

ASSESSING THE USE OF ACTIVATED PRESS MUD IN STRENGTH OF LOW GRADE CONCRETE

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S21B32/077

**A FINAL YEAR RESEARCH AND DESIGN PROJECT REPORT SUBMITTED TO THE
FACULTY OF ENGINEERING, DESIGN AND TECHNOLOGY, IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE AWARD OF A DEGREE OF BACHELOR OF SCIENCE
IN CIVIL AND ENVIRONMENTAL ENGINEERING OF UGANDA CHRISTIAN UNIVERSITY**

April, 2025



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ABSTRACT

Concrete is the most widely used construction material globally, valued for its benefits in cost and versatility. There are many classes of concrete one of being low grade concrete. The purpose of this research was to assess the use of activated press mud in enhancing the strength of low-grade concrete.

Activated press mud contains pozzolanic compounds that react with calcium hydroxide to form calcium silicate hydrate which enhances concrete strength. To evaluate its effectiveness, activated press mud was used to partially replace cement at 0% - 20%. X-ray fluorescence, loss on ignition, Chapelle test, specific gravity, slump test and compressive strength were done. Results confirmed pozzolanic properties and contribution to concrete strength. Slump results showed workability remained within acceptable limits (25 mm - 50 mm). Most notably 44% increase in compressive strength was observed upgrading concrete from class C15 to C20.

The findings support the adoption of industrial waste materials in concrete production to reduce cement consumption and environmental impact. It is recommended that further studies explore long-term durability and field performance to optimize its application in large-scale construction projects.

DECLARATION

I hereby declare that this is my original work, it isn't plagiarized and has not been submitted to any other institution or company for any award.

Signed:

.....

Date:

.....

APPROVAL

I certify that this report is written by KIRABO JESSE ALLAN and I fully accept that he has been under supervision and so submitted to the Faculty of Engineering, Design and Technology at Uganda Christian University in partial fulfillment of the requirements for an award of a Bachelor of Science in Civil and Environmental Engineering.

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ACKNOWLEDGEMENTS

I would like to thank God for enabling me to carry out this research project and giving me the ability to see it through till its completion.

I would also like to thank my parents for their support financially and emotionally for their support enabled me to complete and focus on the project and without them I would not have finished this project.

I would also like to extend my thanks to Mr. Zzigwa Marvin, who guided me through vital concepts and advised me throughout my research project as my academic supervisor. I would also like to thank him for the time he accorded me and my project partner in this research project.

I would like to thank my project partner Mr. Lwanyaga Joshua for being active and helpful throughout the project time.

Finally, I would like to thank the Faculty of Engineering, Design and Technology at Uganda Christian university for supporting us and allowing us to do this research under their guidance and supervision.

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List of acronyms and abbreviations

APM	Activated Press mud
ASTM	American Society for Testing and Materials
BS	British Standard
C-S-H	Calcium Silicate Hydrate
CEM	Cement
LOI	Loss on ignition
PPC	Pozzolana Portland Cement
SCM	Supplementary Cementitious Material
XRF	X-ray Fluorescence

CHAPTER ONE: INTRODUCTION

1.0 BACKGROUND

Concrete is the most widely used construction material globally, valued for its benefits in cost and versatility. There are many classes of concrete one of being low grade concrete characterized by reduced strength and this often leads to structural inefficiencies and increased durability loss. Enhancing the performance of such concrete is essential, particularly in regions where economic constraints limit the use of high performance alternatives.

In Uganda, the construction industry frequently utilizes low grade concrete due its affordability and the high cost of quality construction materials. This practice poses significant challenges. The use of insufficient cement in concrete mixes often as a cost saving measure results in weak structures prone to crumbling under pressure. A notable example is the collapse of Speke Courts extension building in Jinja, attributed to inadequate cement content in concrete mixture used for the foundation and beams (Zziwa, 2023). Additionally, the widespread use of low grade concrete in construction has led to structural deficiencies including reduced compressive strength and durability issues. Factors contributing to these problems include mix designs, inadequate curing and use of low strength cement (Delmec, 2023).

To address these issues, there is a growing interest in incorporating supplementary cementitious materials (SCMs). Industrial by products provide an alternative to commonly used SCMs like metakaolin, volcanic ash among others. These are used to enhance concrete properties like strength, workability and chemical resistance. SCMs

often react with calcium hydroxide during cement hydration to form binding compounds which improves concrete strength (Singh et al., 2024). Press mud, a by product of the sugar industry is a potential SCM in its activated form due to its pozzolanic characteristics. When activated thermally or chemically, press mud can react with cement hydration products contributing to the formation of calcium silicate hydrate gel (C-S-H gel), which are crucial for strength development in concrete. This research aims to evaluate the effectiveness of activated press mud in improving the strength and durability of low grade concrete by assessing its pozzolanic properties.

1.1 PROBLEM STATEMENT

In Uganda, the widespread use of low grade concrete in construction has led to structural deficiencies, including reduced compressive strength and durability. Factors that contribute to these problems include poor mix designs, inadequate curing and use of low strength cement. These have been linked to foundation failures and early structural deterioration of structures (Delmec, 2023). A notable example is the collapse of Speke Courts extension building in Jinja, attributed to inadequate cement content in concrete mixture used for the foundation and beams (Zziwa, 2023).

Despite Uganda's abundant natural pozzolans particularly in volcanic areas like Kisoro and Kable their potential to improve concrete performance remains underutilized (Olupot et al., 2014). Research has shown that pozzolanic materials when properly processed and combined in cementitious compounds can enhance concrete properties. However, there is limited research on pozzolanic materials in low grade concrete.

This gap presents an opportunity to develop concrete solutions for low grade concrete based on potential pozzolanic materials that are locally available and provide a source of alternative supplementary cementitious materials, this research focuses on the use of activated press mud as a potential pozzolan to improve low grade concrete strength in Uganda.

1.2 OBJECTIVES

1.2.1 Main Objective

To assess the use of activated press mud in strength of low grade concrete.

1.2.2 Specific Objectives

1. To determine the chemical and physical properties of activated press mud.
2. To assess the impact of activated press mud on workability of low grade concrete.
3. To assess the effect of activated press mud on the compressive strength of low grade concrete.

1.3 RESEARCH QUESTIONS

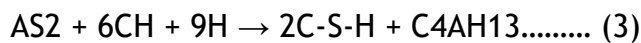
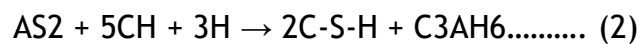
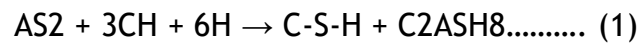
1. What are the chemical and physical properties of activated press mud and how can they be obtained?
2. What methods can be used to obtain impact of activated press mud on low grade concrete?
3. What is the effect of activated press mud on the compressive strength of low grade concrete?

1.4 JUSTIFICATION

1.4.1 Potential Pozzolanic Reaction

Activated press mud contains high Silica (SiO_2) & Alumina (Al_2O_3), essential for pozzolanic activity. These react with $\text{Ca}(\text{OH})_2$ in cement hydration form C-S-H gel improving concrete strength due to the increase of C-S-H gel formed from the excess lime content in the concrete mix to form a binder.

Chemical reactions of activated press mud in concrete



where: AS₂ is activated pressmud ($\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$), CH is calcium hydroxide ($\text{Ca}(\text{OH})_2$), H is water (H_2O), C-S-H is the collective term for calcium silicate hydrates having wide range of C/S molar ratios (C: CaO; S: SiO_2), C₂ASH₈ is hydrated stratlingite, C₃AH₆ is tricalcium aluminate hydrate, C₄AH₁₃ is tetracalcium aluminate hydrate (Weise et al, 2022).

1.4.2 Potential Strength Enhancement

Activated press mud has the potential to improve compressive strength by increasing C-S-H gel formation due to its high amorphous silica and alumina content. The fine particles of activated press mud provide an increased surface area for pozzolanic reactions since they have similar sizes to that of cement for effective dispersion and reactivity.

1.5 SCOPE

1.5.1 GEOGRAPHICAL SCOPE

Press mud was obtained from Sugar Corporation of Uganda Ltd (SCOUL) in Lugazi town, Buikwe District at 0°22'59''N, 32°56'27'E (Latitude :0.383056, Longitude :32.940833).

The cement was obtained from a hardware store in Mukono other materials including fine aggregates, coarse aggregates and water where obtained from Stirling Civil Engineering Ltd.

1.5.2 CONTENT SCOPE

The scope of this research was aimed at improving strength of low grade concrete generally using activated press mud that has been processed from its raw form.

1.5.3 TIME SCOPE

This research was be carried out from August 2024 to March 2025.

CHAPTER TWO: LITERATURE REVIEW

2.0 INTRODUCTION

This chapter focuses on the theoretical aspect of which the research was carried out and centered, therefore it brings to light the important issues from reading and analyzing different scholars' research findings.

2.1 CONCRETE

Concrete refers to a mixture of cement, water and aggregates i.e. sand and gravel which are bound together over time to create a solid substance. It is used in a lot of construction projects due to its affordability, durability and its ability to be molded into nearly any shape.

2.2 CONCRETE COMPOSITION

Concrete is made up of three main compositions i.e. cement, aggregates and water. Cement is the paste that glues the concrete together while the aggregates, sand and gravel, provide strength and bulk. The water is used to hydrate the cement and activate the chemical process that hardens the concrete. The water to cement ratio (w/c) is an ideal state in concrete for workability and is required to be calculated because the higher the w/c the weaker and less durable the concrete which makes it more prone to cracking and erosion while lower the w/c ratio, the stronger the concrete which makes it less prone to cracking and erosion.

2.3 CLASSIFICATION OF CONCRETE

Concrete is classified basing on its density, strength, intended use or application and composition.

2.3.1 Based on density

- i) Light weight concrete: This type has a density of less than $1,920 \text{ kg/m}^3$ and is often used for thermal insulation and non-load bearing applications (Nevile,2011) for example foam concrete and aerated concrete.
- ii) Normal weight concrete: This has a density ranging from $1,920$ to 2500kg/m^3 , and this is the most used type of concrete for general construction.
- iii) Heavy weight concrete: This type is primarily used for radiation shielding in nuclear power plants and it has a density greater than $2,500 \text{kg/m}^3$. To achieve the high density, Barite and magnetite aggregates are specifically used for this mix (Gambhir, 2004)

2.3.2 Based on strength

- i) Ordinary concrete or low grade concrete: This has a compressive strength ranging from 10 to 20MPa and it is commonly used for simple applications like pavements, blinding and mass concrete. (Mehta &Monteiro, 2014).
- ii) Standard concrete or normal concrete: This has a strength ranging between 20 to 50MPa making it suitable for high-rise buildings and commercial structures
- iii) High strength concrete: This concrete exceeds over 50MPa and it is used for load-bearing applications like retaining walls, and dams.

2.3.3 Based on composition

- i) Plain cement concrete which is just a simple mix of cement, sand and aggregates without reinforcement.
- ii) Lime concrete which uses lime as a binding agent instead of cement.

- iii) Fiber-reinforced concrete contains fibers like steel, glass, or synthetic materials in order to improve the mechanical properties.
- iv) Self compacting concrete this flows and consolidates under self-weight without external vibration.

There are many other types of concrete based on concrete the above represent a few common types used around the world for various reasons.

2.4 CONCRETE GRADES

Grades of concrete are normally defined by their strength and composition. The minimum strength of concrete should be measured at 28 days for accepted strength parameters. The grade of concrete is understood by measurements in MPa, where “M” stands for mix design for example M10, M20 as per Indian Standards and “C” stands for concrete strength class and can be denoted as C15, C25 as British Standards (Muhammad, 2019).

