The Effect of Rice Husk Ash and Silica as Admixtures on The Properties of Concrete

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DEDICATION

This thesis is dedicated to each individual who has helped me improve academically and personally and has supported and encouraged me, whether directly or indirectly. It is dedicated to my family, my supervisor Pn Sushella Edayu Binti Mat Kamal, as well as to the friends who kindly offered their time and knowledge to the study. I thank them for believing in me and for their encouragement and support.

ABSTRACT

This study explores the impact of rice husk ash (RHA) and silica as admixtures on concrete properties for building applications. The research project used a 1:2:0.5 ratio for concrete production, with varying percentages of admixtures. Three types of mixtures were tested: RHA 1, RHA 2, and SP 1, with different amounts of cement, fine sand, water, and admixtures. The research follows ASTM standards and uses a detailed process flowchart to test various admixture ratios and percentages. The process flowchart outlines a detailed procedure for investigating the impact of waste materials as admixtures on concrete properties for buildings. The experiment begins with material selection, mixing ratio, and apparatus purchase. The slump test, compressive strength, water absorption, and scanning electron microscopy tests are conducted, analyzing concrete qualities and providing recommendations. Workability tests reveal that RHA enhances workability even with reduced cement content. Compressive strength tests show that an increase in RHA percentage may reduce compressive stress, while higher silica percentages boost compressive stress. Unconfined compressive strength of the mixture increases slower with higher RHA content and higher with longer curing age. Water absorption tests reveal that higher RHA percentages increase water absorption, potentially posing durability concerns. However, silica consistently shows improved moisture resistance, highlighting its effectiveness in mitigating water absorption issues. SEM analysis reveals that elevated RHA percentages create voids, fractures, and pores, indicating potential challenges at the microstructural level. As water evaporates, more voids form, increasing porosity, and filling these voids with air reduces thermal conductivity due to low thermal conductivity. The study's recommendations emphasize the need for careful admixture selection, considering the impact on both macroscopic and microscopic concrete properties. The findings contribute to the development of sustainable and enduring concrete mixes tailored to specific applications.

ABSTRAK

Kajian ini menyelidiki kesan abu sekam padi (RHA) dan silika sebagai adunan terhadap sifat-sifat konkrit untuk aplikasi pembinaan. Projek penyelidikan menggunakan nisbah 1:2:0.5 untuk penghasilan konkrit, dengan peratusan adunan yang berbeza. Tiga jenis campuran diuji: RHA 1, RHA 2, dan SP 1, dengan jumlah simen, pasir halus, air, dan adunan yang berbeza. Kajian ini mengikut standard ASTM dan menggunakan carta alir proses yang terperinci untuk menguji pelbagai nisbah dan peratusan adunan. Carta alir proses menggariskan prosedur terperinci untuk menyiasat impak bahan buangan sebagai adunan terhadap sifat-sifat konkrit untuk bangunan. Eksperimen bermula dengan pemilihan bahan, penentuan nisbah adunan, dan pembelian alat. Ujian kebolehkerjaan menunjukkan bahawa RHA meningkatkan kebolehkerjaan walaupun dengan kandungan simen yang kurang. Ujian kekuatan mampat menunjukkan bahawa peningkatan peratusan RHA mungkin mengurangkan tekanan mampatan, sementara peratusan silika yang lebih tinggi meningkatkan tekanan mampatan. Kekuatan mampat tanpa terikat campuran meningkat lebih perlahan dengan kandungan RHA yang lebih tinggi dan lebih tinggi dengan tempoh pengerasan yang lebih lama. Ujian penyerapan air mendedahkan bahawa peratusan RHA yang lebih tinggi meningkatkan penyerapan air, berpotensi menimbulkan kebimbangan ketahanan. Walau bagaimanapun, silika secara konsisten menunjukkan rintangan lembapan yang lebih baik, menekankan keberkesanan dalam mengatasi masalah penyerapan air. Analisis SEM menunjukkan bahawa peningkatan peratusan RHA mencipta rongga, retakan, dan liang, menunjukkan cabaran potensi pada peringkat mikrostruktur. Apabila air menguap, lebih banyak rongga terbentuk, meningkatkan porositi, dan mengisi rongga-rongga ini dengan udara mengurangkan kekonduksian termal disebabkan oleh kekonduksian termal yang rendah. Cadangan kajian menekankan keperluan pemilihan adunan dengan berhati-hati, mengambil kira impak pada sifat konkrit sama ada pada peringkat makroskopik atau mikroskopik. Penemuan ini menyumbang kepada pembangunan campuran konkrit yang mampan dan tahan lama yang direka khusus untuk aplikasi tertentu.

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LIST OF SYMBOLS AND ABBREVIATIONS

ASTM	-	American Society for Testing and Materials
LOI	-	Loss On Ignition
ASR	-	Alkali-Silica Reaction
RHA	-	Rice Husk Ash
POFA	-	Palm Oil Fuel Ash
BA	-	Bagasse Ash
CCA	-	Corn Cob Ash

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CHAPTER 1

INTRODUCTION

1.1 Background

Concrete is one of the most widely used building materials and is frequently utilised in building construction because of its strength, durability, and adaptability (Vasoya & Varia, n.d.). 30 billion tonnes of concrete are used annually around the world (nature, 2021) . In the upcoming years, urbanisation and rising population, particularly in emerging nations, are likely to drive up demand for concrete.

The price of producing concrete and the cost of the natural raw resources used to make it both rise as use of concrete rises (Novotny et al., 2019). Natural raw materials such as cement and aggregates. This is due to the fact that the price of the raw materials used in manufacturing has a direct impact on the cost of creating concrete.

Alongside a typical increase in population, waste items have also grown in quantity and variety. Many of the waste products that don't degrade will stay in the environment for hundreds or even thousands of years. The non-decaying waste materials lead to a crisis in trash disposal, which worsens the environmental issues (Batayneh et al., 2007). Concrete is a typical building material made of aggregates and cement that binds them together. Besides the transportation sector, concrete is the third-largest source of human-induced greenhouse gas emissions for the principal pollutant of carbon dioxide in the atmosphere (Kurtulus & Baspinar, 2022).

