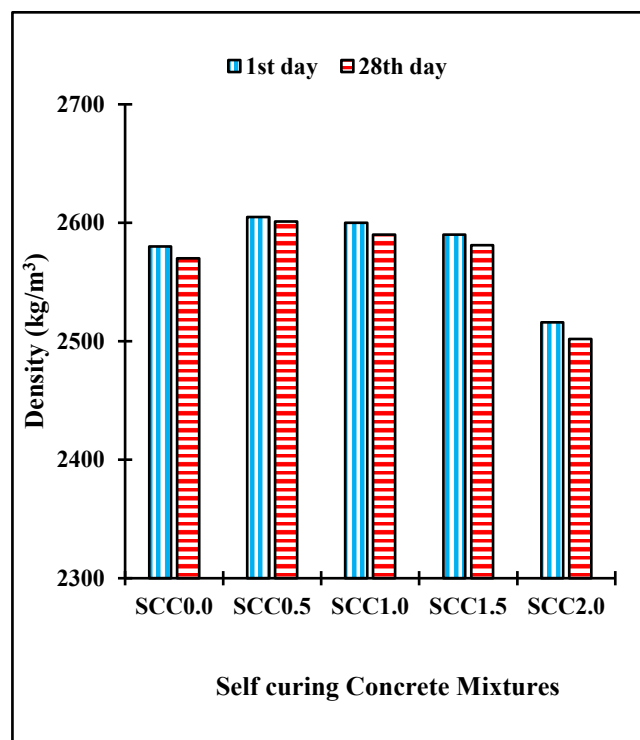


Fig. 4. Impact of PEG on the density of self-curing concrete

3.3 Compressive Strength

The compressive strength of concrete is the most important attribute for predicting its quality. It displays the load-bearing capability of concrete at a specific load, after which the concrete fails. Fig. 5 illustrates the concrete compressive strength at 28 days for self-curing concrete mixtures SCC0.0, SCC0.5, SCC1.0, SCC1.5, and SCC2.0. The concrete mixture SCC0.5 exhibits the maximum compressive strength, surpassing the control self-curing concrete SCC0.0 by 20% (44.87 MPa). The concrete mixtures SCC1.0, SCC1.5, and SCC2.0 have strength values that are 8.5% (34.13 MPa), 27% (27.18 MPa), and 30% (26.17 MPa) lower than those of control self-

curing concrete SCC0.0 that is 37.35 MPa, respectively. PEG aims to reduce water evaporation from concrete and improve its water retention capacity relative to standard concrete, hence enhancing compressive strength [31].

The potential capacity of PEG-400 to retain moisture within the concrete matrix and reduce evaporation from concrete surfaces accounts for the enhancement in compressive strength when 0.5% PEG-400 is added. During the early phases of concrete formulation, any reduction in mixing water leads to worse concrete quality; hence, this step is essential. The hydration process is enhanced by the preservation of mixing water, leading to stronger self-cured concrete [32]. A less porous and more solid matrix is produced when concrete cures correctly. A greater compressive strength is the result of this denser structure's improved resistance to compressive forces [33].

Strength was lowest for SCC1.0, SCC1.5, and SCC2.0 concrete mixes compared to the control concrete. SCC0.0. In concrete technology, an increase in water concentration diminishes concrete strength. Injecting an excessive quantity of PEG-400 enhances the water volume, leading to reduced strength in self-curing concrete, apart from SCC0.5. Excess PEG-400 may enhance the water-to-cement ratio by holding internal moisture, but it can also produce entrapped air, alter hydration kinetics, and interfere with matrix production at larger doses [34]. The excess water in the concrete generates many cavities during evaporation, leading to inadequate bonding and diminished strength [35].

