

# **ASSESSING THE USE OF WASTE ENGINE OIL IN SANDCRETE BLOCKS**

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**A FINAL YEAR RESEARCH AND DESIGN PROJECT REPORT SUBMITTED TO THE  
FACULTY OF ENGINEERING, DESIGN AND TECHNOLOGY, IN PARTIAL FULFILLMENT  
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## ABSTRACT

Dampness in sandcrete blocks can lead deterioration of a structure, reduce durability and increase maintenance issues. This study assessed the use of waste engine oil (WEO) as an additive to reduce water absorption in sandcrete blocks. Laboratory experiments determined the physical and chemical properties of WEO and assessed its effect on the compressive strength and water absorption of sandcrete blocks. The results showed that WEO exhibits hydrophobic properties that help limit moisture penetration. The optimum proportion of WEO was found to be 0.5% by weight of cement which effectively reduced the water absorption by 20% and increased the compressive strength by 8%. However, higher concentrations of WEO ( $\geq 1.0\%$ ) weakened the blocks due to interference with cement hydration process. These results suggest that incorporating WEO in sandcrete block production offers a sustainable and eco-friendly solution for reducing dampness while promoting waste recycling in construction.

## **DECLARATION**

I hereby declare that this is entirely my own original work, is not plagiarised and has not been submitted to any other institution for assessment other than this University.

Signature: .....

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## **APPROVAL**

This is to certify that this report was compiled under my supervision and is ready to be handed in to the Faculty of Engineering, Design and Technology as one of the requirements for the degree of Bachelor of Science in Civil and Environmental Engineering at Uganda Christian University.

**MR. KENNETH ECONI**

Academic Supervisor

Signature: ..... Date: .....

## **DEDICATION**

I dedicate this report to my parents for their tireless effort they have placed in my education, comfort and support.

## **ACKNOWLEDGEMENT**

I thank the Almighty God for enabling me to carry out this research project and guiding me through this entire research duration. I would also like to thank my parents for their continued support financially since their unwavering support allowed me to focus on this research project and it would not have been possible without this support.

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## LIST OF ACRONYMS

WEO	Waste Engine Oil
TAN	Total Acid Number
WMO	Waste Motor Oil
ASTM	American Standards of Testing Materials
BS	British Standard
WCO	Waste Cooking Oil
UNBS	Uganda National Bureau of Standards
PCB	Polychlorinated Biphenyls
ISO	International Organisation for Standards
MW	Molecular weight
BP	Boiling points

## CHAPTER ONE: INTRODUCTION

### 1.1 Background

Dampness will cause secondary damage to a building. It can even lead to problems like mortar fall from the affected areas, failure of affected building components and also causes serious health effects to the humans (Vidyakar, 2019). Flooding, leakages, water penetration and construction water are major causes of dampness in a building. Surface efflorescence just above skirting/floor, dampness at the base of walls up to 1.5m in horizontal band, softening and deterioration of plaster and blistering and flaking of paint are main symptoms associated with dampness (Delgado et al 2016). This not only compromises the aesthetics of a building but also structural integrity.

Traditional methods for minimising dampness involve the use of synthetic chemicals, silicone sealants, and bitumen coatings. While effective, these solutions may have negative environmental implications, raising concerns about sustainability in building practices. As the construction industry increasingly prioritizes eco-friendly solutions, alternative materials and methods.

In Uganda, sandcrete blocks are favoured for their affordability, ease of manufacture, and versatility (Acayo, 2020). They are commonly used in walls, fences, partitions, and various structural elements across residential, commercial, and industrial applications. However, their porous nature leads to a relatively high-water absorption capacity, making them susceptible to dampness. To solve this problem, incorporating waste motor oil into the sandcrete block mixture can help to reduce the levels of absorption of water by the sandcrete blocks. Waste motor oil is hydrophobic due to its non-polar

composition, allowing it to interact effectively with the cement in the mixture. This lowers the overall water absorption capacity of the sandcrete blocks but also provides a way for recycling waste products, contributing to environmental sustainability.

The incorporation of waste motor oil could also enhance the durability and longevity of sandcrete blocks, making them a more viable option in regions prone to moisture-related issues. This research proposes the use of waste motor oil in sandcrete block production as a sustainable and environmentally friendly solution to minimize dampness in sandcrete blocks hence contributing to both sustainable construction practices and waste management efforts.

## **1.2 Problem Statement**

In Kawempe division, the sandcrete blocks made by local manufacturers have a high-water absorption capacity which makes them more susceptible to dampness (Ahumuza, 2020). Sandcrete blocks also known as concrete blocks which are used for masonry have a water absorption capacity of 18.7% which is higher than the required capacity of 12% set by UNBS (US 596:2017) and the average compressive strength of 2.396 Nmm<sup>2</sup> was below the 3.5 Nmm<sup>2</sup> value considered in practice (Acayo, 2021). This dampness may cause structural failure and mortar deterioration hence compromising on the durability and structural integrity of the block. The area under study is a low-lying area hence has a high-water content in the soil so use of these blocks can reduce the durability of the structure. Different methods to combat the dampness levels in sandcrete blocks are being used today like use of bitumen coating, synthetic chemicals like Dr. Fixit, silicon sealants and these may be harmful to the environment. This research therefore

proposes to assess the feasibility of incorporating waste motor oil into sandcrete block production as a sustainable and environmentally friendly solution to minimize dampness in sandcrete blocks hence contributing to both sustainable construction practices and waste management efforts.

### **1.3 Main Objective**

To assess the use of waste motor oil to minimize dampness in sandcrete blocks

### **1.4 Specific Objectives**

1. To determine the physical and chemical properties of the waste motor oil
2. To determine the optimum proportion of waste motor oil required to minimize dampness in sandcrete block
3. To assess the performance of the sandcrete blocks with waste motor oil

### **1.5 Research Questions**

1. What are the physical and chemical properties of waste motor oil?
2. What is the optimum proportion of waste motor oil required to minimize dampness in sandcrete blocks?
3. What are the properties of sandcrete blocks with waste motor oil?

### **1.6 Justification**

Sandcrete blocks made of cement, sand, gravel and water have high water absorption due to the porous nature of the blocks, as the particles of sand create voids within the material. Waste motor oil is known to have a higher viscosity, small density as well as a low emulsifying ability making it easy to be absorbed into sandcrete, affecting the

permeability and porosity of the sandcrete block (Kipkorir et al. 2021). Incorporating waste motor oil into sandcrete blocks can help address the issue of high-water absorption. Therefore, mixing petrol and diesel engine oil together for use in sandcrete helps to optimize the viscosity of the oil ensuring that there is even distribution of the oil in the sandcrete as well as enhancing the hydrophobic effect to minimize dampness (Hamad et al., 2003). Used diesel engine oil is thicker and can provide long-lasting waterproofing while used petrol engine oil is lighter and is better in absorption. When mixed together, they balance distribution and durability. Waste motor oil is hydrophobic, meaning it repels water. This hydrophobic nature is attributed to the fact that waste motor oil does not contain any charge and is non-polar (Warden, 2017). When waste motor oil is mixed with the cement used to produce sandcrete blocks, it reacts with the cement physically through adsorption to form a gel-like substance (Chen, Qin & Lau 2021). The incorporation of waste motor oil into concrete results in the formation of air bubbles due to the similarity with air entraining agents (Yaphary et al., 2020). These voids of air reduce internal pressure within the concrete by creating interconnected chambers that lead to the volumetric expansion of the water molecules during freezing (Sun et al., 2020). This gel-like substance coats around the particles of sand in the sandcrete mixture, effectively sealing the pores and reducing the permeability of the blocks to water. As a result, the water absorption capacity of the sandcrete blocks is significantly reduced.

## **1.7 Significance**

The importance of this research is to address dampness in sandcrete blocks which is mainly caused by their high-water absorption capacity making them to absorb a lot of water which can compromise on their durability and structural integrity especially when used in areas where the damp proof course has proven to be inefficient or has worn out as well as low lying areas. This is by using waste motor oil which is a waste from motor vehicles and has adverse effects on the environment when disposed of improperly that is mixed in the sand and cement mixture to make them be able to have the required water absorption capacity as stated by the UNBS.

## **1.8 Scope of study**

Kawempe division is located in the northern part of Kampala, the capital city of Uganda. It includes various neighbourhoods and suburbs such as Bwaise, Komamboga, Kawempe town, Kisaasi, among others. The area of study is  $0.374188^{\circ}\text{N}$ ,  $32.591037^{\circ}\text{E}$  in Kisaasi.

## **1.9 Time scope**

This research is expected to be carried out from October 2024 to March 2025.

## CHAPTER TWO: LITERATURE REVIEW

### 2.1 Blocks

Blocks are rectangular elements used in construction for building walls, making pavements as well as other structures for masonry works. A block is typically a unit composed of materials such as concrete, cement or other aggregates (Campbell, 2024). Blocks can be assembled using mortar, adhesives or even by interlocking mechanisms. Their production is classified according to different types and sizes which may differ depending on the time and region, and are often manufactured in bulk quantity.

A block can also be defined as a fundamental building material typically available in a rectangular shape and manufactured from materials like concrete or cement (Singh, 2022). Blocks serve as essential components in construction projects, offering versatility and structural support.

### 2.2 Classification of blocks

Classification of blocks based on type and size. They can be classified as below;

#### 2.2.1 Solid blocks

These are blocks made of solid concrete only and are typically used in load-bearing walls where structural strength is required (Smith, 2018). Fully solid blocks are often used for projects like paving where stability and durability are crucial. Solid blocks are more stable than hollow blocks and are suitable for load-bearing applications (JK Cement, 2024).

### **2.2.2 Hollow blocks**

These blocks have hollow cores which reduce weight and material usage while still providing structural support. They are commonly used in non-load-bearing walls and partitions (Jones, 2019). They are further classified in grade depending on their density;

1. Grade A: These blocks have a minimum density of 1500 kg/m<sup>3</sup> and are used in load-bearing walls (BigRentz, 2021).
2. Grade B: These blocks have a density of less than 1500 kg/m<sup>3</sup> and they are blocks are also used in load-bearing walls.
3. Grade C: These have a density greater than 1000 kg/m<sup>3</sup> and are used in non-load-bearing walls. They are lighter due to the holes and can be useful when running wiring or piping.

