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Spent coffee grounds as partial replacement of fine aggregates in concrete hollow blocks

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ABSTRACT

In the Philippines, general garbage is one of the major issues, and the majority of coffee grounds are thrown away and added to general waste. Therefore, in order to aid the community in lessening its growing waste issue, researchers are studying the use of Spent Coffee Grounds (SCG). The objectives of this study are to design a Non-load bearing Concrete Hollow Block (CHB) with SCG as partial replacement of fine aggregates with the given percentages of 5%, 10%, and 15%, to evaluate the CHB with the SCG in terms of Compressive Strength Test and Water Absorption Test and lastly, to compare the quality and cost of the CHB with SCG to the standard CHB. The study used experimental research to obtain the results needed. The researchers produced CHB with 5%, 10%, and 15% replacement of fine aggregates cured for 7, 14, and 28 days. The study includes Compressive Strength Test and Water Absorption Test that were performed in testing centers. The major findings of the study are: the experimental block with 5% SCG and cured for 28 days was measured to have the highest compressive strength; the experimental block with 15% SCG and cured for 7 days was measured to have the lowest compressive strength; in Water Absorption Test, an increase is seen at the maximum replacement of 15%, and a drop is generally seen between 0% and 5% replacement; it was observed that samples that had been cured for 28 days with 5% replacement had the highest percentage of moisture, while samples that had been cured for 7 days with 15% replacement showed the least amount of water absorption on all samples. Based on the

analysis of the findings, the researchers concluded that SCG has a potential as partial replacement of fine aggregates in non-load-bearing CHB if only a significant amount of spent coffee grounds is added.

Keywords: *Spent Coffee Grounds (SCG), non-load bearing Concrete Hollow Block (CHB), Compressive Strength Test, Water Absorption Test*

1.INTRODUCTION

A concrete block that contains hollow areas between its walls is referred to as a concrete hollow block. The same materials used to make poured concrete walls are also used to make hollow blocks, which are used to construct a variety of walls for a variety of purposes, including retaining walls, decorative walls, traditional walls, etc. Ingredients include gravel, sand, Portland cement, and water. An expanding number of building applications, from residential to industrial, are using hollow concrete blocks. They provide design flexibility, durability, energy efficiency, and resilience to adverse weather conditions (Hessam, 2022).

One of the most consumed and well-liked drinks in the world is coffee. The consumption of coffee-based beverages is projected to rise by 1.3% in 2021, or roughly 166 million bags (9978 million kg), although social isolation caused by the COVID-19 pandemic limits the typical out-of-home coffee consumption and the global economy's recovery (ICO, 2021). Coffee is well known for its capacity to wake people up by effectively boosting serotonin. It became prevalent, particularly among students who study all night in the hopes that it will help them wake up.

Coffee shops have been well-known throughout our nation for their aesthetics and their calming vibes when the COVID-19 pandemic-related lockdown was lifted. The amount of coffee spent also rises as coffee shops and coffee become more popular. Spent coffee grounds result from brewing coffee that remains in a pot or coffee maker. Most coffee grounds were being dumped and added to general waste, which is one of the significant problems in the Philippines. Several works have already been done showing that spent coffee grounds have the potential as a replacement for fine aggregates in the concrete hollow block. The researchers came up with the use of spent coffee grounds to help the community reduce the increasing waste problem by conducting a study of spent coffee grounds and their properties as a partial replacement for a non-load bearing Concrete Hollow Block.

2. BACKGROUND OF THE STUDY

According to Humanitarian Shelter Working Group (2014) in the Philippines, Concrete Hollow Blocks (CHB) are one of the most often utilized walling materials. This is due, in part, to their relatively low cost as compared to other materials and the rapidity with which semi-skilled laborers can install them. CHB walls are extremely vulnerable to lateral loads (pushing or pulling forces from typhoon or earthquake). They also added that local sourcing of good quality raw materials and CHBs can be difficult. After shaping, concrete hollow block has properties including strong shrinkage, poor thermal conductivity, and recurrent contraction after moisture, which causes a lot of issues when used as a wall material. The causes of cracks in concrete hollow block walls are discussed in detail in this article from a variety of angles, including temperature expansion, air shrinkage, construction quality, and design structure. Additionally, the article suggests solutions based on the causes from production, design, construction, and technique improvement aspects (Zhang, 2013).

