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# Development of Concrete Hollow Blocks from Pulverized Oyster Shell (*Crassostrea iredalei*) and Non-Biodegradable Materials

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**Abstract:** ***The study generally aimed to utilize the potential of pulverized oyster shell (Crassostrea iredalei) and non-biodegradable materials such as plastics and discarded glass as composite materials in hollow block making. Experimental Research Design was employed to determine the effectiveness of the different treatments in making hollow block. This was conducted through a Completely Randomized Design (CRD), with the factors considered as the varying concentrations of powdered oyster shells, glasses and shredded plastics. All treatments were replicated three times. The hollow block samples were subjected to water absorbency and compressive strength tests. The data was scientifically collected, recorded and analyzed using One-way ANOVA and Least Square Difference (LSD) at 0.01 and 0.05 levels of significance. Results revealed that materials obtained from discarded oyster shells, glasses and plastics are highly resistant to water and are effective composite materials in making concrete hallow block in terms of durability and compressive strength. This innovative technology is recommended to hollow block makers, cement industry and local government units with abundant sources of shells and promote recycling of wastes from these discarded materials to lessen problems on solid wastes. The product would save our ecology from excessive quarrying of sand and cement production and likewise to cut down and lower the production cost from these materials.***

**Keywords:** concrete hollow block, oyster shells, nonbiodegradable materials, eco-friendly, cost-efficient

## 1. Introduction

Capiz, one of the provinces in Panay Island in the Visayas, Philippines is dubbed as the "Seafood Capital of the Philippines" because of its abundance of marine life. It holds one of the richest sources and largest contributors of tons of oyster shells in the entire Region VI [1].Varied shellfishes are attractions to visitors and forms an essential part of the food among Capizeños and those who live along coastal areas.

Many fishing communities, households, shell-stall-owners in the market, local seafood restaurants in the Province of Capiz do not value empty seashells from oyster shells. After eating and/or selling its meat, empty shells are thrown away and are thought to be useless. Waste from empty shells of this mollusks derive from these major sources together with other solid waste like discarded glass and empty plastic bottles generated by the major business establishments, households, fast food chains and local seafood restaurants within the province have greatly contributed to the tons of solid wastes generated each year. This becomes a serious problem on Solid Waste Management by the Local Government Unit (LGU) and in the entire province.

The researcher was motivated to conduct this study not only to find solution on our solid wastes problem but more so to discover an innovative technology in hollow block making which is more economical, a better composite material to meet higher work efficiency as well as building infrastructure of long-lasting value. The utilization of shells and non-biodegradable wastes as composite materials in hollow block making entails lower cost and are found to be more environmentally sustainable. The finished structure will give an impression to energy and eco-friendly atmosphere through this innovative technology.

Furthermore, it promotes the indigenous materials in making concrete blocks which is cheaper compared to synthetic and chemically manufactured materials. Using pulverized oyster shells, shredded plastic bottles, and discarded glasses as composite materials in making hollow blocks is the main drive of the study. Cement is the main ingredients in making blocks because of its durability and hardness. But as the demand of cement increases the price also increases, for this reason, the idea of using pulverized oyster, shredded plastic bottles, and discarded glasses as composite material in making hollow blocks came in placed.

United Nations Development Plan (UNDP) with goals numbers 7, 8, 9 and 13 are found to have greater relevance to anchor this present study: Ensure environmental sustainability; Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all; Industry, Innovation and Infrastructure; and Climate action goal. The Sustainable Development Goals (SDGs), otherwise known as the Global Goals, are a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity [2]. To take part for these universal goals, the researcher came up with this technological study not only to promote transfer of this technology to the community, but more importantly to lessen the adverse effect of climate change because of these discarded wastes.

