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Development and Utilization of Structural Panel with Indian Almond Seed

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Abstract: This study investigated the potential of processed Indian Almond (*Terminalia catappa*) seed shell particles, locally known as Talisay, as reinforcement for sustainable cement-based structural panels. Using an experimental developmental design, three panel formulations were developed by varying the proportions of ground Talisay seed shells and sand while maintaining a constant cement-to-water ratio. The panels underwent mechanical testing and qualitative evaluation by 30 industry professionals and construction practitioners. Results showed that all treatments exhibited a flexural strength of approximately 0.1 MPa. However, Treatment B, composed of equal proportions of Talisay seed shells and sand, demonstrated the highest performance with a peak load capacity of 857 N, compressive strength of 8.8 MPa, and low water absorption rate of 11.25%. Panel densities ranged from 1.34 to 1.41 g/cm³, classifying them as lightweight materials. Evaluators rated the panels as "Very Acceptable" and "Very Applicable" for interior wall and ceiling applications. The findings support the use of Talisay seed shells as eco-friendly construction materials.

Keywords: Indian Almond Seed shells, Talisay seed shells, Terminalia catappa, Structural Panel, sustainable building materials, lightweight composites.

I. INTRODUCTION

Cement-based composite panels are widely utilized in modern construction because of their strength, durability, and dimensional stability. Materials such as cement-bonded particle boards and fiber-cement boards are commonly used as alternatives to conventional materials like gypsum boards and plywood due to their enhanced performance and longer service life. However, the increasing environmental impact and rising costs associated with the extraction of traditional raw materials have encouraged researchers to explore sustainable and locally available alternatives (Bumanis et al., 2024)[1]. One promising resource in the Philippines is the Indian Almond (Terminalia catappa), locally known as Talisay, whose seed shells are abundant yet often discarded as waste materials.

The utilization of agricultural residues as reinforcement in cement composites has gained attention because of its potential to reduce environmental waste and dependence on timber-based products. Incorporating processed Talisay seed shells into cement mixtures may contribute to the development of lightweight, eco-friendly, and cost-efficient construction materials while promoting sustainable waste management practices (Sathiparan & De Zoysa, 2020)[2]. This approach supports the growing demand for sustainable construction solutions and aligns with global efforts toward environmental conservation and resource efficiency.

The study contributes to sustainable construction practices by introducing an eco-friendly alternative to conventional composite boards. It provides opportunities for local communities and entrepreneurs to develop new products from agricultural waste, thereby promoting livelihood generation and environmental stewardship. Furthermore, the research strengthens educational initiatives in sustainability and disaster risk reduction, equipping students and communities with practical knowledge of waste management and resource use.

The primary purpose of the study aimed to develop and evaluate a structural panel with Indian Almond Seed. Specifically, it sought to:

1. Evaluate the mechanical properties of the structural panel with Indian Almond seeds in terms of flexural strength, compressive strength, water absorption, and density in the three (3) treatments;

2. Determine the acceptability of the structural panel with Indian Almond seeds in terms of appearance, texture, and rigidity;

3. Determine the acceptability of the structural panel with Indian Almond seeds when applied to walls and ceilings.

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II. METHODOLOGY

This study employed an experimental-developmental research design to develop and evaluate cement-based structural panels reinforced with processed Indian Almond (Terminalia catappa) seed shell particles, locally known as Talisay. The experimental aspect of the study determined the effects of varying proportions of Talisay seed shells and sand on the physical and mechanical properties of the structural panels, while the developmental component focused on the fabrication of an alternative eco-friendly construction material.

III. EXPERIMENTAL DESIGN TREATMENT

Three treatments were designed and formulated to develop a structural panel. The three treatments, labeled A, B, and C, were made using the same cement and water, varying the amounts of Indian almond seed shell and sand while keeping the cement-to-water proportions constant. Treatment A contained 75 g of Indian Almond seed and 25 g of sand; Treatment B contained 50 g of Indian almond seed and 50 g of sand; and Treatment C contained 25 g of Indian almond seed and 75 g of sand, with each mixture combined with 200 grams of cement and 120 ml of water. All panels were fabricated in a standard size of ½ x 6 × 6 inches. This controlled setup allowed the researcher to isolate the effects of the independent variable (material composition) on the dependent variables, which included mechanical properties, sensory acceptability, and applicability.

A. Materials

The following are the materials to be used in the process of structural panel board; Grinding machine, sieving screen, trowel, mold, weighing scale, measuring cup, ground Indian Almond Seed, cement, sand and water.

B. Cost Analysis

Materials / Equipment	Units	Description	Value (₱)	Remarks
Talisay seed shells	150 g	Ground powder	N/A	Collected
Cement	600 g	Portland Cement	₱3.60	Purchased
Sand	150 g	Fine river	₱1.00	Purchased
Mold	1 pc	6×6 in	N/A	Fabricated
Total			₱ 4.60.00	

IV. RESULTS AND DISCUSSION

The data presented in Table 1 presents the computed mean of the mechanical strength of composite board, such as flexural strength, compressive strength, water absorbency, and density.

