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Activated Carbon from Organic Waste as Adsorptive Reinforcement Cement Material

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Abstract

The growing concern of odor problems in developing urban areas in the country has contributed to the development of different techniques to improve the odor quality of the environment especially in building spaces for quality living. The study addresses the idea of integrating organic waste materials, specifically Coconut Shell Activated Carbon (CSAC) into building materials as solution to improve indoor odor quality.

The study identified the integration of Coconut Shell Activated Carbon (CSAC) as an admixture to produce an odor-adsorptive concrete. Throughout the research, the properties of the material such as odor-adsorptive, compressive, and water absorption, of the output material were thoroughly explored through different tests. Odor Adsorption Test, Compressive Strength Test, and Water Absorption Test was conducted to measure the odor-adsorption rate, maximum compressive strength and structural capacity, and water absorption rate of CSAC concrete, respectively. Results showed that among the treatments, CSAC Concrete Treatment 3, Class C--with ratio of 1:2:3 (cement: sand: gravel) having 10 kg, 20 kg, 30 kg, respectively with 16 kg CSAC--exhibits the fastest odor adsorption capacity of 5 hours and Treatment 1, Class AA—with ratio of 1:2:4 (cement: sand: gravel) with only 2 kg CSAC as the least odor-adsorptive capacity of 24 hours. With these results, CSAC Concrete is suitable as a solution to minimize odor and improve indoor odor quality in spaces with poor air quality.

I. INTRODUCTION

Odor is becoming a growing concern in developing urban areas and is said to lower the people's quality of life by cumulative odor exposure that could lead to odor annoyance (Page, 2010). Historically, unpleasant odor has been considered as a warning sign or indicator of potential risks to indirectly trigger health effects but citizen complaints to public health agencies suggest that odor may not simply serve as a warning of potential risks but that odor sensations themselves may cause health symptoms (Liu & Leung, 2006). More recently, the removal of odor is increasingly considered important because of growing suburbanization (Melse, 2005). There are methods and techniques used for the removal of odor such as purifications and odor removal equipment such as filters and air purifiers used in air heating and cooling system in industries which utilizes activated carbon (Redner, 1995).

Activated carbon or activated charcoal is known to be from a variety of raw and renewable materials found in the environment such as wood, coconut shell, and some agricultural by-products such as fruit stones and various nut shells can be used as suitable raw material and produce high-quality activated carbons (Wolfgang & Klose, 1995). With its immense capacity for odor adsorption and wide production worldwide, activated carbon occupies a special place in terms of producing a clean and odorless environment as it is widely used in water purification as well as separations and purifications in chemical industries (What are Activated Carbon, 2015). Odor adsorption characteristics of activated carbon is due to its good porosity determined by its internal pore structure (Aygun, Karakas, & Duman, 2003). The internal pore characteristics are very important properties of aggregates in concrete mixing, which are composed of porosity, permeability and water absorption. Activated carbon is produced from raw coconut shell distributed widely in the country, especially in Mindanao. Coconut is nurtured in large amounts in wide areas of land because of its high demand in the different industries globally. This study explores the properties of Coconut Shell Activated Carbon (CSAC) as admixture of concrete to determine the odor adsorptive property of waste Coconut Shell as Activated Carbon (CSAC) as admixture of concrete. The agricultural sector will also benefit to this study as farmers will have additional income for larger demand for the production of coconut shells. This study will also contribute to scientific researches as it will also serve as baseline data and the information such as the mechanical and physical properties of concrete with activated carbon as admixture gathered from this study can be used as source of information in other studies regarding the production of odor adsorptive concrete.

Other testing of properties of concrete were not included in the study due to time constraints and equipment availability such as slump test, modulus of elasticity, and fire resistance. Odor and moisture removal test is limited to the basic concept of olfaction due to the availability of the needed equipment and budget constraints.

II. MATERIALS AND METHODS

Materials needed for the study were gathered, namely: Portland cement, sand, gravel, water, and activated carbon from waste coconut shell. The activated carbon was tested for their moisture content (%), ash content (%), hardness (% ASTM) and particle size distribution (% ASTM).