2.5 CONCRETE MIX RATIO

Concrete mix ratio is the process that involves selecting the suitable ingredients and determining their quantities to produce a concrete mix for a specified purpose. This could be in terms of workability, high strength and durability, the proportion of the concrete ingredients will depend on their characteristics (JK Cement, 2023). The mix depends on water, cement and aggregates where the cement forms the binding agent for the aggregates.

For an ideal concrete mix the following must be considered:

- Ratio of cement paste to aggregates

- Ratio of water to cement
- Ratio of fine to coarse aggregates
- Use of admixtures to improve quality

2.5.1 Types of Concrete mix ratio

Nominal mix concrete

In nominal mix concrete, the proportions of concrete are prefixed. Normally nominal mix is used for small scale constructions. This is for grades from M5 to M20. The water content for any mix is proportionately increased if the quantity of water in the mix has to be increased which could be due to placement or compaction issues.

Standard concrete mix

In standard concrete mix, the proportions 1:2:4, and the grades are normally from M25 to M50.

Design mix concrete

For design mix concrete, a professional civil engineer determines the mix ratios after analyzing the properties of each ingredient. The ratio is determined according to the requirements of quality and strength of concrete. Various additives can be added to obtain the desired strength of concrete per the construction requirement (JK Cement, 2023).

Table 1: Concrete mix ratio design

Type of Concrete	Concrete Grade	Mix Ratio (Cement: Sand: Aggregates)	Characteristic Strength of Concrete at 28 Days in	Compressive
Ordinary Concrete	M5	1:5:10	5 N/mm ²	
	M7.5	1:4:8	7.5 N/mm ²	
	M10	1:3:6	10 N/mm ²	
	M15	1:2:4	15 N/mm ²	
	M20	1:1.5:3	20 N/mm ²	
	M25	1:1:2	25 N/mm ²	
Standard Concrete	M30	Design Mix	30 N/mm ²	
	M35	Design Mix	35 N/mm ²	
	M40	Design Mix	40 N/mm ²	
	M45	Design Mix	45 N/mm ²	
	M50	Design Mix	50 N/mm ²	
High Strength Concrete	M55	Design Mix	55 N/mm ²	
	M60	Design Mix	60 N/mm ²	
	M65	Design Mix	65 N/mm ²	
	M70	Design Mix	70 N/mm ²	

Source : JK Cement, 2023

2.6 LOW GRADE CONCRETE

Low grade concrete is commonly used in non-structural applications, where high strength is not a primary requirement. However recent research has explored its performance for other uses by incorporating SCMs and other industrial by products.

2.6.1 Properties of low grade concrete

Low grade concrete is typically classified by its compressive strength, which is normally 15 MPa according British Standards (Neville, 2011). It is used in mass concrete,

pavements and temporary works. However, it normally exhibits poor durability and low strength. The performance of low grade concrete is influenced by its mix design and curing conditions (Aïtcin, 2003).

2.6.2 Improvement strategies using supplementary cementitious materials

To enhance the properties of low grade concrete, researchers have explored the use of SCMs such as fly ash, metakaolin among others (Chalee, 2009). These have been showed to improved properties like compressive strength, workability, sulphate resistance, durability reduced permeability among other important properties that lea to better concrete.

Activated press mud is an emerging alternative SCM that has the potential to improve strength and durability of concrete due to its pozzolanic activity.

Low grade concrete, despite its limitations remains a crucial material in construct. By incorporating SCMs and industrial by products its mechanical and durability properties can be significantly improved. Future research should focus on optimizing mix designs and assessing the long term performance of modified low grade concrete.

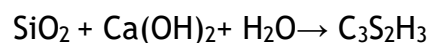
2.7 SUPPLEMENTARY CEMENTITIOUS MATERIALS

Supplementary cementitious materials (SCMs) play a crucial role in enhancing the properties and sustainability of concrete. These materials, including fly ash, slag, silica fume, and metakaolin are used in partial replacement of Portland cement in concrete mixes, providing multiple benefits. Improving concrete durability stands out as a significant advantage of using SCMs. They improve the concrete's microstructure by reducing pore sizes thus lowering permeability and enhancing resistance to chemical

attacks like carbonation and chloride ingress, particularly important for structures in challenging environments such as marine or industrial areas.

In addition to durability, SCMs boost the mechanical properties of concrete by enhancing strength development over time. They undergo pozzolanic reactions with the calcium hydroxide produced during the hydration of Portland cement, resulting in the formation of additional calcium silicate hydrate (C-S-H), which contributes to concrete strength. Decreasing reliance on Portland cement also reduces the carbon footprint of concrete production, making it an eco-friendlier choice. Recent studies have focused on the combined effects of different SCMs to optimize concrete performance. For example, using fly ash and slag together can lead to greater long-term strength gains compared to using each material independently. Additionally, research has explored innovative SCMs derived from waste products, such as municipal solid waste ash and recycled concrete, to further improve sustainability while maintaining or enhancing concrete performance. Progress in processing techniques, such as incorporating nanomaterials or pre-treating SCMs, has demonstrated promising results in increasing the reactivity and performance of these materials in concrete mixes.

The common reason for this due to the silicon dioxide content in the materials that reacts with the calcium hydroxide that is deposited in the hydration process to form C-S-H gel that hardens and forms concrete. i.e.;



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2.8 ACTIVATION OF SUPPLEMENTARY CEMENTITIOUS MATERIALS

The activation of SCMs plays a crucial role in enhancing overall performance in concrete. Activation methods improve pozzolanic reactions enabling them to contribute effectively to cement hydration and strength development. Various international standards provide guidelines like ASTM, BS EN and IS codes provide guidelines on activation of SCMs.

2.8.1 Activation methods

a. Chemical activation

This involves addition of activators such as alkalis, acids and sulphates to enhance the reactivity of SCMs. According to ASTM C618-19, the pozzolanic reactions of SCMs can be

enhanced by chemical treatment particularly with low reactivity or inert materials.

Common activators include;

- Alkalis (NaOH, KOH): Used to dissolve silicates and aluminates promoting early hydration.
- Sulphates (CaSO_4 , Na_2SO_4): these help to improve sulphate resistance and accelerate hydration.

b. Thermal activation

This involves heating SCMs to enhance their pozzolanic potential and reactivity. Most SCMs with organic content like metakaolin for instance is produced by calcining kaolin clay at 600°C - 800°C to transform it into a reactive amorphous phase (ASTM C618, 2019). Furthermore, according to Bureau of Indian Standards 2018, studies show that thermally activated SCMs exhibit improved compressive strength and reduced setting time.

c. Mechanical activation

Mechanical activation involves grinding or milling SCMs to increase surface area and improve their reactivity. According to ASTM C1709-21, when SCMs are made finer in terms of particle size this leads to enhanced hydration kinetics and better particle packing density in concrete. BS EN 197-1 also supports mechanical activation particularly for blast furnace slag and fly ash finer particles contribute to higher pozzolanic reactivity. Research indicates that when the fineness of SCMs is increased it leads to improved compressive strength and durability (Juengar et al, 2015).

2.8.2 Performance and evaluation based on standards.

Some standards provide methods for assessing effectiveness of SCMs and the parameters are reactivity based on purpose and chemical resistance based on durability.

- Pozzolanic reactivity index. This measures the reactivity of potential pozzolanic materials and basing their effect on strength gain a popular method used is the Chapelle's test of reactivity.
- Chemical attack resistance. This tests for chemical durability and the effect of finely ground SCMs on packing of particles and increased formation of C-S-H gel to reduce voids and lime deposits that would otherwise be entrance points of sulphates and the like.

2.9 PRESS MUD IN CONCRETE

Press mud also known as sugarcane press residue is a by product from the sugar manufacturing process. It is the solid residue left after juice clarification in sugar mills (Feedipedia, 2015).

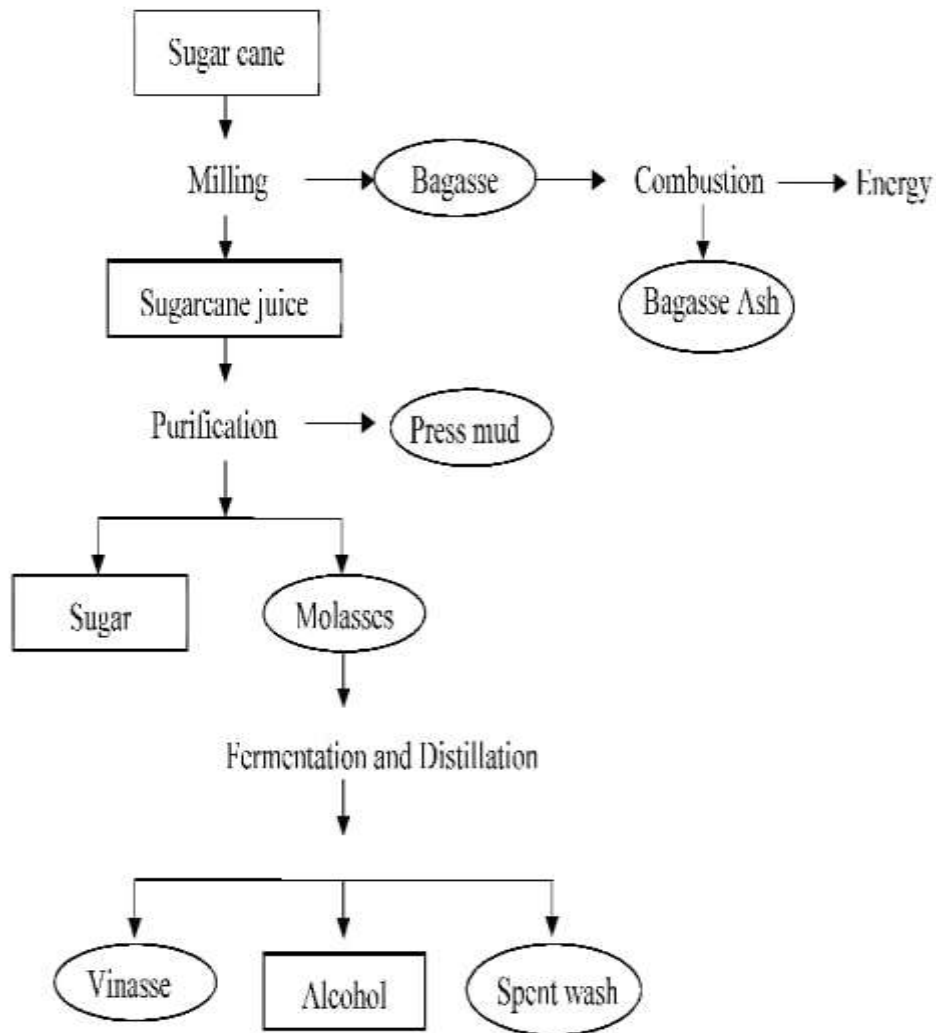


Figure 1: The sugar production sequence

2.9.1 Composition of press mud.

It contains a combination of organic and inorganic materials.

Organic matter: these include cellulose, lignin, sugars and proteins.

Inorganic matter: these include, silica, alumina, iron among others in an inert state (Moshfekus,2012).

2.9.2 Uses of press mud

There is little information about the use of the natural form of press mud in concrete whoever it is use after it is being activated has been proposed in some literature with not a lot of information of its action.

Soil fertilizing

Since it is rich in organic matter and nutrients like phosphorus, nitrogen and potassium it is a good fertilizer and is used as such in its primary role with additions of other materials.

Biogas production

It can be anaerobically digested to produce biogas (Jaswant, 2022).

Cementitious applications

When activated for example through calcination, press mud can act as an SCM in concrete to improve strength and durability (Alfar, 2022).