### **2.2.3 Common sizes of sandcrete blocks**

Different blocks have different sizes and these sizes determined by their grade most of the time. They vary since different wall sizes are needed for different purposes like load bearing walls, partitioning walls and retaining walls among others. Table 2.1 shows the different common sizes of concrete blocks used.

*Table 2.1 Common sizes of block used*

Length(mm)	Width(mm)	Height(mm)
390	140	140
390	190	140
390	225	190
390	290	190

Source: (Alpha Sand, 2024)

## **2.3 Raw materials**

### **2.3.1 Cement**

Cement is a binding agent used to bind many different construction materials. It is an essential ingredient of concrete and mortar due to its adhesive and cohesive properties. It is mixed with water to form a paste that binds aggregates or crushed rocks with sand (Hasan, 2010). Calcium, silicon, iron and aluminium compounds are closely ground to form a fine powdered product called cement. Different types of cement used in construction today;

1. Non-Hydraulic cement. It is formed through the reaction of powdered cement with water and can be used in all types of construction even underwater construction projects since it sets and becomes adhesive due to carbonation.
2. Hydraulic cement. This is the most common and used cement. Hydraulic cement like Portland cement has always been a preferred choice for architects, engineers and constructors majorly due to its ability to harden quickly.

### **2.3.2 Sand**

Sand is a granular material made of finely divided mineral particles. It has different compositions but it is defined by its grain size. Sand grains are smaller than gravel and coarser than silt. Sand can also be referred to as a textural class of soil or soil type i.e. soil containing more than 85 percent sand-sized particles by mass (Plant and Soil Sciences eLibrary, 2022).

The composition of sand varies depending on the local sources of rock and conditions but the most common component of sand in continental inlands and non-tropical coastal areas is silica (silicon dioxide  $\text{SiO}_2$ ) mostly in form of quartz.

In construction, sand is a very crucial material used primarily in concrete, mortar and plaster. The type of sand used in building construction is typically referred to as construction sand or building sand. There are different types of sand used in construction;

1. River Sand: This is naturally occurring sand collected from beds of rivers. It is fine, rounded and has a smooth texture hence making it ideal for concrete and plastering (Deloney, 2023).
2. Pit Sand: It is found in deep pits. It is coarse and angular and is often used in concrete due to its binding properties.
3. Manufactured Sand (M-Sand): It is made by crushing hard granite stones, M-sand is a substitute for river sand. It has a rough texture and angular which helps in bonding in concrete (Admin, 2021).

### **2.3.3 Gravel**

Gravel is a loose collection of small rock fragments formed through the natural processes of weathering and erosion or produced in quarries where larger rocks like sandstone, limestone and basalt are crushed (Charles 2024). With particle sizes ranging from 2 mm to 60 mm, gravel has various colours, textures, and types. It has a vital role in construction being essential for concrete production and asphalt mixing in road construction.

## **2.4 Benefits of sandcrete blocks**

Sandcrete blocks are known for their compressive strength, providing excellent structural integrity to buildings. They are resistant to fire and pests making them durable and long-lasting (Homes, 2016).

Sandcrete blocks have various sizes, shapes and finishes hence offering flexibility in design and construction. They are used in load-bearing and non-load-bearing walls, partitioning walls, retaining walls and other structural elements.

Sandcrete blocks are pre-casted and readily available allowing for fast and efficient construction. They are easy to handle, transport and install hence reducing labour costs and construction time.

Some sandcrete blocks are designed with built-in insulation improving thermal efficiency and reducing energy costs for heating and cooling buildings. Additionally, concrete has inherent thermal mass properties that help to regulate indoor temperatures.

Sandcrete blocks provide excellent sound insulation reducing noise transfer between rooms and entrance from external sources. This is beneficial in residential and commercial buildings where acoustic comfort is very important.

Sandcrete blocks have inherent fire-resistant properties offering protection against fire spread and minimizing damage in the event of a fire. This makes them suitable for use in fire-rated walls and structures (The Concrete Centre, 2019).

## **2.5 Limitations of sandcrete blocks**

Due to their porous nature, sandcrete blocks absorb water easily which can weaken them over time. This moisture can cause issues such as mould growth, efflorescence and deterioration thereby reducing the durability of the structure.

Sandcrete blocks are more brittle compared to other building materials making them prone to cracking during transportation or construction. This brittleness increases the risk of wastage during handling.

Sandcrete blocks may offer substandard thermal and sound insulation properties. This results in higher energy consumption for heating or cooling the interior and less soundproofing which is less desirable for residential applications.

In areas with high moisture or flooding, sandcrete blocks can erode over time if not adequately waterproofed leading to reduced durability and a need for frequent repairs.

Sandcrete blocks often vary in quality due to inconsistent manufacturing processes particularly where they are made by hand. Differences in the sand-cement ratio and improper curing can lead to weak and non-durable blocks

## **2.6 Dampness in blocks**

When building a concrete structure, moisture is among the most important factors since it hydrates the cement and helps in the curing process. However, once the building is constructed and inhabited, moisture can be harmful to the walls and the occupants (Administrator, 2024). Building defects like leaking gutters, damaged roofs as well as defective seals around windows and doors are all causes of penetrating damp in a

structure (Administrator, 2024). Any building defects should be fixed as soon as possible as they can provide a constant source of dampness which can ruin internal décor.

## **2.7 Waste motor oil**

Modern automobile engines require engine oil to function. These automobile engines cannot run on just any oil and “current design philosophies largely owe their feasibility to engine oils tailored to the demands of advanced engine design”.

Waste motor oil refers to “petroleum-based or synthetic oil” that has been used and no longer fit for its original use due to the presence of impurities like dirt, metal scrapings, water or chemicals (US EPA, OLEM, 2018). These impurities accumulate during normal use rendering the oil ineffective. As a result, this used oil must be replaced with new oil to ensure proper functioning of engines and machinery.

This used oil is considered hazardous waste due to its dangerous properties. A single litre of waste motor oil can contaminate up to one million litres of water hence posing a significant threat to aquatic life and water quality. Moreover, if disposed of improperly such as being left on the ground, waste motor oil can lead to severe soil contamination (US EPA, OLEM, 2016).

The potential environmental impact of WEO in construction materials requires careful consideration. Although the enclosure of WEO in concrete may reduce immediate leaching risks, long term studies are limited on the stability of PAHs within the cement matrix. Research by Omoregie et al. (2024) shows that some additives could assist in immobilising heavy metals from oil contaminated construction materials. However,

their effectiveness in block making is yet to be tested. While WEO poses environmental risks, its enclosure in the sandcrete blocks could offer a containment solution provided long-term stability is confirmed.

## **2.8 Chemical composition of waste motor oil**

Used motor oil comprises of both high and low molecular weight hydrocarbons, various additives, metals and other compounds. It consists of hydrocarbons in different quantities i.e. 73-80% Aliphatic Hydrocarbons, 11-15% Monoaromatics, 2-5% Diaromatics and 4-8% Polyaromatic Hydrocarbons. Lubrication additives make up about 20% of the oil including Zinc Diaryl, Molybdenum oils Disulfide and Zinc Dithiophosphate (Cvengroš et al. 2017). Notably, PCBs which have been linked to health risks and environmental concerns, were historically used in transmission fluids but are no longer utilized in new motor due to their potential to form dioxins (Cvengroš et al. 2017).

Used motor oil is notably rich in Polycyclic Aromatic Hydrocarbons (PAHs), with concentrations significantly higher than those found in new motor oil because of the accumulation of PAHs during engine operation (Akintunde et al., 2015). The Polyaromatic Hydrocarbons content in used motor oil can also be modelled basing on the common PAH compounds each contributing equally to the overall composition. The impact of PAHs on the environment and human health is well-documented emphasizing the importance of proper management and disposal of used motor oil to mitigate potential risks (Armioni et al., 2024). Table 2.2 shows the composition of different hydrocarbons in WEO.

*Table 2.2 Waste motor oil hydrocarbon composition*

PAH Components	Formula	MW	BP (°C)
Naphthalene	C <sub>10</sub> H <sub>8</sub>	128.17	218
Acenaphthene	C <sub>12</sub> H <sub>10</sub>	145.21	279
Anthracene	C <sub>14</sub> H <sub>10</sub>	178.23	340
Pyrene	C <sub>16</sub> H <sub>10</sub>	202.25	404
Benz(a)anthracene	C <sub>18</sub> H <sub>12</sub>	228.29	438

Source: (Pollution Direct, 2020)

## 2.9 Infiltration of oil into concrete

Published research on the infiltration of oil into concrete is relatively scarce. The significance of these studies arises from the construction of substantial concrete infrastructures for oil-related activities where the impact of crude oil on concrete's characteristics remains largely unexplored. It is known that mineral and fuel oils do not compromise mature concrete as they lack components that chemically interact with set cement (Creaney, 2022). However, vegetable and animal oils pose a greater threat through chemical reactions with cement hydration products hence leading to expansive soap formation and matrix degradation (Staroń, 2023) and this presence of vegetable or animal oils can actively deteriorate concrete with documented instances of structural damage. The degree of harm oil inflicts on concrete is influenced by its viscosity oils with higher viscosity pose less risk to concrete integrity. Conversely, oils with lower viscosity such as diesel and kerosene have viscosity less than 6cP at 21°C and are prone to seep through concrete potentially leading to significant leakage from storage tanks (Pradena and César, 2021). The long-term effects of oil exposure include

reduced tensile strength, increased chloride permeability and accelerated carbonation compromising structural durability (Abdeliazim et al., 2024).

## **2.10 Reaction between waste motor oil and cement**

Previous works suggest that waste motor oil can be incorporated into concrete since waste motor oil can function similarly to chemical additives like water-reducing agents and air-entraining admixtures (Shafiq et al., 2006). “Waste motor oil has similar features to the ASTM C393 type A water-reducing admixture in concrete” (Yaphary et al., 2020). Introduction of waste motor oil into concrete leads to formation of many air bubbles due to its likeness to air-entraining admixtures. These air bubbles reduce the internal pressure in the concrete by providing “interconnected chambers for the volumetric expansion of water molecules during freezing” (Sun et al., 2020). The concrete containing waste motor oil will improve significantly under freezing-thaw cycles hence more durable. When waste engine oil is compared together with new engine oil, waste motor oil contains very little amount of dirt which has impurities that are inactive and react with the cement physically by adsorption to coat the sand and hence fill the free pores in the concrete mixture leading to increase in the strength of the concrete (Poon and Chan, 2007). These effects of waste motor oil in concrete account for the improved performance of concrete when the proper dosage levels of waste motor oil are used.