The cost of manufacturing and the natural raw materials used to manufacture concrete both rise as concrete use grows. This is the reason precisely efforts are being made to develop substitutes for the natural raw materials currently utilised in the manufacturing of concrete. The substitute resources are made from waste materials and are added to concrete as admixtures. It has a favourable impact on the characteristics of concrete for the constructio. Through incorporating waste materials into the manufacturing of concrete, the amount of garbage transported to landfills is decreased, as is the carbon footprint associated with the production of concrete.

Green construction has become increasingly popular due to the need to reduce carbon emissions. According to the World Green Structure Council (WGBC), green construction is a building that reduces or eliminates negative impacts and can create positive impacts on the climate and natural environment. Green concrete is concrete that has at least one recycled component, was produced using environmentally friendly methods, or has excellent life cycle sustainability (Hashmi et al., 2022).

1.2 Problem Statement

Building and infrastructure construction have expanded significantly in the modern, civilised world as a result of a growing population and higher life demands. Concrete is one of the most adaptable and popular constructed building materials when compared to other building materials (Vasoya & Varia, n.d.). Such development efforts use up a significant amount of priceless natural resources. This results in both a quicker depletion of natural resources and an increase in the cost of building structures (Vasoya & Varia, n.d.).

Numerous elements, such as the price of raw materials, labour expenses, and energy prices, can have an impact on the cost of producing concrete (Raut et al., n.d.). The price of making concrete may rise along with the price of natural raw materials, which might affect the overall cost of construction projects that employ concrete as a key building material (Novotny et al., 2019).

Construction industry waste makes up 45–65% of the waste disposed in landfills, contributing 35% of the world's carbon dioxide emissions. Additionally, it generates 30% of the world's greenhouse gas emissions, of which 18% are attributable to the transportation and processing of building materials (Ahmad et al., 2021). Due to the natural resources it uses and the one tonne of carbon dioxide it produces every tonne of Portland cement (OPC), concrete has a considerable negative impact on the environment (Hashmi et al., 2022).

There are many opportunities for green infrastructure construction using waste materials because of the present high demand for natural resources to meet construction demands. These waste products may be categorised as local, industrial, or agricultural waste (Hashmi et al., 2022). Reusing and recycling these resources is important. Prior to usage, it is necessary to adequately process and test the waste materials being evaluated for use in building construction. Additionally, to reduce the jeopardy of environmental contamination, precise handling and disposal procedures should be followed. To guarantee the structural integrity and safety of the structure, building rules and standards should also be observed.

1.3 Research Objective

The primary goal of this study is to identify waste materials that may be added to concrete to improve its qualities for building. The following are the specific goals:

a) To identify the advantages and disadvantages of the existing admixtures in concrete.

b) To propose the reuse and recycling of rice husk ash and silica as concrete admixtures.

c) To analyse the impact of rice husk ash and silica as admixtures on the mechanical characteristics of concrete.

1.4 Scope of Research

The scope of this research are as follows:

- Investigating the physical, chemical, and mechanical characteristics of rice husk ash and silica, to decide whether or not they are suitable for use as concrete admixtures.
- Study of the effects of rice husk ash and silica added to concrete as admixtures on the material's workability, water absorption, compressive strengths, and microstructure.
- Evaluation of the mechanical properties and workability of concrete using rice husk ash and silica used as admixtures, taking into account the impact on drop, flow, and setting time.
- Studying potential obstacles and difficulties related to adding rice husk ash and silica to concrete.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Concrete is a popular building material due to its ease of manufacture, strength, and durability. It is used in a variety of common situations, such as buildings, highways, tunnels, bridges, and trains. However, it is important to look for alternate aggregate sources to provide more sustainable, eco-friendly concrete. Waste materials can be used as a natural admixture, lowering the ecological harm caused by trash, while also lessening the burden waste places on the environment.

2.2 Sustainability and Sustainable Concrete

The worldwide concrete business is concerned about sustainability, which entails limiting negative environmental effect, balancing natural resource use and generation, and seeking a balance between economic development and environmental preservation. Engineers have a professional responsibility to inform and educate customers, the general public, and their peers on current building standards and laws, as well as the long-term benefits of sustainable concrete. Engineers must be attentive and accountable in order to accomplish sustainable development, utilize by-products and reuse materials, and limit carbon dioxide emissions and natural resource extraction from quarries. Other industrial leftovers and biogenic waste can also be useful in this way. (Karim et al., 2011)

2.2.1 Necessity and Opportunity of Sustainable Concrete Using Waste Materials

The cement industry produced 1.4 billion tons of carbon dioxide gas in 1995, and developing nations create biogenic wastes such as palm oil fuel ash, rice husk ash, sawdust ash/ash from timber and industrial by-products slag, silica, and fly ash. Waste materials use is an important component in energy saving or conservation, and the use of waste materials in cement manufacturing in Malaysia could be a potential step towards reducing carbon dioxide emissions and conserving energy. This procedure would be beneficial and relevant for the following reasons: waste reduction, environmental pollution reduction, raw material and energy savings, and carbon dioxide emission reduction. (Karim et al., 2011)

2.2.2 Benefits of Using Waste Material in Concrete

The use of supplemental cementing materials from other sources has become increasingly important due to technical, environmental, and economic reasons. These include industrial by-products such as slag, fly ash, ash from timber, agricultural waste, rice husk ash, palm oil fuel ash, ceramic waste, kiln dusts, sludge, concrete demolition waste, incineratorash, and post-consumer waste glass, plastic, tires, steel, fibers. Palm oil fuel ash can be used as pozzolans to replace part of cement, improving compressive strength, flexural strength, split tensile strength, rice husk ash showing better durability, and resistance to sulfate attack. (Karim et al., 2011)

2.3 Waste Materials As Aggregate/Admixtures In Concrete

Aggregate is one of the major components of concrete blocks and is essential for their properties. Waste materials have been recycled and used as aggregate in concrete blocks, exhibiting lower strength, lower density and higher water absorption. This is because the quality requirements for raw materials used in the production of concrete blocks are relatively low compared to other conventional concrete products. Additionally, most waste materials have unique characteristics and can be utilized in concrete blocks for special applications. (Bostanci, 2020)

2.3.1 Plastic Waste

Plastic waste is any wasted plastic material that is no longer required to use which encompasses a wide range of plastic products such as bottles, bags, packaging materials, containers, and other plastic objects. Plastic debris may be used to make concrete in a process known as "plastic concrete" or "plastic-aggregate concrete" which is as shown in Figure 2.1. This entails mixing shredded or granulated plastic debris into the concrete mix.

