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# Assessment of the Utilization of Pulverized Golden Apple Snail (*Pomaceacanaliculata*) Shells as Partial Replacement for Ordinary Portland Cement in Concrete

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## Abstract:
Cement production is a significant supplier to CO□ emissions and environmental degradation, evident in its substantial carbon footprint and strain on natural resources. Additionally, the depletion of vital resources like limestone poses long-term sustainability challenges. Also, economic challenges such as fluctuating raw material prices and market demand volatility further compound the industry's complexities. Furthermore, Golden Apple Snail has become a notorious invasive species in many aquatic ecosystems worldwide. Once established, these snails rapidly reproduce, consuming vast quantities of aquatic vegetation, disrupting local food webs, and altering nutrient cycling dynamics. Addressing these challenges requires innovative approaches, this research proposes an idea to assess the utilization of GAS Shell to partially replace cement in Ordinary Portland cement in concrete. The study has three (3) specific objectives: (1) To determine the optimal design mixture among 3%, 5%, and 8% cement replacements in concrete. (2) To assess the effectiveness of the optimal design mixture through slump tests and compressive strength measurements. (3) To conduct a cost analysis comparing the optimal design mixture with the standard concrete mixture. It also undergoes two testing which are: slump cone test and compressive strength test. To attain the result of compressive strength, the proponents employed 6 in. by 12 in. cylindrical sample consisting of 36 samples (0%, 3%, 5%, and 8%) with different curing age (7th, 14th & 28th day). Universal Testing Machine (UTM) was utilized to test the concrete cylinder samples, and later revealed that GAS shell is a potential partial replacement to cement in concrete after 28th days. A material-based cost analysis is also shown to compare the commercial price rates with the GAS shell employed mixtures.

*Keywords* **—Cement, Compressive Strength, Concrete, Golden Apple Snail**

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## I. INTRODUCTION

This Over the last few years, there has been a increasing awareness of the environmental effect linked with traditional construction materials, particularly cement, a key component in concrete production [1]. As societies strive to achieve sustainable development and address the challenges of climate change, the construction industry has begun to explore alternative approaches to reduce its carbon footprint. One significant avenue involves the partial replacement of cement in concrete mixtures with environmentally friendly alternatives. This shift is driven by a recognition of the detrimental effects of cement production on the environment, including substantial carbon dioxide emissions, resource depletion, and energy-intensive manufacturing processes [2].

Consequently, in the delicate equilibrium of ecosystems, the golden apple snail

  

(Pomaceacanaliculata) emerges as a captivating protagonist, wielding a dual impact on agriculture and construction. Initially introduced to the Philippines in 1983 as a potential food source, these freshwater snails unintentionally burgeoned in waterways, swiftly transforming into a severe agricultural pest [3]. Particularly notorious in rice fields, their robust reproductive capacity and rapid growth inflict substantial ecological and economic harm, earning them a spot among the top 100 notorious invasive species globally [4].

However, amidst the agricultural challenges posed by these snails, a distinctive avenue for resource utilization emerges. Aquaculture waste, primarily appear as golden apple snail shells, ingeniously finds purpose in creating nano-modified concrete. This resultant powder, when integrated into concrete mixtures, enhances qualities without compromising strength [5].

The agricultural narrative takes a different turn as golden apple snails, voracious consumers of rice seedlings, become destructive pests. Their penchant for devouring early-growing seedlings poses a significant threat to rice cultivation, with a single giant snail capable of consuming 7-24 rice seedlings daily [6]. This destructive capacity extends beyond Philippine borders, infiltrating the rice fields of Malaysia and inflicting substantial economic impact on farmers.

Amidst the challenges posed by golden apple snails in agriculture, their shells offer an intriguing solution to environmental concerns associated with concrete production. Recognized as solid waste from the agricultural industry, these shells have the potential to transform construction practices by providing an environmental-friendly substitute to traditional concrete, reducing the wasteful use of natural resources [5].

Relative thereof, concrete, a complex material comprised of cement, water, aggregates, and additives, is the bedrock of modern construction. It embodies strength and stability, forming the backbone of diverse structures ranging from residential buildings to bridges and dams. Its adaptability allows for versatile applications, enabling the creation of intricate architectural designs and providing the foundation for essential infrastructure. The importance of concrete lies in its durability, resilience against environmental factors, and energy efficiency, making it an indispensable material in shaping the built environment. As a fundamental building block, concrete plays a essential role in guaranteeing the longevity, safety, and sustainability of constructions that define the contemporary landscape [7].