2.9.3 Action of raw press mud in concrete

The organic plasticizing effect of press mud

This refers to the ability to improve the workability and flowability of the concrete mix without requiring any more water. This is because press mud contains organic compounds, fine particles and calcium-based materials that interact with the cementitious matrix to alter the rheological properties of concrete (Smith et al., 2020). The plasticizing effect enhances the ease of mixing, handling and placing the concrete especially in complex formworks or areas with dense reinforcement (Smith et al., 2020). Furthermore, it also reduces the need for additional water helping to achieve a lower water-cement ratio which is determinant for higher strength and durability (Kumar et al., 2021).

The mechanism of the plasticizing effect in press mud

The plasticizing effect of press mud in concrete is primarily due to its organic and fine particle composition, which improves workability by reducing internal friction between cement and aggregate particles (Gupta, 2019). Its fine particles disperse cement grains uniformly, preventing clumping and enhancing flowability (Smith et al., 2020). The hygroscopic nature of press mud aids in retaining moisture, supporting better cement hydration and extended workability (Kumar et al., 2021) in addition to this, its organic compounds have the ability to trap air bubbles which enhances the plasticity of the mix while the calcium based components may chemically interact with hydration products thus further influencing the concrete rheological properties (Patel et al., 2018)

2.9.4 Action of activated press mud in concrete

Activated press mud refers to press mud that has undergone a treatment process in order to enhance its physical, chemical or thermal properties and making it more

suitable for use in construction materials and this aims to improve the pozzolanic activity, specific surface area and reactivity of press mud by eliminating impurities, modifying its chemical composition and increasing its fineness.

The process of incinerating press mud involves subjecting it to high temperatures in order to remove its organic matter, residual moisture and impurities, thus enhancing its pozzolanic activity. Incineration converts non-reactive compounds, like carbonates, into reactive oxides like calcium-oxide which reacts with cement hydration products to form the C-S-H gel thus improving the strength and durability (Gupta, 2019). The ash produced after incineration is rich in lime and silica, making it comparable to supplementary cementitious materials like fly ash (Kumar et al., 2021). In addition to the above, grinding of the ash increases its surface area, enhancing its reactivity when mixed with cement (Patel et al., 2018).

2.9.5 Reaction of silicon in concrete present in press mud.

The chemical composition of silicon in natural press mud differs significantly from that in activated press mud due to the removal of impurities and structural changes during activation processes in this case, incineration. In natural press mud, silicon is primarily present in its inert forms, combined with organic matter, moisture and impurities which reduce its pozzolanic activity (Kumar et al., 2021). In contrast, activated press mud, particularly through incineration, has a higher concentration of reactive silica (SiO_2), due to the elimination of organic matter and the conversion of amorphous silica into more reactive phases (Gupta, 2019). This process also increases the fineness and surface area of silicon, further enhancing the reactivity and ability of concrete. Thus, activated press mud is significantly more effective as a supplementary cementitious

material compared to its natural form. The table below shows different types of scms and their pozzolanic properties.

Table 2 : Pozzolanic composition of different SCMs

Constituent	Mass content (%)				
	SF	FA (Type C)	FA (Type F)	GGBS	RHA
Silicon dioxide	90.00	32.5	49.02	38.35	87.2
Aluminum oxide	1.21	21.9	26.67	8.76	0.15
Ferric oxide	3.87	5.1	12.31	0.61	0.16
Calcium oxide	0.34	27.4	2.37	32.34	0.55
Magnesium oxide	1.43	4.8	0.95	18.64	0.35
Sodium oxide	0.46	1.1	0.21	0.22	1.12
Potassium oxide	1.49	2.34	0.71	3.68
Manganese oxide	1.41

Source: Supplementary Cementitious materials for high performance concrete, 2006.

2.10 CHEMICAL ATTACKS IN CONCRETE

2.10.1 Formation of ettringite and gypsum

There are two forms by which sulphate attacks occur in normal concrete each with its varying time and these are the chemical or classical form and the physical or salt attack form according to ACI's Guide to Durable Concrete.

Classical (chemical) form of sulphate attack

Primary Ettringite formation

Primary ettringite is formed just after a few hours (2 to 24 hours) of blending water and cement in a process termed as Early Ettringite Formation (EEF), this process does not cause any remarkable damage despite of its remarkable volume. It is consistently and individually distributed at sub-microscopic levels across the cement paste thus functions as a covering over surfaces of cement grains shortly after mixing. Due to its core filling function, primary ettringite can raise strength, lower permeability, porosity and provide dimensional stability.

Secondary Ettringite Formation

This occurs in Delayed Ettringite Formation (DEF) process that occurs with-in 7-14 days. This starts when the primary ettringite generated dissolves at high temperatures over 65-70°C, the ettringite re-forms to secondary ettringite, causing the hardened concrete to expand and crack. DEF causes the paste to expand while the aggregate does not, resulting into fractures/gaps surrounding the aggregate with the larger gap.

Gypsum formation

Gypsum is formed when sulphate ions reacts with calcium hydroxide which results into higher solid volume, which contributes to concrete degradation.

Physical form of sulphate attack

Under specific environmental conditions, concrete is primarily affected by physical sulphate damage (Suleiman, 2014). Bloom, chemically known as sodium sulphate, at exposed concrete surfaces is a common sign of physical sulphate attack. Apart from being an aesthetic issue, it is a visual sign of chemical and microstructural destruction in concrete.

Capillary action and diffusion allow sulphate salts to enter the pore spaces of concrete in solution. Due to wick's motion, sulphate solutions are drawn to the exposed surfaces where they evaporate, which gradually increases the sulphate ion concentration until it crystallizes. The sulphate ions go through cycles of crystallization and dissolution, or hydration and dehydration, as the ambient and relative humidity change. Repeated cycles of crystallization and hydration with volumetric expansion can induce concrete deterioration.

CHAPTER THREE: METHODOLOGY

3.0 INTRODUCTION

This chapter focuses on the procedures, methods and materials which were done to achieve the specific objectives of the project.

Research design

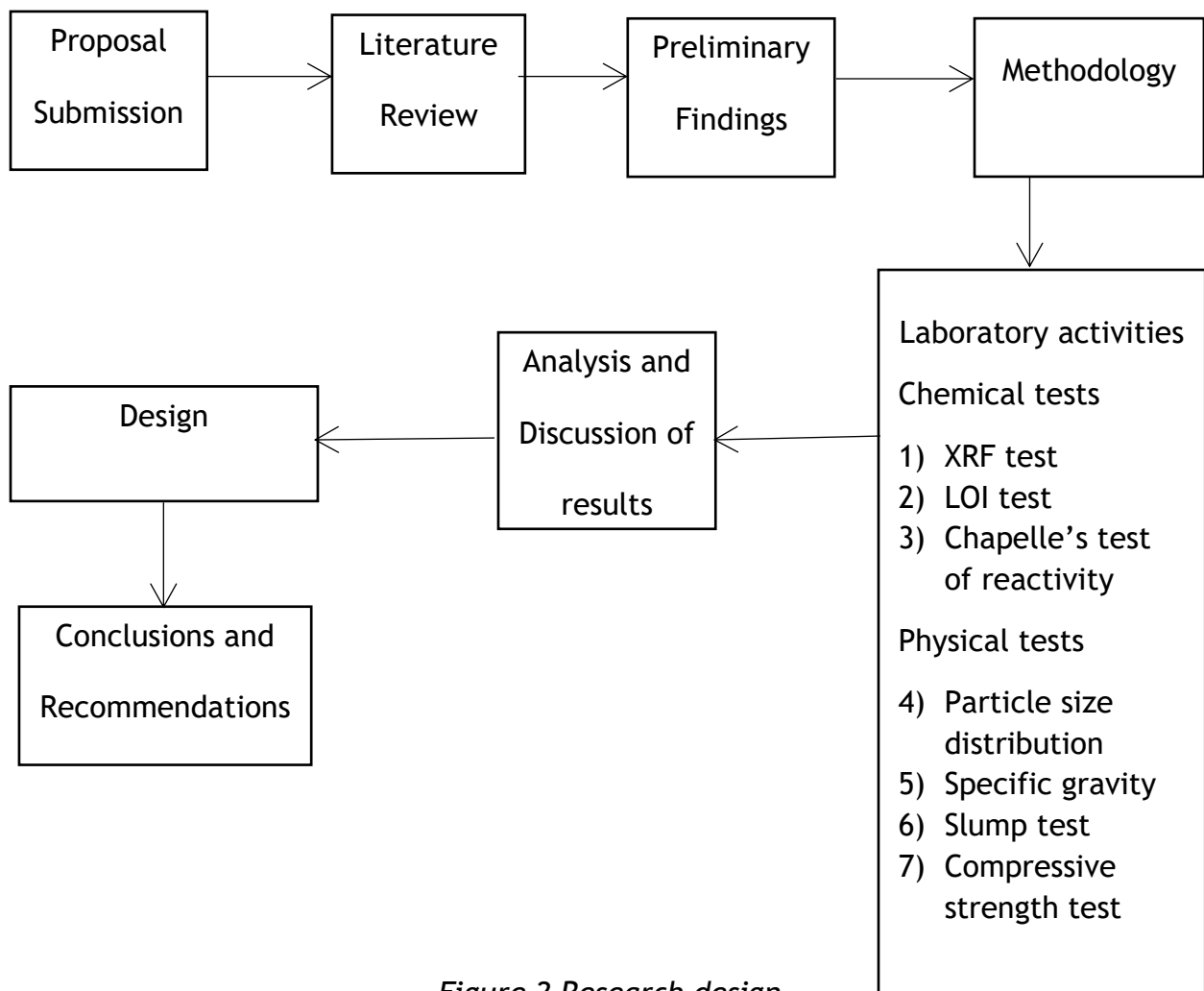


Figure 2 Research design

3.1 MATERIALS

3.1.1 Materials description

Press Mud

This is a by-product of sugarcane processing obtained from juice clarification during sugar production. This material was obtained from Sugar Corporation of Uganda Ltd (SCOUL) in Lugazi. It consists of organic matter, fibrous material and some inorganic impurities. In this research press mud will be used in activated form. The press mud will be added in quantities of 5%, 10%, 15% and 20%.

Raw press mud: in its natural state press mud is soft and clay like with high organic content. It contains residual sugars, phosphorus and other nutrients.

Activated press mud: when processed through thermal activation, it transforms into a pozzolanic material with improved binding properties. It has enhanced silica and alumina content making it suitable as a supplementary cementitious material (SCM).

Cement

This is a fine powder that when mixed with water undergoes hydration and hardens to bind aggregates together in order to form concrete. In this research Pozzolana Portland Cement was used and obtained from a general hardware in Mbalala it was noted that it follows Ugandan specifications for cement that is US EAS 18 - 1.

Pozzolanic cement refers to cement that has been enhanced with SCMs like fly ash among others and in this case press mud both in its activated form. The table below shows specifications of the cement that was used with description on setting times which show how long it takes to harden and the specific gravity shows that it contributes

to the overall strength of concrete because it is between 2.9 - 3.2 according to US EAS 18 - 1.

Table 3: Properties of cement

Properties of cement	
Specifications	Results
Grade	35
Initial setting time	60 mins
Final setting time	600 mins
Specific gravity	3.13

Lake sand (fine aggregates)

The fine aggregates are to be acquired from Stirling Laboratory along the Kampala-Jinja Highway, Mbalala. The following are results obtained from tests carried out on the sand as per BS standards. Table 3 shows specifications of the fines used basing on properties of lake sand with a fineness modulus of 2.3 indicates the average particle size of the aggregate. The scale used according to ASTM standards shows that fineness modulus 2.0 - 2.6 is fine sand and is suitable for concrete applications which makes 2.3 within acceptable range since its not too fine which could impact workability and increase water demand.