Concrete that contains plastic waste as an additive can help cut waste and advance environmental sustainability. Additionally, it can increase weight reduction, durability, and workability. The cement matrix and plastic particle compatibility and bonding, however, might be problematic. Plastic materials could not offer the same strength and load-bearing capability as conventional aggregates, raising questions about the structural integrity of concrete mixed with plastic waste admixtures. The aesthetics and appearance of concrete may be impacted by the use of plastic waste admixtures.

Plastic waste may be used to create value-added eco-friendly concrete blocks with low water permeability, acid resistance, lightweight construction, and improved insulation. Meng et al., (2018) found that concrete blocks with a higher amount of plastic material have higher compressive strength, mechanical strength, water absorption, ductility, and energy absorption capacity. Because of the angular, sharp edges and elongated form, plastic substitution of sand affects concrete workability.

Steyn et al., (2021) shows that plastic in concrete reduces compressive strength in general, although with low plastic concentration (20%), compressive strength improves. Plastic with a low stiffness has a lower elastic modulus and absorbs more water, whereas impermeable plastic particles create a bridge over micro-cracks, limiting permeability. Plastics can also be used to lower slump values according to Hashmi et al., (2022).

Figure 2.1 Appearance of plastic waste. (Steyn et al., 2021)

2.3.2 Glass Waste

Glass waste is any discarded glass material that is no longer needed. Crushed glass as shown in Figure 2.2 is distinguished by characteristics such as minimal water absorption, stability, hardness, impermeability, and intrinsic qualities.

Admixtures made from glass waste can be used to concrete to decrease waste, enhance aesthetics, boost strength, and lower heat conductivity. The compatibility with cement and other concrete components, the possibility of an alkali-silica reaction (ASR), processing and handling issues, safety concerns, and quality control issues can all be problems. Glass needs to be appropriately crushed and sized to guarantee adequate particle distribution and prevent problems with workability and segregation during concrete mixing and placing. If sufficient safety precautions are not followed, the sharp edges of glass particles can cause injuries.

Meng et al., (2018) identified crushed glass incorporation has been shown to reduce the density of concrete blocks while increasing mechanical qualities such as compressive, flexural, and splitting tensile strengths. It also has the benefit of activating titanium dioxide to produce a self-cleaning function by transmitting more light to a deeper depth from the surface layer of concrete. Glass workability is uneven, which affects packing density and increases concrete air content.

It has been shown that glass addition will lower concrete compressive strength, but it may also function as a pozzolan and boost concrete splitting tensile capacity, particularly when the particles are extremely tiny. It also enhances water absorption and permeability while promoting the pozzolanic reaction (Steyn et al., 2021). Hashmi et al., (2022) noted slump values can also be reduced by using waste materials such as glass.

Figure 2.2 Appearance of glass waste material. (Steyn et al., 2021)

2.3.3 FlyAsh Waste

Sivakrishna et al., (2020) stated fly ash waste is a fine, powdery substance extracted from exhaust using electrostatic precipitators or other filtration methods. It is widely employed as a supplemental cementitious ingredient in the manufacturing of concrete. Fly ash has properties comparable to pozzolanic materials like silicon dioxide and aluminum oxide, and it may be utilized as a cement substitute ingredient in porous concrete. Fly ash contributes to making concrete less porous and more water resistant. It has been evaluated as a binder for improving the compressive strength and toughness of cementitious composites.

A pozzolanic substance called fly ash combines with calcium hydroxide to produce more cementitious compounds, which have higher long-term strength, durability, and performance. Additionally, it enhances workability, lessens environmental effect, and lessens the heat of hydration. However, the source and makeup of the material might affect the quality. The appropriateness of fly ash for the specified application, setting time and curing, mixing and compatibility, availability and logistics should all be carefully considered. For the pozzolanic reaction to take place and to provide the requisite strength and durability, enough curing is necessary.

2.3.4 Silica Waste

Silica waste, also known as microsilica, is a byproduct of the manufacture of silicon and ferrosilicon alloys. It is an amorphous silica-based substance that is extremely reactive and fine-grained. Silica which is a byproduct of ferrosilicon manufacture, has been utilized as supplementary cementitious materials in concrete for decades.

Sivakrishna et al., (2020) indicated silica is a pozzolanic substance with a high degree of reactivity that improves the durability and strength of concrete. The concrete matrix becomes denser and more compact as a result of filling the spaces between the cement particles, increasing the concrete's compressive strength, flexural strength, and resistance to chemical attack, abrasion, and chloride penetration. Additionally, it lessens concrete's permeability, enhancing workability and cohesiveness and boosting long-term stability. However, it can be difficult to handle, store, and mix into concrete, and it is often more costly than other cementitious materials. Concrete's setting time may be sped up, necessitating careful management of the concrete mix design and curing processes. Its dark gray tint can also have an impact on the shade and look of concrete.

Sivakrishna et al., (2020) also observed the addition of silica to concrete has been proven to lower total carbon dioxide emissions while improving mechanical qualities. Silica is a super-pozzolan that is made up of silicon dioxide, magnesium, iron, and alkali oxides.

Meng et al., (2018) found in the manufacturing of concrete, silica waste is frequently used as a supplemental cementitious ingredient. Silica increased concrete compressive strength by 12%, 16%, and 20%, respectively. The addition of silica to concrete enhanced its modulus of elasticity, and the addition of silica and rice husk ash up to the ideal concentration boosted concrete's flexural strength.

2.3.5 Rice Husk Waste

Rice husk waste as shown in Figure 2.3 is a byproduct of rice manufacturing that can be used efficiently in a variety of applications. Hashmi et al., 2022 stated rice husk ash is a carbon-neutral green product made from raw rice husk that has been burned to ash. It has an amorphous silica content of 85% to 90% and may be utilized in concrete mixtures. Rice husk ash may be utilized as a pozzolanic ingredient in concrete due to its high silica concentration and highly reactive pozzolanic qualities. The furnace's duration and temperatures are critical characteristics.