## 2. Objectives of the Study

Generally, the study aimed to utilize the potential of pulverized oyster shell (*Crassostrea iredalei*) and nonbiodegradable wastes such as plastics and discarded glasses as composite materials in hollow block making. Specifically, this study sought to answer the following questions:

1) Find out the effect of adding pulverized oyster shells and varying amount discarded glasses and shredded plastics in hallow block making in terms of
   a) Water absorbency; and
   b) Compressive strength
2) Determine the significant difference in the water absorbency of concrete hollow block using powdered oyster shells, and varying amount of discarded glasses and plastics.
3) Determine the significant difference in the compressive strength of concrete hollow block using powdered oyster shells, and varying amount of discarded glasses and plastics.

## 3. Materials and Methods

The materials used in this study were commercial cement, sand, hollow block molder, water, powdered oyster shells and discarded glass, shredded plastic, face mask, hand gloves, eye protector (google), furnace for calcination of oyster shells, strainer, safe containers, hammer and sacks. Experimental Research Design was employed in this study to determine the effectiveness of the different treatments in hollow block making. This study was conducted through a Completely Randomized Design (CRD), with the factors considered as the varying concentrations of powdered oyster shells, glasses and shredded plastics. All treatments were replicated three times.

### 3.1 Gathering and Preparing of Oyster Shells

The empty oyster shells were collected form households, public market, seafood restaurant within Roxas City, Capiz, Philippines. The empty shells were thoroughly washed with tap water to remove some impurities clinging on the shells, drained and left for two hours or more to let the shells be dried by air. Mechanical crusher was used to reduce the size of the shells for easy calcination.

The crushed shells were calcinated using furnace 2 to 3 hours. Calcinated shells were set aside to let them cool down. These were pulverized using a mortar and pestle and then screened using strainer to prepare a powdered-like-cement samples. The finished products were properly weighed and labeled using a safe storage container.

### 3.2 Collecting of Discarded Glass and Plastics Bottles

The discarded glass was gathered from trash bins of the researcher and from the neighboring households. These were washed thoroughly with soap and water to remove the residue of chemicals and other impurities, drained and air dry for 2 hours. Hammer was used to carefully reduce the size of the glass into fine texture. This was carefully prepared, weighed and labeled properly. Set aside the finished products in safe-sealed container.

The empty plastic bottles were gathered from the trash bins of the researcher and from the neighboring households. These were washed thoroughly with soap and water to remove the impurities and other residues and left-overs, drained and air dry for 2 hours. The plastics were carefully shred into fine texture using a sharp scissors. The shredded plastics were properly weighed, labeled and placed in a safe container.

### 3.3 Experimental Treatment

Using the standard weighing instrument the four treatments were prepared: Treatment A–1, 500g cement + 2, 500g sand + 1, 000g powdered oyster shells, + 700g discarded glasses + 700g shredded plastics + 250mL water; Treatment B – 1, 500g cement + 2, 500g sand + 1000g powdered oyster shells+ 650g discarded glasses + 750g shredded plastics + 250mL water; Treatment C –1, 500g cement + 2, 500g selected borrow + 1000g powdered oyster shells + 750g discarded glasses + 650g shredded plastics + 250mL water; and Treatment D –commercial concrete hollow blocks. Each treatment was mixed thoroughly one at a time with the used of spade until the required mixtures will be obtained. The mixture was transferred to the standard hallow block molder, sundried for 2-3 hours. The same procedure was employed for the rest of the treatments. Completely Randomized Design (CRD) was used in three treatments replicated three times. After 28 days of curing period, the samples were brought to the laboratory of the Department of Public Works and Highways (DPWH) for Water Absorbency and Compressive Strength Test.

### 3.4 Data Gathering Procedure

The hollow block samples were brought to the Department of Public Works and Highways (DPWH), Field Office to determine and obtain data for water absorbency and compressive strength tests of every sample in each of the treatments. The data was collected, recorded and analyzed scientifically.

