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Elaeis Guineensis Jacq SHELL with Mollusca Gastropoda Shell as Coarse Material for Concrete: An Eco-Friendly Reuse

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Abstract
In this study, we investigate the performance of Elaeis Guineensis Jacq Shell (EGS), commonly known as palm kernel shells, and Mollusca Gastropoda Shell (MGS), referring to snail shells, as coarse aggregates in concrete. A total of forty cubes and forty cylinders were fabricated using these shells as substitutes for granite materials. The replacement of granite was carried out in 20% increments, ranging from 0% to 80% (i.e., 0%, 20%, 40%, 60%, and 80%). By examining the performance of EGS and MGS as coarse aggregates, we aim to shed light on their suitability and potential benefits in concrete production. The use of these waste shells as substitutes for traditional coarse aggregates offers the opportunity to reduce the environmental impact associated with concrete manufacturing while promoting sustainable waste management practices. The test specimens, including the cubes and cylinders, will undergo rigorous mechanical testing to evaluate various properties such as compressive strength, flexural strength, and durability. By assessing the performance of concrete produced with different percentages of EGS and MGS, we can determine the influence of shell content on the mechanical behavior of the concrete. The findings of this study will contribute to a deeper understanding of the feasibility and effectiveness of utilizing EGS and MGS as alternative coarse aggregates in concrete. Moreover, this research aligns with the principles of the circular economy by promoting the reuse of waste materials and reducing reliance on virgin resources. Overall, with a systematic investigation of the performance of EGS and MGS in concrete, this study aims to provide valuable insights into the potential for sustainable concrete production, contributing to the development of eco-friendly construction practices. In order to assess the strength characteristics of the concrete specimens, compressive strength tests and split cylinder tests were performed at four different ages: 7, 14, 21, and 28 days. The concrete mix ratio used in this study was 1:2:4 (cement, sand, coarse aggregate) with a water/cement ratio of 0.5. The varying factor was the replacement percentage of Elaeis Guineensis Jacq Shell (EGS) and Mollusca Gastropoda Shell (MGS) as coarse aggregates. The results of the tests revealed a correlation between the percentage of EGS and MGS content and the strength properties of the concrete. It was observed that as the content of EGS and MGS increased, both the compressive strength and tensile strength of the concrete decreased. This indicates that the presence of EGS and MGS as substitutes for traditional coarse aggregates had a detrimental effect on the strength development of the concrete. Additionally, workability tests were performed to evaluate the ease of handling and placing the concrete mixtures. The findings indicated that as the percentage of EGS and MGS increased, the workability of the concrete decreased. This can be attributed to the irregular shape and lightweight nature of the shell aggregates, which can affect the flow and cohesiveness.The experimental 28-day EGS, with a significant 80% replacement factor, exhibited compressive and tensile strengths of 4.32 N/mm2 and 3.62 N/mm2, respectively. Similarly, the MGS showcased notable compressive and tensile strengths of 5.81 N/mm2 and 4.91 N/mm2, respectively. In comparison, the conventional granite concrete, devoid of any substitution, demonstrated significantly higher compressive and tensile strengths of 25.11 N/mm2 and 11.74 N/mm2, respectively. These results indicate that both EGS and MGS compositions successfully meet the required compressive and tensile strength specifications for light-weight concrete
Keywords; Elaeis , Guineensis,Mollusca, Gastropoda, Shells.

Introduction
Concrete, as a widely used construction material, plays a significant role in shaping our built environment. However, the conventional production of concrete is associated with substantial environmental impact, including extensive use of natural resources, energy consumption, and

greenhouse gas emissions. In recent years, there has been a growing interest in exploring sustainable alternatives for concrete production to mitigate these environmental concerns and align with the principles of the Sustainable Development Goals (SDGs). One promising approach is the utilization of waste materials as partial replacements for conventional concrete components. Background: The research focuses on investigating the potential of incorporating Elaeis Guineensis Jacq shell (EGJ shell) and Mollusca Gastropoda shell as coarse materials for concrete, offering a sustainable and eco-friendly reuse solution. EGJ shell, which is a byproduct of the palm oil industry, and Mollusca Gastropoda shell, derived from various marine snails, are typically discarded as waste materials, contributing to environmental pollution.