The cement, sand and gravel were mixed to achieve Class AA and Class C concrete mixture, with a cement: sand: gravel ratio of 1:2:4 and 1:2:3, respectively. For the study, three (3) treatments and 1 controlled setup were prepared with different amounts of CSAC. For both Class

AA and Class C, the same amount of CSAC was mixed for each treatment. For the controlled setup of both Class AA and Class C mixture, zero (0) kilograms of CSAC was mixed to the concrete mixture. For Treatment 1, 2 and 3, two (2) kilograms, seven (7) kilograms, and sixteen (16) kilograms, respectively, of CSAC were mixed. The concrete mixtures were poured carefully to cylinder steel molds and rectangular molds, and underwent curing period for 28 days. The rectangular mold for the concrete block samples had inside dimensions of 6 in. width by 12 in. length and 1 ½ in. depth.

The physical properties of the concrete samples were recorded, including their weight, color, surface texture, mass, volume and density. The mass was obtained using a weighing scale, and the volume was obtained using the formula for cylinder and rectangular prism volume.

$$= \quad 2h$$

$$= \times\times h$$

Where r is the radius of the cylinder concrete sample, h is the height, l is the length of the rectangular concrete block, and w is the width of the block.

The density of the concrete samples was also obtained using the following formula, where is the density, m is the mass and V is the volume of the concrete sample.

$$= \frac{}{}$$

There were three tests conducted to evaluate the concrete block samples with CSAC admixture: the Odor Removal Test, the Compressive Strength Test and the Water Absorption Test.

The odor removal test for all samples were conducted at the same time to ensure uniformity. The concrete block samples were placed inside sealed glass containers. Along with the sample, a single piece of unscented tissue was sprayed with ammonia using a spray bottle and placed inside each glass container., An ammonia meter test was conducted using Hydrion paper which determined the ppm (parts per million) of ammonia in the air using a color chart. The ammonia meter strip changes in color when exposed to ammonia. The amount of ammonia was recorded and the samples were observed for 24 hours, after which data was recorded and photo documentation was done. Three (3) trials for the odor removal test were conducted.

The compressive strength test was conducted at the Department of Public Works and Highways, Tugbok, Davao City. A hydraulic compressive strength machine equipment was used to test the cylinder concrete samples. Each setup was subjected to 3 trials, hence a total of 24 samples were tested. The compressive strength was obtained using the compressive strength formula:

$$=$$

where σ is the compressive strength of a specimen, P is the ultimate compressive strength in kilograms (kg), and A is the cross-sectional area of a specimen in square meters (sq. m).

For the water absorption test, the concrete samples were submerged under water inside a drum for 24 hours. The concrete block samples were weighed before and after submersion using a weighing scale, and the water absorption rate was computed using the water absorption formula:

$$\% = - 100\ \%$$

where % Absorption is the percentage of water absorption and Ww is the weight of the wet concrete, and Wd is the weight of the dried concrete. The water absorption of concrete will determine the rate of absorption of water of the concrete sample.

III. RESULTS AND DISCUSSION

The physical properties studied were the mass, color and texture of the concrete samples. The mass of Class AA cylinder concrete samples had higher mass for all treatments compared to Class C. Class AA Treatment 1 had the highest mass among all cylinder concrete samples, as illustrated in Figure 3.1.