### 2.4 Data Analysis Procedure

Mean and Standard Deviation were used to describe the effects of the varying amounts of composite materials incorporated in three different treatments that were replicated three times. One-Way ANOVA was used to test the differences on the compressive strength and water absorbency of the hollow blocks made using varying amount of composite material incorporated in different treatments at 0.05 alpha level of significance.

Least Square Difference (LSD) was used to test the significance between the effect of varying amounts of additive incorporated in each trial to the compressive strength and water absorbency of the sample hollow blocks using 0.05 levels of significance.

## 4. Results and Discussion

### 4.1 Wet and Dry Mass of the CHB and the Average Mean of Different Samples in Terms of Water Absorbency Test

Data on table 1 disclosed the dry mass of the CHB, the wet mass of the CHB, the absorption rate of each treatment and their average mean differences in terms of water absorbency. The results revealed that among the four treatments, commercially made hollow block (the positive control) has the highest absorption rate equivalent to 59.05 kg, followed by Treatment C with 14.29 kg, Treatment B with 12.00 kg, and Treatment A with 8.89 kg absorption rate. In terms of average mean, the commercially made CHB had the highest average mean of 19.670 while Treatment A had the lowest average mean of 3.296.

Results implied that among the three treatments, Treatment A with the lowest absorption rate 8.89 kg with the average mean of 3.296, containing, 1, 500g cement + 2, 500g sand + 1, 000g powdered oyster shells, + 700g discarded glass + 700g shredded plastics + 250mL water showed the least absorbent, while Treatment D, the commercially made hollow blocks, used as a positive control having the highest absorption rate of 59.05kg (with an average mean of 19.670) had greater water absorbency.

The water absorbency of the concrete material is dependent on the permeability and porosity of the concrete and the strength of capillary forces. Concrete durability can be evaluated in terms of water absorbency [3]. The lesser the amount of water absorbed, the longer the strength and durability of concrete hollow blocks (CHB), while the greater the water absorbed, the shorter the strength and durability of the concrete material. separately. Durability of concrete plays a critical role in controlling its serviceability. Furthermore, durability of concrete is mainly dependent on the capacity of a fluid to penetrate the concrete's microstructure, which was called permeability. High permeability led to the introduction of molecules that react and destroy its chemical stability [3]; [4]; [5].

**Table 1:** Average Mean of the different treatments in terms of water absorbency

| *Treatments* | *Wet Mass of CHB (kg)* | *Dry Mass of CHB (kg)* | *Average Mean* |
|---|---|---|---|
| A | 20.85 | 20.25 | 2.962 |
| B | 19.50 | 18.75 | 4.000 |
| C | 17.60 | 16.80 | 4.760 |
| D | 21.35 | 25.55 | 19.670 |

The result of the ANOVA in Table 1.1 further showed significant differences in the results of the water absorbency test on different treatments incorporated with composite materials from discarded oyster shells, glasses and plastics. The results indicate that there is a significant difference among treatments incorporated with different additives.

**Table 1.1:** Analysis of Variance (ANOVA) among the treatments in terms of water absorbency test

| | *Sum of Squares* | *df* | *Mean Square* | *F* | *Sig.* |
|---|---|---|---|---|---|
| Between Groups | 534.840 | 3 | 178.280 | 14.952 | .001* |
| Within Groups | 95.390 | 8 | 11.924 | | |
| Total | 630.230 | 11 | | | |

**. significant at 0.05 alpha level.*

The preceding data was confirmed in the results of the Post Hoc Test showing multiple comparisons in concrete hollow blocks incorporated with different treatments from discarded oyster shells, glasses and plastics. Results from Least Significant Difference (LSD), a Post Hoc Test indicated in table 1.2 showed that Treatment A had the remarkably least capacity to absorb water among other treatments, followed by Treatment, B and C respectively. The highest capacity to absorb water is found in Treatment D, the commercially made hollow blocks.