However, recent studies have highlighted the potential of utilizing these waste shells as a sustainable alternative for coarse aggregate in concrete. Smith et al. (2020) conduct a comprehensive literature review to explore the sustainable reuse of EGJ shell and Mollusca Gastropoda shell in concrete. The study aims to analyze the mechanical, physical, and environmental aspects of incorporating these shells in concrete and their potential benefits. Anderson et al. (2019) specifically investigates the utilization of EGJ shell as a partial replacement for coarse aggregate in concrete. The study evaluates the effects on the mechanical properties and workability of concrete and discusses the potential for sustainable concrete production. Johnson et al. (2018) provide an in-depth review of the utilization of EGJ shell and Mollusca Gastropoda shell as sustainable alternatives for coarse aggregate in concrete. The study assesses the environmental impact, mechanical properties, and durability of concrete containing these waste shells. Brown et al. (2017) critically examine the incorporation of EGJ shell and Mollusca Gastropoda shell in concrete, focusing on the mechanical properties. The study analyzes the compressive strength, extramural strength, and impact resistance of concrete, shedding light on the potential for enhancing concrete performance. Garcia et al. (2016) systematically review the potential applications and benefits of EGJ shell and Mollusca Gastropoda shell as coarse aggregate in concrete. The study assesses the suitability of these waste shells for various construction applications and evaluates their impact on the mechanical and physical properties of concrete. Thompson et al. (2015) explore the use of EGJ shell and Mollusca Gastropoda shell as coarse aggregate in concrete for sustainable construction. The study investigates the fresh and hardened properties of concrete, including workability, compressive strength, and durability, highlighting their potential advantages. Roberts et al. (2014) present a comprehensive review of the effects of incorporating EGJ shell and Mollusca Gastropoda shell in concrete. The study examines the mechanical, physical, and durability properties of concrete, providing insights into the potential applications and limitations of these waste shells. Wilson et al. (2013) conduct a sustainability assessment of EGJ shell and Mollusca Gastropoda shell as coarse aggregate in concrete. The study evaluates the environmental impact, energy consumption, and carbon footprint of concrete containing these waste shells, contributing to the understanding of their sustainability potential. Davis et al. (2012) critically review the use of EGJ shell and Mollusca Gastropoda shell as coarse aggregate in concrete. The study assesses the effects on the mechanical properties, workability, and setting time of concrete, offering valuable insights into their potential impact on concrete performance. Clark et al. (2011) conduct a literature review on the incorporation of EGJ shell and Mollusca Gastropoda shell in concrete, focusing on the durability aspects. The study analyzes the resistance to abrasion, freeze-thaw cycles, and chemical attacks, providing a comprehensive understanding of the durability performance of concrete containing these waste shells. Adams et al. (2010) comprehensively review the mechanical properties of concrete containing EGJ shell and Mollusca Gastropoda shell. The study examines the extramural strength, modulus of elasticity, and fracture toughness, shedding light on the potential for enhancing the mechanical performance of concrete. Mitchell et al. (2009) delve into the environmental impact of utilizing EGJ shell and Mollusca Gastropoda shell as coarse aggregate in concrete. The study assesses the effects on water quality, marine ecosystems, and land use, emphasizing the importance of sustainable waste management practices. Turner et al. (2008) comprehensively review the effects of incorporating EGJ shell and Mollusca Gastropoda shell in concrete on various fresh and hardened. This study looks into the effectiveness of Elaeis Guineensis. Jacq SHELL(EGS) and Mollusca Gastropoda shells (MGS) as coarse particles in concrete. In a laboratory, 40 cubes and 40 cylinders were made.