Table 4: Properties of fine aggregates

Fine aggregates properties	
Specification	Results
Type	Lake sand
Silt content	2%
Fineness modulus	2.3
Organic matter	Lighter than reference colour

Coarse aggregates

These are larger particles used in concrete and these were acquired from Stirling Laboratory. We used natural aggregates i.e. stones of different sizes that is C14-20, C10-14 and C6-10 this was to ensure no voids during the mix of concrete cubes and slump tests. Tests were carried out on these as well following the BS standards. Table 4 shows properties of coarse aggregates used which significant properties of absorption and moisture which are low therefore coarse aggregates are relatively dry therefore won't draw a lot of water from the mix.

Table 5: Properties of coarse aggregates

Coarse aggregate properties				
Aggregates size	% Weight in mix	Specific gravity (g/cc)	Absorption (%)	Moisture w (%)
14 - 20	25	2.622	0.301	0.071
10 - 14	14	2.613	0.362	0.058
6 - 10	24	2.606	0.471	0.141

3.1.2 Test Plan

Material distribution for slump test and compressive strength test.

Table 5 describes the test plan used when distributing the materials used in making the concrete for the slump and compressive stress tests. The most important thing to note is the composition of cement and activated press mud. As that of cement decreases, the composition of activated press mud increases this due to the fact that the plan is focused on the strength properties of the mix after 28 days. Since cement composition directly affects strength the partial replacement of cement with activated press mud which is meant to act as a SCM directly affects strength.

Table 6: Material distribution for tests on concrete properties

Material Distribution						
Press mud (%)						
Materials	Units	0%	5%	10%	15%	20%
Cement	kg	6.000	5.700	5.400	5.100	4.800
Fines	kg	13.547	13.547	13.547	13.547	13.547
Coarse	kg	24.949	24.949	24.949	24.949	24.949
Water	kg/liter	3.239	3.239	3.239	3.239	3.239
Press mud	kg	0.000	0.300	0.600	0.900	1.200



Figure 3 Activated press mud in the electric kiln

3.1.3 Flow chart of steps taken in obtaining results for the research project.

The flow chart below shows a step by step approach taken to achieve the research objectives set with the overall goal of assessing the effect of activated press mud.

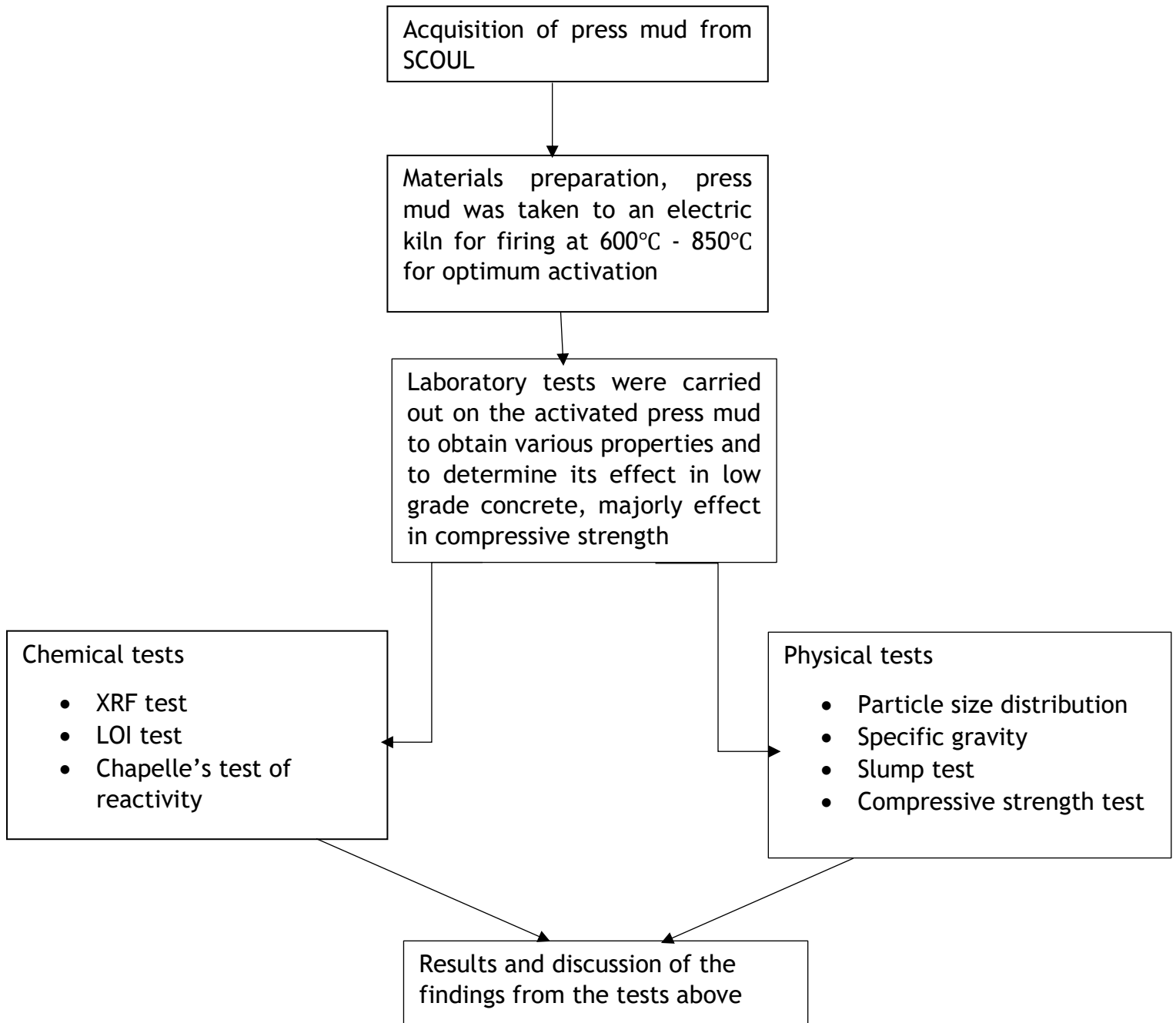


Figure 4 Flow chart of steps taken to achieve research objectives

3.2 LABORATORY TESTS AND METHODS

To determine the chemical and physical properties of press mud.

As the press mud was to be used in activated form some of the quantity was taken to African Village Pottery Institution in Kiyunga to use the electric kiln for firing of the press mud the following outcomes were determined as no literature was found for proper activation. Table 7 shows different temperatures and their effect during the activation process of pressmud. The temperatures used were based on thermal activation standards as per ASTM C618 for potential pozzolanic materials.

Table 7: Action of press mud when fired in an electric kiln

Temperature	Duration	Expectation
600°C	1 - 2 hours	Organic matter decomposition and initial calcination
600°C - 800°C	1 -2 hours	Optimum activation of the press mud
Above 850°C	Above 1 - 2 hours	Press mud got burnt and formed a black charcoal like substance.



Figure 5: The electric kiln used in processing the activated press mud

3.2.1 Chemical analysis of press mud

X-ray fluorescence test (XRF), BS EN 10315: 2006

This is a method used to determine the elemental composition of a material with reference to the oxides and trace elements within the material. In this research the focus was on the silica, alumina and iron content within activated press mud which are the most important properties for a pozzolanic material.

In this experiment, the activated press mud was used this is because of its potential to exhibit the desired outcomes as the raw material is calcinated hence can't show oxidized agents in its inert state.

Chapelle test for pozzolanic activity, BS EN 196 -9

This method quantifies the pozzolanic reactivity by measuring the amount of calcium hydroxide consumed by a sample material. In this experiment the pozzolanic reactivity

of press mud will be determine by its ability to react with calcium hydroxide in presence if water to achieve this titration method was used.

Loss on ignition test (LOI), BS EN 15935: 2012

This experiment is done to determine the organic content in the material and for this research the raw form was used due to increased presence of organic matter in its natural state and the experiment was done using thermogravimetric method with the apparatus of a marble furnace and weighing balance. The sample was heated to a temperature of 1000°C and the weight loss was determined using;

Weight loss = initial weight of sample - final weight of the sample.

3.2.2 Physical characterization of press mud

Particle size distribution, BS EN 933 -1 :1977

This was measured by using sieve analysis. In this process press mud is sieved through a set of standard sieves that is 35 mm - 150 µm and the distribution is plotted to determine the fineness of the material.

The material that passed through the 300 µm sieve was used for the other experiments below based on fact that cement is of that size and this research is focused on its partial replacement furthermore it makes mixing easier due to similar particle sizes. It is important to note that this process so removes the fibrous material and other unwanted particles in the final concrete cubes.



Figure 6 Sieve analysis trays setup

Specific gravity, BS 812:PART 2: 1995

This test is used to measure the density of a substance with reference to the density of other substance in most cases water. It also gives an idea on how much water is need for desired consistency.

$$\text{Specific gravity} = \frac{\text{Weight of material}}{\text{Weight of water}}$$



Figure 7 Pycnometer setup before specific gravity test

Water absorption, BS 812: Part2: 1995

Water absorption is determined by measuring the amount of water a material absorbs when submerged for a specified period of time. It is used to measure the absorption rate and express it as a percentage.

The sample the prepared by oven drying for 24 hours at 105°C to 110°C to remove all moisture. It is then left to cool to room temperature and the dry weight (W_d) is obtained. It is then immersed in water at room temperature and is then weighed after to obtain its saturated weight (W_s).

$$\text{Water absorption} = \frac{W_s - W_d}{W_d} \times 100$$

W_d - dry weight

W_s - saturated weight

To determine the properties of fresh concrete in terms of workability

3.2.3 Workability test on concrete

Slump test, BS 1881: PART 102: 1983

This test is used to assess the workability and consistency of fresh concrete. This is important for low grade concrete due to its major problems with workability and is an important factor for durability. It gives an idea on the concrete's ability to be compacted during placement.

The workability of fresh concrete is determined by its slump value and for good workability it should range between 35 mm - 75 mm. For the test a cone-shaped mold was used and filled with concrete and then removed, allowing the concrete to subside (slump). The vertical difference between the height of the mold and the slumped concrete is measured in millimeters.

3.2.4 Preparation for compressive stress tests

Casting of concrete cubes

Metallic cube molds were cleaned and lubricated for easy placement of the concrete. The dimensions of the cube molds used were 150 mm x 150 mm x 150 mm which follows specifications of BS EN 12390 -2: 2000. The molds were filled with concrete in layers and compacted for uniformity and left for 24 hours before curing.

Curing of concrete cubes

The concrete cubes are kept in a curing tank in order to gain strength after being removed from the molds and the tests on the cubes are to be done at 7 days, 14 days and 24 days. This follows BS EN 12390 - 3: 2002. This process is important to ensure proper development of compressive strength.

To determine the compressive strength of low grade concrete with activated press mud

3.2.5 Compressive stress test on concrete cubes

Compressive strength test, BS EN 12390-3: 2019

After the curing period, the cubes are subjected to a compressive strength test. The cubes are loaded at a constant rate until failure occurs. The maximum load at which failure occurs is recorded and the compressive strength calculated from;

$$\text{Compressive strength} = \frac{\text{load at failure}}{\text{cross sectional area}}$$

This is done to the cubes of activated press mud at the varying percentages shown above to obtain the optimal mix with best compressive strength and corresponding slump value.

The strength gain as a ratio is also obtained to give an expression of the potential gained by using press mud. This is calculated from;

$$\text{Strength gain ratio} = \frac{\text{Optimal compressive strength} - \text{compressive strength at 0\%}}{\text{compressive strength at 0\%}}$$



Figure 8 Compressive stress machine before loading of cubes

CHAPTER FOUR: RESULTS AND DISCUSSION

4.0 INTRODUCTION

This chapter shows the results obtained from the various tests carried out. This was to achieve the specific objectives stated in chapter one for the overall goal of the research project.

4.1 Chemical analysis on press mud

Chemical analysis was performed on the activated press mud and a compilation of the results are shown in the table below of XRF, LOI and Chapelle test.