## **2.11 Knowledge gap**

Prior investigations have explored the utilization of used cooking oil in concrete showing that it increases the slump value of concrete (Salmia et al., 2013). Incorporating waste materials like “oil drill cuttings” treated by thermal desorption has been shown to produce sandcrete with reduced levels of water absorption, increased density and comparable compressive strength to control samples demonstrating the potential for reuse of waste materials in improving sandcrete properties (Khedaywi et al., 2022). Initially the blocks have been dipped into the waste motor oil but this causes the block not to bond with the mortar easily when used due to its oily surface. This therefore prompted the incorporation of waste motor oil into the sandcrete mix so that the final product can easily bond with the mortar during construction.

The practical aspects of incorporating WEO in block production is not yet largely explored and the difference in oils from different sources is expected to yield different results in field applications. Compatibility of such blocks with standard mortars and finishes should be established as the hydrophobic characteristics of oil could further compromise the bonding strength and surface treatments (Bamigboye et al., 2023)

## CHAPTER THREE: METHODOLOGY

### Introduction

This shows the methods used in the incorporation of WEO in the production of sandcrete blocks. It includes material collection, mix proportioning, sample preparation, curing and testing to assess the effects of WEO on the compressive strength and water absorption capacity of sandcrete blocks.

#### 3.1 Material collection and preparation

Materials needed for the making of sandcrete blocks with waste motor oil are; used motor oil, cement, sand, water and aggregate. This was done following the ISO 14001 standard for handling of waste materials and ASTM C140 for casting of masonry units.

The waste motor oil from petrol car engines and motorcycles was collected from Shell petrol station garage in Wandegeya Kampala and from Kibalizi auto garage in Wandegeya opposite Makerere small gate. It was collected in a 5-Litre jerrycan. This waste motor oil was transported by vehicle to Kulambiro where three different smaller samples of 500ml each were obtained and prepared to be taken to the laboratory for testing. The balance was stored in a tightly closed container to prevent it from contamination by external impurities. One sample was taken to Molecule Technology Africa Limited Labs in Industrial Area opposite Uganda Foundry for testing of presence of contaminants. It was also tested for its viscosity, total acid number and stored at room temperature. The other sample was taken to Terzaghi's Soil and Materials Lab in Kireka to be tested for density and pH as these can affect its interaction with cement.

Materials needed for the making of sandcrete blocks without waste motor oil are; cement, coarse sand and water.

The cement was bought from hardware world Ntinda. Two bags of cement were bought. It was transported by vehicle to Kulambiro where it was split into two parts i.e. half each weighing about 25kg and prepared to be used for mixing of the mix for making the blocks then taken to the laboratory for testing. A mold for making of the blocks was obtained from Divine Concrete in Najeera and was used to make the sandcrete blocks. It was of dimensions 150 mm x 200 mm x 400 mm commonly known as a 6-inch block. The sand was obtained from Waswa transporters and suppliers in Kyanja and then transported to Kulambiro where it was kept. 4 kg were then obtained and taken to the lab for grading to know if its suitable for the sandcrete blocks.

### **3.2 Determining the physical and chemical properties of WEO**

#### **3.2.1 Contaminant analysis (ICP test)**

Waste motor oil often contains contaminants such as heavy metals like Lead and Copper which have various negative effects on the environment as well as the quality of the sandcrete blocks. This is done to ensure that the waste motor oil used has little or no harmful heavy metals in it. Heavy metals in the waste motor oil are tested for using Inductively Coupled Plasma (ICP) test.

Sample of 500ml obtained and stored under room temperature. Waste motor oil is filtered to remove any solid contaminants or particulates and treated with nitric acid to break it down into a form that can be analysed. The instrument is calibrated using blanks of known heavy metal concentration. The sample is then introduced into the

autosampler and the uptake rate of the samples is ensured to be consistent to avoid bubbles in the sample. The acquisition process is then started via the software (Qtegra) and the data is monitored as the samples are analysed. When the samples are all analysed, the data is saved and checked for consistency to ensure accuracy. It is then exported for review and reporting.

### **3.2.2 Viscosity test (ASTM D445)**

Viscosity refers to the resistance of a liquid to flow under gravity. This test is carried out to measure the oil's flow as this greatly influences its ability to bond with the cement and sand during mixing of the materials to make the sandcrete blocks. It was done with reference to ASTM D445: Standard test method for low-temperature pumping viscosity of engine oils.

Preparation and collection of a representative sample of about 500ml is done in a clean container and filter out solid contaminants in the waste motor oil. A capillary viscometer is used to test for the kinematic viscosity of the waste motor oil. It is calibrated to the viscometer as per the manufacturer's instructions and test is conducted at controlled temperatures typically 40°C or 100°C using a thermostatic bath. The viscometer with oil is filled and the time it takes to flow through the tube is measured.

### **3.2.3 Density test (ASTM D1298-99)**

Density of a substance is important to ensure the consistency of the mixture with the sand. It also provides an understanding of the effectiveness of the oil in binding the sand particles together without compromising the block's overall structural integrity. It was tested for using a Hydrometer.

A sample of 500ml was obtained and stored under room temperature. The hydrometer is calibrated with a substance of known density and then the waste motor oil is poured into a transparent cylinder. The hydrometer is gently placed in the liquid and the reading is taken at the meniscus level. Temperature corrections are applied to standardize results at 30°C.

### **3.2.4 pH test (BS 1377: Part 3)**

Testing for pH of used motor oil shows how acidic or alkaline it is. Acidic pH can cause corrosion or degradation of the sandcrete block's materials over time. It ensures that the oil is not acidic to ensure that it won't interfere with the curing and strength of the sandcrete blocks. A pH meter is used to determine the pH of the waste motor oil

The sample to be tested is collected and the pH meter is calibrated using standard buffer solutions. The electrode is submerged into the oil sample and the pH value is recorded.

### **3.2.5 Total Acid Number (TAN) (ASTM D664)**

Checking the TAN of used motor oil shows how much acidic content a substance has. A high TAN indicates that the oil has a lot of acidic content likely from the over degradation of the oil during its use and can cause corrosion or degradation of the sandcrete block's materials over time. It ensures that the oil is not acidic to ensure that it won't interfere with the curing and strength of the sandcrete blocks. A potentiometer is used to determine the TAN of the waste motor oil

The sample to be tested is collected and then dissolved in a solvent. The titrant of NaOH is prepared and the electrode is calibrated using standard buffer solutions. The sample is placed inside a beaker and the electrode connected to a potentiometer is inserted. The burette is filled with the titrant and solution stirred while NaOH is added slowly and the potential monitored.

## **3.3 Determining the optimum proportion of WEO needed to minimise dampness**

### **Mix Design**

The WEO is added with different percentages by weight of cement. The mix ratio for the sandcrete blocks is the standard 1:6 cement to sand ratio with reference to the mix design for production of sandcrete blocks as specified by UNBS. The amount of WEO used should not be more than 5% of the mass of the cementitious material (Yaphary et al., 2020). Table 3.1 shows the different mix design ratio used for mixing.

*Table 3.1 Mix design ratios*

Sample	WEO (%)	CEMENT	SAND	WATER
1	0	1	6	0.5
2	0.5	1	6	0.5
3	1	1	6	0.5
4	2	1	6	0.5
5	5	1	6	0.5

### **3.3.1 Grading of the sand (BS 1377-2:1990)**

This test determines the gradation of the sand to be used in the sandcrete mixture. It follows the BS 1377-2:1990 standard.

A 1kg sample of sand is dried and weighed then a set of sieves of different sizes is prepared with sieve sizes from big to smallest and the sand is sieved. The amount of sand retained on each sieve is measured and results computed. A gradation curve is plotted and the sand graded.

### **3.3.2 Preparation, mixing and casting of sandcrete blocks**

For each mix design, four identical blocks were casted to attain statistical reliability and homogeneity of test results. All constituent materials like cement sand water and where applicable WEO were accurately measured and prepared in accordance with the established mix proportions. The cement and sand were first dry mixed until a uniform consistency was achieved after which water and the designated percentage of WEO was added and thoroughly blended to produce a consistent and workable mix. The mix was placed in pre oiled moulds in two layers and each compacted to eliminate air voids.

Curing of all samples was undertaken at a controlled temperature of  $25 \pm 2^\circ\text{C}$  and  $75 \pm 5\%$  relative humidity to ensure that any environmental variability was eliminated and ensure consistent hydration and strength development in all block samples.

### **3.3.3 Compressive strength test on sandcrete blocks (BS EN 772-1:2011)**

The compressive strength test determines the ability of the blocks to withstand loads without failure. Low strength can lead to structural failure over time. This test ensures that the blocks have enough strength to support both the dead loads of the structure and meet the building guidelines. It is measured using a universal testing machine. Strength is measured in Pascal.

After curing the blocks, they are allowed to dry for 24 hours under air and the dimensions of the block are measured to ensure that they are uniform. The weight of the block is measured to and the mass of the block is recorded. The compression testing machine is set up and the block inserted ensuring that the load is aligned with the centre of the block in order to apply the load evenly. The load is gradually applied at about 0.25Mpa per second and it is applied until the block fails or cracks. The maximum load at a failure is recorded in Newtons and compressive strength is calculated.

### **3.3.4 Water absorption test on the sandcrete block (BS EN 772-11:2011)**

Water absorption test determines the ability of the blocks to absorb moisture. High water absorption can weaken blocks leading to reduced durability and failure over time. It is done with reference to the British Standard for porosity of masonry units.

After curing the block and air drying it, it is placed in an oven at 105°C for 24 hours to completely dry the block. It is removed from the oven and allowed to cool at room temperature. The weight of the block is then taken and recorded. It is then immersed in water for 24 hours ensuring there are no air pockets then removed and wiped with a cloth and the weight of the block immediately taken and recorded. The water absorption of the block is then calculated using the formula below;

$$\text{Water Absorption} = \frac{W_w - W_d}{W_d} \times 100$$

Where;  $W_d$  - Dry weight of the block

$W_w$  - Saturated weight of the block

### 3.3.5 Capillary action (BS EN 772-11:2011)

This is done to check the resistance of the block against capillarity of water. The capillarity of the block when used in masonry unit will be assessed to find out if it actually resists dampness when used in a wall masonry.