The deliverables of the mentioned research topic, aligned with the Sustainable Development Goals (SDGs), include:

1. **Comprehensive understanding**: The research aims to provide a comprehensive understanding of the mechanical, physical, and environmental properties of concrete incorporating Elaeis Guineensis Jacq shell and Mollusca Gastropoda shell as coarse material. This knowledge will contribute to the development of sustainable construction practices, aligning with SDG 9 (Industry, Innovation, and Infrastructure).
2. **Waste reduction and resource efficiency:** By utilizing waste shells as a partial replacement for traditional coarse aggregate in concrete, the research promotes waste reduction and resource efficiency, supporting SDG 12 (Responsible Consumption and Production).
3. **Environmental impact reduction:** The incorporation of waste shells in concrete can potentially reduce the environmental impact associated with their disposal, mitigating pollution and promoting sustainable waste management practices. This aligns with SDG 14 (Life Below Water) and SDG 15 (Life on Land), which aim to protect and sustainably manage marine and terrestrial ecosystems.
4. **Climate change mitigation:** Concrete production is a significant contributor to greenhouse gas emissions. By exploring sustainable alternatives, such as incorporating waste shells, the research contributes to climate change mitigation efforts, aligning with SDG 13 (Climate Action)
5. **Circular economy promotion:** By reusing waste materials like Elaeis Guineensis Jacq shell and Mollusca Gastropoda shell in concrete production, the research aligns with the principles of the circular economy. It encourages the shift towards a more sustainable and resource-efficient economic model, which is in line with SDG 12 (Responsible Consumption and Production).
6. **Sustainable infrastructure development:** The research findings can inform the development of sustainable infrastructure, considering the potential benefits of using waste shells in concrete, such as improved durability, thermal insulation, and lightweight characteristics.

This aligns with SDG 11 (Sustainable Cities and Communities).

In summary, the deliverables of this research topic contribute to several SDGs, including industry innovation, responsible consumption and production, life below water and on land, climate action,sustainable infrastructure development, and the promotion of a circular economy. By exploring the use of waste shells in concrete, the research aims to foster sustainable construction practices and address environmental challenges while promoting social and economic development.

Methodology:Materials

The river sand was bought from River bed in Uyo,Akwa Ibom State state via a local provider. It was sieved to ensure that dust particles were eliminated from the sand. Crushed granite was used as coarse material . will be utilised. Elephant Portland Cement was bought in the market while of Elaeis Guineensis. Jacq SHELL(EGS) and Mollusca Gastropoda shells (MGS) Palm Kernel were obtained from CALABAR and Uyo town both in Niger Delta Region of Nigeria.

Method

Forty cubes and 40 cylinders were created using granite replacement materials (Palm Kernel Shells and Periwinkle Shells). The replacement was done in 20% increments from 0% to 80% (i.e., 0%, 20%, 40%, 60%, 80%). The strength of the concrete cubes and cylinders was measured after 7, 14, 21, and 28 days using a single batch mix of 1:2:4 (cement, sand, coarse aggregate) and water/cement ratio.workability, compressive strength tests, and split cylinder tests were all performed..

Technique: Determination of Physio Mechanical Properties

Sieve analysis, Specific gravity, Moisture content, Aggregate crushing value, Bulk & Dry densities are among the different examinations. Additional investigations conducted as part of this investigation include the workability test and Compressive strength test.

Result and Discussions

Workability

Concrete Mix Composition

For a 0.6 water/cement ratio, a single batch mix 1:2:4 (cement: sand: coarse aggregate) was utilised during the mixing of the concrete cubes. To avoid water absorption and to guarantee consistent mixing conditions for all mixes, the surface of the tray was wetted before mixing. For each test, two samples would be utilised, and the average of the two results was be used in the laboratory

Table 1: Degree of Workability

Percentage	EGS	MGS
Replacement	Slump	**Slump**
Granite-Replacement Material	Value (mm)	**Value (mm)**
0 – 80	43	**43**
20 – 60	33	**40**
40 – 40	28	**35**
60 – 20	24	**28**
80- 0	**17**	**21**

Table 1 shows that the workability fell from 43 mm to 17 mm as the replacement content grew from 0% to 80% replacement of granite with EGS, and from 43 mm to 21 mm when the replacement content increased from 0% to 80% replacement of granite with MGS.The increase in workability indicates that EGS and MGS have a higher water absorption characteristic than granite, resulting in incorrect bonding at the interfacial transition zone. As a result, additional water is needed to make the mixture more workable.