Table 8: Chemical analysis of press mud

Parameter	Units	Results for DFD 024/2025 Press mud sample
Loss on Ignition	% m/m	9.038
Chapelle test	%Mg Ca (OH) ₂	3.382
Elemental Composition		
Silicon dioxide	% m/m	63.496
Aluminum oxide	% m/m	13.552
Iron (III) Oxide	% m/m	8.957
Magnesium Oxide	% m/m	4.745
Calcium Oxide	% m/m	3.382
Sodium oxide	% m/m	2.497
Manganese (II)Oxide	% m/m	1.573
Titanium di oxide	% m/m	1.119
Europium (III) oxide	% m/m	0.332
Potassium Oxide	% m/m	0.346

Loss on Ignition

The Loss on Ignition (LOI) test is a method used to determine the weight loss or reduction of organic matter and volatile substances. That is basically done by heating the material at high temperature usually 1000°C according to ASTM standards.

The 9.038 % on LOI shows that weight reduction from the raw to activated form in press mud isn't significant. This shows that not a lot of the material is lost in activation and more can be used in the activated form. However, when compared to other SCMs like fly ash the LOI of press mud is relatively high but doesn't affect the concrete performance in anyway.

Chapelle's test

For the Chapelle's test the pozzolanic activity of the material i.e. activated press mud is determined. A higher pozzolanic reactivity shows that the material is highly reactive in hydration conditions with introduction of lime. Chapelle test of reactivity shows an overall rating of 3.382 out of 10 meaning the reactivity of press mud is low this means that it quickens the hydration process but at a low rate. Additionally, research by Frias et al, (2000) highlights that pozzolanic activity of materials strongly depends on their fineness and thermal treatment.

Therefore, despite the low value obtained from the test the fineness of activated press mud compensates with an increase in surface area for potential reaction which can contribute to the overall performance of concrete in terms of strength gain furthermore the increase in particle packing of the fine materials enables proper distribution of the overall mixture. Lastly this enables gain of strength over a longer period of time is a

positive for low grade concrete because it isn't used for fast setting applications for example dam construction.

XRF Tests

In the XRF tests the significant compounds relevant to pozzolanic reactions found were silicon dioxide, aluminum oxide, iron (III) oxide and low percentage of calcium oxide. These are the most important oxidized agents because they are the activate compounds that react in concrete to form C-S-H gel in the hydration process that binds the aggregates together and contributes to the strength of the material.

The low calcium oxide content suggests that activated press mud doesn't add any calcium content into the concrete mix that would otherwise lead to increase of lime deposits that can lead to chemical attacks in the further affecting the concrete strength at a later period of time.

Since the summation of the silicon dioxide, aluminum oxide and iron (III) oxide was above 70% according to BS standards this shows that activated press mud is a Class F pozzolan due to its low calcium content and its use in strength improvement.

4.2 Physical Characterization on press mud

Specific gravity

The bulk density of 2.24 shows that it is lower than that of cement which is 3.15. the lower value means that when used as a partial replacement for cement in low grade concrete, the press mud occupies a larger volume per unit mass this potentially can affect the overall mix design. However, for low grade concrete applications it improves the strength development of the class. Due to the proved pozzolanic potential when

activated, it contributes to secondary cementitious reactions and its lower specific gravity helps reduce the overall density of the concrete which is beneficial in applications where lightweight properties are required due to the strength gain.

Its finer particles and increased surface area increase the water demand which may rise a concern of water cement ratio in order to obtain good workability. The value of 2.24 plays a crucial role in determining mix design adjustments, strength performance and workability characteristics for optimizing the overall design.

Water absorption

Water absorption refers to the ability of a material to absorb and retain water, expressed as percentage of its dry weight. Calculated by measuring the increase in weight of a material when submerged in water for a specific period compared to its original dry weight.

The water absorption of activated press mud at 5.2 shows its ability to retain moisture relative to its dry weight. Since the value is moderate it speaks to the hydrophilic nature of the material. This has direct implications on the workability, water demand and strength and if not adjusted properly could necessitate use of plasticizers.

In terms of strength performance, the value is potentially the reason for better hydration and internal curing of the concrete hence having increased strength parameters over time. This is beneficial for long term strength gain particularly in low grade concrete where the early strength gain is not a primary requirement.

4.3 Impact of press mud on workability of concrete

The graph below shows the relationship of slump in (mm) and activated press mud in (%) increasing from (0 - 20) % this is according to ASTM standards of replacement where too little replacement may have no influence on the results and too much might cause a decline in deserved result which is a normal trend in optimization.

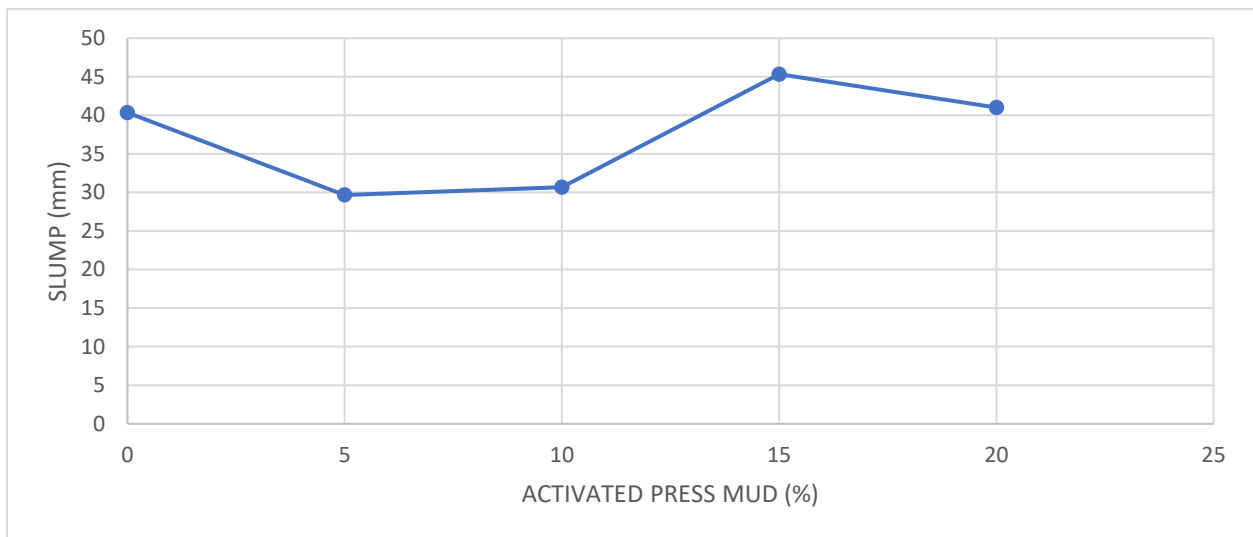


Figure 9 Workability of the varying replacement percentages

Considering a slump value of 25 mm - 50 mm for low grade concrete, the initial slump (0% activated press mud) is relatively high at 40 mm suggesting a good workability of the control mix without activated press mud. There is a reduction in the slump with (5% - 10% activated press mud) with a slight increase to 10%, this could be due to the hydrophilic nature of activated press mud leading to a stiffer mix and there is slight stabilization at the 10% replacement level suggesting at this level the effect on workability is less severe which could be possibly due to better particle packing.

At 15% activated press mud replacement, the optimum is reached where the slump rises again to its peak at 45mm which might be due to a more cohesive mix that improves the flowability of concrete. The drop (20% activated press mud) to 41mm suggests that at higher activated press mud replacement workability is significantly affected that could lead to drier mixes reducing flowability of concrete furthermore this could be attribute to excessive fines and increased moisture demand.

4.4 Compressive Strength analysis

The graph shows the compressive strength trend of activated press mud after curing and doing compressive stress tests. The small error bars in this section represent consistency in the results, since the 15% optimal replacement doesn't overlap with the control this suggests significant strength increase. The trend displayed by the graph is polynomial, this suggests a typical trend of material optimization due to an expected decline with material effects as seen at 20%.

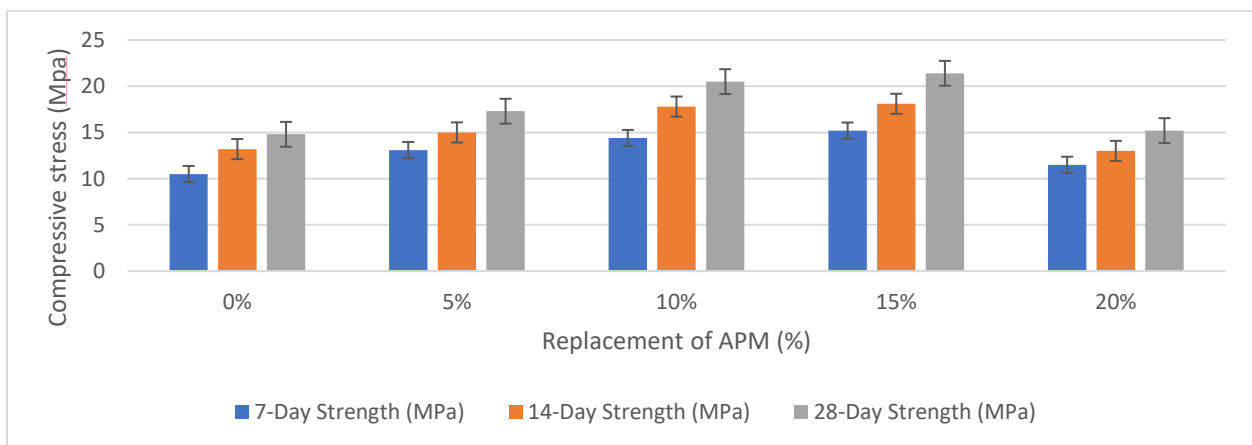


Figure 10 compressive strength chart results

Compressive strength is a critical property that determines its ability to withstand axial loads without failure. It is one of the most important parameters in structural design,

influencing the durability and performance of concrete structures. The compressive strength of concrete is typically measured at different curing ages these are 7 days, 14 days and 28 days, to evaluate its strength development overtime.

The results in the graph show the compressive strength of concrete with varying percentages of Activated pressmud percentages. It shows an increasing trend in compressive strength up to 15% which shows that the material enhances pozzolanic reaction leading to a denser concrete matrix and improved strength development. This suggests that 15% is the optimal level at which the material can contribute effectively to cement hydration while maintaining structural integrity due to it having the highest compressive strength value.

At 20% replacement. A decline in the compressive strength is observed across all the curing ages which suggests that excessive material content may lead to reduction of strength due to reduction of cement available for hydration weakening the overall concrete. This may also be attributed to increased presence of unreacted material which could potentially disrupt the formation of strong C-S-H gel bonds in the concrete matrix.

The optimal replacement is at 15% where the highest compressive strength was achieved with a 44% increase in strength at this replacement percentage.

The significance of these findings lies in demonstrating the potential of APM as an effective partial cement replacement. Optimizing the replacement level at 15% makes it possible to enhance concrete performance while reducing reliance on cement which is beneficial. The use of the material in concrete aligns with sustainable construction

practices by utilizing industrial by products to reduce carbon emissions associated with cement production.

4.5 Design for application of concrete with activated press mud.

4.5.1 Material preparation and casting process

Ensure that the activated press mud is finely ground (<75 micro meters) to achieve proper pozzolanic activity then dry it before mixing avoid moisture interference. Use Portland Pozzolana Cement as indicated.

Use natural sand of fineness modulus 2.3 and aggregates in different sizes (6 -10) mm, (10 - 14) mm and (14 - 20) mm as the maximum to ensure good particle packing and reduce voids in the mix.

Combine and add coarse aggregates, sand, cement of 255 kg and activated press mud of 45 kg which is 15% of the total composition then mix.

Gradually add water based on 0.52 w/c ratio for improved hydration and homogeneity.