The block is dried at 105°C in an oven to constant weight. A pan is filled with water up to 5mm and the block is inserted into the pan. The bottom of the block is submerged in water for about 24 hours. The level of water rise in the block is measured at regular intervals typically every 6 hours over a period of 24 hours. The rate of capillary rise and the total water absorbed are recorded and analysed.

## CHAPTER FOUR: RESULTS AND ANALYSIS

### Introduction

This chapter shows the results of laboratory tests conducted on waste motor oil and sandcrete block samples. The tests include the determination of heavy metal concentrations, Total Acid Number (TAN), viscosity, density, pH, compressive strength test, water absorption test and capillarity test. The findings are discussed together with their potential impacts on industrial and environmental applications of the sandcrete blocks.

#### 4.1 Physical and chemical properties of WEO

##### 4.1.1 Contaminant analysis (ICP test)

Data Collected: Concentrations (ppm) of heavy metals (e.g., Lead (Pb), Zinc (Zn), Copper (Cu), Cadmium (Cd). Table 4.1 shows the different concentration of heavy metals in the WEO

*Table 4.1 Concentrations of contaminants in the WEO*

Parameter	Unit	Result
Lead	ppm	42.51
Barium	ppm	0.525
Calcium	ppm	328.26

The WEO has a lead content of 42.51ppm due to its prolonged use and it accumulates contaminants including heavy metals like lead (Pb) from engine wear and tear. This

shows that the WEO has undergone degradation and is contaminated with Lead due to wear and tear from the engine during its use (Chaineau et al., 2011).

Lead is a toxic heavy metal that poses serious health and environmental risks at high concentrations (US EPA, 2014). High lead level in waste engine oil is dangerous to individuals, especially if it exceeds 50ppm as indicated by the EPA, because lead is a heavy metal that is detrimental to both people. High amounts of lead can induce lead poisoning leading to neurological, renal, and cardiovascular disorders (Navas-Acien et al., 2007). Lead-containing materials in construction can also leak lead particles over time, affecting indoor air quality and causing health concerns (US EPA, 2014).

Lead concentration in the oil is lower than the EPA limits hence it is safe and friendly to use in sandcrete blocks because the end users are not exposed to excessive lead content, which might cause poisoning. Figure 4.1 shows the heavy metal concentrations in the WEO in ppm.

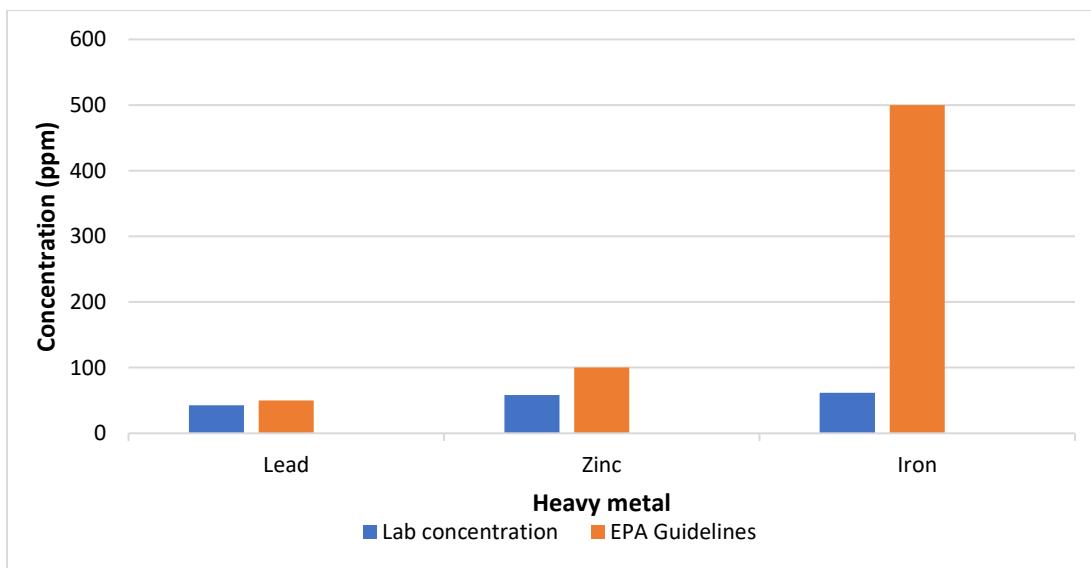


Figure 4.1 Heavy metal concentrations vs. EPA standard guidelines

#### **4.1.2 Viscosity (ASTM D445)**

Viscosity indicates that the fluid's resistance to flow. Table 4.2 shows the viscosity and viscosity index of the WEO.

*Table 4.2 Viscosity of WEO*

Test No.	Temp. of the sample (°C)	Viscosity of sample (cSt)	Viscosity Index Value
1	40	101.8	
2	100	14.2	95

The value suggests that the oil has a thickness which is common for used engine oils (Onyeji et al., 2011). This viscosity combined with prolonged use shows that it has undergone degradation and has thickened over time due to the contaminants in it hence its overall characteristic. The WEO has a VI of 95 because it has degraded and during degradation some of the additives become less viscous hence causing the oil to have a high viscosity index (Luo et al.). A viscosity index of 95 shows that the WEO can be used in all temperatures and can mix and penetrate the porous sandcrete filling the micro cracks and pores as well as the capillaries in the sandcrete block and mix effectively with the cement sand mixture hence good for use in reducing dampness in sandcrete blocks (Omopariola, 2014).

#### **4.1.3 Density (ASTM D1298-99)**

Density indicates mass per unit volume of a substance. The density value of 940 kg/m<sup>3</sup> suggests that the oil has a certain consistency which is common for used engine oils (Veluri, 2022). This density, combined with the oil's prolonged use, suggests that it has

gone through degradation processes, and it has likely accumulated contaminants over time including heavier compounds that affect its overall characteristics (Bonal et al., 2018).

The density of 940 kg/m<sup>3</sup> indicates that the used engine oil is consistent and stable hence uniform when mixing it with other materials like sand and cement to create concrete or sandcrete blocks. This consistency ensures that the oil blends effectively hence contributing to a uniform mix that is crucial for the structural integrity of the blocks.

#### **4.1.4 pH (BS 1377: Part 3)**

A pH of 4.02 shows that the WEO is acidic. This is because of the degradation of the oil after prolonged use especially due to oxidation of the WEO leading to the generation acidic byproducts. According to the pH scale values below 7 indicate that the substance is acidic. The pH of 4.02 means the oil has a moderate level of acidity but it is not extremely corrosive.

Acidic pH can cause long-term degradation of the sandcrete blocks because of the increased risk of corrosion of the materials or chemical reactions with the materials in the sandcrete blocks leading to weakening or deterioration of the blocks over time (Ferdinand et al., 2020).

pH of the WEO is less than 7 but not less than 3 it means that the WEO is safe for use in the sandcrete blocks as it is not very acidic to cause a reaction in the block matrix that can affect the durability of the block.

#### 4.1.5 Total Acid Number (TAN) (ASTM D 664)

TAN Value = 1.89mg KOH/g

TAN of 1.89mg KOH/g is because the oil has been degraded and oxidation has occurred in the oil over its period of use. Oxidation occurs due to high temperatures in the engine during its course of work hence formation of acidic byproducts as this oil degrades it increases the concentration of organic acids which can cause wear and tear (Jorge & Nunes, 2021).

TAN value of 1.89 is relatively low compared to the limits set by industrial players. TAN values above 2.0 show that the oil is heavily degraded and very acidic and can cause a reaction between the oil and the cement matrix affecting hydration process.

Since the oil TAN value is less than 2.0mg KOH/g it means that the WEO is safe for use in the sandcrete blocks as it is not very acidic in order to cause a reaction in the block matrix that can affect the durability. Table 4.3 shows the TAN value standards

*Table 4.3 TAN value standards*

TAN Value (mg KOH/g)	Significance
<1	Not Degraded
>1	Moderately Degraded
>2	Heavily Degraded

TAN > 1 mg KOH/g indicates significant oxidation, common in waste oil.

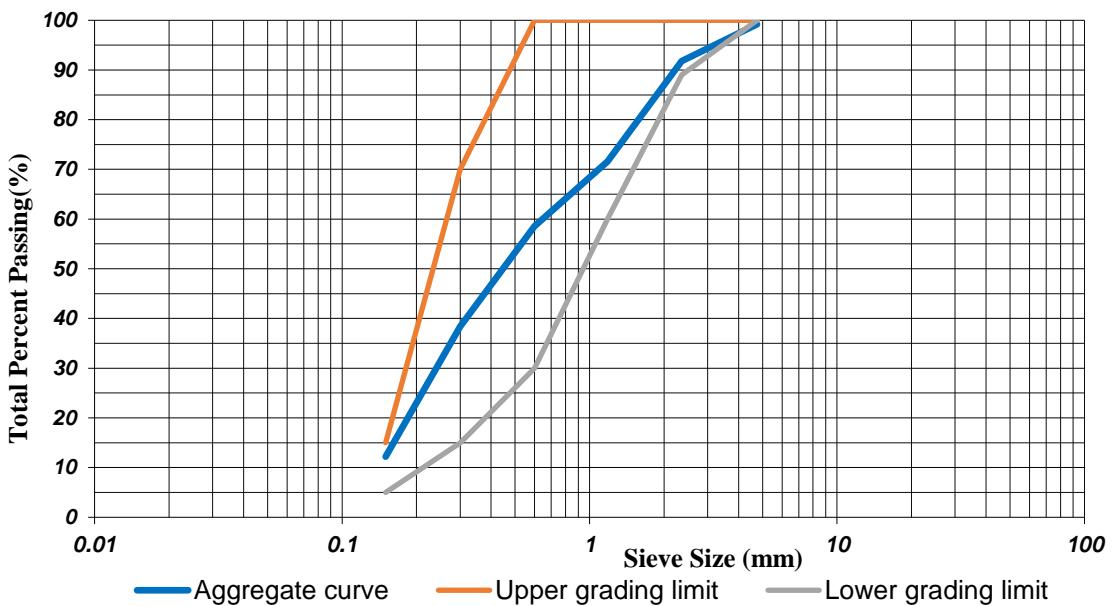
TAN > 2.0 mg KOH/g indicates heavy oxidation, hence presence of many organic acids.