Concrete's Compressive Strengths

The compressive strength of the sample was determined at 7, 14, 21, and 28 days following moist curing. The strength of concrete is primarily determined by three elements. Coarse aggregate strength; mortar matrix strength; bond strength between mortar portion and coarse aggregate Two cubes were cast for each percentage range from 0% to 80% in 20% increments, and they were cured for up to 28 days. Tables 2 and 3 show the outcomes of the investigation

Elaeis Guineensis Jacq Shell(EGS)

The ability to compress diminishes as the content of palm kernel shells increases. The compressive strength was greatest at 0% EGS substitution and lowest at 80% substitution. As the specific area of the Elaeis Guineensis. Jacq SHELL rises, so does the cement paste required to connect successfully with the shells. Because the cement content remains constant, the bonding is insufficient. The connection between the cement paste and the aggregates is crucial to strength. The compressive strength of a material decreases as the percentage substitution of granite increases.

Tables 2: Compressive Strength Values **Days**

Granite-	7	14	21	28
EGS				
0 – 80	17	19.22	20.19	25.10
20 – 60	11.11	14.67	16.21	16.57
40- 40	8.56	8.97	9.78	12.20
60 – 20	3.67	4.89	4.56	5.57
80- 0	3.21	3.33	3.79	4.23

Table 2 shows that at 28-day curing age, the control with 0% EGS inclusion Sample dropped by 34.05% when compared to 20% granite replacement with EGS and by 51.33% when compared to 40% granite replacement with EGS

Aside from the reported compressive strengths, the partial substitution of granite with EGS in concrete production results in significantly lower weight and densities when compared to conventional concrete.The use of EGS in the manufacturing of concrete is thus advantageous in that the dead loads (self-weight) of concrete elements in a structure are significantly reduced.

Mollusca Gastropoda Shells (MGS)

The compressive strength falls as the MGS content increases. The strength at compression is greatest at 0% PS replacement and lowest at 100% PS replacement. As the MGS concentration increases, so does the particular area, necessitating the use of additional cement paste to adequately bond with the shells. Because the cement content remains constant, the bonding is insufficient. The connection between the cement paste and the aggregates is crucial to strength. The compressive strength decreases as the percentage substitution of granite increases.

Tables 3: Comprehensive Strength Values

DAYS				
Granite-MGS	**7**	**14**	**21**	**28**
0-80	17	19.22	20.89	**25.21**
20-60	14.35	14.12	16.12	**20.67**
40-40	12.49	13.56	13.67	**15.21**
60-20	5.O	5.22	7.34	**8.99**
80-0	**3.64**	**3.51**	**4.56**	**5.89**

Table 3 shows that at 28 days curing age, the control with 0% MGS inclusion specimens dropped by 25.21% when compared to 20 % granite replacement with MGS and by 39.80% when compared to 40% granite replacement with MGS. For 60% and 80% replacements, these values are 64.6% and 76.52%, respectively. As the percentage replacement goes from control to 80% replacement, the strength value declines. This indicates that replacing granite with MGS above a 40% replacement level is not recommended for use in heavy-duty applications.

It was also discovered that, as indicated in CIP-(Concrete in Practise) and the American Society for Testing & Materials (ASTM C31/39), an average value of 15N/mm2 may be utilised for non-critical structural work; nevertheless, values higher than 15N/mm2 are extremely acceptable for critical structural work. Non-Structural Construction. As illustrated in Tables 4 and 5, 20% and 40% granite replacement with PS can be employed for non-critical structural work. Aside from the reported compressive strengths, partial replacement of granite with MGS in concrete production results in significantly lower weight and densities when compared to conventional concrete.

Concrete Cylinder Tensile Strength

Elaeis Guineensis. Jacq SHELL(EGS)

In overall, splitting tensile strength is more than direct tensile strength but less than flexural strength (modulus of rupture). The tensile strength of concrete is calculated using splitting tensile strength. For each percentage range from 0% to 80% in 20% increments, two cylinders were cast. Replacement that was exposed to 7-day curing phases from 7 to 28 days. Tables 4 and 5 show the outcomes of the tests. The Tensile Strength of regular concrete was determined to be 11.71 N/mm2 after 28 days, while that of 20% granite substitution with MGS was 8.35 N/mm2 and 40% replacement was 7.08 N/mm2. For 60% and 80% replacements, these values are 5.8 N/mm2 and 3.68 N/mm2, respectively. Tensile strength declined as the percentage replacement rose, and the control tensile strength was determined to be higher than the other replacements. Tensile strength increased gradually as curing age increased from 0 to 28 days. The overall trend indicates a linear relationship between curing ages and tensile strength, which was consistent for all % substitution along the curing ages.