Waste from rice husks may be used to concrete as an additive to lessen waste, increase insulation, and produce lightweight concrete. Additionally, it may have pozzolanic activity, which might improve the durability, strength, and long-term performance of concrete. Nevertheless, depending on the type of rice, the processing techniques, and the storage circumstances, it may differ in content and qualities. Although rice husk waste is a crucial ingredient in concrete, it is challenging to create uniform mix designs and performance standards due to its moisture sensitivity and lack of standardization. To guarantee that the addition does not adversely influence the concrete's overall performance, compatibility testing is required.

Sivakrishna et al., (2020) mentioned rice husk ash is a cementitious substance that may be used to boost the compressive strength of concrete. It has been proven to lower total carbon dioxide emissions while improving mechanical qualities. However, the addition of rice husk ash to concrete has a negative impact on its fresh qualities, such as higher water demand and decreased flowability.

Figure 2.3 Appearance of rice husk ash (RHA). (Sivakrishna et al., 2020)

2.3.6 Rubber Waste

Steyn et al., (2021) stated crumb rubber as shown in Figure 2.4 has a detrimental impact on slump due to the establishment of an interlocking structure and higher air content due to its hydrophobic nature.

Rubber scraps used to concrete can save waste, increase impact resistance, increase flexibility and fracture resistance, and dampen vibration and noise. However, it can also lessen the material's total load-bearing capability and compressive strength. When employing rubber waste admixtures in concrete, compatibility and bonding problems, durability issues, and aesthetics and appearance issues may all need to be taken into account. Rubber particles may not be as strong as with traditional aggregates since they generally have lesser stiffness and strength compared to those of traditional aggregates.

Hashmi et al., (2022) indicated to reduce water absorption, rice husk ash-cement composites manufactured from scrap rubber tyres and polypropylene fiber might be used. Meng et al., 2018 mentioned crumb rubber can also be utilized to improve the performance of concrete blocks, with reduced thermal conductivity, greater sound absorption, and a higher noise reduction coefficient.

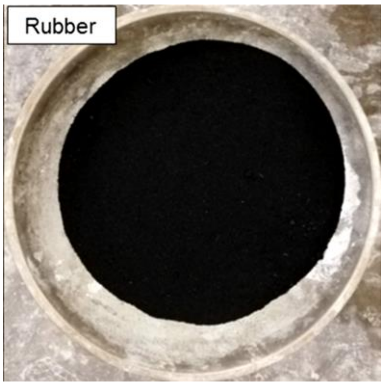


Figure 2.4 Appearance of rubber waste. (Steyn et al., 2021)

2.3.7 Seashells Waste

Waste from seashells can be added to concrete as an additive to give it a distinctive visual appeal, better workability, and perhaps even pozzolanic activity. It can be difficult to produce consistent results and quality control in the design and construction of concrete mixes because the characteristics of seashell trash, such as shell type, size, form, and composition, can differ greatly depending on the source and environmental circumstances.

Mo et al., (2018) determined with a salt level of 0.35%, seashells have a chemical composition comparable to limestone and may be replaced for up to 10% of aggregate in concrete. They exhibit 96.9% flakiness, a specific gravity of 2.09-2.73, and an absorption capacity of 1.80-7.70%. They can lower concrete hardened density while increasing compressive strength owing to higher surface area and weaker strength. For compressive strength increase, there is an ideal degree of aggregate substitution with seashells. Seashells can reduce concrete's compressive strength, tensile strength, elastic modulus, and dynamic modulus.

Mo et al., (2018) also mentioned oyster shells enhance concrete shrinkage and porosity, whereas scallop shells increase porosity. Oyster shell powder has the ability to improve concrete porosity by up to 20% while simultaneously decreasing it by up to 15%. In reinforced concrete, seashell powder can lower thermal conductivity, enhance heat absorption, and improve sound absorption.

2.3.8 Recycled Concrete Waste

Ahmad et al., (2021) pointed out recycled aggregate concrete as shown in Figure 2.6 is formed using recycled aggregate derived from building and demolition debris as a partial or total alternative for natural aggregates. The physical and mechanical qualities of the recycled aggregate, the amount of recycled aggregate included, the moisture content of the recycled aggregate, the water-cement ratio (w/c) of the mix, and the microstructure of the resultant matrix all influence the compressive, flexural, and split-tensile strength of recycled aggregate concrete. Recycled aggregate replacement content has a substantial effect on recycled aggregate concrete at constant w/c, and replacing recycled aggregate concrete entirely can lower by up to 30%. The parent concrete age from which recycled aggregate is taken influences the development of recycled aggregate concrete significantly.

(Batayneh et al., 2007) found that crushed concrete was used in concrete mixes to replace up to 20% of natural coarse particles. The particle size distribution of recycled aggregates is comparable to that of natural aggregates. Superplasticizers or regulated percentages are required for the decreased slump and workability of recycled concrete aggregate mixtures.

Figure 2.5 Appearance of recycled concrete waste. (Meng et al., 2018)

2.3.9 Palm Oil Fuel Ash (POFA) Waste

Palm oil fuel ash is a waste product produced by the combustion of palm oil residues such as fiber and shells in biomass thermal power plants to generate steam for electricity generation. Figure 2.6 below shows the global production of palm oil in 2009 (Oil Palm market monitor, 2014). Palm oil production in Malaysia and Thailand is likely to increase due to plantation. In comparison to other types of palm-oil byproducts, palm oil fuel ash is considered a nuisance to the environment and is disposed of without being put to any other use. Palm oil fuel ash is a type of ash formed when palm oil husk or fiber and palm kernel shell are burned as fuel in a palm oil mill boiler.