On the other hand, cement is a key component in concrete, serving as the binding agent that holds together the various materials in the mixture. Ordinary Portland Cement (OPC), the most commonly used type, consists primarily of limestone, clay, iron ore, and gypsum. These raw materials are finely ground and blended in specific proportions to form a powder. The critical components of OPC include dicalcium silicate (C2S), tricalcium silicate (C3S), tetracalciumaluminoferrite (C4AF), and tricalcium aluminate (C3A). When water is added, these compounds undergo chemical reactions, leading to the formation of a strong and durable material, providing the essential binding and structural properties to concrete. Furthermore, ordinary Portland cement (OPC) typically consists of approximately 95% clinker, a lumpy substance created by heating a blend of limestone and clay to a high temperature [8]. The remaining composition includes gypsum, added during the grinding process to control the setting time, with trace amounts of other additives that may be incorporated for specific performance enhancements.

The calcium-rich layers of golden apple snail shells, particularly the prismatic layer, present a valuable source for creating calcium compounds. With over 95% of the shell composed of calcium carbonate (CaCO3), studies explore applications ranging from soil conditioning to environmentally friendly thermoplastic composites. Seashells, including those of golden apple snails, have been investigated as alternatives to traditional building materials, offering benefits such as reduced porosity, increased compressive strength, and diminished water demand in concrete [9].

As the demand for high-quality limestone rises and concerns over environmental degradation intensify, the potential for utilizing golden apple snail shells as a sustainable resource gains prominence. The transformation of snail shells into calcium oxide (CaO) and the exploration of their calcination properties at varying temperatures underscore the versatility of these shells in diverse applications.

In summary, this thesis endeavors to unravel the complex interplay between the agricultural menace of golden apple snails and their potential as a sustainable resource in construction. Through an in-depth analysis of studies exploring snail behavior, agricultural consequences, and construction innovations, the study aims to shed light on the dual role of these intriguing creatures in shaping the ecological and economic landscapes.

## II. METHODOLOGY

### *A. Material Development*

In this phase, the researchers acquired golden apple snails in a rice field at San Matias, Guagua, Pampanga. The researchers made sure that the acquisition is consented to. Necessary preparations were guaranteed for this phase. Set standards were considered in this phase to avoid compromising the process. The following were the processes in preparation of materials:

1) ***Boiling of Golden Apple Snail:*** Obtained GAS were boiled in water for 20 mins [22]. This is to remove the impurities from the shell as well as to easily remove the flesh of the snail from the shell.

2) ***Sun Drying of Golden Apple Snail:*** This process is necessary to avoid the shells from having molds and infested by worms.

3) ***Pulverizing of Golden Apple Snail:*** GAS Shells were pulverized to produce cementitious material. This enabled the material to have the same texture with ordinary Portland cement as it is the material that the researchers intended to partially replace.

4) ***Calcination of Golden Apple Snail:*** GAS is known to comprise calcium carbonate in the form of aragonite. However, limestone is primarily composed of calcite. Calcination through 900ºC within an hour is a necessary process to convert aragonite into calcite.

5) ***Sieving of Golden Apple Snail:*** Once the shells are pulverized, the powder undergone sieving through Sieve No. 200 in order to achieve the particle size of cement.

### *C. Proposed Design Mixture of Specimens*

TABLE I
Summary of sand and gravel for 36 samples

NOTE: Sand Unit Weight = 1637 kg/m3
Gravel Unit Weight = 1585 kg/m3

| Classification | | Specimen Mark | Day | No. of Specimen | GAS kg | OPC kg | SAND kg | GRAVEL kg |
|---|---|---|---|---|---|---|---|---|
| Standard Concrete Mix | | 1 | 7 | 3 | 0 | 6.00942 | 13.663 | 26.46 |
| | | | 14 | 3 | 0 | 6.00942 | 13.663 | 26.46 |
| | | | 28 | 3 | 0 | 6.00942 | 13.663 | 26.46 |
| **TOTAL** | | | | **9** | **0** | **18.02826** | **40.95** | **79.38** |
| GAS Concrete Mixture Cement Replacement (%) | 3 % | 2 | 7 | 3 | 0.18027 | 5.82912 | 13.663 | 26.46 |
| | | | 14 | 3 | 0.18027 | 5.82912 | 13.663 | 26.46 |
| | | | 28 | 3 | 0.18027 | 5.82912 | 13.663 | 26.46 |
| | **TOTAL** | | | **9** | **0.54081** | **17.48736** | **40.99** | **79.38** |
| | 5 % | 3 | 7 | 3 | 0.30048 | 5.70894 | 13.663 | 26.46 |
| | | | 14 | 3 | 0.30048 | 5.70894 | 13.663 | 26.46 |
| | | | 28 | 3 | 0.30048 | 5.70894 | 13.663 | 26.46 |
| | **TOTAL** | | | **9** | **0.90144** | **17.12682** | **40.99** | **79.38** |
| | 8 % | 4 | 7 | 3 | 0.48075 | 5.52867 | 13.663 | 26.46 |
| | | | 14 | 3 | 0.48075 | 5.52867 | 13.663 | 26.46 |
| | | | 28 | 3 | 0.48075 | 5.52867 | 13.663 | 26.46 |
| | **TOTAL** | | | ***9*** | **1.44225** | **16.58601** | **40.99** | **79.38** |
| **GRAND TOTAL** | | | | ***36*** | **2.88450** | **69.22845** | **163.96** | **317.52** |

