APPLICATION OF HYBRID SYSTEM IN MULTIFUNCTIONAL DEVICES USING BOTH RENEWABLE AND CONVENTIONAL ENERGY RESOURCES

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Abstract

In this article we examine hybrid renewable energy systems that combine solar and wind energy technologies, focusing on their current challenges, opportunities, and policy implications. Despite the individual merits of solar and wind energy systems, their intermittent nature and geographical limitations have spurred interest in hybrid solutions that maximize efficiency and reliability through integrated systems. A critical analysis of available literature indicates that hybrid systems significantly mitigate energy intermittency issues, enhance grid stability, and can be more cost-effective due to shared infrastructure. The review identifies key challenges, such as system optimization, energy storage, and seamless power management, and discusses technological innovations like machine learning algorithms and advanced inverters that hold the potential for overcoming these hurdles. Importantly, the review elucidates the role of policy in accelerating the adoption of these systems by highlighting successful case studies of government incentives, public-private partnerships, and regulatory frameworks that have fostered investments in hybrid renewable energy systems. The study concludes with the outcomes obtained that signify the potential for hybrid renewable energy systems to not only meet but exceed future energy demands sustainably, provided there is concerted effort in research, investment, and policy-making.

Key words: AshCO_2 treatment ,Construction materials, Solid waste, Mechanical properties

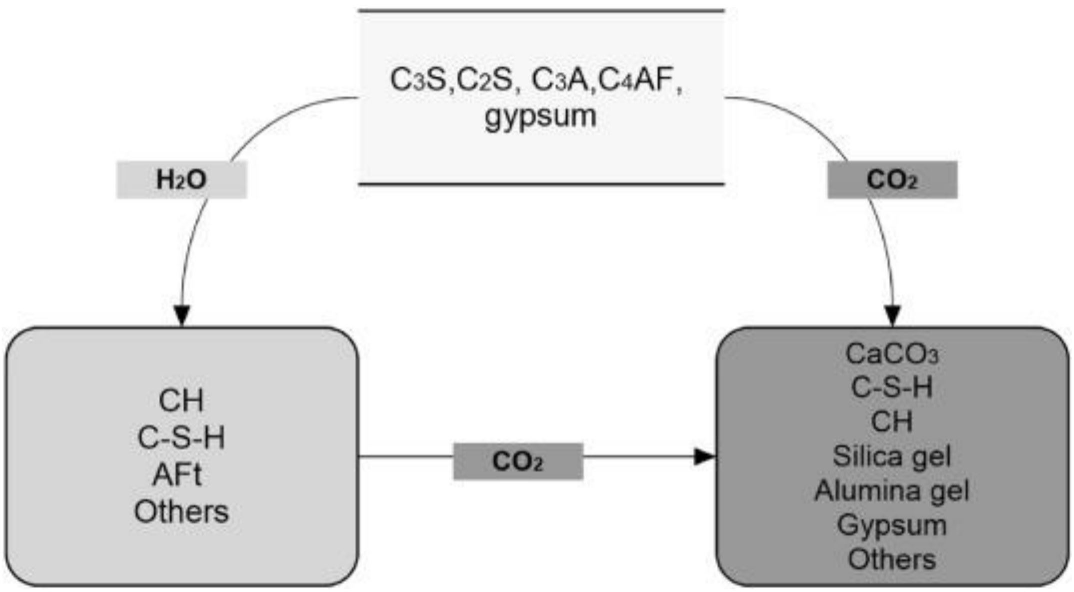
Introduction

Sustainability, environmental concerns, and technological advancements are the main motivations for the construction industry to employ more designed high-performance materials that are environmentally friendly and affordable than traditional construction materials. Such materials can considerably enhance the service life of buildings while also drastically reducing the need and cost of maintenance . Industrial and agricultural wastes that fulfill the mineral composition criteria of cement have prompted many researchers to investigate their application in construction . Such wastes can replace cement or aggregate, enhancing its chemical and physical characteristics, saving costs, and reducing environmental effects [1-5]. The use of plastic waste materials, building and demolition debris, and bottom ash as aggregates in cement mortars and concrete has been a focus of several studies . The use of such recycled aggregate may affect the properties of fresh concrete. It has been found that the use of recycled coarse aggregates reduces the consistency and fluidity of concrete within the first hour after mixing when compared to concrete created with natural aggregates . The use of a sufficient amount of bottom ash improves the strength of concrete; the addition of 10 % increases the strength of plain and self-compacting concrete . The abrasion and shrinkage resistance of normally vibrated bottom ash concrete has improved, but it has decreased in self-compacted concrete at various curing ages [6-9].

