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PERFORMANCE ASSESSMENT AND ANALYSIS OF RECYCLED FINE AGGREGATE SELF–CURING CONCRETE: A DETAILED REVIEW

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ABSTRACT
Concrete is a popular construction material that consumes a significant amount of water during manufacture. Therefore, there is a pressing need for research to reduce the amount of water required in the process. This research reviews self-curing materials, mechanisms, and qualities of fine aggregate recycled from concrete using the Self-curing technology involves a method where the cement within concrete is hydrated internally, eliminating the requirement for an external source of curing, such as water. Improper curing can cause self-desiccation, autogenous shrinkage, and other negative effects on concrete qualities. Researchers have employed several materials, including porous lightweight aggregates, chemical admixtures, polymers, natural fibers, and pozzolanic, to create self-curing (SC) agents with high water resistance. Thesis self-curing materials were utilized as a replacement for recycled fine aggregates and as manufactured sand. Researchers evaluated the efficacy of self-curing in concrete by analyzing its physical, mechanical, durability, and microstructure qualities. Utilizing a self-curing methodology in concrete improves its qualities. Self-curing research primarily focuses on high performance concrete to address shrinkage issues caused by low water to cement ratio
Keywords: self-curing, self-curing agents, Recycled Fine Aggregates, physical-properties, mechanical-properties, microstructure properties,durability properties.

Introduction
Ensuring the proper curing of concrete structures is crucial for attaining the intended performance and durability. Traditional curing techniques achieve this by applying external curing processes after the concrete has been mixed, placed, and finished. An alternative approach is self-curing, or internal curing, which introduces additional moisture within the concrete itself. This technique enhances cement hydration and mitigates self-desiccation, leading to improved concrete quality.

Literature
Alaa A. Bashandy, Amal A. Nasser [2024] The results of the study showed that the structure exhibiting the highest strength cement ratio of 0.36, 0.05% steel fiber, no synthetic coarse fiber and 10% recycled stone. Furthermore, the analysis showed that the two main factors affecting the change in compressive strength are the total proportion of recycled materials and the amount of PEG 400 in the mixture.
Zhenhua Duan et al. [2023] The results of the study demonstrated that the RCA carrier was more effective in repairing than RFA, with a maximum healing width of 0.27 mm seen on day 28. The effectiveness of microbial healing was strongly impacted by the dispersion of old mortar. Whereas the RCA specimens displayed a more concentrated formation, the RFA specimens displayed a scattered and dispersed distribution of restored products. SEM, MIP, and XRD are examples of advanced characterisation techniques that were used to clarify the repair mechanisms. The applicability of a time-dependent repair model for improving concrete through microbial healing was confirmed after it was developed and verified against experimental data. These results may have industrial ramifications, encouraging the incorporation of sustainable and intelligent qualities into recycled aggregates.