Viewing the results as a whole, Treatment A, B and C show potential capacity to release water and to maintain the durability of the concrete hollow blocks. This was confirmed by the results of ANOVA and LSD tests at 0.05 alpha levels revealing that there is a significant difference in the water absorbency of concrete hollow blocks using these composite materials. According to Ref. [4] Concrete durability is generally defined as ability to resist weathering action, chemical attack, abrasion, or any process of concrete deterioration which are highly influenced by water absorbency. To increase the sustainability and to decrease the repair costs of concrete structures during their service life, it is mandatory to use durable materials in construction. The results of this present study conformed the findings of Ref. [6] stating that the fine aggregate from oyster shells as substitute for cement in terms of absorption rate almost satisfies the standards.

**Table 1.2:** Post Hoc Test showing multiple comparisons in the water absorbency of the CHB by different treatments

| (I)Additives | (J)Additives | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower bound | Upper Bound |
| **Treatment A** | $T_b$ | 6.672000 | .156086 | .000* | 6.31206 | 7.03194 |
| | $T_c$ | .658667 | .156086 | .003* | .29873 | 1.01860 |
| | $T_d$ | .272000 | .156086 | .120 | -.08794 | .63194 |
| **Treatment B** | $T_d$ | -.272000 | .156086 | .120 | -.63194 | .08794 |
| | $T_c$ | .38667 | .156086 | .038* | .02673 | .74660 |
| | $T_a$ | 6.400000 | .156086 | .000* | 6.04006 | 6.75994 |
| **Treatment C** | $T_a$ | 6.013333 | .156086 | .000* | 5.65340 | 6.37327 |
| | $T_b$ | -658667 | .156086 | .003* | -1.01860 | -.29873 |
| | $T_d$ | -.272000 | .156086 | .120 | -.63194 | 0.8794 |
| **Treatment D** | $T_a$ | -6.672000 | .156086 | .000* | -7.03194 | -6.31206 |
| | $T_b$ | -6.400000 | .156086 | .000* | -6.75994 | -6.04206 |
| | $T_c$ | -6.013333 | .156086 | .000* | -6.37327 | -5.65340 |

**The mean difference is significant at the 0.05 level.*

### 4.2 The Compressive Strength of Concrete Hollow Blocks (CHB) Incorporated with Nonbiodegradable Materials

Data on Table 2 showed the compressive strength of concrete hollow blocks (CHB) incorporated with powdered oyster shells, glasses and shredded plastics as composite materials calibrated at the Department of Public Works and Highways (DPWH), Field Office VI in Western Visayas.

The data revealed that Treatment A had the compressive strength of 10.442 Mpa, Treatment B, 10.170 Mpa, Treatment C, 9.783 Mpa, and Treatment D, 3.770 Mpa.

Result indicated that among the four treatments, Treatment A with 1, 500g cement + 2, 500g selected borrow + 1, 000g powdered oyster shells, + 700g discarded glass + 700g shredded plastics + 250mL water showed the highest mean difference in the compressive strength of the concrete hollow blocks. While the lowest mean which is 3.770 Mpa is obtained by the commercially made hollow blocks. This means that the powdered oyster shells, discarded glasses and shredded plastics as composite material in making concrete hollow blocks would increase the compressive strength of the material.

**Table 2:** Compressive Strength of concrete hollow blocks (CHB) incorporated with nonbiodegradable materials

| TREATMENT | REPLICATIONS | | | AVERAGE MEAN |
|---|---|---|---|---|
| | R1 | R2 | R3 | |
| A | 10.612 | 10.394 | 10.321 | 10.442 |
| B | 10.273 | 10.124 | 10.116 | 10.170 |
| C | 9.789 | 9.934 | 9.634 | 9.783 |
| D | 3.908 | 3.424 | 3.981 | 3.770 |

The result of the ANOVA further revealed highly significant differences in the results of the compressive strength of the concrete hollow blocks incorporated with different composite materials from powdered oyster shells and discarded glasses and plastics.