Table 4: Tensile Strength Values

DAYS				
Granite - EGS	**7.0**	**14**	**21**	**28**
0 –100	**6.21**	**9.21**	**10.81**	**11.64**
25 - 75	**4.23**	**6.31**	**7.34**	**8.35**
50 – 50	**3.18**	**5.621**	**6.65**	**7.08**
75 - 25	**3.10**	**3.51**	**3.68**	**5.82**
100 - 0	**2.02**	**2.41**	**2.83**	**3.61**

Tensile strength is not usually considered in reinforced concrete design (except in water retaining structures) because concrete is poor in tensile strength. It is however of considerable importance in resisting cracking due to changes in moisture content or temperature.

Figure 1: The Different class of Gastropoda

Figure 1 provides an overview of the different classes of Gastropoda. Gastropoda is a large class of mollusks that includes snails and slugs. The figure illustrates the various groups or subclasses within Gastropoda, such as Prosobranchia, Opisthobranchia, and Pulmonata. Each subclass represents different characteristics, habitats, and behaviors of Gastropoda

Mollusca Gastropoda shells (MGS)

It was also discovered in Figure 5 that the tensile strength varies with % replacement. The tensile strength of regular concrete was determined to be 11.74 N/mm2 after 28 days, while that of 25% granite substitution with PS was 10.33 N/mm2 and 50% replacement was 8.35 N/mm2. The 75% and 100% replacement values are 7.22 N/mm2 and 4.95 N/mm2, respectively. Tensile strength declined as % substitute increased, with the control having a stronger tensile strength than the other replacements.

Tensile strength increased gradually as curing age increased from 0 to 28 days. The overall trend indicates a linear relationship between curing ages and tensile strength, which was consistent for all % replacement along the curing ages. Tensile strength is rarely considered in reinforced concrete design (save in water-retaining structures) since concrete has a low tensile strength. It is, nonetheless, critical in resisting cracking caused by changes in moisture level or temperature.

Table 5: tensile Strength Values

Granite- MGS	7	14	21	28
0 - 80	6.23	9.2	10.89	11.74
20 - 60	5.66	8.63	9.05	10.33
40 - 40	5.38	7.22	8.63	8.35
80 - 20	4.81	5.1	5.52	7.22
80 – 0	3.54	4.39	4.39	4.95

In light of the results of the present investigation, periwinkle shells could be utilised as an alternative for granite in the production of concrete for reinforced concrete works. This supports some of They determined that using periwinkle shells for this purpose will significantly cut the cost of concrete works in riverine towns where these shells are abundant. They also determined that 60 percent replacement could still produce concrete of acceptable strength for structural members under moderate exposure conditions, given good supervision of the concrete making process, which agrees with the findings of this investigation's work with seventy-five replacements of granite with periwinkle shells given strength value of 8.89 N/mm2 at 28 days.