Z. Awadh et al. [2022] This study leverages the typically undesirable characteristic of RCA its high moisture retention or absorption of watercapacity to serve as internal curing water for strength development. This approach aims to enhance the recycling of (C&D) Construction and Demolition waste.
Lakshmi Thotakura et al. [2021] The weight variations for the mixes with and without the self-curing agent indicate slight differences attributable to aging, with more pronounced variations observed in partially cured specimens. The incorporation of recycled concrete aggregates (SSD) in place of normal aggregates resulted in increased weights.
S.K Kirthika, S.K Singh [2020] The primary objective of this research is to investigate the prudent application of (RFA) Recycled Fine Aggregate in concrete and its performance across various durability conditions. RFA stands as a significant alternative material, produced in large quantities, which can be effectively utilized with appropriate precautions. The impact of incorporating recycled fine aggregate (RFA) in concrete was meticulously evaluated by examining factors such as alkali-silica reaction, porosity, water permeability, acid-alkaline exposure, drying shrinkage, rapid chloride penetration, surface electrical resistivity, and carbonation. Additionally, the accompanying microstructural changes were also thoroughly analyzed. The findings revealed that an increase in RFA content in concrete has an adverse effect on its durability.
Nagasree D, KL Radhika [2018] It has been found through this research that adding PEG600 and PVA significantly increases the efficacy of traditional curing methods. The findings suggest that a strength level that is similar to conventional concrete can be achieved with an optimal dosage of 1% for PVA and 2% for PEG600. The report also emphasizes how selfcuring concrete is just as durable as regular concrete in every assessed area.
Suresh Kunchapu [2017] The research investigated the autogenous healing capabilities of standard aggregates (SA) and repurposed aggregates (RA) in concrete mixtures. Through a side-by-side evaluation, the study assessed disparities in moisture retention, compressive resilience, tensile splitting resistance, and flexural durability after a 28-day period between samples cured using conventional techniques and those allowed to selfcure. The results suggested that the self-healing aggregates demonstrated enhanced performance across all measured attributes when compared to traditional stone conditioning approaches.
Peddaraju et al. [2017] To explore how Poly Vinyl Alcohol (PVA) impacts the physical qualities of concrete, the PVA-to-cement weight ratio was changed from 0% to 0.48. Notably, concrete with 0.24% PVA had better workability and compressive strength than ordinary concrete mixtures.
Indirajith et al. [2016] Tests were conducted to compare self-healing concrete (exterior and interior) using PEG with conventional concrete in grades M20, M25, and M40. Self-hardening concrete increases hydration as it dries compared to regular concrete. Increasing the amount of PEG provides more benefits. The study found that different amounts of PEG (1% for M20 and M25, 0.5% for M40, and 0.3% for high-strength self-healing) increased strength.
Banothu[2016] An exploratory inquiry used polyethylene glycol (PEG 200) as a self-curing agent. The PEG 200 dosage was 0.1, 1, and 2% by weight of cement. Comparative research on workability. Water retention and compressive strength tests were conducted on specimens cured using various curing procedures. Using less self-curing chemicals and a low water-to-cement ratio improves concrete's compressive strength and water retention.
Alaa A. Bashandy [2015] Studies have shown that self-curing concrete remains effective even when exposed to high temperatures, although there may be a slight decrease in strength. Although conventional concrete benefits more from air cooling, it's still more efficient, self-compacting concrete (SCC) may benefit from water cooling at temperatures up to 400°C. It is observed that increased temperatures and prolonged heating durations lead to a reduction in residual strength values.
Stella [2014] The goal of the current research investigation was to analyze the impact of using polyvinyl alcohol (PVA) in concrete as a self-curing (SC) agent. Following a 28-day curing time, the self-curing concrete's tensile, compressive, and flexural strengths were tested and compared to those

of conventional concrete made with the same mix composition. The differences in toughness between the two varieties of concrete were clarified by this comparison, the compressive, tensile, and flexural strengths were enhanced by the addition of polyvinyl alcohol at a concentration of 0.48% of the cement's weight. Furthermore, a reduction in the quantity of weight loss was observed when the proportion of polyvinyl alcohol was increased.

M.V. Jagannadha Kumar et al. [2012] Explored using polyethene glycol (PEG 400) as a shrinkage-reducing additive in concrete to enhance hydration and promote self-curing, thereby improving strength. Their study examined the impact of different PEG 400 concentrations, ranging from 0% to 2% by weight of cement, on the compressive strength, split tensile strength, and modulus of rupture in M20 and M40 concrete mixes. The findings indicate that PEG 400 supports self-curing by providing strength comparable to conventional curing methods. Additionally, the study concludes that incorporating 1% PEG 400 by weight of cement is ideal for M20 grade concrete, whereas a 0.5% incorporation is optimal for M40 grade concrete. These proportions maximize strength while maintaining workability.

El-Dieb [2007] An experiment was conducted to analyze the characteristics of concrete, such as self-curing chemicals, focusing on water sorptivity, hydration, absorption, and permeable pores. Self-curing concrete (SCC) displayed lower self-desiccation when sealed, in contrast to traditional concrete. SCC showed improved hydration compared to traditional concrete. As SCC aged, water permeability and water sorptivity decreased, suggesting a decrease in the number of permeable pores due to cement hydration.

Xiao J, Li J and Zhang C [2005] This study shows the impact of various factors related to recycled content (RCA) on the stress and energy of recycled content (RAC). Uniaxial compression tests with different RCA changes such as 0%, 30%, 50%, 70% and 100% were performed on concrete samples. The study analyzes the failure modes and evaluates how the RCA content influences the maximum and ultimate strains, compressive strength, and elastic modulus of RAC. Furthermore, the article introduces mathematical models for the stress-strain behavior and maximum strain of RAC, which are beneficial for theoretical investigations, numerical analyses, and practical engineering applications in RAC construction.

