WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

A Review of the Literature on Seashell Powder as a Workable Substitute for Cement-Based Materials

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A B S T R A C T :

In cementitious matrix structures, seashells have been investigated as a partial substitute for cement in an effort to reduce the emissions associated with cement production and support sustainable waste management. In order to direct future research on the viability of using seashells as a filler, it is crucial to compile current findings and practices as this field of study grows. employing a comprehensive literature review across six scientific databases, this study examined the body of research on employing seashells as a partial cement substitute in cementitious composites, resulting in 24 studies for data synthesis and analysis. The main conclusions assessed the effect on mechanical characteristics in binary combinations, defined the shell processing techniques, and provided typical ranges for the physical-chemical properties and dose of shell powder. The influences on mechanical qualities that have been reported
vary between investigations, possibly as a result of variations in the shells' origins and processing methods. In binary mixtures, the greatest increases in composite characteristics were seen when 5% to 30 % of the cement was substituted. All things considered, adding shell powder lowers the carbon emissions of the composites that are created. It is advised that more thorough research be done on shell processing parameters and doses in order to comprehend how these affect the final composites' characteristics.

Keywords: sea shell ash, OPC cement, Concrete, Flexure strength test, splitting tensile strength test, compressive strength test.

Introduction

One of the world's most adaptable building materials is concrete. Concrete is the second most consumed material in the world and is being used more and more frequently each year due to its low cost, ease of maintenance, long service life, excellent strength, and resistance to adverse weather conditions [1]. According to studies, industrial civilization uses more than 10 billion tons of concrete annually [2,3]. Nearly 18 billion tons of concrete will be used annually as the world's population grows [2,4]. Cement, particles, and water make up the majority of the composite material known as concrete. Concrete requires more than 20 billion tons of aggregates and 1.5 billion tons of cement annually, according to figures [5,6]. The exploitation of natural raw materials, including river sand, has increased dramatically as a result of the surge in demand. The environment has suffered greatly as a result of this mismatch between supply and demand. Taxes have been used by governments around the world to restrict the use of natural resources [7, 8]. Numerous studies have been conducted to address the issue of excessive traditional material consumption by substituting waste materials from a variety of sources, including waste shells [1,9], glass [10], rubber [11], and coral reefs [12], in an attempt to move the concrete industry toward sustainability.

China has a wealth of marine resources, much like South Korea, Japan, and several coastal nations in Southeast Asia. China is expected to become the world's top producer of shellfish in 2020, with an estimated 15 million tons produced. The United States, South Korea, Thailand, France, and Spain are the top five producers, with Japan coming in second. However, only a small percentage of this massive trash gets recycled for reuse due to its low commercial value [13]. The vast bulk of trash is thrown into open fields at random. When untreated shellfish waste is stored for an extended period of time, bacteria may break down the salt into gasses including amines, ammonia, and hydrogen sulfide [7]. Flies and foul smells could result from this, which could eventually have a detrimental effect on the environment and general public's health. The damage to the ecosystem will become more irreversible if these wastes are not adequately eliminated.

Numerous solutions to this issue have been put out by academics during the last thirty years. For instance, discarded oyster shells have been utilized to make soil adsorbents, water treatment chemicals, and agricultural fertilizer. However, widespread use of these technologies was hindered by their restricted availability and high production costs. Furthermore, the use of seashells in the manufacturing of soil sorbents was further restricted due to their high energy consumption and pollution [13]. Thus, it is essential to create sustainable, economical, and ecologically beneficial solutions to the expanding seashell issue. More than 90% of seashell components are calcium carbonate, which is categorized as an inert material in cement-based structures, according to recent chemical investigations [7]. As a result, they can be recycled and turned into cement alternatives, coarse aggregates, or fine aggregates. the variety of seashells that were used in this project in place of cement or aggregates. First of all, it is a more cost-effective and

efficient method of getting rid of this garbage. Additionally, using seashells as an aggregate or cement alternative in concrete will lessen the need for natural raw materials. Seashells can therefore be utilized to save the natural resources needed to make concrete and lessen environmental issues brought on by excessive use.