The study found that WEO has a viscosity of 101.8 cSt at 40°C and a density of 940 kg/m<sup>3</sup>, indicating that it retains its thickness even at moderate temperatures. The pH value of 4.02 suggests mild acidity, but within acceptable limits for use in construction applications. Contaminant analysis revealed a lead concentration of 42.51 ppm, which is below the EPA safety limit of 50 ppm hence making the WEO safe for controlled incorporation into sandcrete. The physical and chemical analysis of WEO showed that it has a moderate viscosity, relatively acidic pH and small trace amounts of contaminants hence making it suitable for use in sandcrete blocks when properly controlled in different percentages.

#### **4.2 Optimum proportion of WEO required to minimise dampness**

##### **4.2.1 Particle size distribution of sand**

The sand was dried and a sample of 4kg used for grading. Poorly graded sand can lead to segregation, bleeding, or a weak sandcrete mixture. The sand was sieved, graded and limited to the grading envelope as specified in BS 882:1992. Figure 4.2 shows the aggregate grading curve for the sand used for the making of sandcrete blocks.



*Figure 4.2 Gradation of sand*

The particle-size analysis of the sand used showed that it had a fineness modulus of 3.2 a range close to well-graded aggregates (Coarse Sand) suitable for sandcrete block production (Neville, 2011). This shows a dense arrangement of particles which reduce the permeability paths for water. The well-graded structure improves the quality of sandcrete blocks by improving interlocking of the particles thus enhancing compressive strength and reducing the demand for water the optimal water-cement ratio was achieved at 0.5.

This grading shows that there are fewer voids in the sand for water to permeate through. This indicates improvement in the durability of the sandcrete blocks hence making the sand suitable for use in construction since the sand used in sandcrete must be well-graded to ensure proper workability, strength, and durability.

#### 4.2.2 Compressive strength

The compressive strength test was done to determine the early-age and full-strength characteristics of the sandcrete blocks. The results show that compressive strength of the blocks varied with the percentage of WEO incorporated into the sandcrete mix. Figure 4.3 shows the variation between compressive strength and WEO percentage added at 7 and 28 days of curing.

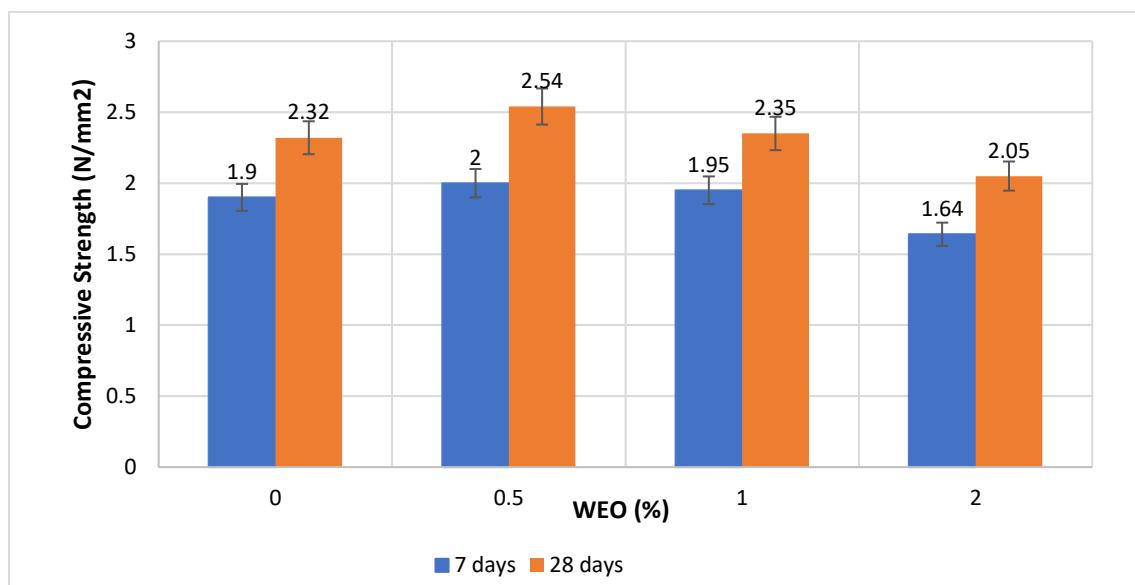


Figure 4.3 Compressive strength at 7 and 28 days

The control mix (0% WEO) showed a high compressive strength of 1.90N/mm<sup>2</sup> at 7 days of curing meaning that the hydration process of cement occurred efficiently in the sandcrete mix in the absence of WEO. However, as the percentage of WEO increased, there was a significant decline in the strength of the sandcrete block. At 0.5% WEO an increase in compressive strength from 1.90N/mm<sup>2</sup> to 2.0N/mm<sup>2</sup> was seen showing that that small amounts of oil don't have a significant influence with the cement matrix.

At 1.0% WEO the compressive strength decreased meaning that the WEO had a negative effect on the internal bonding of the sandcrete. This could be due to WEO coating the cement particles and preventing full hydration of the cement hence weakening the cohesion between the aggregate and the binder. At 2.0% WEO the compressive strength decreased significantly and this confirmed that high amounts of WEO disrupt the hydration of cement, leading to weak sandcrete blocks that may not be structurally viable for load-bearing applications.

At 28 days of curing the control mix (0% WEO) showed a high compressive strength of  $2.32\text{N/mm}^2$  curing meaning that hydration of cement occurred efficiently and fully in the sandcrete mix in the absence of WEO. Unlike at 7 days of curing as the percentage of WEO increased, there was a significant increase in the strength of the sandcrete block. At 0.5% WEO the compressive strength increased from  $2.32\text{N/mm}^2$  to  $2.54\text{N/mm}^2$  showing that small amounts of oil do not influence the cement matrix or affect the hydration process of the cement hence efficient production of hydration products.

At 1.0% WEO the compressive strength decreased meaning that the WEO negatively affected the internal bonding of the sandcrete. This could be due to WEO coating the cement particles and preventing full hydration of the cement hence weakening the cohesion between the aggregate and the binder. At 2.0% WEO the compressive strength decreased significantly confirming that high amounts of WEO disrupt the hydration of cement, leading to weak sandcrete blocks that may not be structurally viable for load-bearing applications.

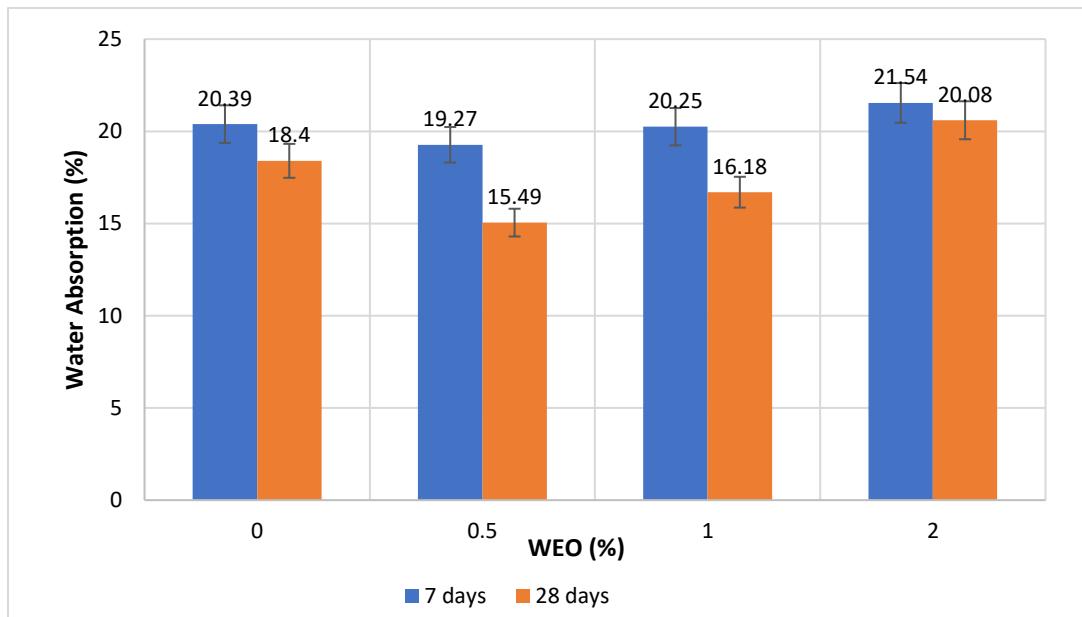
This suggests that addition of WEO in small amounts does not significantly affect the hydration process of the cement hence production of hydration products. The decrease in compressive strength is due to the effect of WEO with cement hydration preventing proper bonding within the concrete matrix. At lower concentrations i.e. 0.5% WEO this effect is less but as the percentage of WEO increases the impact becomes more hence reducing the structural integrity of the concrete. However, excessive WEO content disrupts the cement matrix, a phenomenon consistent with findings by Sun et al. (2020) who noted that excessive entrained air weakens concrete.

The optimum proportion of 0.5% WEO achieved a 28-day compressive strength of 2.54 N/mm<sup>2</sup> which is 8% improved compared to control samples. But this still does not achieve the UNBS standard of 3.5 N/mm<sup>2</sup> for load-bearing blocks. This restriction suggests that WEO-modified blocks are suitable for only non-load-bearing applications unless combined with other strength enhancers. The decrease in compressive strength at higher concentrations of WEO ( $\geq 1.0$ ) is accompanied by interference in cement hydration. This supports the findings of Chen et al. (2021) who stated about the interference of oil within cement matrix.

#### **4.2.3 Water Absorption**

Water absorption test is important when determining the performance of sandcrete blocks in conditions of excessive moisture and humidity. The results show that the water absorption capacity of the blocks varied with increasing percentage of WEO incorporated into the sandcrete mix. It was obtained with reference to the BS standards as in the methodology and the results that were obtained are shown in the graph below.

Figure 4.4 shows the variation between water absorption capacity and WEO percentage added at 7 and 28 days of curing.



*Figure 4.4 Water absorption Capacity of sandcrete blocks at 7 and 28 days*

The results indicate a gradual decline then increase in water absorption as the WEO percentage increased when the blocks had cured for 7 days. The control mix, with 0% WEO had a highwater absorption capacity of 20.39%. However, when 0.5% WEO was used there was a reduction in water absorption capacity of the blocks observed from 20.39% to 19.27% indicating that the waste engine oil acted as a barrier against moisture penetration.

At 1.0% WEO, there was a decrease in water absorption from 20.25% to 16.18% showing that the hydrophobic nature of WEO reduced the sandcrete affinity for water. This shows that the WEO filled some of the pores hence making the sandcrete less permeable. At 2.0% WEO the water absorption capacity of the sandcrete blocks was noticed to increase significantly from 20.25% to 21.54% absorption rate was recorded.