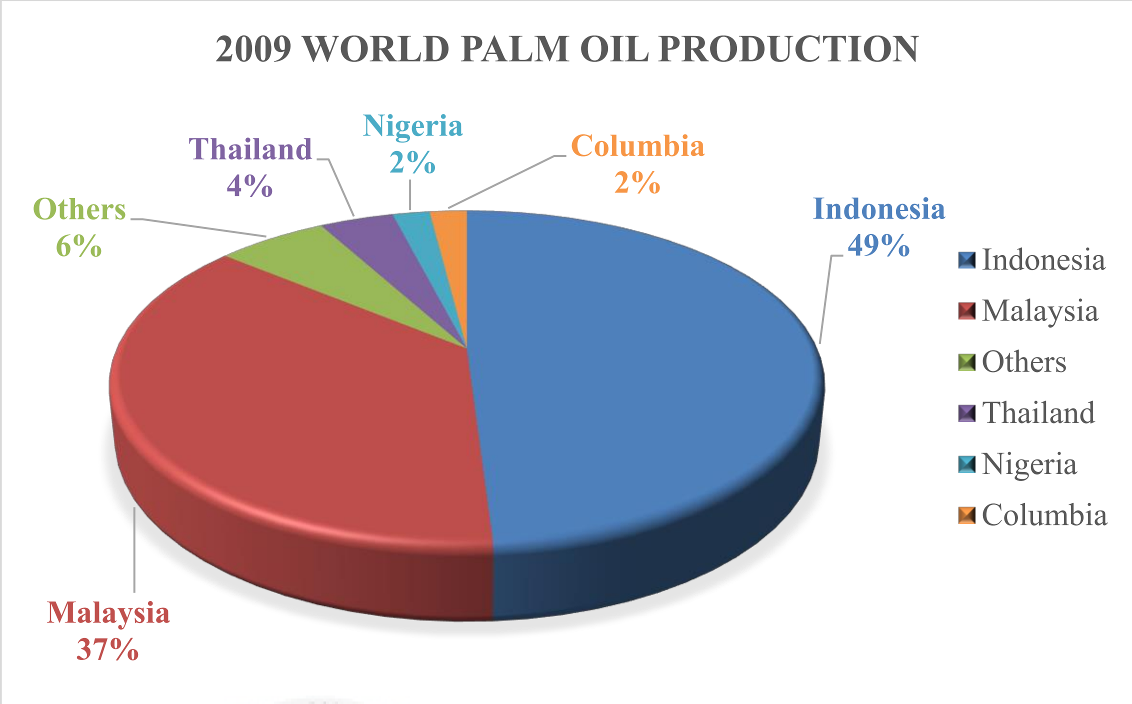


Figure 2.6 World Figure palm oil production in 2009. (Aprianti S, 2017)

Aprianti S, (2017) mentioned it contains a considerable amount of silica (59.62%) and iron (5.02%). The physical properties of palm oil fuel ash are controlled by the operational system and combustion process in the palm oil factory. Palm oil fuel ash's pozzolanic reaction is a simple acid-base reaction using calcium hydroxide and silicic acid. By having a loss on ignition (LOI) of less than 10%, the usage of palm oil fuel ash as a binder meets the chemical criterion in ASTM C618 as pozzolanic material. The compressive strength mortar owing to the pozzolanic reaction of palm oil fuel ash ranged from 4.5 Mpa at 7 days to 22.5 Mpa at 90 days for 40% cement substitution by weight of binder. It revealed that the pozzolanic response of palm oil fuel ash was minor at first and would become more significant as time goes on.

Palm oil fuel ash concrete has increased compressive, flexural, and water permeability. Palm oil fuel ash may be utilized as a cement substitute up to 30% in the production of high-strength concrete, and the resulting compressive strength is greater than that of cement. Furthermore, palm oil fuel ash may lower the water permeability of high-strength concrete, and the inclusion of ultrafine palm oil fuel ash tends to minimize the high-strength concrete's water requirement.

Overall, palm oil fuel ash has considerable promise as pozzolanic cementing materials with potentially superior technical qualities when mixed and cured properly. (Aprianti S, 2017)

2.3.10 Bagasse Ash (BA) Waste

Bagasse ash is a byproduct of the sugar cane bagasse cogeneration and combustion process. It is a potential pozzolanic substance that may be employed as a supplemental ingredient in cement mortar and concrete. The chemical and physical characteristics of bagasse ash are the primary determinants of the existence of pozzolan minerals.

Accounrding to Aprianti S, (2017) the utilization of bagasse ash have shown excellent results in the physical and mechanical qualities of concrete. Bagasse ash is responsible for the early strength development of concrete because to its tiny particle size, degree of bagasse ash reactivity, and silica concentration. The powdered bagasse ash revealed that the concrete had up to 30% bagasse ash and had a compressive strength of 68.6 MPa. It may be inferred that because the bagasse ash particle is finer than the ordinary portland cement particle, it has a higher water absorption and, of course, a bigger surface area to respond, as well as a faster initial and final setting time. Because of its high silica and alumina content, the hardening process was hastened.

2.3.11 Wood Waste Ash Waste

Wood waste ash is a byproduct of the burning of wood products such as chips and bark. It is restricted to specific levels for crop development and should be appropriately technical owing to tiny particles and the ease of air pollution.

Aprianti S, (2017) discovered that the flexural and compressive strength optimum was attained for 10% wood waste ash. As predicted, the carbonation depth of cement mixes including wood waste ash was larger than that of cement mixtures. Wood waste ash has the potential to be a good pozzolanic material for cement substitution, adding to the sustainability of eco-constructions.

2.3.12 Bamboo Leaf Ash Waste

Aprianti S, (2017) said in recent years, research has concentrated on the use of agricultural waste as pozzolans in the production of concrete. Bamboo leaf as shown in Figure 2.7 is a solid waste from agriculture that may be utilized as fiber and for other important functions in construction materials. Only a few research have been conducted to investigate the usage of bamboo leaf ash as shown in Figure 2.7 in concrete mixtures. The hydration process of bamboo leaf ash as a binder with an optimal percentage of 20wt% bamboo leaf ash that is equivalent to standard cement was explored.