The findings of the study confirm that Indian Almond (Terminalia catappa) seed particles can be utilized as a reinforcing component in cement-based structural panels. The improved flexural strength observed in Treatment C suggests that higher sand content contributed to stronger internal bonding and better resistance to bending forces. This supports the findings of Taiwo et al. (2024) [3], who emphasized that natural biomass reinforcement can improve crack resistance and structural performance when properly incorporated into cement composites.

The superior compressive strength demonstrated by Treatment B indicates that a balanced proportion of Talisay seed particles and sand provides optimal compactness and matrix interaction within the composite structure. The results are consistent with the studies of Banogbanog et al. (2024) [4], which reported that proper proportioning of natural fibers and aggregates significantly enhances the load-bearing capacity and durability of cement-based materials.

The low water absorption rates recorded in all treatments indicate that the addition of Talisay seed particles did not adversely affect the moisture resistance of the fabricated panels. Treatment B, which exhibited the lowest absorption rate, may have developed fewer internal voids due to improved compaction and bonding. These findings align with the observations of Belakroum et al. (2021) [5], who noted that effective fiber-matrix interaction reduces water penetration in cement composites.

The lightweight density of the fabricated panels further supports their suitability for interior construction applications. Lightweight materials offer practical advantages such as ease of handling, lower transportation costs, and simplified installation procedures. Similar findings were reported by Ferraz et al. (2020) [6], who highlighted the potential of agro-based composites in producing sustainable and lightweight construction materials.

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Treatment A had an average flexural strength of 2.39 MPa and a coefficient of variation (CV%) of 15.9%**,** indicating significant inconsistency across its five (5) samples, suggesting the mixture was not yet fully refined. Treatment B showed a notable increase in durability, achieving an average strength of 3.0 MPa and resisting a peak force 2.5 times higher. While stronger, it still maintained a relatively high degree of variability. Treatment C resulted as the superior formulation. It achieved the highest flexural strength of 3.28 MPa and, more importantly, the lowest variability of 9.1%**.** This level of consistency showed a highly stable internal structure, making it the best option for structural use. For strength and accuracy, Treatment C had a good mixing proportion in the flexural strength test, thereby addressing the engineering challenge of creating a predictable, resilient material.

These panel treatments comply with ASTM C348, the global benchmark for testing the flexural strength of cement-based materials. This standard ensures accurate results by setting strict rules for how the test is conducted. For instance, it requires that every specimen have the same shape and a cross-sectional area of 6400.00 mm² so that the internal stress is evenly distributed during the test. To prevent the material from breaking too quickly due to a sudden shock, the machine applies force slowly at a steady 1 mm/min. By measuring the exact moment the material finally snaps—recorded as the maximum force or Fmax—researchers can calculate the Rbe, which represents the material's overall flexural strength. Following these guidelines ensures that the panels tested fairly and that the data are reliable enough for real-world construction use. These results align with those of Taiwo et al. (2024) [3], who found that natural biomass improves crack resistance when properly bonded within a cement matrix. This connection confirms that the Talisay particles are performing a similar reinforcing role in this study. The lower CV% obtained with Treatment C further validates its stability and reliability, indicating that the mixture produced more uniform and predictable results than the other treatments. Moreover, the observed increase in flexural strength with increasing sand content supports existing studies that emphasize the importance of proper bonding and particle distribution in cement composites.

In terms of compressive strength, which reveals significant differences among the treatments. In Treatment A, where 75 g of Talisay and only 25 g of sand were used, the panel proved to be the weakest. It recorded an average load of 1196 N and a compressive strength of 0.4 MPa. Treatment B emerged as the “sweet spot.” Using a 50:50 mix of 50 g of Talisay and 50 g of sand, the compressive strength increased to 8.8 MPa, supporting a much heavier load of 4590 N. Treatment C, although it used the same proportions as Treatment A, performed slightly better, recording a compressive strength of 0.6 MPa and a load of 1970 N. Nevertheless, it was still insufficient for safe construction use and remained highly unpredictable, with a variation of 40.8%.

In terms of water absorbency, results revealed that Treatment A had the highest moisture intake at 12.20%, while Treatment B had the lowest at 11.25%. These values indicate that Treatment B exhibits the strongest resistance to moisture penetration among the tested samples. Because the absorption rates across all three (3) treatments remain relatively close, it is evident that the inclusion of Talisay seed particles does not significantly compromise the panel's overall moisture resistance. In the future, maintaining these low absorption levels will be essential for ensuring the long-term durability and dimensional stability of the structural panels in humid environments.

In terms of density, the results indicated that Treatment A had the highest density at 1.41 g/cm³, followed by Treatment B at 1.39 g/cm³, while Treatment C was the lightest at 1.34 g/cm³. Since the mold volume was constant across all samples, these variations directly reflect the mass and composition of the Talisay seed mixture. This range confirms that the panels are lightweight, which is advantageous for construction applications as it enhances ease of handling, reduces transportation costs, and simplifies installation.