This means that at higher oil concentrations, the sandcrete becomes increasingly permeable to moisture penetration due to WEO coating the cement particles and preventing full hydration of the cement hence weakening the cohesion between the aggregate and the cement leading to formation of more pores in the sandcrete block.

At 28 days of curing the results show a gradual decline followed by an increase in water absorption as the WEO percentage increased. The control mix, with 0% WEO had a highwater absorption capacity of 18.4% indicating that conventional sandcrete has a relatively open pore structure due to the sand that allows moisture penetration into the block. At 0.5% WEO used the water absorption capacity of the blocks was observed to reduce from 18.4% to 15.49% meaning that the waste engine oil acts as a partial barrier against moisture penetration into the sandcrete block by filling of the pores present caused by the sand.

At 1.0% WEO the water absorption reduced from 18.4% to 16.18% showing that the hydrophobic nature of WEO reduced the sandcrete ability to absorb water. This shows that the WEO filled some of the capillary pores, making the sandcrete less permeable. At 2.0% WEO the water absorption capacity of the sandcrete blocks was noticed to increase significantly from 15.49% to 20.4%. This is similar to the studies by Shafiq et al. (2011) that at higher WEO concentrations the sandcrete becomes more permeable to moisture penetration due to WEO coating the cement particles hence preventing full hydration of the cement thus weakening the cohesion between the sand and the cement leading to formation of more pores in the sandcrete block that allow moisture penetration.

The reduction in water absorption at 0.5% of WEO is because of the hydrophobic nature of WEO which repels water. It reacts with cement to fill the voids in the sandcrete, leading to reduced water absorption capacity. This makes the sandcrete blocks suitable for applications where moisture resistance is a priority such as in environments prone to high humidity or water exposure as evidenced by the results of 28 days of curing.

This showed that small amounts of WEO at 0.5% can improve the properties of sandcrete blocks without compromising its structural integrity leading to improved compressive strength and reduced water absorption. However, as the WEO content increases beyond 1%, it negatively affects cement hydration weakening the internal bonding of the cement and sand hence increasing permeability of the sandcrete blocks. At 2.0% WEO, the blocks become structurally weak and highly permeable, making them unsuitable for load-bearing applications.

Therefore 0.5% WEO is the optimal proportion having a compressive strength of  $2.54\text{N/mm}^2$  and reduced water absorption of 15.49% that shows there is balanced strength, durability, and water resistance making it a potential additive for sandcrete blocks in environments prone to moisture exposure. This reduction in water absorption at lower WEO concentrations aligns with observations by Chen, Qin, and Lau (2021), who reported similar hydrophobic effects when used engine oil was incorporated into concrete having an optimum percentage of 0.3%.

#### 4.2.4 Capillary action

The capillarity test was carried out to know how the sandcrete blocks resist moisture movement through capillary action. This is one of the causes of dampness issues in structures. The results show that capillary rise through the blocks varied with increasing percentage of WEO incorporated into the sandcrete mix. It was obtained with reference to the BS standards as in the methodology and the results that were obtained are shown in the graph below. Figure 4.4 shows the variation between capillary action and time at different WEO percentages after 24 hours.

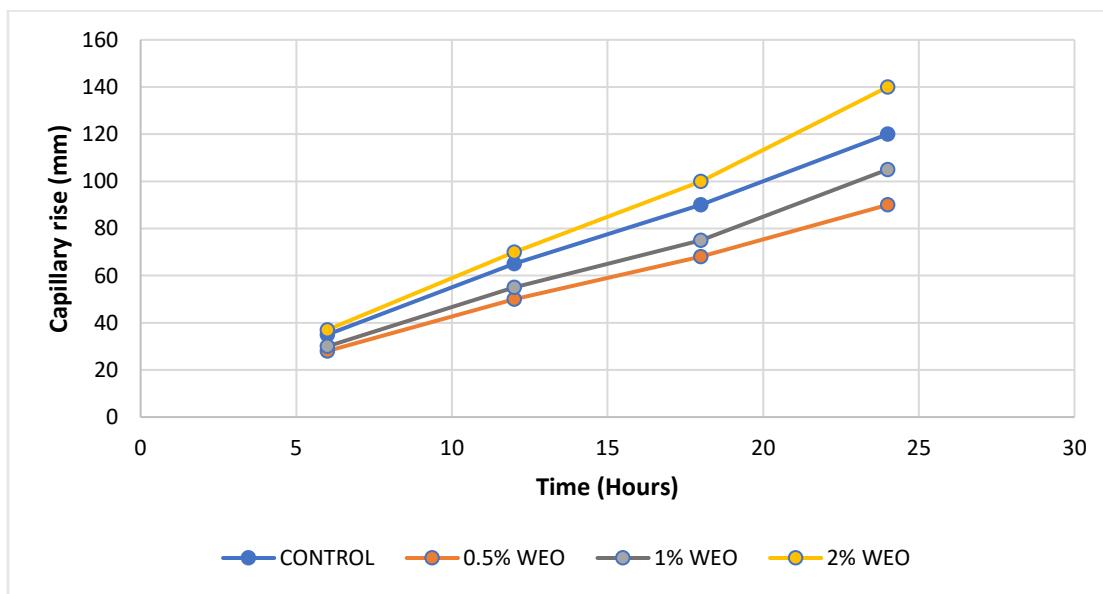


Figure 4.5 Capillary rise through the blocks

From the results, there is a distinct relationship between WEO content and capillary rise performance. The blocks with content of 0.5% WEO are seen to have much lower water uptake due to capillary action compared to the control mix. There was a 30% decrease in capillary rise from 120mm in the control to 90mm in the block with 0.5% WEO in a period of 24 hours during the test. This can be due to the hydrophobic

properties of WEO filling and sealing the microscopic pores of the sandcrete matrix (Adewuyi & Adegoke, 2021) when it physically reacts with the cement to form the gel-like substance.

At 1.0% WEO concentration, the capillary rise of the block with 0.5% WEO was surpassed with water rising higher than in the samples having 0.5% WEO concentration. This is consistent with the results of other tests which showed that excess WEO disrupts cement hydration and forms a more permeable structure, which would favour water movement. The samples with 2.0% WEO showed measurements relating to capillary rise close to those of blocks utilized for control, which indicates that some advantages of WEO aren't possible at excess concentrations. This outcome hence further confirmed the assertion that 0.5% WEO gave maximal wetness resistance with structural carrying strength in the production of sandcrete blocks.

Accordingly, these results from the capillarity test supplement and reinforce those of other major findings of the study which included the compressive strength and water absorption measurements and correlate with findings of Mehta & Monteiro, (2017). Thus, these three tests bring a complete view of how the WEO modifies the properties of sandcrete all of them confirm that 0.5% is the ideal dosage. Moreover, this reduced capillary action at this concentration would thus be in practical terms good for even damp constructions since it would inhibit the ground moisture rising through masonry columns. The same feature together with the previously mentioned enhancement about absorption as well as strength makes WEO modified sandcrete blocks better placed in

foundation and other below-grade applications (American Concrete Institute, 2019) where dampness becomes crucial.

#### **4.3 Findings**

1. The study found that WEO has a viscosity index of 95 and density of 940kg/m<sup>3</sup> showing that it remains thick and viscous at all temperatures. The ph. value of 4.02 suggests that the WEO is mildly acidic but within acceptable limits for use as an additive in construction. Lead concentration of 42.51ppm is below the safety limit of 50ppm hence making the WEO safe for use in sandcrete blocks.
2. The optimal WEO proportion was observed to be 0.5% WEO as it effectively reduced water absorption by 20% from 18.7% to 14.54% and increased the compressive strength by 8% without compromising it. However higher concentrations ( $\geq 1.0\%$ ) were found to reduce compressive strength due to interference with the cement hydration process, which weakens the bond between cement particles and ultimately weakens the block.
3. The results showed at small amounts of 0.5% WEO, the compressive strength, water absorption and capillarity of the blocks improved favourably. This is because WEO gives an added advantage by protecting the entire wall as opposed to simply sealing the surface. Results from capillary rise showing a 30% reduction prove the WEO's performance in keeping rising damp levels low which is not typical for surface-applied treatments in the areas of Kawempe Division.

#### 4.4 Research Design

The sandcrete mix was done using standards set by UNBS. A mix ratio of 1:6 was obtained from these values and was used during the experimental investigation. Table 4.4 below shows the mix design details and final figures after calculation.

*Table 4.4 Mix design for sandcrete blocks*

Parameter	Value
Characteristic strength	3.5 N/mm <sup>2</sup>
Target mean strength	5 N/mm <sup>2</sup>
Cement Sand ratio	1:6
Free water cement ratio	0.5
Cement content	285.1 kg/m <sup>3</sup>
Sand content	1710.6 kg/m <sup>3</sup>
Specific gravity of sand	2.6

The WEO was added in different percentages of 0%, 0.5%, 1.0% and 2% in different mixes and the optimum mix design was obtained at 0.5% WEO added to the sandcrete mix.

##### 4.4.1 Optimum mix design

The WEO is added in different amounts based on the percentage of the weight of cement. It improves the water resistance of the blocks due to its hydrophobic nature and filling of the pores in the sandcrete blocks. Table 4.5 below shows the material

composition and quantities that compose of the sandcrete blocks incorporating the optimum percentage of WEO in them which is 0.5%. It also contains the quantities to make 1m<sup>3</sup> of sandcrete. The mix design with 0.5% WEO performs best showing relatively good strength and water resistance.