Previous investigations have shown that presenting chemical or physical treatments for the waste materials could overcome these issues such as the calcination, grinding and carbon dioxide (CO_2) curing process which results in a faster rate of growth in waste-based materials properties than the conventional curing processes .Since CO_2 is the principal greenhouse gas and a contributor to global warming, it is important to understand its role. One of the main sources of CO_2 emissions is the cement sector; a contemporary cement plant will create between 0.49 and 0.92 kg of CO_2 for every kg of cement produced .On average, it is reported that 0.79 tons of CO_2 will be emitted to produce one ton of cement .As a result, responsible companies and researchers have made major efforts to minimize CO_2 emissions from industrial and especially cement production by establishing a new manufacturing technique and substituting cement or aggregates with supplemental materials of equal or greater importance [10-15].

Many strategies for reducing CO_2 emissions as well as the collection, storage, and sequestration of emitted CO_2 have been the subject of research .As a result, there has lately been a lot of interest in using collected CO_2 in a process that yields valuable materials. One of the most well-known instances of CO_2 sequestration is the carbonation of CO_2 and the creation of a product with commercial value .Numerous studies in this area have shown that CO_2 curing of cement-based materials (such as mortar, paste, concrete, aggregates, and solid waste from these cement-based products) is a more effective type of CO_2 collection . Prior research has found that CO_2 improves the durability and properties of cement-based building materials . Such a process can improve the mechanical properties of concrete and reduce its drying shrinkage . CO_2-cured concrete is known to provide an extremely rapid strength growth rate and can improve its resistance and durability performance. Introducing the carbonation process early during the cement hydration process will expedite the reaction rate as compared to the conventional hydration processes. The compressive strength of the mortar was nearly the same after 1 h of CO_2 curing as it had been after 7 days of wet curing .

CO_2 reacts with cement clinker materials (calcium silicates and their hydrate products) through the carbonation reactions to form calcium carbonate ($CaCO_3$) . Such reactions can positively affect the concrete properties by improving their strength . Formation of dimensionally stable crystals of $CaCO_3$ and the associated expansions when young plain concrete is exposed to high concentrations of CO_2 attributes to considerable early strength . depicts a description of the carbonation and hydration of various cement mineral phases [16-20].



Methodology

The systematic review was performed by using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria . PRISMA is an effective method for being acquainted with the greatest accessible research information on a specific issue. The effectiveness of a systematic review is enhanced by the clarity of each stage of the synthesis process, as well as allowing the reader to concentrate on the advantages of each finding made in collecting information, instead of being attracted to the unnoted difference between studies, as is sometimes the case in other types of reviews . While bibliometrics is a popular approach for building a large picture in a literature evaluation .

This work provides a thorough and systematic analysis that seeks to synthesize, identify, and evaluate the literature by detecting curing with CO_2 for solid waste-based construction materials in publications. More specifically, all publications during the last six years have been collected and investigated based on the standards for the systematic reviews and our research objectives. The available literature was collected by utilizing search engines from various databases. The same search possibilities were repeated for each database, utilizing the keyword combinations depending on the search strategy accredited in the database.