Coffee is a highly traded beverage and the second-largest worldwide market after oil consumed globally. It gives 135 million individuals a daily income, including 20 to 25 million small producers in more than 50 developing nations. According to the International Coffee Organization, 166.3 million 60 kg of coffee were used globally in 2020–2021; Brazil was the top exporting nation (50.7 million 60 kg bags), while the top importing nation was the Union of European States (40.2 million 60 kg-bags). According to the SCA (Specialty Coffee Association), 300 kg of coffee is consumed every second. The solid waste from coffee drinking is known as spent coffee grounds (SCG).

The Philippines ranks second-largest consumer of coffee in Asia; therefore, it is not surprising that Filipinos share the world's most extensive affection for coffee, given that it is the second most consumed beverage after water. Filipinos consumed 3.4 kilograms of coffee per person annually before the Covid pandemic. Covid significantly impacted the Philippines' coffee consumption. Before Covid hit, the amount of coffee consumed per person in 2019 was 3.4 kilos. Therefore, the amount consumed in 2020, 3.05 kilograms, was a 10% decrease from the previous year. Although "barako" has never again enjoyed the same level of quality as it did two centuries ago, several cafés and companies in the Philippines (and around the world) still recognize its potential. Starbucks is the biggest coffee chain in the world, with locations in almost every nation, including the Philippines. Indeed, the most well-known coffee chain is Starbucks. The most well-known coffee shop in the country generated revenues of $155 million in 2020. The Coffee Bean and Tea Leaf is the second-largest chain, but its sales over the same period were only $17.54 million.

SCGs are an excellent substitute for use in various civil engineering applications since they are produced in excess worldwide and have a modular, stable, and robust chemical makeup in their husk. For instance, SCG has the potential to be used in road subgrades due to its solid physical similarity to sand (Arulrajah et al., 2017). Besides this, precast concrete panels can be manufactured using SCGs. SCGs can be used to create lightweight structural concrete because of their low density. These can be utilized for non-bearing walls, commercial and industrial flooring, and home-building footings. These applications can be used with 25 MPa concrete (Yin et al., 2016).

Using coffee grounds in place of 5% of the natural sand increased the compressive strength of concrete (Almeida et al.). They discovered that substituting SCG for 6% of the sand reduced thermal conductivity from 0.50 to 0.31 W/m.K. Additionally, a 20% reduction in the building's cooling and heating loads was noted when the suggested material replaced the regular one. Additionally, it was confirmed that using SCG will reduce CO2 emissions for the analyzed example by 1500kg yearly (Guendouz et al.).

3. REVIEW OF RELATED LITERATURES

3.1 Coffee Production in the Philippines

The Philippines is located within the "Bean Belt," where coffee is farmed in 50 countries. The Philippines has ideal climatic and soil conditions throughout its lowland and mountainous terrain. It is one of the few nations producing the four commercially viable types of coffee: Liberica, Excelsa, Robusta, and Arabica. This factor gained the interest of the Department of Trade and Industry and the Department of Agriculture to raise the Philippine Coffee Industry by proposing a roadmap that former President Rodrigo Duterte signed. The roadmap covers the vision, mission, approaches, and treatment plans to accelerate the growth of the coffee sector from 2017 to 2022.

The Philippines intends to be one of the top producers of top-grade coffee, which can be achieved with the signed Philippine Coffee Industry Roadmap 2017- 2022. Bridging the numerous supply chain gaps to create a more dynamic and globally competitive sector, boost the global quality standard, and benefit the farmers, processors, and prospective customers and beneficiaries. As of now, the Philippines produces 37,000 of coffee annually. At the conclusion of the goal period in 2022, it is anticipated that coffee growers will have raised their average output of 1 t/ha, supplied the required volume of 214,626 MT with a self-sufficiency level of 41.60% to 160.16%, and enhanced farmers' income and farm productivity (Vancouver Philippines Consulate General, 2019).