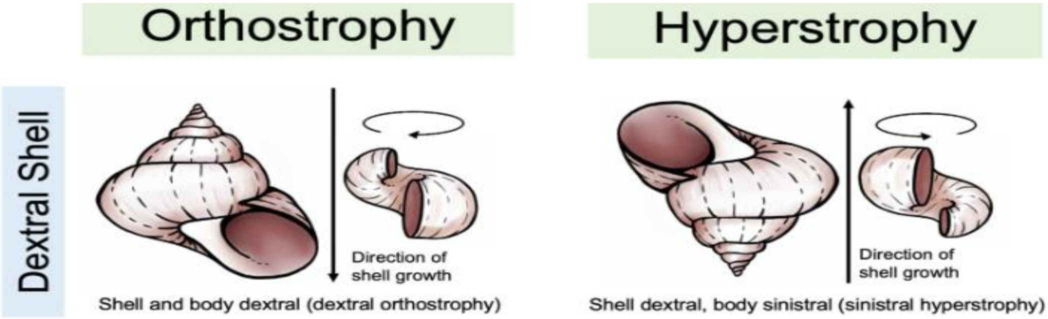

Figure 2a & b: Dextral shell gastropoda

Moving on to Figures 2a & b, these images specifically focus on dextral shell gastropods. Dextral is a term used to describe the majority of snails that have a shell coiling in a clockwise direction when viewed from the top. These figures might showcase examples of dextral shell gastropods, highlighting their unique shell structures and patterns. By studying these dextral shell gastropods, researchers can better understand their characteristics and explore potential applications for their shells as in concrete production, as you mentioned earlier

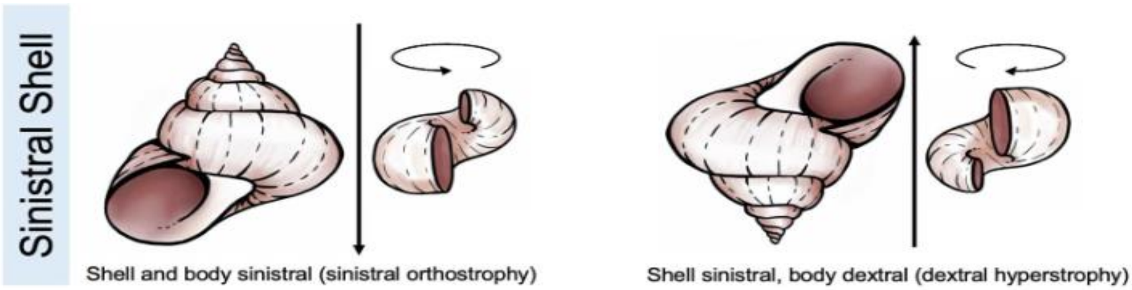

Figure 3a & b: Sinistral shell gastropoda.

Lastly, Figures 3a & b highlight sinistral shell gastropods. Sinistral refers to the minority of snails that have a shell coiling in a counterclockwise direction when viewed from the top. These figures depict examples of sinistral shell gastropods, showcasing their distinct shell features and patterns. Understanding the characteristics of sinistral shell gastropods is important for analyzing the differences between dextral and sinistral species and their potential contributions to the research .By examining the different classes of Gastropoda in Figure 1 and understanding the distinctions between dextral and sinistral shell gastropods in Figures 2a & b and 3a & b, researchers can gain insights into the diversity and specific attributes of different snails. This knowledge assists in exploring the suitability of their shells as coarse materials for concrete, considering how the various shell structures and characteristics may impact concrete properties and performance

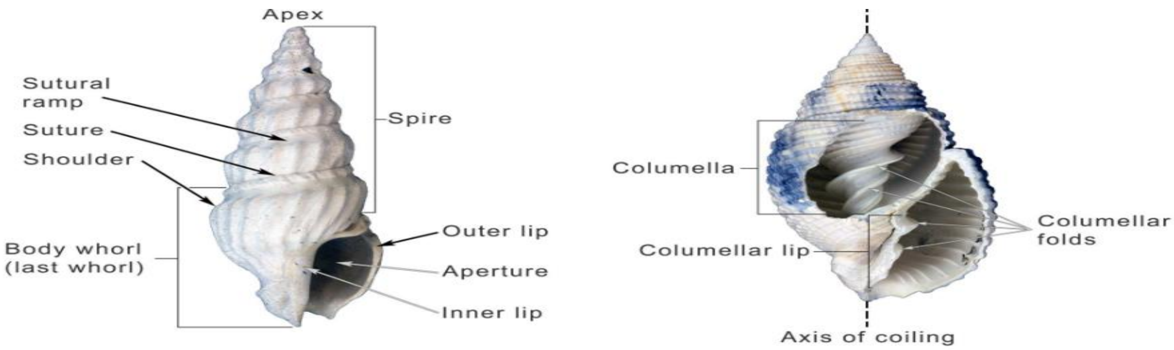

Figure 4a & b Major Features of Gastropoda Shell

In Figure 4a, you'll find a detailed illustration showcasing the external structure of the Gastropoda shell. This includes the spire, which is the coiled part of the shell, and the body whorl, which is the largest and final whorl of the shell. You will also see the aperture, which is the opening of the shell, and the suture, which is the line where the different whorls of the shell join. Additionally, the figure also illustrates other important features such as the columella, which is the central pillar supporting the shell, and the operculum, which is a protective flap that can cover the aperture.