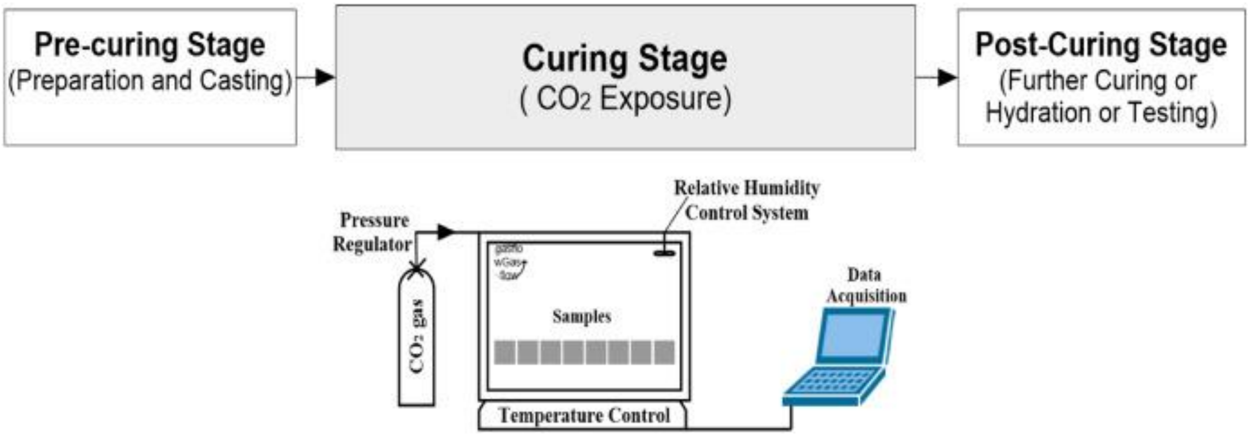
The following terms were checked in each database by applying the advanced search options and setting the search period to the previously mentioned range. The web of science (WoS) database was searched using the intended search terms as" TS= ((carbon dioxide curing OR CO_2 curing OR carbonation) AND (ash OR solid waste) AND (concrete OR aggregate OR cement* OR construction materials))". Also, the Scopus database was searched by using the "TITLE-ABS-KEY (((carbon dioxide curing OR CO_2 curing OR carbonation) AND (ash OR solid waste) AND (concrete OR aggregate OR cement* OR construction materials)))" combination. Publications involving CO_2 curing have increased throughout time, which can be ascribed to the expansion of scientific research itself.

The main body of the literature involved 715 studies. About 80 % of the extracted publications were from WOS with the lion's share of the journal papers distantly followed by conference papers. 572 papers were excluded after examining the titles and abstracts and removing duplicates to avoid repetition. After the full-text reading, only 71 papers were connected to the inclusion criterion. These investigations were thoroughly studied to create the overall foundation for the study map on CO_2 curing in waste-based building materials. The study only used original research publications, reviews, and conference papers. To assure the review's quality, every duplicate was carefully checked. To ensure the accuracy and relevance of the data used in the review process, the article titles were selected and analyzed for evaluation. The validity of the approach and outcomes was then verified by conducting a thorough analysis of the study abstracts.

CO_2 curing of waste-based construction materials

During cement hydration, the dry cement mixes with water and forms a solid hydrate phase, leading to volume expansion and reduced porosity, resulting in a strengthened material . Carbonation, on the other hand, is a more challenging process in which gaseous CO_2 penetrates the concrete, dissolves in the pore solution, and reacts with cementitious phases to form $CaCO_3$ and silica gel . However, due to the fine porosity and water content of hydrated cement, carbonation proceeds slowly under normal conditions . Nevertheless, concrete structures exposed to CO_2 can act as a CO_2 sink over time . Additionally, crushed concrete, demolition debris, and industrial solid wastes can also absorb significant amounts of CO_2, although it may occur in an unpredictable manner [21-22].

This section provides an analysis of the usage of CO_2 as a curing method, including the reaction mechanism, implementation procedure, carbonation quality, and mechanical properties of the final product. It also provides details regarding the effect of carbonation curing on waste-based materials, alternative binders, and recycled aggregates. In addition, looking for the conditions of the curing technique in each study was the major key to understanding the differences in the resulting carbonated construction materials. A pre-curing stage is crucial for achieving effective carbonation developments. Pre-curing regulates the removal of water from a mixture after casting and before CO_2 exposure. The most important sub-reactions happen in the aqueous state, thus there must be enough water before carbonation can start. High water content can impede the process by obstructing CO_2 diffusion to the reactants, while low water content can lead to an insufficient reaction with ineffective outcomes . The CO_2 curing stage may be accomplished in two ways, enclosed and flowable reactor systems. The capacity to support increased CO_2 partial pressures makes the enclosed system has better reaction efficiencies .Laboratory scale experiments are often carried out in enclosed pressure containers where continuous reaction conditions are carefully regulated and monitored .After carbonation, post-curing allows for additional hydration of the remaining unreacted hydraulic phases. To ensure the best hydraulic reaction, water depletion due to carbonation should be effectively considered at this stage [23-24].



Conclusion

Key research needs include understanding the link between CO_2 curing methods and material durability, evaluating long-term performance against various stress factors, and further exploring the environmental benefits, including material design, CO_2 absorption quantification, modeling carbonation processes, and safety considerations.

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