3.2 Spent Coffee Grounds

Reports state that 6 million tons of SCGs have produced annually on a global scale (Getachew & Chun, 2017). As a result, the coffee business generates a significant portion of residues. Typically, this residue is disposed of in landfills, but since it may be harmful and is organic, it should be strictly avoided from getting dispersed into the environment (Ktori et al., 2018). The risk of spontaneous combustion is highly significant when disposing of SCGs in landfills, as it is with most organic wastes. In addition, excessive production of hazardous methane and carbon dioxide may occur, adding to the total atmospheric pollution. The risk of spontaneous combustion is relatively high when disposing of the SCGs in landfills, as it is with most organic wastes. In addition, excessive production of hazardous methane and carbon dioxide may occur, adding to the total atmospheric pollution (Massaro Sousa & Ferreira, 2019). Also, due to the high organic content, SCGs have a high risk of spontaneous combustion, which could result in the production of excessive amounts of methane and carbon dioxide as well as the emission of odors related to the fermentation processes when left untreated and disposed of in large quantities (Cameron & Malley, 2016).

Researchers and enterprises worldwide are becoming increasingly interested in using reusable resources to create more sustainable building materials. Sustainable building and construction materials are the subject of several studies. The results demonstrated that the technical and long-term performance of the new mortars for various building applications could be effectively enhanced by the addition of used coffee grounds. In addition to reducing the environmental impact, the presence of SCG enhances insulating efficacy and boosts water absorption. Technological qualities, such as thermal insulation enhancement, are quite promising. The addition of even 5% SCG results in a significant decrease in thermal conductivity and, as a result, a higher insulating performance.

3.3 Application of Spent Coffee Grounds in the Construction Industry

SCGs have become great replacement to be used in various civil engineering applications since they are overproduced worldwide and have a modular, stable, and strong chemical composition. For instance, SCG has the potential to be used in road subgrades due to its strong physical similarity to sand (Arulrajah et al., 2017a). Additional applications include adding SCGs to clay-fired bricks, which significantly improves the thermal qualities of these composite brick types and can reduce heat loss by up to 50% while still passing construction code requirements (Sena da Fonseca et al., 2014). Furthermore, due to its microscopic characteristics and high compressibility, SCGs are a particularly good addition to precast noise walls since they can effectively absorb medium to high-frequency sound (Berardi and Iannace, 2015). These products are all made from solid waste, which is becoming a more common trend for future construction techniques as the industry favors the low cost and environmental benefits (Lachheb et al., 2019). As a result, the engineering community has been interested in finding new uses for SCGs in engineering practices due to the quantity of SCGs and the need to lessen their environmental effects (Arulrajah et al., 2014).

3.4 Chemical Components of Spent Coffee Ground

The fundamental physical properties of materials, aggregates, and/or binders used in civil engineering projects, including concretes, pavements, geotechnics, brick, etc., are those of the size, shape, surface texture, specific gravity, density, moisture content, porosity, and organic content (Santamaria et al., 2018; Delhomme et al., 2020). In addition, chemical characteristics such as elemental compositions and phase-mineral relationships are essential (Xu and Yi, 2020).

Hemicellulose, fatty acids, cellulose, lignin, proteins, lipids, and other polysaccharides are only a few of the various organic substances found in SCGs (Goh et al., 2020; Valdes et al., 2020). According to (ASTM, 2007) data, the organic content of SCGs measured using the loss of ignition method ranged from 86% to 89% (Arulrajah et al., 2016). As can be observed, the majority of SCGs are composed of potassium oxide, calcium oxide, titanium oxide, and iron oxide as reported by Suksiripattanapong et al. (2017) and Arulrajah et al. (2014); however, according to Andreola et al. (2019), the SCGs' high amounts of organic chemicals resulted in an extremely high Loss on Ignition (LOI). Using XRF analysis, Chun et al. (2015) and Campos-Vega et al. (2019) discovered potassium to be the element with the highest abundance in SCGs which is the main mineral in coffee beans. In addition to these numerous minerals, SCGs also include calcium, phosphorus, magnesium, tin, iron, and zinc. A total of 14 elements, including Magnesium, Phosphorus, Sulfur, Potassium, Calcium, Chromium, Manganese, Sodium, Iron, Copper, Zinc, Bromine, Rubidium, and Strontium, were also found in SCGs, according to Hernandez et al. (2017).