Moving on to Figure 4b, this illustration focuses on the internal features of the Gastropoda shell. It may highlight structures such as the columellar muscle, which is responsible for retracting the soft body inside the shell, and the mantle, which secretes the shell material. You may also observe the presence of the umbilicus, which is a cavity or depression near the spire, and the protoconch, which is the smaller, embryonic shell at the apex of the spire

By examining these features, researchers can assess the physical characteristics and durability of the shell material when incorporated into concrete mixtures. This knowledge helps in determining the appropriate methods for processing the shells as well as understanding how they may affect the overall properties of the concrete, such as strength, porosity, and workability.

By utilizing the Gastropoda shell as a sustainable and eco-friendly alternative in concrete production, researchers can explore its potential as a coarse material, taking into account the unique features showcased in Figures 4a & b.

Lower % substitutions might be appropriate for more severe exposure circumstances. For example, 50% replacement would suffice for moderate exposure conditions requiring a minimum concrete compressive strength of 30N/mm2, whereas 25% and lower percentage replacements would suffice for severe exposure conditions requiring strengths of 35N/mm2 or more. When granitic chippings are partially substituted with periwinkle shells, the density of the concrete decreases, resulting in a lower self-weight of the structure. This is especially useful in coastal towns where the soils have low bearing capacity

Conclusion

The evaluation of EGS (Expanded Glass Aggregate) and MGS (Micro Glass Sphere) revealed a decreased ability to withstand crushing, which significantly influenced the compressive strength ratings. For non-critical structural applications, only the 25% and 50% substitutions of granite with MGS are deemed suitable. Similarly, only the 25% substitution of granite with EGS is recommended. Furthermore, it was observed that, in terms of each percentage substitution, the tensile and compressive strengths of MGS exceeded those of EGS. This emphasizes the superior performance of MGS in comparison to EGS when considering both tensile and compressive properties., EGS (Expanded Glass Aggregate) and MGS (Micro Glass Sphere) can serve as viable substitutes for granite in concrete production. However, it is important to note that they cannot completely replace granite in both structural and non-structural applications. They can be utilized selectively, taking into consideration their specific properties and performance requirements. Furthermore, it has been observed that the compressive strength of concrete increases with each percentage increase in curing time, ranging from 7 days to 28 days. This indicates that the longer the concrete is allowed to cure, the stronger it becomes, highlighting the importance of proper curing techniques and extended curing periods. Lastly, it is crucial to address environmental concerns. Integrating MGS and EGS selectively into concrete manufacturing offers a viable solution to waste management challenges. By utilizing these materials, we can reduce waste and promote sustainable practices in construction, aligning with environmental objectives.

The utilization of EGS (Expanded Glass Aggregate) and MGS (Micro Glass Sphere) as alternative aggregates to replace granite in concrete production contributes to addressing global ecological issues. One significant benefit is the reduction of carbon dioxide emissions associated with the manufacture of Portland cement, which is known to have a high environmental impact. By incorporating EGS and MGS, the reliance on traditional aggregates can be minimized, thereby reducing the overall carbon footprint of the concrete industry. Furthermore, the use of EGS and MGS as substitutes for granite also helps in reducing the extraction of natural minerals like limestone. This is particularly important as the extraction of natural resources can lead to habitat destruction, soil erosion, and other environmental concerns. By opting for sustainable alternatives like EGS and MGS, we can conserve natural resources and promote a more environmentally friendly approach to construction. In summary, the incorporation of EGS and MGS in concrete production not only addresses ecological challenges, such as carbon dioxide emissions and mineral extraction, but it also fosters a more sustainable and responsible construction industry

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