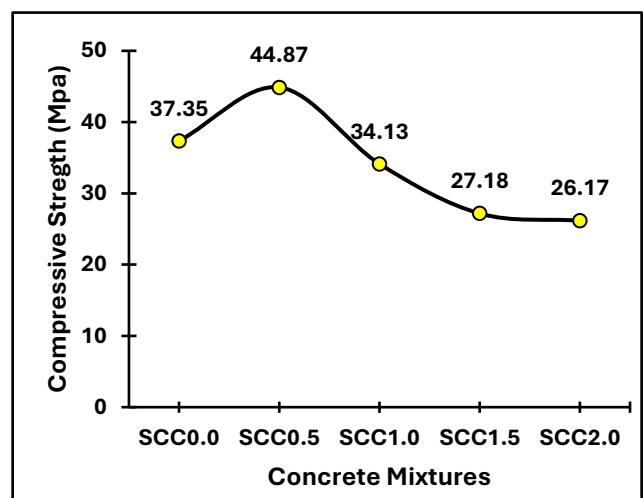


Fig. 5. Influence of PEG on compressive strength of self-curing concrete

3.4 Physical Appearance

An examination of physical appearance was performed to evaluate the finishing of concrete with PEG-400 and its impact on the color of the concrete. An additional observation was conducted to investigate a damp area on the concrete surface to demonstrate PEG-400's water retention capacity. The first phase of concrete is curing; thus, an appearance study was performed just on the first and seventh days of concrete maturation, as seen in Fig. 6 and 7, respectively.

It was found that the concrete mixture containing PEG-400 remained wet on the first day of the concrete curing process. As a result, more attentiveness was required during the demolding of specimens. This is evidence that illustrates the presence of water that is confined inside the concrete. PEG-400 did not have any effect on the color of the concrete despite its presence. However, the texture of the concrete that was finished with PEG-400 was smooth.

After 7 days, the concrete mixture SCC0.0 had dried. Nonetheless, the self-curing concrete SCC0.5 and SCC1.0 exhibited many moist areas, suggesting that the hydration process remains active. The concrete mixes SCC1.5 and SCC2.0 were not fully cured and lacked enough strength. The addition of an excessive amount of PEG-400 disrupts the hydration process of these two combinations. The compressive strength of these two combinations failed to achieve the target strength.



Fig. 6. Physical inspection of self-curing concrete on the 1st day of concrete age

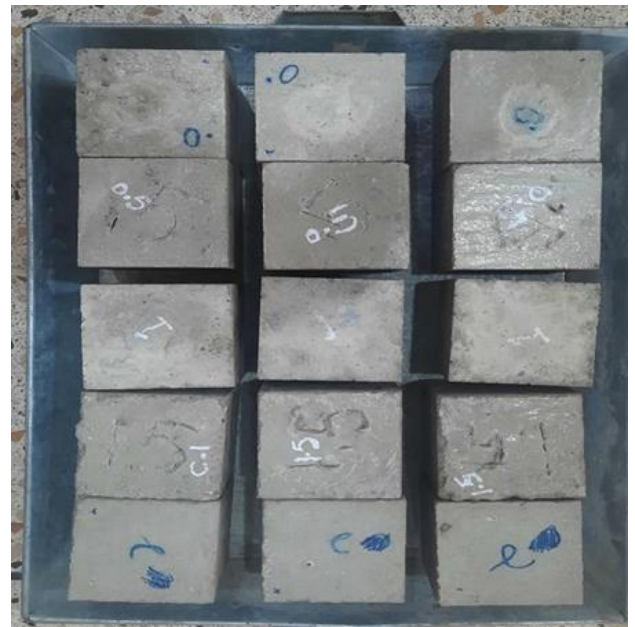


Fig. 7. Physical inspection of self-curing concrete on the 7th day of concrete age

3.5 Thermal Behavior of Self-curing Concrete

Two distinct concrete mixtures were selected to examine the thermal behavior of self-curing concrete. SCC0.0 is the control self-curing concrete mixture, while SCC0.5 is the optimal self-curing concrete mixture out of all the concrete mixes. Optimisation was based on self-curing concrete mixtures maximum compressive strength. The concrete specimen underwent a heat test on the 28th day of its self-curing period. Both self-curing concrete mixes were exposed to temperatures of 200, 400, 600, 800, and 1000 degrees Celsius in the oven for a continuous period of six hours.