3.5 Other Applications of Spent Coffee Grounds

Coffee is a widely consumed beverage in every country in the world. People typically throw away the leftover grounds after it has been brewed because they are unaware that the coffee grounds could have a second life. There are dozens of helpful and practical ways to reuse spent coffee grounds (McDonell, 2018).

Coffee grounds can be used as a bug repellent. Diterpenes and caffeine are two components in coffee that can be highly poisonous to insects. Therefore, coffee grounds can be used as a pest repellent. They successfully repel fruit flies, beetles, and mosquitoes and might also help keep other pests away. Set out bowls of ground coffee or scatter it over outdoor seating areas to utilize it as a pest and bug repellant. Coffee grounds scattered around plants can be an additional pest deterrent. They help create a barrier that slugs and snails do not like to crawl over (McDonell, 2018).

Scrubbing pots and pans with coffee grounds as well. Coffee grounds work well to scour tough-to-clean kitchen equipment because of their coarse texture. Their coarse texture makes removing food that has been caked on easier. They may be used to scrape dishes cleanly. Just sprinkle the grounds directly onto pots and pans and scrub as usual (McDonell, 2018).

Coffee grounds can neutralize odors. Put a bowl of coffee grounds in the refrigerator or freezer to neutralize odors from spoiled or fragrant foods. In other words, coffee grounds can help absorb and eliminate odors. Coffee grounds contain nitrogen, which helps eliminate a foul-smelling sulfur gas from the air when combined with carbon. Additionally, construct portable air fresheners by tying coffee grinds into old socks or panty hoses. Put these in exercise bags, bedroom drawers, behind the car seat, or wherever that needs to freshen up. Even after cutting onions or garlic, leave some coffee grounds beside the sink and scrub it in hands. The grounds will reduce the odor (McDonell, 2018)

Most people throw away the coffee grounds that remain after brewing it. However, there are lots of great uses for them again. Coffee grounds' caffeine and antioxidants may help prevent cellulite, dark bags under the eyes, and other skin- aging symptoms. Additionally, rich in nutrients, coffee grounds can both benefit plants and keep pests out of the yard. They also make an excellent cleaning scrub around the house because of their abrasiveness. Consider utilizing one of the suggestions to reuse the coffee grounds.

3.6 Negative Effect of Spent Coffee Grounds in the Environment

Every year, almost six million tons of spent coffee grounds end up in landfills all over the world. That amount is equivalent to the volume of Egypt's Great Pyramid at Giza. However, spent coffee ground ending up in landfills is a serious consequence (Noone, 2019). According to a recent study co-authored by Dr. Tien Huynh, a food technology scientist at RMIT University, spent coffee ground contains caffeine, chlorogenic acid, and tannins that, in high levels, can be fatal to all species. Coffee waste at this level in landfills has serious consequences, including damage on the soil and sea.

One cup of coffee typically requires between 11g and 14g of coffee, resulting in wet grounds that cannot be made again and are typically disposed of with other garbage. An estimated 65,000 tons of spent coffee grounds are produced annually in Australia alone, with the majority ending up in landfills. Although this may not seem like a problem because it is organic waste, it can significantly impact the environment. Methane is the principal issue. Coffee grounds release methane (CH_4), a potent greenhouse gas that contributes to global warming when decomposing in landfills. One kilogram of methane, according to studies, increase global warming by up to 80 times over 20 years compared to the same amount of carbon dioxide (CO2) (Pavoni, 2021).

4. OBJECTIVES OF THE STUDY

4.1 General Objectives

The general objective of this study is to investigate the potential of spent coffee grounds (SCG) as fine aggregate in non-load bearing Concrete Hollow Blocks by replacing the sand in varying percentages.