Figure 2.7 Appearance of bamboo leaf and bamboo leaf ash (BLA). (Aprianti S, 2017)

2.3.13 Corn Cob Ash (CCA) Waste

Corn cob ash is a fine-grained debris produced by the burning of maize and corn. It contains more than 65% silicon dioxide and an oxide mixture of aluminum oxide and silicon dioxide in the range of 70%e75%. The inclusion of corn cob ash as a pozzolanic ingredient in blended cement causes the concrete to set faster than the control concrete. The compressive strength of corn cob ash in concrete is lower than that of ordinary concrete at first, but it improves dramatically with age. (Aprianti S, 2017)

2.4 Workability of concrete

The phrase "workability" or "workable concrete" refers to the degree of fluidity or movement. Water content, mix proportions, aggregate size, shape, surface roughness, aggregate grading, and additive usage are all factors that affect how workable a mixture is. The most popular technique for determining the consistency of concrete is the slump test, which may be done both in a lab and on the job site. It does not always reflect the concrete's ability to be placed, nor does it quantify all aspects that affect workability. True slump, which occurs when the concrete slumps equally, is distinguished from shear droop, which occurs when just one side of the cone slides down. The height difference between the mold's height and the average value of sinking is used to calculate the slump value. (WORKABILITY OF CONCRETE BY SLUMP CONE TEST 1. Objective, 2013)

Water content, aggregate characteristics, cement content and type, chemical admixtures, mix proportions, temperature, time after mixing, consistency, mixers and equipment, as well as other features like strength, durability, and finishability, all determine how workable concrete is. Aggregate attributes refer to the size, shape, and grading of the aggregates, whereas water content refers to the amount of water in the concrete mixture. Chemical admixtures are added to concrete to improve workability, while cement type and content determine the kind of cement utilized. The ratio of cement, water, aggregates, and admixtures in the concrete mix is known as the mix proportions. Workability is influenced by temperature, although time after mixing can also have an impact. (theconstructor., 2021)

Concrete workability is strongly connected to consistency, and obtaining the necessary workability requires the use of certain mixing methods and tools. When creating and adjusting concrete mix proportions for particular building projects, it's crucial to strike a balance between workability and other qualities like strength, durability, and finishability. (Steyn et al., 2021)

2.5 Elasticity, Flexural, And Compressive Strength of Concrete

The term "elasticity" describes a material's capacity to deform when subjected to force and then recover its original shape when the force has been withdrawn. Young's modulus or the modulus of elasticity are frequently used to explain the elasticity of concrete. It displays the stress to strain ratio for the material's elastic range. Concrete's elastic modulus, a key factor in structural analysis and design, governs the material's capacity to withstand deformation.

The modulus of rupture, sometimes referred to as flexural strength, gauges a concrete's resistance to bending or flexural stresses. A concrete beam or slab's maximum bending moment before failing in tension is indicated by this term. For structural parts susceptible to bending stresses, such as beams and bridge decks, flexural strength is a crucial quality.

The characteristic of concrete that is most frequently mentioned is compressive

strength. It gauges how well concrete can withstand pressures like compression or squeezing. Concrete cubes or cylinders are often tested in a laboratory to measure the material's compressive strength. It is crucial in determining the longevity and structural strength of concrete components.

Concrete's elasticity, flexural strength, and compressive strength are important parameters that are influenced by a variety of factors such as water-cement ratio, cement content, aggregate characteristics, admixtures, curing conditions, aggregate-cement ratio, concrete age, density, and construction techniques. The water-to-cement ratio influences strength and elasticity, whereas cement volume and type affect stiffness and strength. It must be considered to take into account these factors during the design, mixing, and construction processes to provide proper strength and flexibility for intended usage. (Chisholm JGibbs T Harrison & Eng MICE DChisholm BE CPEng IntPE JGibbs BA MICT THarrison C Eng FICT MICE, 2008)

A literature review matrix is put together to indicate the study's findings throughout the conduct of the literature review in order to summarize the whole review. Table 2.1 below provides an overview of data from earlier studies.

Table 2.1 Summary of previous researches findings.

No.	Literature Title	Objective	Methodology	Major Finding	Reference
1.	A scientometric review of waste material utilization in concrete for sustainable construction	It would be more sensible to incorporate waste materials into concrete.	Waste materials can be recycled into chemical compounds that are appropriate for SCMs or into natural aggregate substitutes for concrete. Examples include plastic, rubber, glass, ashes, rubber, recycled concrete material, and slag.	By examining the bibliometric data that is accessible, scientometric analysis is utilized to ascertain the condition of research at the moment.	(Ahmad et al., 2021)
2.	Green Concrete: An Eco-Friendly Alternative to the OPC Concrete	It is advised that these large concrete components be replaced with alternative materials to address sustainability challenges.	Products like fly ash, rice husk ash, pulverized granular blast-furnace slag, silica, and recycled coarse aggregates	Increased resilience to abrasion, shrinkage cracking, permeability, permeability, bleeding control, and acid resistance.	(Hashmi et al., 2022)

No.	Literature Title	Objective	Methodology	Major Finding	Reference
3.	Necessity and Opportunity of Sustainable Concrete from Malaysia's Waste Materials	The use of WM as a cement substitute in the manufacturing of SC.	Cement and concrete are made up of POFA, RHA, sawdust ash, ash from wood, bagasse ash, and industrial waste.	Concrete's strength and tensile characteristics	(Karim et al., 2011)
4.	Green concrete: A review of recent developments	Concrete may be made sustainably using alkali-activated binders, cementitious elements that have been replenished, and recycled resources.	Concrete may be strengthened and made to endure longer by adding materials such fly ash, rice husk ash, silica, plastic, glass, polyethylene, and polypropylene.	Due of their economic significance, new materials have been employed to produce greener, more cost-effective concrete that performs better than traditional concrete.	(Sivakrishna et al., 2020)
5.	Recycling of wastes for value-added applications in concrete blocks: An overview	examines the use of numerous wastes, including recycled concrete, broken brick, soda lime glass, cathode ray tube glass, crumb rubber, and ceramic and tile waste, according to published studies.	Waste from ceramic and tile production, recycled concrete, broken brick, soda lime glass, cathode ray tube glass, crumb rubber, etc.)	Concrete blocks have improved fire resistance, hardness, functionality, and insulation thanks to recycled crumb rubber, plastic waste, and crushed brick.	(Meng et al., 2018)
6.	Concrete containing	Examines the	Glass, rubber, and plastic aggregates	Test for mechanical	(Steyn et al., 2021)

No.	Literature Title	Objective	Methodology	Major Finding	Reference
	waste recycled glass, plastic and rubber as sand replacement	characteristics of used LDPE plastic, shredded rubber from tires, and crushed clear flat glass as a partial replacement for fine aggregate.	are all used in concrete.	properties. Test for durability properties.	
7.	A huge number of artificial waste material can be supplementary cementitious material (SCM) for concrete production e a review part II	Industrial and agricultural wastes can be utilized as an additional cementitious material in the manufacturing of concrete.	In the concrete industry, artificial wastes such as fly ash, slag, silica, rice husk ash, palm oil fuel ash, sugar cane bagasse ash, wood waste ash, bamboo leaf ash, and corn cob ash are employed.	Wastes can be repurposed if their technical, physical, and chemical qualities are understood.	(Aprianti S, 2017)

2.6 Summary

In the literature review, it is examined how the characteristics of concrete for buildings are affected by waste materials used as admixtures. The review begins with an introduction to sustainability and sustainable concrete, including the advantages of employing waste materials in concrete as well as the requirement and possibility for sustainable concrete to use waste materials. It emphasizes the possibility of waste materials as workable substitutes for conventional admixtures with the goal of improving concrete's environmental performance and characteristics.