3.5.1 Density before and after heating

The behavior of density under temperature conditions is illustrated in the graphic Fig. 8. It clearly shows that both self-curing concrete mixes decreased in density as the temperature increased. The concrete mix design specifies that the necessary density for both self-cured and conventional concrete is 2400 kg/m³. At SCC0.5 density remained within acceptable limits for structural integrity up to 800 °C that is 2409 kg/m³, but the control self-curing concrete SCC0.0 only preserved it up to 400 °C that is 2450 kg/m³. The primary factor contributing to the decrease in concrete density is the use of PEG as a phase change material (PCM) or as a self-curing agent, which changes its physical state (solid to liquid) at designated temperatures, hence affecting its density and the overall properties of the concrete. Additionally, rather than PCM action at high temperatures, it attributes density loss to PEG evaporation and breakdown,

which results in micro voids and matrix destabilisation. [36,37,38]

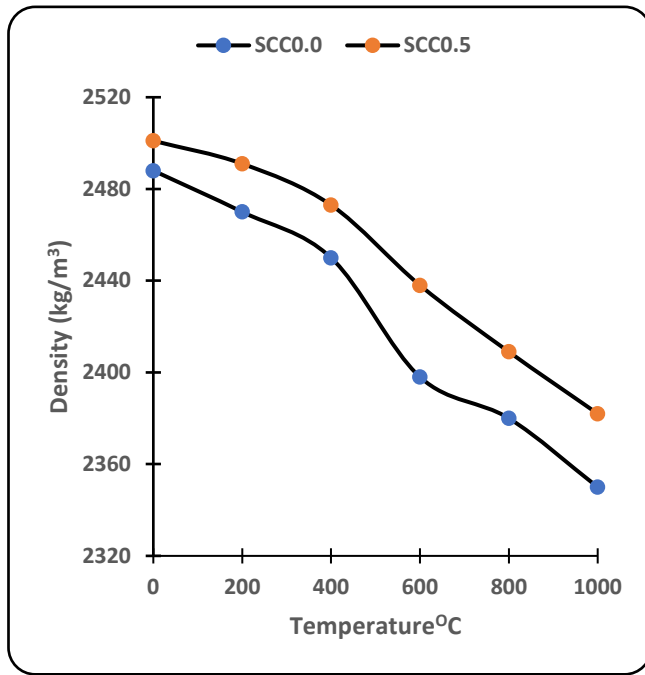


Fig. 8. Effect of elevated temperature on the density of control and optimized Self-curing concrete

3.5.2 Behavior of residual compressive strength against elevated Temperature

Fig. 9 depicts the residual compressive strength of both control self-curing concrete (SCC0.0) and optimized self-curing concrete (SCC0.5). Research revealed that concrete has a reduction in strength with elevated temperature exposure. The concrete mix design was created at grade 30. SCC0.5 (30 MPa) maintained the requisite strength up to 800°C. It suggests that SCC0.5 demonstrated better thermal resilience in compressive strength retention, which may contribute to improved fire performance in further structural evaluations. The SCC0.0 (31.27 MPa) hardly maintains its maximum strength at temperatures over 400 °C.

The reduction in strength of self-curing concrete at increasing temperatures is attributed to water evaporation and bond breaking inside the concrete matrix. Physically bound water is eliminated during the hydrothermal process at 100 °C. Unbound water begins to evaporate at 200 °C. At 300 °C, the silicon bonds within the calcium-silicate-hydrate (CSH) gel begin disintegration. Dissociation of calcium hydroxide starts at 500 °C, while the calcination of calcium carbonate occurs between 600 °C and 700 °C, at which point aggregates begin to deform and expand. Furthermore, the complete loss of water hydration transpired at 800 °C. The concrete layer liquefies at temperatures of 1000 °C or above, resulting in structural instability and rendering it unsuitable [39]. Due to the temperature disparity among the

components of the concrete. Hardened paste and aggregates undergo differential expansion and contraction. Increased temperatures result in a reduction of the concrete's compressive strength. The dihydroxylation of portlandite into free lime and the evaporation of water from the pores contribute to the reduction in strength at 450°C [40].