4.2 Specific Objectives

1. To design a concrete hollow block with spent coffee grounds as partial replacement of fine aggregates with the given percentages 5%, 10%, and 15%.

2. To evaluate the concrete hollow blocks (CHB) with spent coffee ground in terms of Compressive Strength Test and Water Absorption Test.

3. To compare the quality and cost of the CHB with spent coffee grounds to the standard CHB.

5. SIGNIFICANCE OF THE STUDY

Since coffee has become ingrained in our culture, this research aims to reduce the amount of waste dumped in landfills and turn it into a raw material that will benefit everyone.

The Construction Industry. The importance of this study is to give an impact on our society, especially in the construction industry. There will be an alternative raw material for sourcing of good quality CHB.

The Environment. This study will impact the environment since it will lessen the coffee waste disposed of in landfills yearly. Since the consumption of coffee increase annually, the waste of coffee grounds also increases, which will become an environmental problem. Using spent coffee grounds as a partial replacement of fine aggregates in concrete mixtures will help to reduce the landfill demand and help the environment.

The Future Researchers. This study will be useful as a resource for the knowledge and concepts they require to conduct studies — similar to their own.

6. SCOPE AND LIMITATIONS

The study determined how compelling it was to use spent coffee grounds with no specific type of coffee as a partial replacement of fine aggregates in concrete hollow blocks considering the water cement ratio by weight. This study tested the mixture by replacing 5%, 10%, and 15% sand to spent coffee grounds. The researchers used coffee grounds that are obtained from coffee beans. The researchers included Review of Related Literature (RRL) and some facts that made the product effective and proved the efficacy of the study, the researchers performed the following test; Compressive Strength Test and Water Absorption Test. As per limitations, the researcher was not able to conduct Thermal Conductivity and Density Tests due to the lack of testing centers in Pampanga and the availability of samples.

7. METHODOLOGY

This chapter includes methods for using spent coffee grounds as a partial replacement in the concrete mixture used to create concrete hollow blocks, along with the design, materials, preparation, and tools needed to collect data and the settings where the study was conducted.

7.1 Research Design

This study used experimental research to develop spent coffee grounds as a partial replacement for fine aggregate in a concrete hollow block. To determine the most applicable percentage, the researchers evaluated the concrete with 0%, 5%, 10%, and 15% SCG.

7.2 Research Instrument

This study used an evaluation form to collect and analyze the necessary data based on a different test that helped the researcher determine which percentage composition of spent coffee grounds is the best partial replacement over a period of time (7 days, 14 days, and 28 days).

7.3 Research Setting

The researchers collected spent coffee grounds at selected branch of 7/11 (Bacolor, Intersection, Sindalan, San Fernando, and Sta. Rita) and McDonald's (San Antonio, Guagua, Intersection, and Sindalan, San Fernando) branches to proceed with product development.

7.4 Preparation of Spent Coffee Grounds

a. After collection, the spent coffee grounds were properly cleaned by removing any dirt that may have accumulated on the material.

b. The spent coffee grounds were dried in an oven to remove any remaining liquid.

c. After drying, the spent coffee grounds were ready to be used since it already produced a fine sand with a size 0.425mm.

7.5 Proportioning and Mixing

A ratio of 1:3 (cement-fine aggregates) was applied in this study. Materials were measured by weight using the weighing scale. Also, the sand was sieved to remove unwanted and large particles.

In this study, it was important that the materials were mixed thoroughly since they should be able to bind together and produce an accurate paste for the mixture to be consistent. The following steps were taken:

a. The weights of the Portland cement, sand, and spent coffee grounds were calculated using accurate weight measurements from a weighing scale.

b. The measured dry materials were moved to a mixing area. Control samples were taken from the sellers of CHB. On concrete hollow blocks, the percentage of replacement fine aggregates varies.

c. The proper cement-water paste was created by mixing the materials to achieve a homogeneous combination while gradually adding water to prevent the mixture from becoming too thin.

d. After that, the concrete mixture was put into a container to start the molding process.