The review examines how different types of waste materials, including plastic, glass, fly ash, silica, rice husk, rubber waste, seashells, recycled concrete, palm oil fuel ash, bagasse ash, wood waste ash, bamboo leaf ash, and corn cob ash, can be used to alter the properties of concrete. It synthesizes previous studies that evaluate how these waste products affect concrete's workability, elasticity, flexural strength, and compressive strength. The results show that adding these admixtures can enhance concrete's performance while lowering its carbon footprint. The research procedures, experimental approaches, and testing criteria used in the investigations are covered throughout the study.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In general, this chapter will outline the methodology used for this study based on the specific objectives and scopes of the investigation, as well as the fundamental methodology briefly explained in the previous chapter to investigate the effect of rice husk ash and silica as admixtures on the properties of concrete. To accomplish the study objectives, this part explains the experimental parameters, material description, research tests, equipment and experimental procedures.

3.2 Process Flowchart

Figure 3.2 shows a detailed process flowchart constructed to investigate the impact of waste materials as admixtures on the properties of concrete for buildings. It defines the beginning-to-end procedure to create a clear, visual, and structured major task.

Begin with the material selection, which is rice husk ash and silica. The mixing ratio is then set at 1:2:0.5. Then, purchase the materials and apparatus required to carry out the experiment. The experiment then began by mixing according to the ratio and executing the workability test, which is the slump test. Following the slump, continue with sample cures for 14 days before running the test.

There were three tests: compressive strength, water absorption, and scanning electron microscopy. Through the test, collected the necessary data for analyzing the concrete qualities. Finally, the outcomes and future recommendations were concluded.

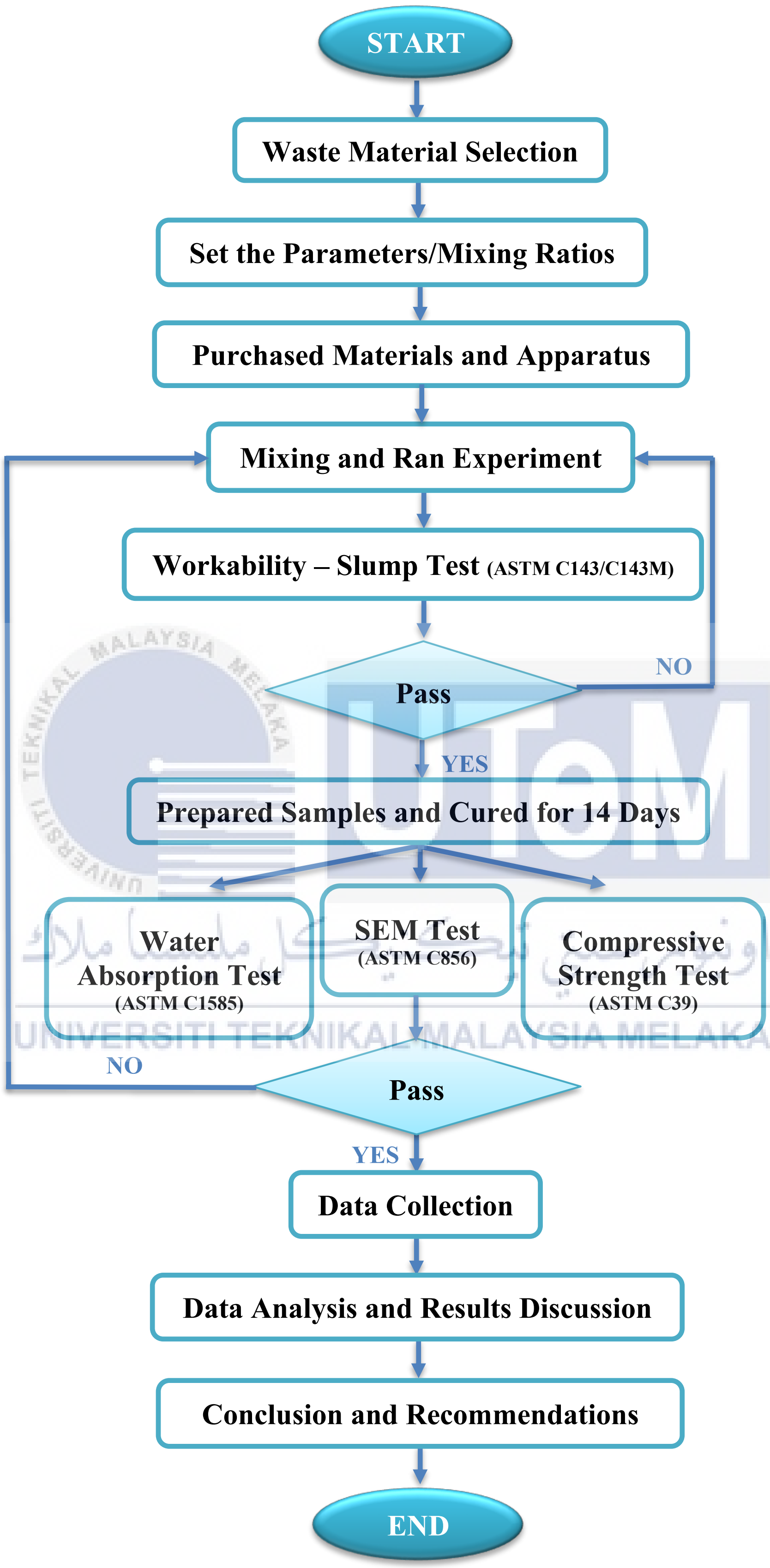


Figure 3.1 Process flowchart of concrete mixing and analyzing.