### *D. Production and Curing of Specimen*

In this phase, different samples undergone curing for 7, 14, and 28 days in consonance with

  

ASTM C31.Each mixture had three samples that undergone curing for the above-specified days as per standards.

***E. Testing***

All the concrete mixtures including the control block and block samples in this study went through two testing, slump test and compressive strength test. These tests determined the behavior of the concrete. Further, the data that were gathered from these testing established the results and conclusions of this study.

Table II
Workability of concrete slump

| Degree of Workability | Slump Values | |
|---|---|---|
| | mm | in |
| Very Low Workability | 0 - 25 | 0 - 1 |
| Low Workability | 25 – 50 | 1 – 2 |
| Medium Workability | 50 – 100 | 2 – 4 |
| High Workability | 100 - 175 | 4 - 7 |

Table III
Total specimen for tssting and their expected compressive strengths

| Classification | | Specimen Mark | Day | No. of Specimen | Expected Compressive Strength in Percentage (%) | Expected Compressive Strength of Concrete with Respect to Class A Mixture (psi) |
|---|---|---|---|---|---|---|
| Standard Concrete Mix | | 1 | 7 | 3 | 65% | 1950 |
| | | | 14 | 3 | 90% | 2700 |
| | | | 28 | 3 | 99% | 2970 |
| GAS Concrete Mixture Cement Replacement (%) | 3 % | 2 | 7 | 3 | 65% | 1950 |
| | | | 14 | 3 | 90% | 2700 |
| | | | 28 | 3 | 99% | 2970 |
| | 5 % | 3 | 7 | 3 | 65% | 1950 |
| | | | 14 | 3 | 90% | 2700 |
| | | | 28 | 3 | 99% | 2970 |
| | 8 % | 4 | 7 | 3 | 65% | 1950 |
| | | | 14 | 3 | 90% | 2700 |
| | | | 28 | 3 | 99% | 2970 |
| Total Specimen | | | | *36* | | |

## III. RESULTS AND DISCUSSON

***A. Slump Cone Test Results***

This assessment followed the guidelines outlined in ASTM C 143, specifically the "Standard Test Method for Slump of Hydraulic Cement Concrete." The slump cone test was conducted during the production of specimens at La Corona Ready Mix Concrete in Sindalan, San Fernando, Pampanga.

Table IV
Slump cone test results

| Sample Identification | Slump Inches | Remarks |
|---|---|---|
| 0% Control Block | 2.3 | *TRUE SLUMP* |
| 3% Block 1 (Pulverized GAS) | 2.5 | *TRUE SLUMP* |
| 5% Block 2 (Pulverized GAS) | 3.4 | *TRUE SLUMP* |
| 8% Block 3 (Pulverized GAS) | 3.5 | *TRUE SLUMP* |

***B. Compressive Strength Test Results***

This assessment adheres to the guidelines outlined in ASTM C39, known as the "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens." Compressive strength tests were carried out following 7, 14, and 28 days of concrete curing as per ASTM C31 standards. The testing took place at the Department of Public Works and Highways – Quality Assurance and Hydrology Division Regional Office III, located in Sindalan, City of San Fernando, Pampanga.