7.6 Production of Concrete Hollow Blocks

Concrete hollow block samples were made using a molder machine that had four molds at once, and they were marked accordingly.

a. A concrete was made.

b. The liquid was once again stirred before being put into the mold to keep the mixture consistent and prevent settlements. A hollow block molder was then filled with the mixture.

c. A smooth and clean top, extra concrete mixture was scraped off the mold's open face using a metal piece. The exposed surface was flattened off by the metal piece as it was moved across it, collecting the leftover mixture for the subsequent batch.

d. Using the machine, compaction was accomplished. Upon completion of the procedure, the molded blocks were removed, labeled with their set, and set up on the curing site.

7.7 Curing

The curing process avoids cracking by maintaining the concrete moisture content. It plays a significant function in the longevity of concrete by preventing shrinkage and surface damage to the concrete as well.

a. The hollow blocks were left in a safe and dry place after they were removed from the mold for drying within 72 hours. After drying, all hollow blocks containing different proportions of coffee grounds undergo curing. The curing procedure was completed by the targeted days of seven, fourteen, and twenty-eight days to provide the hollow blocks with the necessary compressive

b. At the end of the 7th, 14th and 28th days curing, 12 pieces of concrete hollow blocks were transported for testing, while others were left to continue with the curing process.

8. OBSERVATIONS

8.1 Compressive Strength Test

The CHB performed the Compressive Strength Test with the use of a universal testing machine to determine the maximum amount of compressive load that the block can endure. As per this paper’s objectives, the product samples underwent 7, 14, and 28 curing days, with three samples per percentage amounting to 27 CHB samples and 9 CHB purchase from the market tested for compressive strength test and Compressive Strength Test average. In accordance with the DPWH Standard Specification for Item 1046—Masonry Work (1046.6 Strength Requirements) and the ASTM C129 Standard Specification for Non-load bearing Concrete Masonry Units, the compressive strength (average net area minimum) must be 4.14 MPa (600 psi) per average of 3 units and 3.45 MPa (500 psi) per individual unit.

Table-1: Compressive Strength Test result for 7 days curing

7 DAYS CURING		
SAMPLE	AVERAGE OF 3 UNITS (PSI)	AVERAGE OF 3 UNITS (MPa)
CONTROL	417.667	2.88
CHB A (5%)	694	4.787
CHB B (10%)	498.333	3.433
CHB C (15%)	312	2.15

Table 1 shows the results of the Compressive Strength Test performed on the concrete hollow blocks sample after 7 days curing period. The control sample recorded a PSI average of 416.667 or 2.88 MPa. The 5% coffee grounds content CHB registered the highest compressive strength results with an average PSI of 694 or 4.787 MPa, it is 49.94% higher than control sample. Meanwhile the 15% coffee grounds content CHB registered the lowest compressive strength with an average PSI of 312 or 2.15 MPa or 28.73% lower than control sample.

Table-2: Compressive Strength Test result for 14 days curing

14 DAYS CURING		
SAMPLE	AVERAGE OF 3 UNITS (PSI)	AVERAGE OF 3 UNITS (MPa)
CONTROL	525	3.62
CHB A (5%)	744.333	5.13
CHB B (10%)	582.667	4.02
CHB C (15%)	371.333	2.56

Table 2 shows results of the CST performed on the concrete hollow blocks sample after 14 days curing time. The control sample recorded a PSI average of 525 or 3.62 MPa. The 5% cured CHB (CHB A) registered the highest compressive strength results with an average PSI of 744.333 or 5.13 MPa, it is 34.56% higher than control sample. Meanwhile the 28-days cured CHB (CHB C) registered the lowest compressive strength with an average PSI of 371.333 or 2.56 MPa or 34.29% lower than control sample.