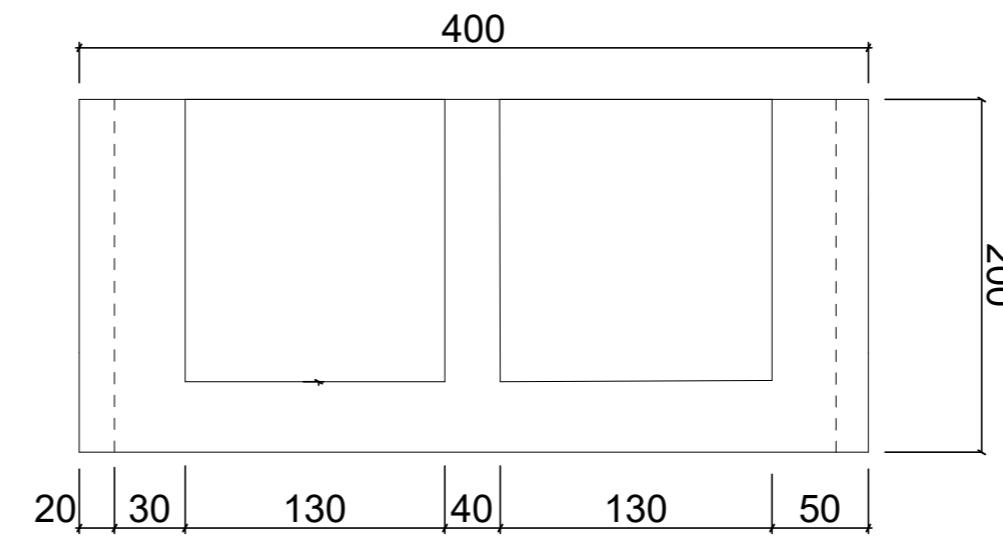
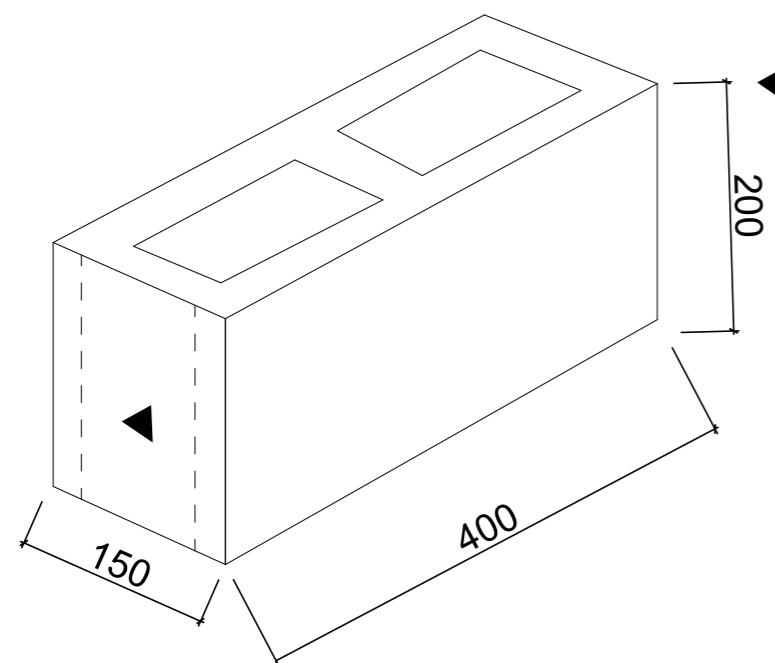
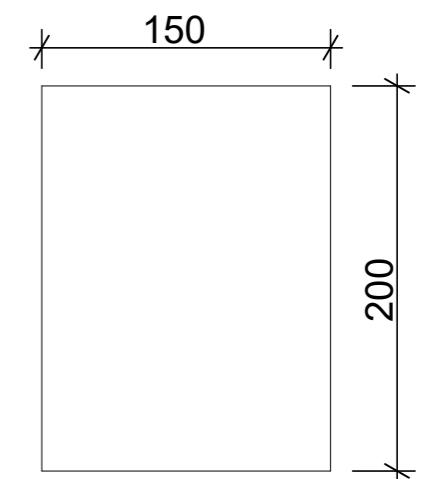
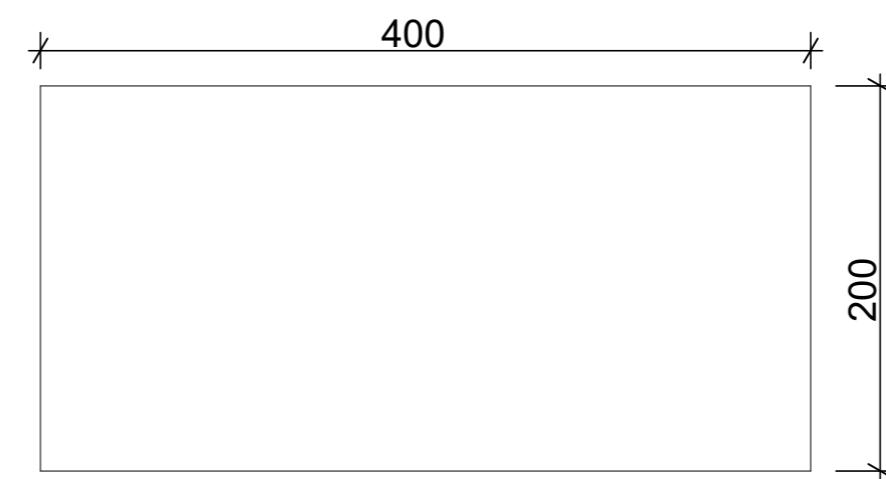
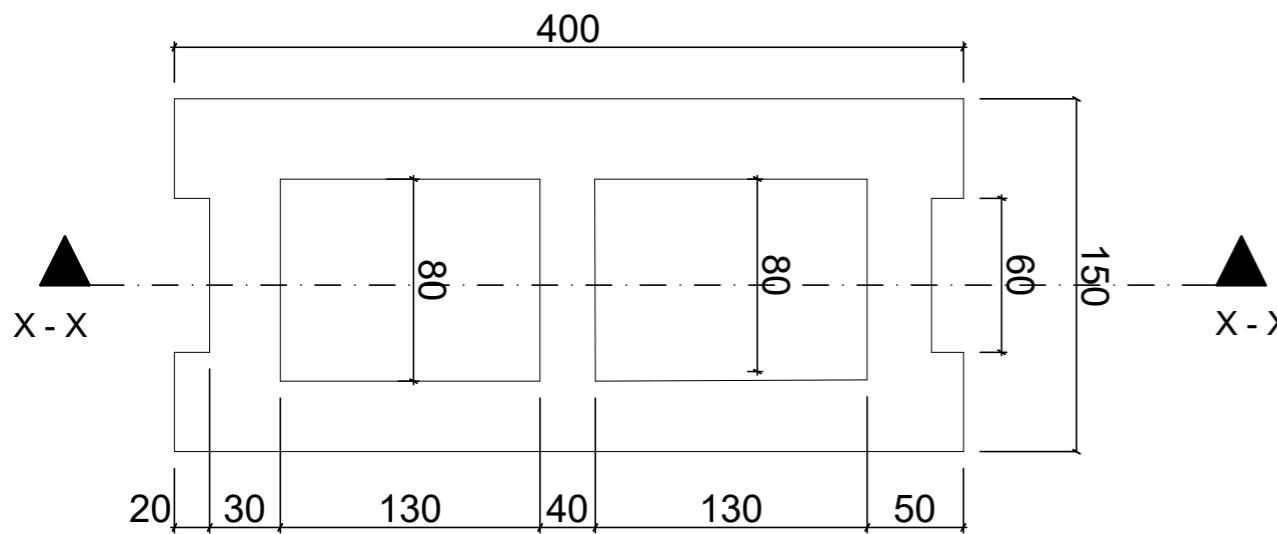
*Table 4.5 Optimum mix design for the sandcrete blocks*

Material	Description	Mix proportion
Cement	OPC 32.5N/mm <sup>2</sup> , Portland cement Cem IV	285.1 kg/m <sup>3</sup>
Sand	Well graded Coarse sand fineness modulus 3.2 specific gravity 2.6	1710.6 kg/m <sup>3</sup>
Water	Clean water	142.6 kg
WEO	Used engine oil from petrol and diesel engines	1.43 kg

#### Optimum mix ratio

*Table 4.6 Optimum mix ratio for the sandcrete blocks*

Cement	Sand	Water	WEO
1	6	0.5	0.005



<b>PROJECT TITLE</b>
ASSESSING THE USE OF WASTE ENGINE OIL IN SANDCRETE BLOCKS
<b>NAME:</b> RWOTBER RAYMOND
<b>DRAWING NAME</b>
SANDCRETE BLOCK
<b>DRAWING SCALE</b>
1:10
<b>LAYOUT</b>
A3

## CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

### 5.1 Conclusions

1. WEO has hydrophobic properties meaning it can repel water while maintaining compatibility with cementitious materials hence reducing the risk of dampness.
2. The sandcrete blocks have a reduced water absorption capacity at 0.5% WEO without compromising the compressive strength. At higher concentrations the compressive strength decreased due to the hindering of cement hydration and weakening of the bond between the cement and WEO and ultimately weakens the block.
3. Water absorption and capillarity tests confirmed that WEO acts as a barrier for water capillarity but high concentrations increase permeability due to inadequate cement hydration hence small amounts of WEO are suitable to reduce dampness in sandcrete blocks.

### 5.2 Recommendations

1. Further research should be done to explore the potential of combining WEO with other waste materials such as fly ash and rice husk ash to create composite additives for sandcrete blocks and increase compressive strength further.

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## APPENDIX

### APPENDIX A: PICTORIAL



Figure 6.0.1 Sandcrete blocks made with WEO



Figure 6.0.2 Sandcrete block Mold



Figure 6.0.3 Prototype wall made with sandcrete blocks having 0.5% WEO



Figure 6.4 Compressive strength test



Figure 6.5 Sandcrete blocks made without WEO

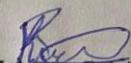
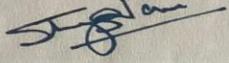


Figure 6.6 Oven used to dry Sandcrete blocks before the water absorption test



Figure 6.7 Prototype wall made with sandcrete blocks having 0% WEO

## APPENDIX B: LABORATORY RESULTS

Plot 15/17 2nd Street Industrial Area Opp Uganda Foundry P.O Box 7155, Kampala Tel. +256779900623, +256705272332 Email: operations@mtal.africa Website: www.mtal.africa		 <b>MOLECULE TECHNOLOGY AFRICA LTD</b>	
<b>Client</b> RWOTBER RAYMOND AND BAKER PURIKERIA		<b>Project</b> ASSESSMENT OF THE USE OF WASTE ENGINE OIL IN SANDCRETE BLOCKS	
<b>LABORATORY RESULTS</b> <b>USED ENGINE OIL: KINEMATIC VISCOSITY</b> <small>Ref: ASTM D 445 - 03</small>			
Reference No.:	MTL/01/25/003	Testing Date:	01/02/2025
Location:	....	Collection Date	01/12/2024
Sample Description:	Dark Brown, viscous liquid with slight particulate matter	Material Source:	Shell Auto workshop, Kampala
Technician	Moses W. Eric	Engineer	Eng. Shyam Nath
SAMPLE NO	Temperature (°C)	Viscosity Reading (cSt)	Viscosity Index
1	40	101.8	95
2	100	14.2	
<b>Remarks</b> The results for the sample are as above			
<b>PREPARED BY:</b>  Laboratory Technician		<b>APPROVED BY:</b>  Engineer	
			

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### MOLECULE TECHNOLOGY AFRICA LTD

Client	Project
RWOTBER RAYMOND AND BAKERA PURIKERIA	ASSESSMENT OF THE USE OF WASTE ENGINE OIL IN SANDCRETE BLOCKS

### LABORATORY RESULTS

#### USED ENGINE OIL: ELEMENT CONCENTRATION

Ref: ASTM D 5185 - 18

Reference No.:	MTL/01/25/004	Testing Date:	01/02/2025
Location:	....	Collection Date:	01/12/2024
Sample Description:	Dark Brown, viscous liquid with slight particulate matter	Material Source:	Shell Auto workshop, Kampala
Technician	Moses W. Eric	Engineer	Eng. Shyam Nath

Parameter	Units	Results
Lead	ppm	42.51
Zinc	ppm	58.25
Chromium	ppm	n.d.
Nickel	ppm	BDL
Cadmium	ppm	22.37
Iron	ppm	61.49
Manganese	ppm	n.d.
Barium	ppm	BDL
Aluminium	ppm	n.d.
Copper	ppm	n.d.