2.Literature Review

Dr. P. Paramaguru, (August 2023)

"Behaviour of concrete by partial replacement of cement with Seashell Powder and fine aggregate by Woodash" The purpose of this project is to investigate the feasibility of using wood ash and seashell powder as partial substitutes in concrete. The high and continuously rising cost of concrete has made construction extremely costly in underdeveloped nations where it is frequently employed. One of the main factors influencing housing delivery worldwide is the high cost of traditional building materials. Research into alternate building materials has become necessary as a result. The primary goal is to promote the use of these items as building materials for affordable structures. Experiments have been carried out in this study using materials that have been gathered and preliminary results from a variety of physical tests. Test samples that are appropriate for the experiment are chosen. The wood ash and seashell powder have undergone chemical analysis. 10% seashell powder is used in place of cement in this project, and wood ash is used in varying amounts to partially replace the fine aggregate—15%, 20%, and 25%, for example. Additionally, the concrete is made in different ratios, tested, and contrasted with regular concrete.

Poliana Bellei et al. (2023)

"Potential Use of Sea Shell Waste in the Composition of Construction Composites: A Review" Sea shell remnants, which are rich in calcium carbonate, can be recycled and used as a raw material to create construction materials. As a result, many researchers have focused on using seashell in composites because it can contribute to economic sustainability by reducing environmental pollution from aquaculture waste, which in turn boosts the construction industry's value chain and reduces its carbon footprint. This work seeks to systematize the scholarly output related to sea shell-based composites in building by doing a search using the Scopus tool and a systematic review based on the PRISMA statement. The results show that the use of seashell in concrete and its incorporation into cementitious mortar mixtures are the main areas of current scientific research. There aren't many studies on seashell integration that address its application as an aggregate or binder in coating and laying mortar composition. While there is limited research in other parts of Europe, Asia currently produces the majority of the research. There were no studies found in Oceania, Africa, or the Americas. Even though the importance of sustainability and the financial problems of products used in the blue circular economy sector are becoming more well recognized, there are currently few studies that consider aquaculture waste or by-products. Future research that bridges these practical and contextual limitations can lead to better use of seashell garbage and its integration into the blue circular economy.

Chao Hu aet al. (2023)

In this study, 40 mesh seashell powder was added to matrix asphalt at 3%, 6%, 9%, 12%, 15%, and 18% to create seashell powder modified asphalt. This was carried out to examine the mechanism of seashell powder modification on asphalt as well as the effect of seashell powder on the mechanical characteristics of asphalt. Using the theory of molecular dynamics, the effect of Sea shell powder on the mechanical properties of asphalt was investigated at the molecular level by building a molecular model of asphalt modified with different concentrations of Sea shell powder. The modification method of Sea shell powder-modified asphalt was evaluated at different scales using dynamic shear rheology, atomic force microscopy, scanning electron microscopy, infrared spectroscopy, and viscosity testing. The results demonstrate that adding sea shell powder enhances the technical performance of asphalt and has a substantial impact on its mechanical properties. Sea shell powder has the greatest modification effect and the greatest influence on the mechanical properties of asphalt when it includes 12% or more, according to the research presented in this paper. .

C. Venkata Sai Nagendra, et al (October 2019)

"An Experimental Study on the Properties of Concrete by Using Crushed Sea Shell for Sand and Dolomite for Part of the Cement" Concrete is the most versatile, robust, and dependable building material available worldwide, and it is a fundamental component of all civil engineering buildings. Concrete is made up of cement, water, and fine and coarse aggregates that are mixed in a certain ratio to achieve the desired strength. There is a strong need to discover cement substitutes for concrete due to the rising demand for cement worldwide. The development of new alternatives reduces CO2, a gas that is a major contributor to the greenhouse effect. Around the world, research is being conducted to find new material possibilities. To meet the demands of population increase, river sand is extracted from riverbeds and used to construct massive infrastructure and homes. The preservation of river sand, which is utilized as a fine aggregate in the production of concrete, has become significantly impacted by the rise of globalization and the sophisticated technology needed to fulfill the demands of the global economy both domestically and globally. In order to alter the qualities of concrete, a modest experiment is conducted in which dolomite powder is used in place of some of the cement, ranging from 0% to 10% at intervals of 2.5%, and fine aggregate is made up of crushed seashell powder at a constant 20%. Concrete's durability and mechanical (compressive and tensile) qualities are assessed using a variety of tests.