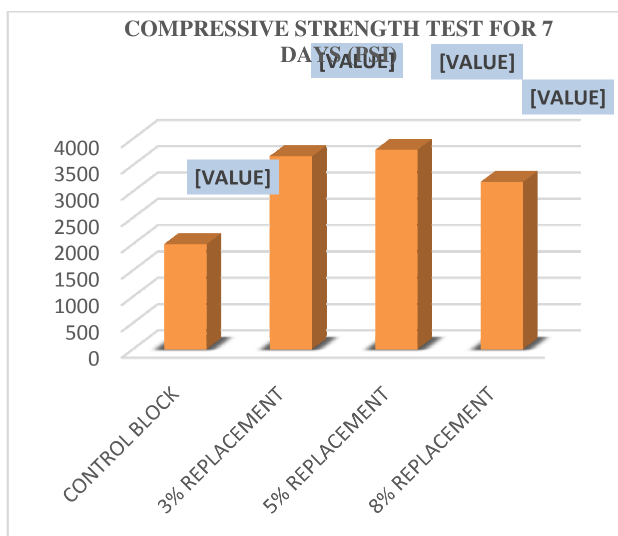


Fig.1. Compressive strength obtained on the 7th day

  

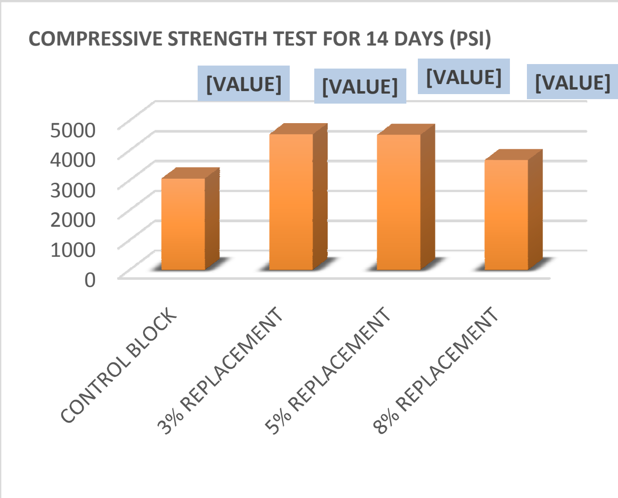


Fig.2. Compressive strength obtained on the14th day

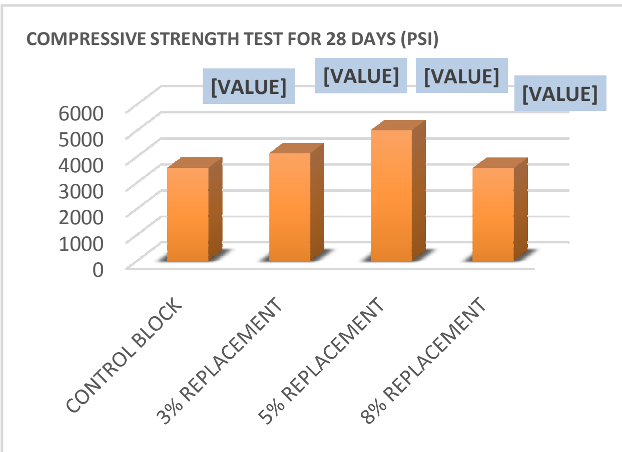


Fig.3. Compressive strength obtained on the 28th day

TABLE V
Compressive Strength Test Results Summary

| Setup Identification | | Mix Ratio | CompressiveStrength(Psi) | | |
|---|---|---|---|---|---|
| | | | 7th | 14th | 28th |
| ControlBlock | | 1 - partcement,2 - partsfineaggregates(sand), 4- parts coarse aggregates (gravel), and 0.5 - parts water. | 2000 | 3060 | 3570 |
| GAS Concrete Mixture Cement Replacement (%) | 3 % | 1 - partcement (97% Ordinary Portland Cement Type 1 and 3% Pulverized Golden Apple Snail Shell),2 - partsfineaggregates(sand), 4- parts coarse aggregates (gravel), and 0.5 - parts water. | 3670 | 4540 | 4120 |
| GAS Concrete Mixture Cement Replacement (%) | 5% | 1 - partcement (95% Ordinary Portland Cement Type 1 and 5% Pulverized Golden Apple Snail Shell),2 - partsfineaggregates(sand), 4- parts coarse aggregates (gravel), and 0.5 - parts water. | 3790 | 4520 | 5010 |
| GAS Concrete Mixture Cement Replacement (%) | 8% | 1 - partcement (92% Ordinary Portland Cement Type 1 and 8% Pulverized Golden Apple Snail Shell),2 - partsfineaggregates(sand), 4- parts coarse aggregates (gravel), and 0.5 - parts water. | 3180 | 3680 | 3560 |

## III. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

### *A. Summary of Findings*

*1) Slump Cone Test:* The analysis of the results from the slump cone test reveals distinct trends among the samples. Block 3, recording the highest replacement percentage at 8%, exhibited the most significant slump, measuring 3.5 inches. It was closely trailed by the sample with 5% OPC replacement, showing a slump of 3.4 inches. In contrast, the 3% OPC replacement sample registered a slump of 2.5 inches, while the control block, devoid of any replacement, recorded a slump of 2.3 inches. These findings indicate a direct correlation between the replacement percentage and the slump measurement, suggesting that as the replacement percentage increases, so does the slump measurement. In line with results, all four samples fell within the acceptable range of 2 to 4 inches, indicating a true slump. This underscores the influence of the Pulverized Golden Apple Snail Shells on the concrete slump, though such effects may not necessarily impact the overall quality and performance of the concrete. Notably, all samples, including both control and experimental blocks, were categorized as having medium workability.