Carry out the slump tests and record the respective results, they should lie within 25 mm - 50 mm because it's the standard of C15 concrete.

Cast concrete cubes and leave them to set in a cool dry place for 24 hours, then place them in the curing tank in order to enhance strength gain for compressive stress tests after 7, 14 and 28 days.

Maintain constant moisture in the curing tank to allow full hydration of cement and pozzolanic reactions of APM.

4.5.2 Quality control and assurance

Quality control refers to implementing procedures and activities to ensure that materials used in manufacturing or construction meet defined quality standards.

Quality assurance refers to implementing systematic process and procedures to ensure that materials used in manufacturing and construction meet specified quality standards.

The quality control and assurance are based on fresh and hardened concrete with the major factors being slump test, water cement ratio, density and compressive strength.

The following table shows specifications of quality assurance and control.

Table 9 Quality control and assurance

Test	Standard C15 mix	15% replacement	Remarks
Slump test	25 - 50 mm	45 mm	Good workability value based on the standard due to APM's fine particles
Water demand	Moderate	Slightly higher	APM absorbs more water
Water cement ratio	0.6 - 0.65	0.52	APM mix produces a stronger but stiffer mix
Density	2300 kg/m ³	2400 kg/m ³	Slightly heavier and denser mix
Compressive strength	15Mpa	21.4 Mpa	Meets and exceeds the standards
Uses	Non-structural works	Light structural works	Can be used for structural works of C20

From the above table it is noted that C15 increased to C20 thus can be used for C20 applications for example floor slabs, oversite concrete and foundation of single-story structures.

4.5.3 Design for 1m³ of concrete with activated press mud.

Mix ratio based on optimum replacement (15%)

For the design concrete the ratio used is 1:2:4. For the 15% mix, the ratio is 0.85:0.15:2:4 with the 0.15 being the ratio of activated press mud.

$$\text{Cement} = 300 \times 0.85 = 255 \text{ kg}$$

$$\text{Activated pressmud} = 300 \times 0.15 = 45 \text{ kg}$$

$$\text{Sand} = 300 \times 2 = 600 \text{ kg}$$

$$\text{Aggregates} = 300 \times 4 = 1200 \text{ kg}$$

The above quantities can be used to make a cubic meter of concrete.

From the strength tests 15% replacement has compressive strength of 21.4 Mpa which is 44% increase from;

$$\text{Potential Strength gain} = \frac{\text{Optimal compressive strength} - \text{compressive strength of control}}{\text{compressive strength of control}} \times 100$$

This shows an improvement in concrete strength of low grade concrete and can be used in standard grade applications since concrete is now C20, such as:

Ground floor slabs, Oversite concrete, Foundation of single story structures

4.4.4 Slab floor design calculation using 21.4 Mpa as the characteristic strength.

$$\text{minimum effective depth}(D) = \frac{\text{span}}{27 * \text{correction factors}(cf)}$$

$$D = \frac{4500}{27 * cf} \text{ (since the span length (L) < 7m, the correction factors can be taken as unity)}$$

thus effective depth is taken as 170mm

XC-1 exposure cover = 25mm, bar diameter = 10mm.

overall depth = 170 + 25 + 5 = 200mm

Slab loading

slab self weight = 200 * 21.4 * 10⁻³ = 4.28kN/ m²

For 1m width of slab

ultimate load = (1.35gk + 1.5qk)4.5 = (1.35 * 6.0 + 1.5 * 3.0)4.5 = 56.7kN

$$M = 56.7 * \frac{4.5}{8} = 31.9$$

Bending reinforcement

$$K = \frac{M}{bd^2 f_{ck}} = \frac{31.9 * 10^6}{1000 * 170^2 * 21.4} = 0.052$$

Lever arm equation

$$Z = d \left[0.5 + \sqrt{0.25 - \frac{k}{1.134}} \right] = d \left[0.5 + \sqrt{0.25 - \frac{0.052}{1.134}} \right] = 0.952d$$

Since Z = 0.952d > 0.95d

Lever arm Z = 0.95d = 0.95 * 170 = 161.5mm

Area for bottom steel A_s

$$A_s = \frac{M}{0.87 f_{yk} Z} = 31.9 * 10^6 = 454.08 \text{mm}^2$$

$$A_{sprov} = \frac{523 \text{mm}^2}{m}$$

Span effective depth ratio

$$\rho = \frac{100A_{sreq}}{bd} = 100 * \frac{454.08}{1000 * 170} = 0.267\% (> 0.13\% \text{ the minimum requirement})$$

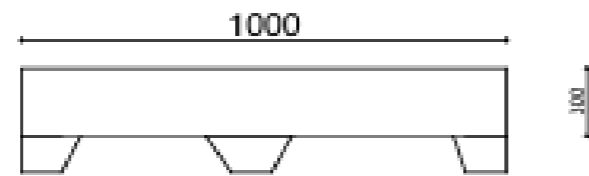
$$\rho_{actual} = \frac{4500}{170} = 26.47$$

Shear (at the face of the support)

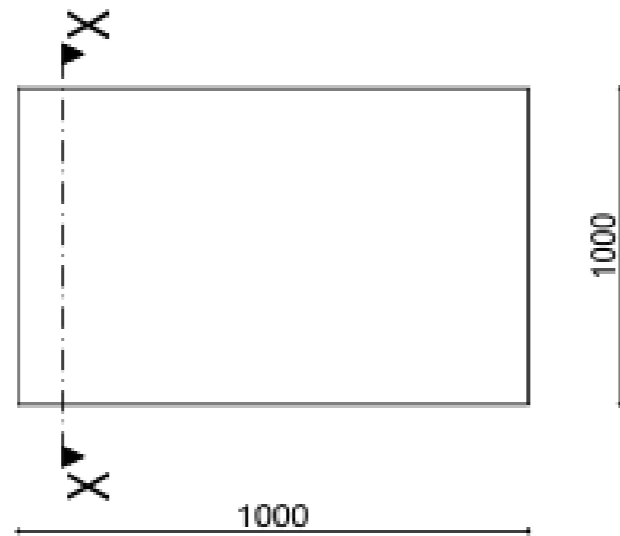
$$shear V_{ed} = \frac{55.5}{2} \left(\frac{2.25 - 0.5}{2.25} \right) = 25.9kN$$

$$V_{rd} = 0.55 * 1000 * 170 = 93.5kN$$

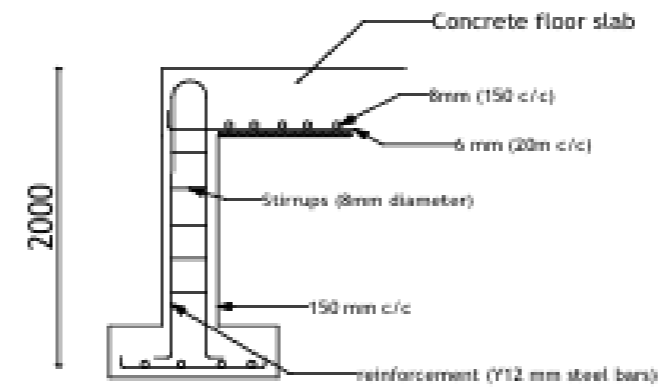
$V_{ed} < V_{rd}$ thus no shear reinforcement is required



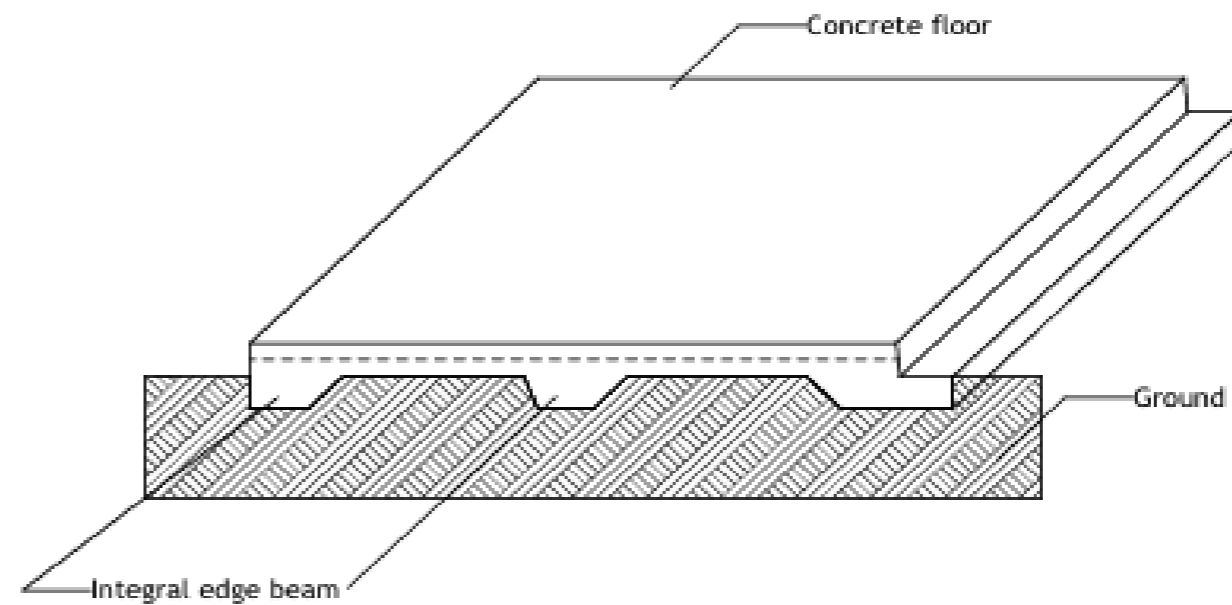
FRONT VIEW
Scale 1:100



PLAN VIEW
Scale 1:100



SECTION X-X
Scale 1:100



ISOMETRIC VIEW

D.

GROUND FLOOR SLAB

1:100

TITLE: ASSESSING USE OF ACTIVATED PRESS MUD IN STRENGTH OF LOW GRADE CONCRETE

DRAWING TITLE: GROUND FLOOR SLAB

AUTHOR: KIRABO JESSE ALLAN & LWANYAGA JOSHUA

REG NUMBERS: S21B32/077 & S21B32/020

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.0 CONCLUSIONS

Activated press mud has a high pozzolanic content $\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3 > 70\%$, making it a suitable supplementary cementitious material and specific gravity of 2.24 positively contributes to strength development.

Workability initially decreases as press mud content increases due to its hydrophilic nature. However, at 15% replacement, an optimal balance is achieved due to improved particle packing hence contributing to strength increase.

Compressive strength increases up to 15% replacement, showing better performance than control concrete due to improved C-S-H gel formation. Beyond 15%, strength decreases due to reduced binding capability and reduction of cement content.

5.1 RECOMMENDATIONS

Based on the study results, 15% replacement of cement with activated press mud provides the best balance of strength and workability. Future research should investigate best percentage replacement between 10% and 15% since this range showed similar strength potential.

Improve Pozzolanic Reactivity of Activated Press Mud. Since the Chapelle test showed low reactivity of 3.382/10, further treatment methods like blending with other pozzolans should be explored to enhance its reactivity considering overall strength increased.

Future research should assess long term durability of the activated press mud mix at optimal replacement for properties such as sulphate resistance, carbonation, freeze thaw performance among others in different environments.

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APPENDIX: LABORATORY RESULTS

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DFD 024/2025
10th February 2025

MR. LWANYAGA JOSHUA AND MR. KIRABO JESSE ALLAN
 REG NO. S21B32/020 & S21B32/077
 UGANDA CHRISTIAN UNIVERSITY
 P.O BOX 4,
 MUKONO-UGANDA
 Tel: 256-780-314873

REPORT OF ANALYSIS

Description of the Samples

One sample in black polythene bag containing press mud sample was submitted by Mr. Kirabo Jesse Allan, on 24th January 2025, and analysed on 30th January 2025. A summary of the sample received is shown in table below

SN	Description	Quantity	Assigned Lab ID
1	Press mud sample packed in a black polythene bag.	01	Sample "A" DFD 024/2025

Analysis Requested

Elemental analysis, loss on ignition and Chapelie test.