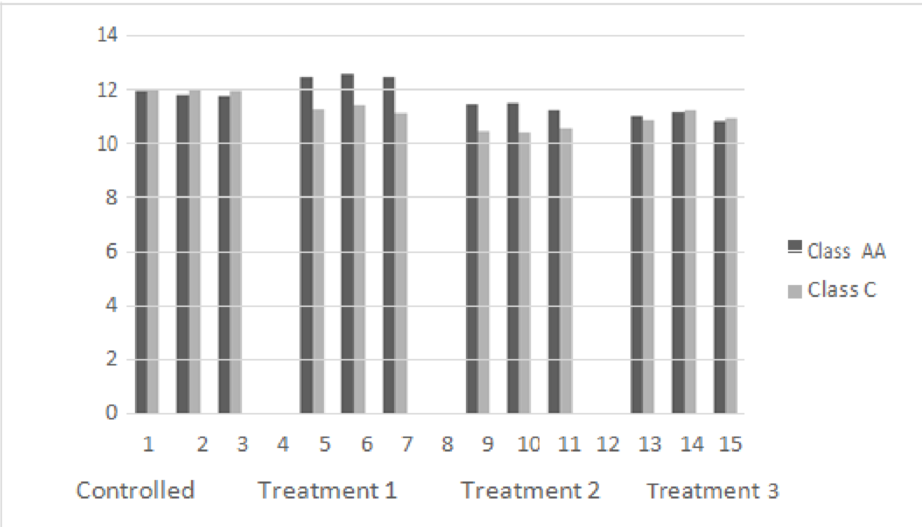

Figure 3.1. *Mass of CSAC samples*

The concrete samples appeared gray in color, but Class C showed a darker gray color compared to Class AA. Additionally, for both Class AA and Class C, the controlled setup showed no marks due to the absence of CSAC.Faint marks appeared on Treatment 1 samples, while the most visible marks showed on Treatment 3, which had the most amount of CSAC. Treatment 3 samples also had rougher texture due to the greater amount of CSAC.

The mechanical properties recorded include the density, compressive strength, water absorption capacity and odor adsorption of the concrete samples. The density of the samples from Class AA ranged from 1923 kg/m^3 to 2165 kg/m^3, meanwhile for Class C, the density ranged from 1793 kg/m^3 to 2120 kg/m^3. Normal weight concrete has a density of 2240 to 2400 kg/m^3. If the density of concrete falls between 1440 to

1840 kg/m^3, it is classified as lightweight concrete.

The results of the compressive strength test showed that Class AA controlled setup had the highest compressive strength of 25.46 MPa and 25.75 MPa. Meanwhile, Class AA Treatment 3 had the least compressive strength of 11.32 MPa. For Class C, the controlled setup also had the highest, with 25.46 MPa, while Treatment 2 had the lowest with 9.05 MPa. Based on the minimum standard compressive strength of 20 MPa, only Class AA Controlled setup, Class AA Treatment 1, and Class C Controlled setup passed the minimum standard. Class AA Treatments 2 and 3, and Class C Treatments 1, 2, and 3 did not reach the standard 20 MPa. A decreasing trend of compressive strength as CSAC increases, was therefore observed based on the results.

For the water absorption test, it was observed that the water absorption capacity of the concrete samples increased the amount of CSAC increased. For Class AA, there was 0% absorption recorded for the controlled setup, however, 24.9% absorption was recorded for Treatment 3. For Class C, the controlled setup had higher water absorption capacity of 22.27%, and Treatment 3 had 33.19% water absorption capacity, which was the highest for all samples.

The Odor Removal Test results showed an increasing trend of odor adsorption as CSAC increased. Class AA and Class C Treatment 1, 2 and 3 showed the most changes within the first 5 hours of the observation period, although the samples were tested and observed for 24 hours (Figure 3.2 and Figure 3.3). The controlled setups of Class AA and Class C showed the least odor adsorption.