Table-3: Compressive Strength Test result for 28 days curing

28 DAYS CURING		
SAMPLE	AVERAGE OF 3 UNITS (PSI)	AVERAGE OF 3 UNITS (MPa)
CONTROL	605.333	4.173
CHB A (5%)	914.333	6.317
CHB B (10%)	748.667	5.16
CHB C (15%)	510	3.52

Table 3 shows results of the Compressive Strength Test (CST) performed on the concrete hollow blocks sample after 28 days curing period. The control sample recorded a PSI average of 605.333 or 4.173 MPa. The 5% cured CHB (CHB A) registered the highest compressive strength results with an average PSI of 914.333 or 6.317 MPa, it is 40.59% higher than control sample. Meanwhile the 28 days cured CHB (CHB C) registered the lowest compressive strength with an average PSI of 510 or 3.52 MPa or 17.09% lower than control sample.

8.2 Water Absorption Test

The results of the water absorption test are shown in the table below, along with the impact of replacing used coffee grounds after 7, 14, and 28 days of curing. The ASTM C 129 Standard was attained by each and every test specimen.

WATER ABSORPTION TEST RESULT				
CURING DAYS	**CONTROL**	**CHB A (5%) SCG**	**CHB B (10%) SCG**	**CHB C (15%) SCG**

Average of 3 units (7 days)	7.54	7.29	6.44	10.61
Average of 3 units (14 days)	6.21	6.69	7.49	10.42
Average of 3 units (28 days)	5.56	5.54	6.88	8.84

Table-4: Average of 3 units Water Absorption Test Result

Table 4, shows the result of the water absorption on each curing day. It is notable that the absorption during each period consistently decreased. As per observation for the totally cured sample (28 days), the CHB A (5%) has the lowest water absorption among the other specimens. This indicates that the control, CHB B, and CHB C absorb more water. This is due to the increased portion of SCG in the CHB B and CHB C mixtures, as the coffee grounds are extremely absorbent.

8.3 Cost Analysis

The researchers conducted a cost estimate for a 30-day period for manufacturing CHB using spent coffee grounds as partial replacement for sand. It can manufacture 3600 CHB pieces in a month. The CHB molder machine costed Php 27,500.00. Cement costs Php 18,000.00 for that amount of production time, or 3 bags per day (Php 200.00 each bag). A total of 10,800 kg of sand were used, costing Php 10,948.00 per truck that can haul 4529.6 kg. The labor expense was 4320 (Php 1.20 per CHB). According to this analysis, CHB A costs Php 16.72 per piece, CHB B costs Php 16.57, and CHB C costs Php 16.42 per piece. These unit values are all higher than the market standard price for CHB, which is Php 12.00. It also shows that even with a higher quality compared to chb in the market, using spent coffee grounds as a partial replacement for fine aggregates was less- economical as it cost more than the chb available in the market.

9. CONCLUSION

The following conclusions are taken from this study of spent coffee grounds as a partial replacement of fine aggregates in Non-load bearing Concrete Hollow Blocks: Through a Compressive Strength Test, researchers found out that the CHBs cured for 7 days with 5%, 14 days with 5%, 28 days with 5% and 10% coffee grounds replacement with a ratio of 1:3 (cement: fine aggregate) met and exceeded the minimum compressive strength of 4.14 MPa or 600 psi as per DPWH Standard Specification 1046.4-Strength Requirements. Additionally, the results of the compressive test also revealed that the compressive strength could be improve by adding the right amount of SCGs. Acquiring the right amount of SCGs is essential for implementation because strength deterioration was seen in samples with excessive or inadequate SCG concentration. Meanwhile, the Water Absorption Test results shows that the totally cured sample (28 days), the CHB A (5%) has the lowest water absorption among the other specimen while the samples containing more portions of SCG absorb more water, as the coffee grounds are extremely absorbent. Given how highly absorbent SCG are, all of the samples provided by the researchers passed the 24.01% maximum water absorption standard of ASTM C129. Furthermore, it has been proven that CHB's compressive strength affects how much water is absorbed because water absorption decreases as compressive strength increases. In addition, the experimental concrete hollow blocks has a higher quality compared to the CHBs available on the market, however the researchers' cost analysis revealed that the experimental CHBs are less economical. Moreover, the researchers discovered that the brown nitrogen substance known as "Melanoidins" was the cause of the physical discoloration of the product that was produced. Melanoidins, which are present in coffee gives the finished product its dark color. Increased SCG content gives CHBs a more prominent brown coloration.

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