Method of Analysis

Elemental analysis was done using the XRF Method while loss on ignition was done using the thermogravimetric method. Chapelie test was done using a titration method.

Results of Analysis

The above sample has been analyzed with the following results as below.

Parameter	Units	Results for DFD 024/2025 Press mud sample
Loss on Ignition	% m/m	9.038
Chapelle test	%Mg Ca (OH)2	3.382
Elemental Composition		
Silicon dioxide	% m/m	63.496
Aluminum oxide	% m/m	13.552
Iron (III) Oxide	% m/m	8.957
Magnesium Oxide	% m/m	4.745
Calcium Oxide	% m/m	3.382
Sodium oxide	% m/m	2.497
Manganese (II)Oxide	% m/m	1.573
Titanium di oxide	% m/m	1.119
Europium (III) oxide	% m/m	0.332
Potassium Oxide	% m/m	0.346

Remarks

- Results relate to sample analyzed and are reported as on received basis.

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DFD 024/2025
10th February 2025

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Europium (III) oxide	% m/m	0.332
Potassium Oxide	% m/m	0.346

Remarks

- Results relate to sample analyzed and are reported as on received basis.

Semalago Fredrick
 Semalago Fredrick

Government Analyst "Go Scientific for a Safe and Just Society"

INSTITUTION	CLIENT	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	JOSHUA LWANYAGA & (S21B32020) & JESSE KIRABO (S21B32077)	Stirling
PROJECT	ASSESSING THE USE OF ACTIVATED PRESS MUD IN STRENGTH OF LOW GRADE CONCRETE	
DETERMINATION OF AGGREGATE'S 10% FINES VALUE DRY AND SOAKED <small>(SEE SUPPLEMENT TO BS 812)</small>		
MATERIAL SOURCE	MAKINDO CRUSHER	OPERATOR: AT/2004 DATE TESTED: 20 December 2024
MATERIAL DESCRIPTION	AGGREGATES	DATE TESTED: 22 December 2024
10% FINE VALUE DRY		
TEST NO.	1	2
WEIGHING FORCE (N)	200	200
WT. OF AGGREG. (g) before washing (g)	207.8	207.0
WT. OF AGGREG. RETAINED ON 75µm sieve (g)	187.0	187.0
WT. AGGREG. (g) PASSING 75µm sieve (g)	20.8	20.0
10% FINE VALUE (PERCENTAGE)	11.8	11.0
AVERAGE RESULTS (%)		11.9
AVERAGE (kN/ton) FORCE (k)		200.0
 200 10% 200		
10% FINE VALUE SOAKED		
TEST NO.	1	2
WEIGHING FORCE (N)	200	200
WT. OF AGGREG. (g) before soaking (g)	209.7	209.0
WT. OF AGGREG. RETAINED ON 75µm sieve (g)	197.0	197.0
WT. AGGREG. (g) PASSING 75µm sieve (g)	12.7	12.0
10% FINE VALUE (PERCENTAGE)	11.4	11.0
AVERAGE RESULTS (%)		11.0
AVERAGE (kN/ton) FORCE (k)		200.0
 209.7 SOAKED WET/DRY (%) = 98		
<p> <small>10 Standard Test Sieves</small> <small>Material conforms to BS 812</small> <small>SPEC. REQUIREMENT 7.5.12.1</small> STIRLING CIVIL ENGINEERING LTD <small>100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120</small> <small>FOR STIRLING</small> <small>P.O. BOX 1755, TORONTO, ONT. M6H 1K1 (CAN)</small> </p>		

INSTITUTION		STUDENTS		TESTING LAB					
EGANDA CHRISTIAN UNIVERSITY		JOSHUA LWANYAGA & (SIRU020) & JESSE KIRABO (SIRU02077)		Stirling					
PROJECT: ASSESSING THE USE OF ACTIVATED PRESS MUD IN STRENGTH OF LOW GRADE CONCRETE									
COMPRESSION STRENGTH FOR CONCRETE									
LOCATION: MUKONO LAB				TECHNICIAN: String Mb					
STRUCTURE:				SAMPLE No:					
CLASS OF CONCRETE: 15/0 FOR CONCRETE				LAB Ref No: Class 15/0					
CEMENT CONTENT:				Date Casted: 9 Feb 25					
				Date Crushed: 9 Mar 25					
CEMENT REPLACED WITH 20% ACTIVATED PRESS MUD									
CASTING DATE	CRUSHING DATE	SLUMP (mm)	WT OF CUBES (gms)	DIMENSION (mm)	DENSITY (KG/M ³)	AGE (DAYS)	CRUSHING LOAD (KN)	ULTIMATE COMP. STRENGTH (MPa)	AVERAGE STRENGTH (MPa)
9 Feb 25	16 Feb 25		7650	150 x 150 x 150	2.364	7	255	11.3	11.6
9 Feb 25	16 Feb 25		7656	150 x 150 x 150	2.357	7	265	11.8	
9 Feb 25	23 Feb 25	45.3	7910	150 x 150 x 150	2.344	14	300	13.3	13.1
9 Feb 25	23 Feb 25		7915	150 x 150 x 150	2.345	14	290	12.9	
9 Feb 25	9 Mar 25		7855	150 x 150 x 150	2.327	28	345	15.3	15.1
9 Feb 25	9 Mar 25		7798	150 x 150 x 150	2.310	28	335	14.9	
Remarks									
FOR TESTING USE									
LAB TECHNICIAN									

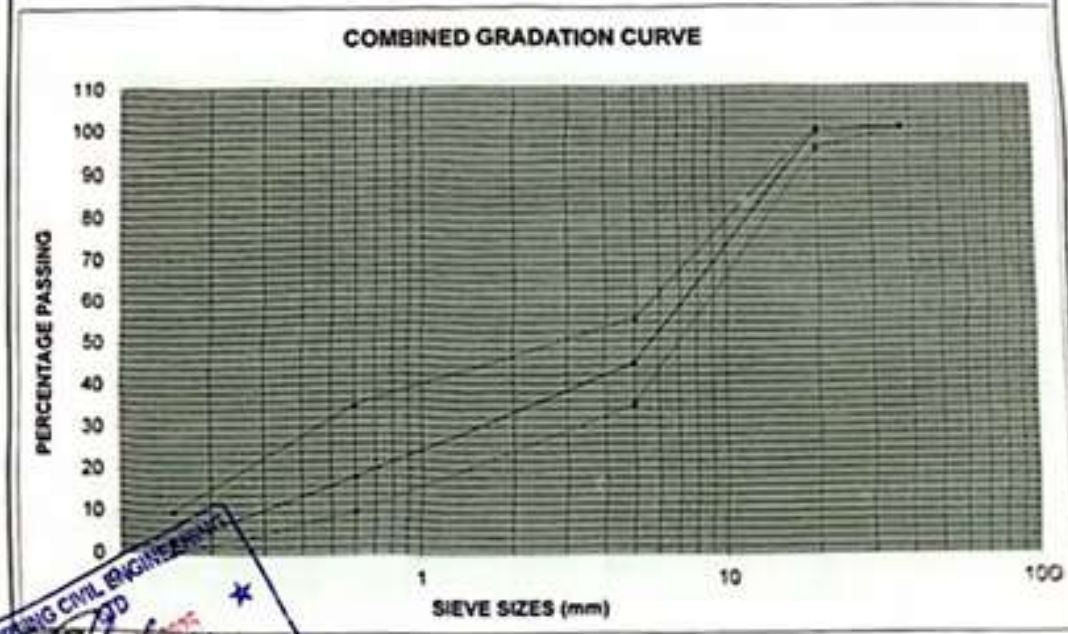
STIRLING
 CIVIL ENGINEERING
 101 TAMMAYI SIKAGO DR
 TAMMAYI, KAMPALA, UGANDA

INSTITUTION		STUDENTS		TESTING LAB					
EGANDA CHRISTIAN UNIVERSITY		JOSHUA LWANYAGA & (S21B2-029) & JESSE KIRABO (S21B2-077)		Stirling					
PROJECT		ASSESSING THE USE OF ACTIVATED PRESS MUD IN STRENGTH OF LOW GRADE CONCRETE							
COMPRESSION STRENGTH FOR CONCRETE									
LOCATION: MUKONO LAB				TECHNICIAN	Doing Job				
STRUCTURE				SAMPLE No.					
CLASS OF CONCRETE: 15/20 FOR CONCRETE				Lab. Ref. No.	Class 15/20				
CEMENT CONTENT				Date Casted	8 Feb 25				
				Date Crushed	8 Mar 25				
CEMENT REPLACED WITH 10% ACTIVATED PRESS MUD									
CASTING DATE	CRUSHING DATE	SLUMP (mm)	WT OF CUBES (gm)	DIMENSION (mm)	DENSITY KG/M ³	AGE (DAYS)	CRUSHING LOAD(KN)	ULTIMATE COMP. STRENGTH (Mpa)	AVERAGE STRENGTH (Mpa)
8 Feb 25	15 Feb 25		7998	150 x 150 x 150	2.370	7	315	14.9	14.4
8 Feb 25	15 Feb 25		8012	150 x 150 x 150	2.374	7	315	14.0	
8 Feb 25	22 Feb 25	30	8025	150 x 150 x 150	2.378	14	400	17.8	17.7
8 Feb 25	22 Feb 25		8019	150 x 150 x 150	2.376	14	365	17.6	
8 Feb 25	8 Mar 25		7960	150 x 150 x 150	2.370	28	475	21.1	20.6
8 Feb 25	8 Mar 25		7965	150 x 150 x 150	2.360	28	450	20.0	
Remarks									
FOR TESTING USE									
LAB TECHNICIAN									

INSTITUTION	STUDENTS	TESTING LAB
UGANDA CHRISTIAN UNIVERSITY	JOSHUA LWANYAGA & (S21B32020) & JESSE KIRABO (S21B32077)	Stirling
PROJECT	ASSESSING THE USE OF ACTIVATED PNEUMIC CEMENT IN STRENGTH OF LOW GRADE CONCRETE	

TEST	COMBINED GRADATION FOR CONCRETE AGGREGATES	DATE	21/06/24
LOCATION	MUKONO LAB CONCRETE MIX DESIGN	SAMPLE No	MIX DESIGN


	14/20MM	10/14MM	6/10MM		SAND	Theoretical wt%	TARGET MO-DUCT	SPC
Proportions	25.0	12.0	20.0		43.0	100.0		
27.8	100.0	25.0	100	12.0	100	20.0	100	100
29	96.3	24.1	100	12.0	100	20.0	99	96-100
8	1.8	0.5	3	0.3	8	0.8	45	15-45
8.8	1.4	0.3	2	0.2	3	0.8	18	10-18
8.18	1.1	0.3	2	0.2	2	0.5	8	8-12






STIRLING CIVIL ENGINEERING LTD
Stirling
 P.O. BOX 195 KAMPALA (U)