*2) Compressive Strength Test:*The peak compressive strength of the concrete blocks typically occurs following a 28-day curing period. In the control block, where no OPC replacement was implemented, the compressive strength measured 2,000 psi after 7 days, 3,060 psi after 14 days, and 3,570 psi after 28 days. Similarly, the sample with 3% OPC replacement achieved 3,670 psi on the 7th day, 4,540 psi on the 14th day, and 4,120 psi on the 28th day. Block 2, featuring 5% replacement, yielded results of 3.790 psi, 4,520 psi, and 5,010 psi, respectively. Finally, Sample Block 3, with an 8% replacement of Pulverized GAS Shells, attained 3,180 psi, 3,600 psi, and 3,560 psi, correspondingly.Both the Control

  

Block Sample and Sample Block 2 (5% replaced) demonstrated consistent progress from the 7th to the 28th day. Conversely, Sample Blocks 1 and 3 showed improvement from the 7th to the 14th day but experienced a slight decline by the 28th day. Despite this decline, Sample Block 1 (3% replaced) maintained a notably increased compressive strength compared to the control block, with a difference of 550 psi. In contrast, Sample Block 3 (8% replaced) flunked by only 10 psi compared to the control block.In summary, despite fluctuations in the compressive strength of the two sample blocks, Sample Block 2 remained the most ideal and optimal replacement mixture, recording 5,010 psi compared to the control block's 3,570 psi, depicting a margin of 1,440 psi. Finally, the documented strength of the ideal mix has also met the design strength criteria for Class P mixture.

### *B. Conclusions*

Considering the study's findings, it is evident that the slumps recorded from the samples are all desirable, indicating medium workability. This level of workability is ideal for concrete applications, ensuring ease of use while maintaining structural integrity.

In terms of material replacement, the study highlights the significant benefits of using Pulverized Golden Apple Snail Shells (PGASS) as a partial replacement in concrete mixes. The incorporation of PGASS not only enhances the environmental sustainability of the concrete but also contributes markedly to improving its compressive strength.

The test outcomes reveal that Block 2, with a 5% PGASS replacement, emerges as the optimal and most effective percentage for this purpose. This mixture yields an impressive compressive strength of 5,010 psi, which meets and exceeds the strength specifications for Class P concrete mixture design. This remarkable performance is particularly noteworthy when compared to the Control Block, which registered a compressive strength of 3,570 psi. The significant increase in strength, over 40%, underscores the potential of PGASS as a valuable additive in concrete production, offering both enhanced mechanical properties and environmental benefits.

These findings suggest that PGASS not only provides a viable alternative to traditional materials but also contributes to achieving higher performance standards in concrete construction. This advancement opens new avenues for sustainable construction practices, leveraging waste materials to create stronger, more durable infrastructure.

### *C. Recommendations*

Based on the findings gleaned from the conducted study, the researchers propose the following recommendations to guide future endeavors:

***1)Investigate the chemical composition of golden apple snail shells***

***2) Utilize mortar cube testing to assess compressive strength***

***3)Experiment with alternative mix proportions or design combinations***

***4)Consider employing sieve no. 325 for ultra-fine powder extraction***

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[45] "Section VI. SPECIFICATIONS SUPPLEMENTAL SPECIFICATIONS TO: DPWH STANDARD SPECIFICATIONS FOR HIGHWAYS, BRIDGES AND AIRPORTS, VOLUME II, 2013 EDITION CONTRACTORS SHALL PURCHASE THE DPWH STANDARD SPECIFICATIONS STATED ABOVE. THIS STANDARD SPECIFICATIONS SHALL FORM PART OF THE CONTRACT DOCUMENTS AND SHALL BE READ IN CONJUNCTION WITH THIS SUPPLEMENTAL SPECIFICATIONS AND THE SPECIAL PROVISIONS OF THE STANDARDSPECIFICATIONS. Construction, Rehabilitation and Improvement of Lucena Fish Port Complex."