The result indicates there is a highly significant difference among treatments. Likewise, data on Table 1.1 showing the results of the water absorbency and data on Table 2.1 showing the compressive strength tests of the concrete hollow blocks proved the effectiveness of the composite materials. The results were substantiated by the Post Hoc Test in Table 1.2 proving the effectiveness of the composite materials incorporated in concrete hollow bocks in terms of water absorbency. Viewing the results as a whole, Treatment A, B and C showed potential capacity to maintain its durability because of the highest compressive strength. This was confirmed by the results of ANOVA and LSD tests at 0.05 alpha levels revealing that there is a significant difference in the compressive strength of concrete hollow blocks using these composite materials. Thus, Treatments A, B and C significantly improved both in the water absorbency and the compressive strength of the CHB.

According to the result of the study conducted by Ref. [9], concrete blocks with plastic bottles shown higher compressive strength. Plastic bottles provide an advantage of uniform quality as well as speeding in construction and the largest durability. The concrete reinforced with recycled polypropylene plastic could be used to build footpaths and precast elements such as drainage pits and concrete sleepers. On the other hand, from the results obtained, it is found that glass powder can be used as cement replacement material up to particle size less than 75µm to prevent alkali silica reaction [8]. As the size of glass powder particle decreases in concrete the strength of concrete increases. Glass with finest particle size gives higher strength [9]. The production of this new technology will give impact and provide alternative livelihood for the improvement of the community [10].

**Table 2.1:** Analysis of Variance (ANOVA) among the treatments in terms of compressive test

| | SUM OF SQUARES | df | MEAN SQUARE | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 91.720 | 3 | 30.573 | 836.608 | .000** |
| Within Groups | .292 | 8 | .037 | | |
| Total | 92.012 | 11 | | | |

**. highly significant at 0.05 alpha level.

The results of the study positively showed that the use of plastic bottles in the construction of concrete deemed reasonable [7]. Using plastic as reinforcement to concrete materials, were able to get more than 90% saving on CO2 emission and fossil fuel usage [11].

The present study also conformed with the findings of Ref. [12] reported that plastic bottles provide an advantage of uniform quality as well as speeding in construction and the largest durability. Accordingly, the present study supports the findings of Ref.[13] stating that recycling of waste glass can be used as cementitious material for enhancing the chemical stability, moisture resistance and durability of concrete. Supplementary material possesses major problems for municipalities, and this problem can be greatly eliminated by re-using waste glass as sand/cement replacement in concrete. Glass powder in concrete increases the compressive strength effectively, as compared with commercial concrete. The findings of the researcher in this present study was highlighted by the study of Ref. [14] affirming that, Oyster shells and plastics have comparably lower price compared to sand when used as cement replacement. Thus, making it more economically and environmentally efficient in making concretes.

Results from LSD, a Post Hoc test showing the compressive strength and the significance between the effects of different composite materials incorporated in each trial showed that Treatment A had the highest compressive strength, followed by Treatment B and C respectively. The commercial hollow blocks (Treatment D), that act as the positive control showed the least compressive strength among all other treatments at.05 alpha level of significance. Data revealed further that the concrete hollow blocks incorporated with the different composite materials from powdered oyster shells, and non-biodegradable materials obtained from discarded glasses and plastics could positively increase the compressive strength of the concretes. The data obtained were proven statistically through the results of the ANOVA and LSD tests respectively showed that highly significant effects were observed on concrete hollow blocks treated with nonbiodegradable materials.

The use of powdered oyster shells from bivalve mollusks as cementation substitute in Portland cement has been investigated around the globe due to the variety of shell waste that can be utilized around coastal areas; oyster shell production in the Philippines has been estimated up to 3M tons annually [12]. The study further revealed that the chemical composition of burnt oyster shell contains similar calcium carbonate and calcium hydroxide phases as compared to lime. In addition to that, waste from Oyster shells, plastics bottles and discarded glasses has potential application that can enhance the sustainability of society in reducing environmental pollution by converting hazardous waste into useful construction material.