#### Remarks

The results for the sample are as above

BDL- Below Detection Limit

n.d.-Not Detected

#### PREPARED BY:

Laboratory Technician

#### APPROVED BY

Engineer



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### MOLECULE TECHNOLOGY AFRICA LTD

Client	Project					
RWOTBER RAYMOND AND BAKERA PURIKERIA	ASSESSMENT OF THE USE OF WASTE ENGINE OIL IN SANDCRETE BLOCKS					
<b>LABORATORY RESULTS</b>						
<b>USED ENGINE OIL: TOTAL ACID NUMBER (TAN)</b>						
Ref: ASTM D 664 - 24						
Reference No.:	MTL/01/25/002	Testing Date:	01/02/2025			
Location:	....	Collection Date	01/12/2024			
Sample Description:	Dark Brown, viscous liquid with slight particulate matter	Material Source:	Shell Auto workshop, Kampala			
Technician	Moses W. Eric	Engineer	Eng. Shyam Nath			

SAMPLE NO	Temperature (°C)	TAN Reading (mg KOH/g)	Average TAN Value (mg KOH/g)
1	30	1.91	
2	30	1.88	
3	30	1.79	1.89

#### Remarks

The results for the sample are as above

#### PREPARED BY:

Laboratory Technician

#### APPROVED BY

Engineer





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#### DENSITY DETERMINATION OF WASTE ENGINE OIL USING A HYDROMETER

<b>Project:</b>	N/A		
<b>Client</b>	Raymond Rwother	<b>Date Received:</b>	18/01/25
<b>Location/ chainage:</b>	N/A	<b>Testing date:</b>	18/01/25
<b>Sample reference:</b>	TS/01/25/C	<b>Technician:</b>	NS
<b>Sample source</b>	Wandegeya shell petrol station garage		
<b>Sample description:</b>	Waste Engine oil		

Reference method: ASTM D 1298 -99

<b>Test No.</b>	<b>Density of reference Substance (Water)</b>		<b>Hydrometer reading of the sample under testing. (Waste Engine oil)</b>			<b>Average Density (Kg/m<sup>3</sup>)</b>
	<b>Temp °C</b>	<b>Density (Kg/m<sup>3</sup>)</b>	<b>Temp °C</b>	<b>Relative density</b>	<b>Density (Kg/m<sup>3</sup>)</b>	
1	28	1000	30	0.96	960	954.7
2	28	1010	30	0.94	949.4	

**Remarks:**

These results relate to the sample that were tested

Prepared by:

Laboratory Technician

Approved by:

Technical manager





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### DETERMINATION OF POTENTIAL HYDROGEN (PH) VALUE OF WASTE ENGINE OIL USING PH METER

Project:	N/A		
Client:	Raymond Rwother		
Location / Chainage:	N/A	Date Received:	18/1/25
Sample Reference:	TS/01/25/C	Testing date:	18/1/25
Sample Source:	Wandegeya shell petrol station	Technician:	NS
Sample description:	Waste engine oil		

#### Reference Method : BS 1377: Part 3

Test No.	Temperature of the sample (°C)	PH Reading of the sample	Average PH Value
1	30	4.58	4.59
2	30	4.59	

#### Remarks

These results relate to the sample that was tested  
The oil had changed from its original colour to black.

Prepared by:

Laboratory Technician

Approved by:

Technical Manager





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### COMPRESSIVE STRENGTH OF BLOCKS TEST REPORT

Project:	Assessment of the use of waste motor oil in sandcrete blocks		
Client:	Raymond Rwotber and Bakera Purikeria	Casting Date:	01/02/25
Location/Chainage:	Mukono	Date received:	07/02/25
Sample Description:	Block sample of (400x200x150) mm cured for 7days	Testing date:	08/02/25
		Technician:	NS

#### Reference Method BS 1881 - 116

Sample no.	Waste engine oil (%)	Type of Construction	Weight (g)	Compressive Strength (N/mm²)	Average Compressive Strength (N/mm²)
TS/22/25/C	CONTROL	Research	3979.2	1.97	1.97
			3867.9	1.80	
TS/23/25/C	0.5	Research	3893.5	1.91	2.00
			3989.4	2.11	
TS/24/25/C	1.0	Research	3754.8	1.87	1.95
			3989.9	1.99	
TS/25/25/C	2.0	Research	3417.4	1.69	1.64
			3319.7	1.81	

#### Remarks

- 1.0. 4no. Block samples of (400x200x150)mm were delivered by the client to the laboratory for testing.
- 2.0. Core pieces from (400x200x150) mm block samples were tested.
- 3.0. These results only apply to the samples that were tested.

Prepared by:

Laboratory Technician

Approved by:

Technical Manager





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### WATER ABSORPTION OF BLOCKS TEST REPORT

Project:	Assessment of the use of waste motor oil in sandcrete blocks		
Client:	Raymond Rwother and Bakera Purikeria	Casting Date:	01/02/25
Location/Chainage:	Mukono	Date received:	07/02/25
Sample Description:	Block sample of (400x200x150) mm cured for 7days	Testing date:	08/02/25
		Technician:	NS

#### Reference Method BS 1881 - 122

Sample no.	Waste engine oil (%)	Type of Construction	Oven Dried Weight (g)	Weight after Submersion (g)	Water Absorption (%)	Average Water Absorption (%)
TS/31/25/B	CONTROL	Research	3987.6	4760.0	19.39	20.39
			3967.9	4815.6	21.39	
TS/32/25/B	0.5	Research	3893.3	4637.9	19.10	19.27
			3999.2	4839.1	21.0	
TS/33/25/B	1.0	Research	3754.5	4476.0	19.23	20.25
			3999.9	4849.6	21.25	
TS/33/25/B	2.0	Research	3317.4	4012.7	20.94	21.94
			3319.7	4080.1	22.90	

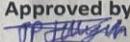
#### Remarks

- 1.0. 4no. Block samples of (400x200x150)mm were delivered by the client to the laboratory for testing.
- 2.0. Core pieces from (400x200x150) mm block samples were tested.
- 3.0. These results only apply to the samples that were tested.

Prepared by:

  
Laboratory Technician

Approved by:

  
Technical Manager





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### WATER ABSORPTION OF BLOCKS TEST REPORT

Project	Use of Waste Engine Oil in Concrete Blocks		
Client:	Raymond Rwother - Student	Casting Date:	N/A
Location/ Chainage:	Mukono	Date received:	7/3/2025
Sample Description:	Block sample of (400x200x150) mm cured for 28days	Testing Date:	9/3/2025
		Technician:	MF

Reference Method: BS 1881- 122

Sample no.	Waste engine oil (%)	Type of Construction	Oven Dried Weight (g)	Weight after Submersion (g)	Water Absorption (%)	Average Water Absorption (%)
TS/61/25/B	CONTROL	Research	3987.6	4718.6	18.33	18.33
			3969.1	4696.4	18.32	
TS/62/25/B	0.5	Research	3893.3	4490.6	15.34	15.49
			3999.1	4624.1	15.63	
TS/63/25/B	1.0	Research	3754.2	4359.9	16.13	16.18
			3999.1	4647.8	16.22	
TS/64/25/B	2.0	Research	3317.4	3983.1	20.07	20.08
			3319.7	3986.5	20.09	

**Remarks:**

1.0. 4no. Block samples of (400x200x150)mm were delivered by the client to the laboratory for testing.

2.0 Core pieces from (400x200x150) mm block samples were tested.

3.0 These results only apply to the samples that were tested.

Key: N/A - Not Available

Checked by  
  
Laboratory Engineer

Approved by  
  
Technical Manager





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### COMPRESSIVE STRENGTH OF BLOCKS TEST REPORT

Project:	Assessment of the use of waste motor oil in sandcrete blocks		
Client:	Raymond Rwother and Bakera Purikeria	Casting Date:	1/2/2025
Location/Chainage:	Mukono	Date received:	7/3/2025
Sample Description:	Block sample of (400x200x150) mm cured for 28days	Testing date:	9/3/2025
		Technician:	NS

#### Reference Method BS 1881 - 116

Sample no.	Waste engine oil (%)	Type of Construction	Weight (g)	Compressive Strength (N/mm²)	Average Compressive Strength (N/mm²)
TS/71/25/C	CONTROL	Research	3989.2	1.99	2.32
			3857.9	2.40	
TS/72/25/C	0.5	Research	3843.5	2.25	2.54
			3969.4	2.75	
TS/73/25/C	1.0	Research	3754.8	2.47	2.35
			3989.9	1.99	
TS/74/25/C	2.0	Research	3417.4	2.09	2.05
			3319.7	2.01	

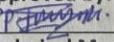
#### Remarks

- 1.0. 4no. Block samples of (400x200x150)mm were delivered by the client to the laboratory for testing.
- 2.0. Core pieces from (400x200x150) mm block samples were tested.
- 3.0. These results only apply to the samples that were tested.

Prepared by:

  
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Approved by:

  
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