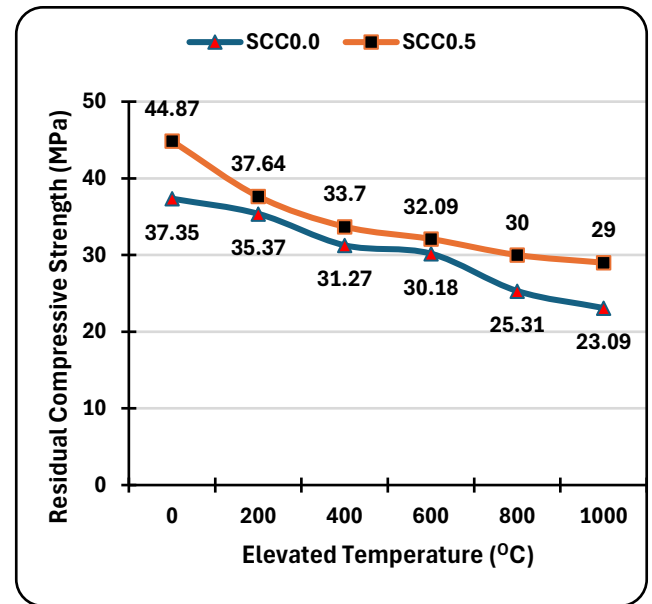


Fig. 9. Impact of Increased Temperature on the Compressive Strength of Control and Optimized Self-Curing Concrete

Fires provide significant hazards to civil infrastructure, possibly resulting in catastrophic structural failures. Although fires are increasingly prevalent, their consequences extend beyond the immediate structural damage. Several governments are unable to conduct a comprehensive assessment of the building prior to determining whether to destroy or restore it due to fiscal constraints. A preliminary thermal analysis of concrete aids authorities in making decisions on the reconstruction or renovation of the building without further research.[41]. Or The findings provide significant information on the thermal resistance of self-curing concrete, which may aid in the development of future post-fire assessment techniques.

The results of this research on residual compressive strength at increased temperatures facilitate the use of self-curing concrete by decision-makers in practical construction applications. This research demonstrates that self-curing concrete containing 0.5% PEG-400 maintains the requisite strength of conventional concrete at temperatures up to 800 °C. This signifies that the authorities chose to refurbish the building instead of demolishing it. When a fire ignites in a concrete building, the peak temperature reaches 750 °C [42].

4. Conclusion

The experimental study produced the following important findings on the behavior of both fresh and hardened concrete as well as thermal performance at high temperatures:

The results indicate that the incorporation of PEG-400 increases the slump of new concrete, hence enhancing its workability. PEG-400 enhances workability largely by retaining water and modifying viscosity, consistent with other studies.

The addition of PEG-400 increased the density of most self-curing concrete mixes, Higher early-age density is primarily caused by improved internal curing and less evaporation. However, high PEG-400 (as in SCC2.0) decreased density, showing an appropriate dosage range is 0.5% PEG-400.

The compressive strength reached its peak at SCC0.5, Effective internal curing was shown by SCC0.5's 20% improvement in compressive strength at 28 days (from 37.35 MPa to 44.87 MPa) over SCC0.0. However, strength decreased at larger PEG-400 amounts than 0.5%, most likely because of excessive water retention that created porosity.

Visual inspection revealed that PEG-400 improves surface smoothness and moisture retention, allowing for longer periods of hydration during the early curing stage. However, excessive PEG-400 impaired hydration and strength development, emphasizing the importance of a controlled dose.

The findings indicate that SCC0.5 sustained its target density up to 800°C, surpassing the control mix SCC0.0, which only maintained it up to 400°C. This signifies PEG-400's potential to enhance thermal stability, while its phase transitions influence total density at high temperatures.

The SCC0.5 mix surpassed SCC0.0 in fire resistance, maintaining a grade 30 residual compressive strength up to 800 °C. SCC0.5 retained approximately 30 MPa whereas SCC0.0 showed a significant decline beyond 400 °C. This confirms the importance of PEG-400 in enhancing the thermal durability of concrete.

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