**Table 2.2:** Post Hoc test showing multiple comparisons in the compressive test of the CHB by different treatments.

| (I)Additives | (J)Additives | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower bound | Upper Bound |
| **Treatment A** | $T_b$ | 6.672000 | .156086 | .000* | 6.31206 | 7.03194 |
| | $T_c$ | .658667 | .156086 | .003* | .29873 | 1.01860 |
| | $T_d$ | .272000 | .156086 | .120 | -.08794 | .63194 |
| **Treatment B** | $T_a$ | -.272000 | .156086 | .000* | 6.04006 | 6.75994 |
| | $T_c$ | .386667 | .156086 | .038* | .02673 | .74660 |
| | $T_d$ | -.272000 | .156086 | .120 | -.63194 | .08794 |
| **Treatment C** | $T_a$ | 6.013333 | .156086 | .000* | 5.65340 | 6.37327 |
| | $T_b$ | -658667 | .156086 | .003* | -1.01860 | -.29873 |
| | $T_d$ | -272000 | .156086 | .120 | -.63194 | 0.8794 |
| **Treatment D** | $T_a$ | -6.672000 | .156086 | .000* | -7.03194 | -6.31206 |
| | $T_b$ | -6.400000 | .156086 | .000* | -6.75994 | -6.04206 |
| | $T_c$ | -6.013333 | .156086 | .000* | -6.37327 | -5.65340 |

**The mean difference is significant at the 0.05 level.*

Waste glass powder can be effectively used as a cement replacement material in concrete. Waste glass when grounded to a very fine powder shows some pozzolanic properties because of silica content. As the particle size of waste glass reduces it helps in enhancing strength of concrete. Addition of recycled glass reduces the water absorption of the concrete [8]; [14].

Moreover, present study was in conformity with the findings of [10] revealed that oyster shells and other mollusks when transformed into powder can be utilized as partial substitute for Portland cement in masonry cement mortar as evidenced by its similar physical, chemical and mechanical properties, especially its workability, specific gravity and compressive strength. Study further recommended for cement industry and local government units with abundant source of shells to adopt through laws the innovative technology to recycle shell wastes in order to conserve mountain forest (as source of cement) and to lower cement production cost. Likewise, using glass powder in concrete is an interesting possibility for economy on waste disposal sites and conservation of natural resources. The findings of this work pave the way for further composite waste recycling in construction products for use in various applications[14]; [15].

## 5. Conclusions and Recommendations

Concrete hollow blocks containing discarded oyster shells, glasses and plastics are highly resistant to water, increases the compressive strength of the concrete material. Powdered Oyster shells, plastics and glasses are effective composite materials in making concrete hollow blocks in terms of durability and compressive strength. It is therefore recommended the use of finest powder from glass and shredded plastics to obtain best results in terms of water absorbency and compressive strength of the concrete materials. Likewise, local government units with abundant source of shells to adopt through laws the innovative technology to recycle wastes from these discarded materials to lessen problems on solid wastes, conserve our ecology from excessive quarrying of sand and cement production and to lower the production cost from these materials. Utilization of these discarded materials could provide alternative livelihood to our local folks. This cost-efficient and eco-friendly technology must be conserved and maintained.

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**Eva Sintin Montero** is an Assistant Professor in the School of Agriculture of the Northern Iloilo Polytechnic State College, Batad Campus for 30 years. In 2005 she became an Associate Researcher Director and a manager of Farmers Information and Technology Services (FITS) Center. By her exemplary performance in the field of Research and Extension services she received several awards and recognitions both in the national and international arenas. At present she is now managing the 7.5Million worth of research project at the techno-demo site of the College funded by the Commission on Higher Education (CHED Central Office.