Wan Ahmad Soffian Bin Wan Mohammad et al (2017)

"A review on seashells ash as partial cement replacement" In order to establish a sustainable environment and lessen the effects of global warming, this review study focuses on using sea shell ash from a variety of marine creatures, including cockle, clam, oyster, mollusc, periwinkle, snail, and green mussel shells, as a partial substitute for cement. Every step of the cement production process has a significant environmental impact. These include noise and vibration from quarry crushing and milling, as well as air pollution from dust and gases. The use of modified cement is one way to address this issue. By integrating and optimizing waste and recycled resources, modified cement is a cementitious substance that performs on par with or better than Portland cement. By doing this, raw materials will be used less frequently and eventually become sustainable building materials. As a result, using different types of sea shell ash in place of cement in concrete may result in significant energy savings as well as significant environmental advantages. This study incorporates earlier research on the mechanical and chemical characteristics of concrete made with seashell ash used in place of some of the

cement, including specific gravity, chemical composition, compressive strength, tensile strength, and flexural strength. The best percentage of seashells to replace cement, according to the results, is between 4 and 5%.

3. Objective of Study

1. To investigate the chemical and physical characteristics of Sea shell ash.
2. To compare the properties of the cubes with the normal mix M35, replace cement with Sea shell ash by 5%, 10%, 15%, 20%, 25%, and 30%.
3. To Examine the behavior of the Workability of Fresh concrete.
4. To Examine the behavior of the compressive strengths of concrete cubes.
5. To Examine the behavior of the split tensile strengths of concrete cylinders.
6. To Examine the behavior of the Flexural tensile strengths of concrete Beams.

4. Material Used

Ordinary Portland Cement:

The most basic type of Portland cement, ordinary Portland cement (OPC), is ideal for use in conventional concrete building. It comes in three different grades: 33, 43, and 53. The quicker rate of strength growth is one of the key advantages. Portland cement clinker, gypsum, and granulated blast furnace slag are combined in an appropriate ratio and ground to create a thorough and intimate mixture of the ingredients to create Portland slag cement. Like OPC, this kind of cement can be used for anything. It is more robust, has a lower heat of evolution, and may be utilized to produce large quantities of concrete.

Figure 1; Ordinary Portland Cement

Fine aggregate (Sand)

Fine aggregate is defined as material that has a gauge of less than 4.75 mm and can be passed through an IS sieve; coarse aggregate is defined as material bigger than this. While fine aggregate makes for the filler matrix, coarse aggregate makes up the concrete's principal matrix. The fine aggregate's main function is to provide the mixture with uniformity and workability. Furthermore, the fine aggregate helps the cement paste hold the coarse aggregate particles in suspension.

Figure 2 ; Fine Aggregate (Sand)

Coarse Aggregate

Coarse aggregate refers to granular material retained on a 4.75 mm (No. 4) sieve, typically ranging in size up to 37.5 mm (1.5 inches) or more. It is a fundamental component in concrete, asphalt concrete, and other construction materials, providing bulk, strength, and stability to the mixture. The properties of coarse aggregate, such as its shape, texture, strength, and durability, significantly influence the performance of the final product. Common types of coarse aggregate include gravel, crushed stone, and recycled concrete aggregate.

Figure 3; Coarse Aggregate

Sea Shell Ash

Sea shell ash is the powdered form of sea shells, often used as a partial replacement for cement in concrete production. It's a sustainable alternative due to its high calcium carbonate content, which is similar to limestone used in cement manufacturing. By utilizing sea shell ash, construction can reduce its reliance on virgin raw materials and minimize environmental impact .

Figure 4; Coarse Aggregate

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5. Conclusion on Seashell Ash in Concrete

1. In conclusion, seashell ash, particularly when derived from calcined shells, can be considered a viable sustainable alternative in cement-based materials.
2. Its primary component, calcium carbonate, allows it to function as an inert material or a reactive component depending on processing .
3. While the use of seashell aggregate can lead to a reduction in workability, density, and mechanical properties like compressive strength, these effects can be managed by controlling the replacement rate.
4. Most studies recommend limiting seashell aggregate replacement to less than 20% to maintain adequate workability and strength .
5. For seashell powder as a cement replacement, optimal levels typically fall between 5% and 15%, where positive effects on mechanical strength, workability, and durability are consistently reported.
6. At these low levels, seashell powder can act as an effective filler, improving particle packing and refining pores.

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