Takayuki Fumoto, Masaru Yamada [2002] In this research, we investigated how different qualities of fine aggregates affect the properties of fresh and hardened concrete using six distinct types of fine aggregates. The findings revealed that, when maintaining consistent mix proportions, a rise in the overall surface area of the fine aggregates resulted in lower air content and reduced slump. Moreover, when factoring in the total water content as the combination of added water and water absorbed by all aggregates, the strength of the concrete was observed to be linked to the ratio of cement content to total water content. This ratio emerges as a crucial measure for managing concrete strength.

Conclusion

Self-curing (SC) concrete with additives like polyethylene glycol and Recycled fine aggregates offers a promising solution to enhance compressive strength and overall performance, addressing common issues related to inadequate curing. Further research and practical implementations can help in refining these techniques and optimizing their use in various construction scenarios.

Based on the past research of experts outlined above, many conclusions can be drawn:

- When using reused fine aggregate with high acceptance, ovendrying it or adding a superplasticizer can reduce concrete's strength loss.
- The percentage of RCA Substitute significantly impacts the stressstrain behavior of RAC.

- The increase in the amount of normal aggregates is greater than that of recycled coarse aggregates.
- Delayed reactivity of self-curing chemicals with recycled coarse aggregate (RCA) may be due to debris.
- Self-curing concrete (SCC) is a customized concrete that doesn't require external curing. SCC has basic self-curing qualities, which eliminate the need for additional water or other curing methods.
- Poly-glycol chemicals can lessen the likelihood of concrete cracking due to drying shrinkage.
- Water cooling can lower compressive and tensile strength by 5-25% for conventional concrete (OC) at temperatures up to 400°C. Selfcompacting concrete (SCC) does not exhibit this effect in the same circumstances.
- Recycled aggregate (RA) self-curing (SC) concrete uses coarse recycled aggregates (CRA) instead of standard coarse aggregates, eliminating the requirement for traditional curing techniques. Polyethylene glycol acts as a chemical agent in this mixture, minimizing water loss and allowing for continuous curing of the concrete
- RAC (Recycled aggregate concrete) is considered less suited for structural applications compared to natural materials. However, the use of high-range water reducers (HRWR), also known as superplasticizers, can significantly improve the fresh and hardened properties of RAC.
- Using PEG 400 as a chemical curing agent enhances the compressive strength of recycled aggregate concrete (RAC) compared to conventional concrete. The compressive strength of self-curing concrete, which includes crushed dolomite, crushed concrete, and crushed brick, showed an increase of approximately 14.1%, 12%, and 1.75%, respectively. However, the bond strength of reinforced recycled aggregate self-curing (RA-SC) concrete diminishes over time when exposed to chlorides.
- The elastic modulus of reinforced concrete "RA-SC" beams decreases over time when subjected to chloride attack. Additionally, the elastic modulus of DC beams is higher compared to both CC beams and BC beams.
- There is enough water in typical concrete to allow for hydration. However, in regions with hot climates or limited water availability, as well as in structures located on inclined or hilly terrain where curing accessibility is challenging, water loss from the concrete can lead to a decline in quality. This situation necessitates further investigation
to address the quality degradation of average strength concrete by exploring SC (self-curing) mechanisms.
- The effectiveness of (SC) self curing concrete is influenced by the water-to-cement (w/c) ratio and the dosage percentage of the selfcuring agent.
- Weights of mixtures with and without self-curing agent vary slightly with aging, with more noticeable changes in partially cured specimens. The weight increase was attributable to replacing normal aggregates with saturated surface-dry (SSD) recycled concrete aggregates.
- Recycled Concrete Aggregate (RCA) can be used to produce both standard and high-performance concrete (HPC). Its integration improves the concrete's strength development and mechanical qualities while without considerably reducing performance due to its strong water absorption capabilities.
- The study found that recycled concrete aggregate (RCA) has increased water absorption capacity, which can promote strength development.

Statements & Declarations:
<u>Data Availability Statement:</u>

Data supporting the study's conclusions are accessible from ResearchGate (https://www.researchgate.net) and DOI.org (https://doi.org) upon reasonable request.

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Both authors were involved in the study's conception and design. Md Mahboob Alam handled material preparation, data collecting, and analysis. Md Mahboob Alam wrote the first draft of the manuscript, while Dr Ravindra Gautam reviewed previous versions. Both authors have reviewed and approved the final manuscript.