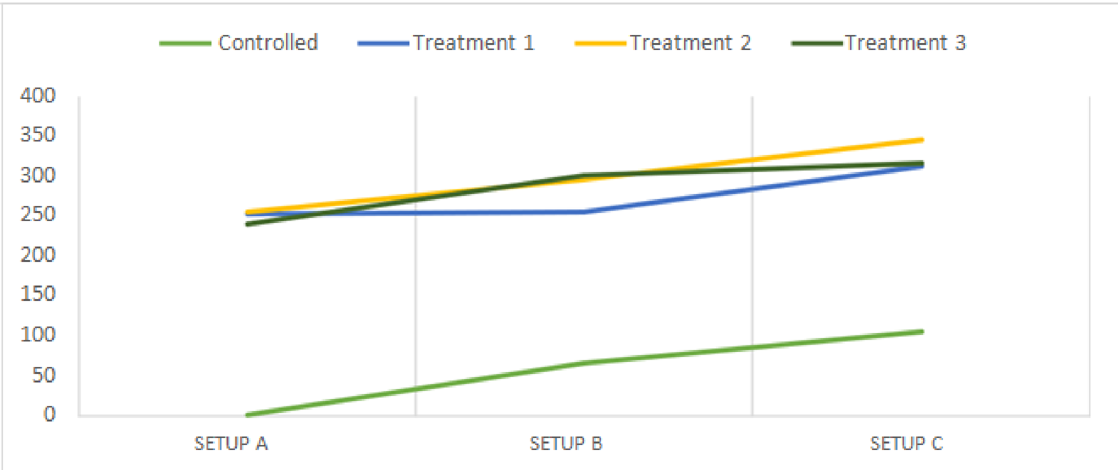

Figure 3.2 *Ammonia ppm (parts per million) recorded for Class AA*

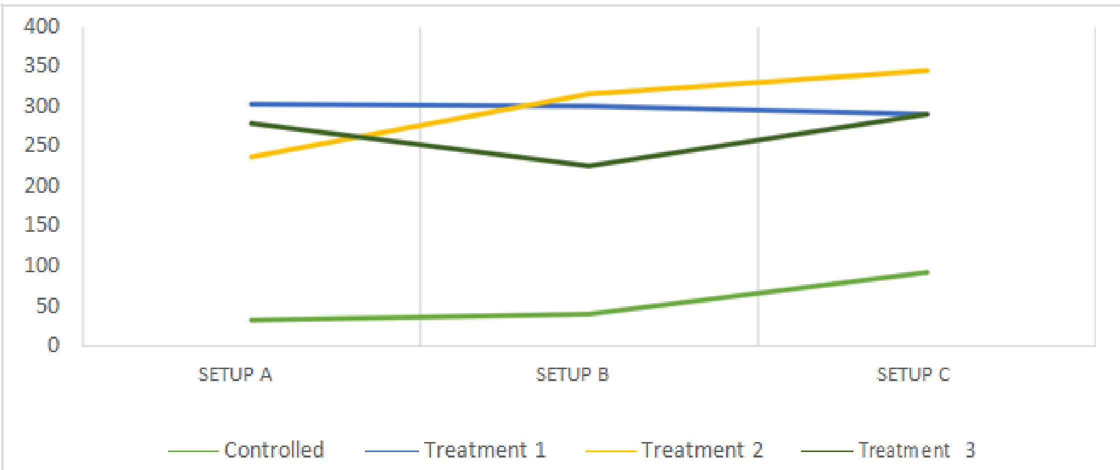

Figure 3.3 *Ammonia ppm (parts per million*

IV. CONCLUSION

Based on the results gathered from the odor adsorption test, CSAC showed potential to add odor adsorption property when it was mixed with concrete. Greater amount of CSAC increased the odor adsorption rate, hence reflecting a direct relationship. Class C Treatment 3 had the most efficient odor adsorption property. Furthermore, results also showed a direct relationship between the water absorption capacity and the amount of CSAC in the concrete mixture. As the amount of CSAC increased, the greater was the water absorption capacity of the concrete sample. Hence, it can be concluded the CSAC provides potential for water absorption and odor adsorption in concrete.

Moreover, the density of the concrete samples falls below the normal weight concrete density and closer to the range of the density of lightweight concrete. The results of the compressive strength test also showed an inverse relationship between the compressive strength of the concrete samples and the amount of CSAC. Greater amount of CSAC in the concrete sample resulted to lesser compressive strength. Hence, the concrete with CSAC is applicable only for accent, non-load bearing walls. It is also highly recommended as a plaster product. Further recommendations include exploration of other possible organic material with odor adsorption properties as admixture of concrete.

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