INSTITUTION		STUDENTS		TESTING LAB						
EGANDA CHRISTIAN UNIVERSITY		ROSEAL WANYAGA & (S21B12029) & JEANNE KIBABO (S21B12077)		Stirling						
PROJECT		ASSESSING THE USE OF ACTIVATED PRESS MUD IN STRENGTH OF LOW GRADE CONCRETE								
COMPRESSION STRENGTH FOR CONCRETE										
LOCATION: MAKONO LAB				TECHNOLOG: Stirling lab						
STRUCTURE:				SAMPLE No:						
CLASS OF CONCRETE: 15.0 FOR CONCRETE				Lab. Ref. No: Class 15.02						
CEMENT CONTENT				Date Casted: 8 Feb 25						
				Date Crushed: 18 Mar 25						
CEMENT REPLACED WITH 5% ACTIVATED PRESS MUD										
CASTING DATE	CRUSHING DATE	SLUMP (mm)	WT OF CUBES (gm)	DIMENSION (mm)	DENSITY (kg/m ³)	AGE (DAYS)	CRUSHING LOAD (KN)	ULTIMATE COMP. STRENGTH (MPa)	AVERAGE STRENGTH (Mpa)	
8 Feb 25	15 Feb 25		8148	150 x 150 x 150	2.414	7	295	13.1	13.0	
8 Feb 25	15 Feb 25		8096	150 x 150 x 150	2.399	7	290	12.9		
8 Feb 25	22 Feb 25	50.0	8035	150 x 150 x 150	2.381	14	345	15.3	15.0	
8 Feb 25	22 Feb 25		8052	150 x 150 x 150	2.366	14	330	14.7		
8 Feb 25	8 Mar 25		8070	150 x 150 x 150	2.378	28	305	17.6	17.3	
8 Feb 25	8 Mar 25		8073	150 x 150 x 150	2.360	28	305	17.1		
Remarks										

100% COMPLIANT

INSTITUTION		CLIENT		TESTING LAB
UGANDA CHRISTIAN UNIVERSITY		JOSHUA LWANYAGA & (S21B32/020) & JESSE KIRABO (S21B32/077)		Stirling
PROJECT:		ASSESSING THE USE OF ACTIVATED PRESS MUD IN STRENGTH OF LOW GRADE CONCRETE		
A.C.V. LABORATORY TEST RESULT FORM (BS 812PART 110 1990)				
MATERIAL SOURCE:	MUKONO CRUSHER	Operator	LAB TEAM	
MATERIAL DESCRIPTION	AGGREGATES	Date	22 Dec 24	
A.C.V				
(A) WT BEFORE CRUSHING (gm)	2411		2705.5	
(B) WT AFTER CRUSHING (gm)	2411		2705	
(C) WT RETAINED AFTER CRUSHING (gm)	2392		2348	
(D) WT PASSING SIEVE 2.36 mm	440		447	
A.C.V (%) (D/B)*100	18.0		18.0	
AVERAGE RESULTS %	16.0			
NB If (C) is more than B by 10gms repeat the test				
A.I.V				
(A) WT BEFORE TEST (gm)	312.5	349.5	367.0	
(B) WT AFTER TEST (gm)	312.5	349.5	366.5	
(C) WT RETAINED AFTER TEST (gm)	214.5	293	306.0	
(D) WT PASSING SIEVE 2.36 mm	58.0	56.5	60.5	
A.I.V (%) (D/B)*100	18.5	16.2	16.5	
AVERAGE RESULTS %	16.4			
NB If (C) is more than B by 1gms repeat the test				
SPECIFIED LIMITS IN ACCORDANCE WITH THE REQUIREMENTS OF MATERIALS 				

INSTITUTION		STUDENTS		TESTING LAB			
UGANDA CHRISTIAN UNIVERSITY		JOSHUA LWANYAGA & (521832/020) & JESSE KIRABO (521832/077)		Stirling			
PROJECT		ASSESSING THE USE OF ACTIVATED PRESS MUD IN STRENGTH OF LOW GRADE CONCRETE					
Location _____		CONCRETE MIX DESIGN		Technician _____			
Sample _____		CLASS 2020		DATE 20/12/2024			
Lab Ref _____							
MIX FOR 1M ³				Weight (kg)	Volume (dm ³)		
CEMENT OPC 42.5				Wt c =	Vc =		
CM 1	250 kg			250	79.37		
WATER (w/c)				Wt w =	Vw =		
	0.5			125	125		
ADMIXTURE				Wt a =	Va =		
	%						
AIR							
	2 %			20	20		
				Total (1) 224.37			
VOLUME AGGREGATES		1000 - (1) = 775.63492 (2)					
AGGREGATES	% WEIGHT	S. SPEC Gr (g/100)	ABSORPTION abs (%)	MOISTURE w (%)	Correction quantity H ₂ O Wc = abs + w (%)		
Ø 14 - 20 mm	25 a	2.622 f	0.301	0.071	0.229		
Ø 10 - 14 mm	12 b	2.613 g	0.362	0.058	0.304		
Ø 6 - 10 mm	20 c	2.606 h	0.471	0.172	0.298		
Ø Nat Sand mm	43 e	1.037 k	27.024	0.42	26.601		
		(2)		775.6349 = 12.256 (3)			
		25 a 12 b 20 c 43 e		63.286			
		2.622 2.613 2.606 1.037					
AGGREGATES IN 1 M ³			DRY WEIGHT dwt (kg)	REAL WEIGHT wtdwt x (1+w/100) (kg)	Correction quantity H ₂ O Wc = dwt x Wc1 % /100		
Ø 14 - 20 mm	25 % X	12.256 (3)	306.401	306.620	0.702		
Ø 10 - 14 mm	12 % X	12.256	147.072	147.158	0.447		
Ø 6 - 10 mm	20 % X	12.256	245.121	245.543	0.732		
Ø Nat Sand mm	43 % X	12.256	527.009	529.242	140.168		
			Total		142.049		
COMPOSITION OF THE MIX				BOX (7)	FOR 1 M ³	IN LAB: 0.060 M ³	
CEMENT TYPE OPC				bags =	5	Wt c = 250 kg	15.000 kg
WATER						Vw + Wc = 267.1 dm ³	16.024 dm ³
ADMIXTURE							
AGGREGATES Ø 14 - 20 mm				25 %	6	Wt a = 306.620 kg	18.397 kg
Ø 10 - 14 mm				12 %	3	147.158 kg	8.829 kg
Ø 6 - 10 mm				20 %	4	245.543 kg	14.733 kg
Ø Nat Sand mm				43 %	11	529.242 kg	31.755 kg
REMARKS: (70%) Box Volume = 0.036 m ³ W/C =							
							
							
							

INSTITUTION		STUDENTS		TESTING LAB					
UGANDA CHRISTIAN UNIVERSITY		JOSHUA WANYAGA & OSIBIZA RUSI & JESSE KURABO (121812077)		Stirling					
PROJECT: ASSESSING THE USE OF ACTIVATED PULVERIZED FIBER IN STRENGTH OF LOW GRADE CONCRETE									
COMPRESSIVE STRENGTH FOR CLASS 15 CONCRETE									
LOCATION: MUKONO LAB		TECHNICIAN: Spring 18							
STRUCTURE:		SAMPLE No:							
CLASS OF CONCRETE: 15/20 FOR CONCRETE		LAB. Ref. No.: Class 15/20							
CEMENT CONTENT:		Date Casted: 8 Feb 25							
		Date Conducted: 8 Mar 25							
CONTROL MIX									
CASTING DATE	CRUSHING DATE	SLUMP (mm)	WT OF CUBES (gm)	DIMENSION (mm)	DENSITY (KG/M ³)	AGE (DAYS)	CRUSHING LOAD (KN)	ULTIMATE COMP. STRENGTH (MPa)	AVERAGE STRENGTH (Mpa)
8 Feb 25	15 Feb 25		8095	150 x 150 x 150	2.387	7	230	10.2	18.4
8 Feb 25	15 Feb 25		7966	150 x 150 x 150	2.360	7	240	10.7	
8 Feb 25	22 Feb 25	40	8135	150 x 150 x 150	2.410	14	295	13.1	13.2
8 Feb 25	22 Feb 25		8144	150 x 150 x 150	2.413	14	290	12.9	
8 Feb 25	8 Mar 25		8206	150 x 150 x 150	2.330	28	345	15.3	15.4
8 Feb 25	8 Mar 25		8277	150 x 150 x 150	2.421	28	350	15.6	
Remarks:									

INSTITUTION	STUDENTS		TESTING LAB	
UGANDA CHRISTIAN UNIVERSITY	JOSHUA LWANYAGA & (S21B32020) & JESSE KIRABO (S21B32077)		Stirling	
PROJECT	ASSESSING THE USE OF ACTIVATED PRESS MUD IN STRENGTH OF LOW GRADE CONCRETE			
SPECIFIC GRAVITY & WATER ABSORPTION FINE AGGREGATES				
(AASHTO: T84-03) ASTM DESIGNATION: C 128-97				
LOCATION			OPERATOR	
SAMPLE No			CHECKED	
TYPE	ACTIVATED PRESS MUD		DATE: 20/12/2024	
	TEST NO	A	B	C
	(A) wt. of oven dry sample in air (gm)	347.79		427.21
	(B) wt. of pycnometer filled with water (gm)	1908.26		1768.58
	(C) wt. of pycnometer with specimen and water (gm)	2021.48		1999.3
	(S) wt. of saturated surface dry sample (gm)	478.89		447.72
	Bulk Specific Gravity on oven dry basis	$\frac{A}{(B+S-C)}$	2.043	1.993
	Bulk Specific Gravity on saturated surface dry basis	$\frac{S}{(B+S-C)}$	2.117	2.063
	Apparent Specific Gravity	$\frac{A}{(B+A-C)}$	2.309	2.174
	Water Absorption (%)	$\frac{100(S-A)}{A}$	38	48
AVERAGE RESULTS				
BULK SPECIFIC GRAVITY			2.008	
BULK SPECIFIC GRAVITY ON SATURATED SURFACE DRY BASIS			2.118	
APPARENT SPECIFIC GRAVITY			2.240	
WATER ABSORPTION			5.2	
TESTING LAB				
Lab Technician				

INSTITUTION		CLIENT		TESTING LAB	
UGANDA CHRISTIAN UNIVERSITY		JOSHUA LWANYAGA & (S21B32/020) & JESSE KIRABO (S21B32/077)		Stirling	
PROJECT		ASSESSING THE USE OF ACTIVATED PRESS MUD IN STRENGTH OF LOW GRADE CONCRETE			
RESISTANCE TO DEGRADATION BY ABRASION AND IMPACT TO LOS ANGELES MACHINE (AASHTO T96 - 99)					
		OPERATOR		LAB TEAM	
MATERIAL SOURCE		MUNDING CRUSHER		TOTAL 80 (2x) WT. OF THE SAMPLE 1	1,000.0
				TOTAL 80 (2x) WT. OF THE SAMPLE 2	1,000.0
MATERIAL		AGGREGATES		DATE SAMPLED	20/06/2024
SPECIFICATION				DATE TESTED	21/06/2024
Test 1 Grading of Test Samples					
SIEVE SIZE		Mass of retained Sizes g			Grading
Passing	Retained on	A	12 balls	B	11 balls
mm	mm	20	10		
17.5 (3/4")	75.0 (3")	1250 ± 25			
25.0 (1")	75.0 (3/4")	1250 ± 25			
19.0 (3/4")	12.5 (1/2")	1250 ± 10	2500 ± 10		
12.5 (1/2")	6.3 (1/8")	1250 ± 10	2500 ± 10		
9.5 (3/8")	4.75 (No. 4)			7500 ± 10	
6.3 (1/4")	2.36 (No. 8)			2500 ± 10	
4.75 (No. 4)					10000 ± 10
TOTAL		5000 ± 10	5000 ± 10	10000 ± 10	10000 ± 10
Speed of Rotation: 33 Rev/min. Max. 500 Rev.					
Max Duration: 15 min					
GRADING USED FOR TEST		SAMPLE 1	SAMPLE 2	Wt after crushing	4,980.0
Wt of Mat. Retained on 1.75mm sieve		4,100.0	4,149.2	Wt after crushing	4,982.3
Wt of fine material		850.0	851.8	Average	17.0
Percentage of wear		17.0	17.0	Spec Req	15.0%