References
1. Alaa A. Bashandy, Amal A. Nasser, "Improving Mechanical Properties of Recycled Aggregate Pervious Concrete Using Taguchi Method" April 26th, 2024. DOI: https://doi.org/10.21203/rs.3.rs-4263370/v1.
2. Zhenhua Duan et al., "Study on the Performance of Recycled Coarse and Fine Aggregates as Microbial Carriers Applied to Self- Healing Concrete"Materials2023,16,2371.https://doi.org/10.3390/ma16062371https://www.mdpi.com/journal/materials
3. Z. Awadh et al. , Construction and Building Materials Program, Energy and Building Research Centre, Kuwait Institute for Scientific Research, Kuwait, "Using the Moisture Retention Property of Recycled Coarse Aggregates for Self-Curing of High Performance Concrete" International Journal of Structural and Civil Engineering Research Vol. 11, No. 1, February 2022. doi: 10.18178/ijscer.11.1.1-5
4. L. Thotakura et al. "Performance Characteristics of Self-cured Recycled Aggregate Concrete with SCM's" © Springer Nature Switzerland AG 2021
5. K. Dasgupta et al. (eds.), Proceedings of SECON 2020, Lecture Notes inCivil Engineering 97, https://doi.org/10.1007/978-3-030-55115-5_68
6. S.K. Kirthika , S.K. Singh, "Durability studies on recycled fine aggregate concret" Construction and Building Materials 250 (2020) 118850. https://doi.org/10.1016/j.conbuildmat.2020.118850 0950-0618/ 2020 Elsevier Ltd. All rights reserved.
7. Nagasree D , KL Radhika. Department of Civil Engineering, Osmania University, "Strength and Durability of Self-Curing Concrete using Recycled Aggregate" International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887 Volume 6 Issue III, March 2018- Available at www.ijraset.com
8. Kunchapu Suresh, K. Divya Bharathi, Aindala Dinesh, Kailash Bishnoi. ICNASET | February 24-25, 2017 Madhav University, Sirohi (Rajasthan), India. "Study on Comparison of Self Curing of Concrete by using Normal Coarse Aggregate and Recycled Coarse Aggregate"

International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958,Volume-6, Issue-NASET17, February 2017

9. Peddaraju Naveen Kumar and A. Hari Krishna,” A Brief Study on Self Curing of Concrete”, International Journal of Innovative Research in Science Engineering and Technology, Vol. 6, Issue 2, February 2017, pp.2809-2816.
10. Indirajith .A.J and Vishnu.A,” Self-Curing Concrete –Case Study”, International Journal of Advanced Research Trends in Engineering and Technology (IJARTET), Vol. 3, Special Issue 8, March 2016.
11. Banothu Anusha,” Study And Analysis of Self-Curing Concrete Using
    a. Polyethylene Glycol”, International Journal of Engineering Research-
    b. Online, Vol.4., Issue.1., (Jan-Feb) 2016, pp. 662-666
12. Alaa A Bashandy* Department of Civil Engineering, Faculty of Engineering, Menoufia University, Egypt. ‘‘Performance of self-curing concrete at elevated temperatures” Indian Journal of Engineering & Materials Sciences Vol. 22, February 2015, pp. 93-104.
13. Stella Evangeline,” Self Curing Concrete and Its Inherentproperties”, Journal of Engineering Research and Applications, Vol. 4, Issue 8(Version 7), August 2014, pp.66-71.
14. M.V.Jagannadha Kumar, M. Srikanth and K. Jagannadha Rao,” Strength Characteristics of Self-Curing Concrete”, International Journal of Research in Engineering and Technology (IJRET), Volume: 01, Issue: 01, Sep-2012, pp. 51-57.
15. Amr S. El-Dieb,” Self-curing concrete: Water retention, hydration and moisture transport”, Elsevier, Construction and Building Materials, Vol.21, 2007, pp. 1282–1287.
16. Xiao J, Li J and Zhang C. (2005) ‘Mechanical properties of recycled aggregate concrete under unaxial loading’, Cement and Concrete Research 35 (2005) 1187–1194
17. Takayuki Fumoto, Masaru Yadama. (2002). Influence of Quality of Recycled Fine Aggregate on Properties of Concrete.Mem. Fac. Eng., Osaka City Univ., Vol. 43, pp.97-103