TABLE 1. MECHANICAL PROPERTIES OF COMPOSITE BOARD IN TERMS OF FLEXURAL STRENGTH, COMPRESSIVE STRENGTH, WATER ABSORBENCY, AND DENSITY

Treatment	**Compressive (CV%)**	**Verbal Interpretation**	**Flexural (CV%)**	**Verbal Interpretation**	**Water Absorption (%)**	**Density (gcm³)**	**Verbal Interpretation**
A	51.9%	Weak and Highly Inconsistent	15.9%	Moderately Strong and Less Consistent	12.20%	1.41	Very High Density
B	15.4%	Strong and Moderately Consistent	13.1%	Strong and Moderately Consistent	11.25%	1.39	Very High Density
C	40.8%	Slightly Stronger but Inconsistent	9.1%	Strongest and Highly Consistent	11.39%	1.34	Very High Density

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The data in Table 2 shows the acceptability of the composite board in terms of sensory qualities such as appearance, texture, and firmness.

Results revealed that incorporating Indian Almond seed was highly effective, as all tested versions of the structural panel received a quality rating of "Very Acceptable." Treatment A emerged as the top choice for those who preferred a refined finish, achieving the highest scores for both visual appearance (4.73) and smooth texture (4.67). By successfully combining these aesthetic qualities with dependable strength, it attained the highest overall satisfaction mean of 4.66. This balance of form and function exemplifies the potential of bio composites, where the appropriate mix of organic filler and binder can produce a surface that is both professional in quality and sustainable in design.
Treatment B was established as the structural powerhouse among the treatments. It achieved a peak rigidity score of 4.83, the highest individual rating in the study, demonstrating exceptional sturdiness and reliability. Although its surface feel and appearance were slightly less refined than those of Treatment A, its overall mean of 4.55 confirmed that it remained a high-quality option. This finding aligns with engineering research showing that agricultural waste can significantly enhance the mechanical stiffness of cement-based materials. Treatment C, despite its more rugged texture (3.93), maintained impressive structural integrity with a rigidity score of 4.63, proving that it is a durable and functional material even with a less polished finish. Collectively, these results confirm that seed-based panels are a viable, eco-friendly alternative for modern construction and suggest that Indian Almond seeds are a highly effective and versatile material for panel production.

TABLE 2. ACCEPTABILITY OF THE STRUCTURAL PANEL WITH INDIAN ALMOND SEED IN TERMS OF APPEARANCE, TEXTURE, AND RIGIDITY.

Treatments	Appearance	Texture	Rigidity	Overall Mean	Quality Description
Treatment A Mean	4.73	4.67	4.57	4.66	Very Acceptable
Treatment B Mean	4.43	4.40	4.83	4.55	Very Acceptable
Treatment C Mean	4.23	3.93	4.63	4.26	Very Acceptable

Table 3 presents the results of the suitability assessment, showing that all treatments are rated as "Very Applicable" for both wall and ceiling applications. Specifically, Treatment A ranked highest for wall use, with a score of 4.87, while Treatment B ranked highest for ceilings, with a score of 4.67. These high ratings demonstrate that the panels possess a strong potential for use in interior construction. Because performance is consistent across all treatments, these Talisay-based panels are reliable and adaptable for practical building needs. Future studies will explore how these panels perform under real-world environmental conditions to further confirm their long-term viability.

TABLE 3. APPLICABILITY OF THE STRUCTURAL PANEL WITH INDIAN ALMOND SEED FOR WALLS AND CEILINGS

Treatments	**Wall**	**Verbal Interpretation**	**Ceiling**	**Verbal Interpretation**
Treatment A Mean	4.87	Very Acceptable	4.60	Very Acceptable
Treatment B Mean	4.67	Very Acceptable	4.67	Very Acceptable
Treatment C Mean	4.50	Very Acceptable	4.47	Very Acceptable
Total	**4.68**	**Very Acceptable**	**4.58**	**Very Acceptable**

V. CONCLUSIONS

Based on the findings of the study, the following conclusions were drawn:

The mechanical properties of the structural panels differed depending on the proportion of Indian Almond (*Terminalia catappa*) seed particles and sand used in each treatment. Treatment C showed the highest flexural strength, while

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Treatment B had the highest compressive strength and the lowest water absorption. All fabricated panels were lightweight and suitable for interior construction applications. The study concludes that the proportion of Talisay seed particles and sand greatly affects the strength, moisture resistance, and overall performance of the panels.
The fabricated panels also showed acceptable physical properties in terms of appearance, texture, and rigidity. Treatment A had a smoother and more appealing surface, while Treatment B was more rigid and compact. These findings indicate that Indian Almond seed particles can be used effectively in cement-based composite panels without negatively affecting their physical qualities.

The panels were further evaluated as "Very Applicable" for wall and ceiling applications, showing their potential for non-load-bearing interior construction use.
Overall, the study concludes that Indian Almond seed particles have strong potential as an eco-friendly alternative material for lightweight structural panels. The findings support the use of agricultural waste materials in developing sustainable and innovative construction products.

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