3.3 Methodology

The proposed approach describes the American Society for Testing and Materials (ASTM) to be followed for testing concrete specimens for workability, water absorption, scanning electron microscopy, and compressive strength. These tests are necessary to evaluate the performance of concrete from various angles and determine whether it is appropriate for a certain application.

3.3.1 Experimental Parameters

Here we will discuss the parameters that were designed to be used for the research project. There are various ratios available to produce concrete, but the ratio used for this project is 1:2:0.5, which is one part cement, two parts fine sand, and 0.5 part water. The percentage of admixtures used was 0%, 5%, 10%, and 15%. The tables below are for three types of mixtures: RHA 1 (rice husk ash 1), RHA 2 (rice husk ash 2), and SP 1 (silica powder 1), with different propositions of cement, aggregates (fine sand), water, and admixtures (rice husk ash and silica powder), all measured in grams (g).

Table 3.1 shows RHA 1 type samples, which are A1, A2, A3, and A4, with their specific amounts of cement, fine sand, rice husk ash, water, and admixtures. There is a decrease in the volume of cement and the aggregates, which are fine sand, but an increase in the volume of water and percentage of admixture, which is rice husk ash. Table 3.2 shows the concrete mixture parameters for RHA 2 type samples, which are B1, B2, B3, and B4. Table 3.3 focuses on the SP 1 type with C1, C2, C3, and C3 samples. RHA 2 and SP1 show that the volumes of cement, fine sand, and water were fixed, but the admixture differs in percentage, which is 0%, 5%, 10%, and 15%. Table 3.1 was formed to identify the characteristics and performance of the concrete when the usage of waste material is increased. Tables 3.2 and 3.3 compare which waste materials are best to use in producing concrete.

Table 3.1 Concrete mixture parameters for the RHA 1 sample.

Type	Samples	Cement (g)	Aggregates	Water (g)	Admixture
			Fine Sand (g)		Rice Husk Ash (g)
RHA 1	A1	3000	6000	1500	0
	A2	2000	4000	1000	150
	A3	1000	2000	500	100
	A4	500	1000	250	75

Table 3.2 Concrete mixture parameters for the RHA 2 sample.

Type	Samples	Cement (g)	Aggregates	Water (g)	Admixture
			Fine Sand (g)		Rice Husk Ash (g)
RHA 2	B1	750	1500	375	0
	B2	750	1500	375	37.5
	B3	750	1500	375	75
	B4	750	1500	375	112.5

Table 3.3 Concrete mixture parameters for the SP 1 sample.

Type	Samples	Cement (g)	Aggregates	Water (g)	Admixture
			Fine Sand (g)		Silica Powder (g)
SP 1	C1	750	1500	375	0
	C2	750	1500	375	37.5
	C3	750	1500	375	75
	C4	750	1500	375	112.5

3.3.2 Material Description

Figure 3.3 shows YTL CASTLE Portland Cement, a high-performance cement for general-purpose concrete applications with better workability, lesser waste, and increased water retention. It substitutes clinker with high-quality limestone and is produced by applying modern energy-efficient technologies, decreasing carbon footprint and providing smoother finishing.

Figure 3.2 Cement.

Fine sand as shown in Figure 3.4 is a ready to use material used in the production of concrete. For the concrete, cement and sand were mixed together. Smaller particles make up fine sand. These materials are readily available.

Figure 3.3 Fine sand.

Figure 3.5 shows Rice husk ash (RHA) which is a waste product from rice cultivation used in concrete manufacturing. Burned rice husk produces silica dioxide, which can be used as a supplementary cementitious material. Rice husk is a pozzolana, a siliceous material with little cementitious value, which forms a stable cementitious material. Burning rice husk into ash ensures physical characteristics and chemical compounds, making it an active pozzolanic material. Quality depends on incineration method, time, and temperature, with 1440°C melting point recommended. (Joel, 2020)

Figure 3.4 Rice husk ash.

Figure 3.6 shows silica powder also known as silica or microsilica, is frequently used in concrete as a supplementary cementitious material. Silica powder, produced from naturally occurring silica in minerals like quartz and sand, is used in construction, manufacturing, cosmetics, and pharmaceuticals due to its high heat resistance, hardness, and chemical inertness. Its application can improve the strength, durability, and resistance to chloride penetration of concrete.

Figure 3.5 Silica powder.

3.3.3 Test, Equipment and Procedure

3.3.3.1 Workability

The slump test is used to determine the consistency of fresh concrete. It is used indirectly to ensure that the proper amount of water has been added to the mix. It measures the vertical fall or settling caused by lifting a cone-shaped mold, ensuring the mix meets workability specifications. The test is carried out in accordance with the ASTM C143/C143M standardized method used in the construction sector to assess the consistency of freshly mixed concrete. (Anon,1966)

The Figure 3.7 shows concrete slump test set is used to determine the workability of mixed concrete and is considered an initial test before moving on to other tests. It is a simple, low-cost, quick, and easy test for determining the workability of mixed concrete. The set includes a base plate, a slump rod, and a cone, all of which are manufactured in Malaysia and can be purchased from Builders Trade MY on Shopee. During the slump test, relevant standards such as ASTM C143 and proper testing procedures were followed.

Figure 3.6 Concrete Slump Test Set.

Concrete test cube molds are used for compressing concrete specimens, adhering to ASTM C470 as the relevant standard as shown in Figure 3.8. The ABS Concrete Test Cube Plastic Mould is a lightweight, portable, and simple-to-use product perfect for ready-mix concrete. It is high-quality and reusable, with a smooth inner wall for easy concrete removal. For the experiment, three 100mm x 100mm links were used. Builders Warehouse in Shopee provided the Concrete Test Cube Mould.

Figure 3.7 Concrete Test Cube Mould.

The slump cone must first be cleaned, its inner surface wet, and it must be placed on a level surface. Next, it must be filled evenly with freshly mixed concrete, each layer compacted, and excess concrete struck off with the top of the slump cone. Finally, the slump cone must be lifted vertically and steadily to prevent any lateral or twisting movements as shown in Figure 3.9. The slump is defined as the height difference between the top of the slump cone and the displaced center of the concrete slurry, and it must be measured. (yohanj, 2023)

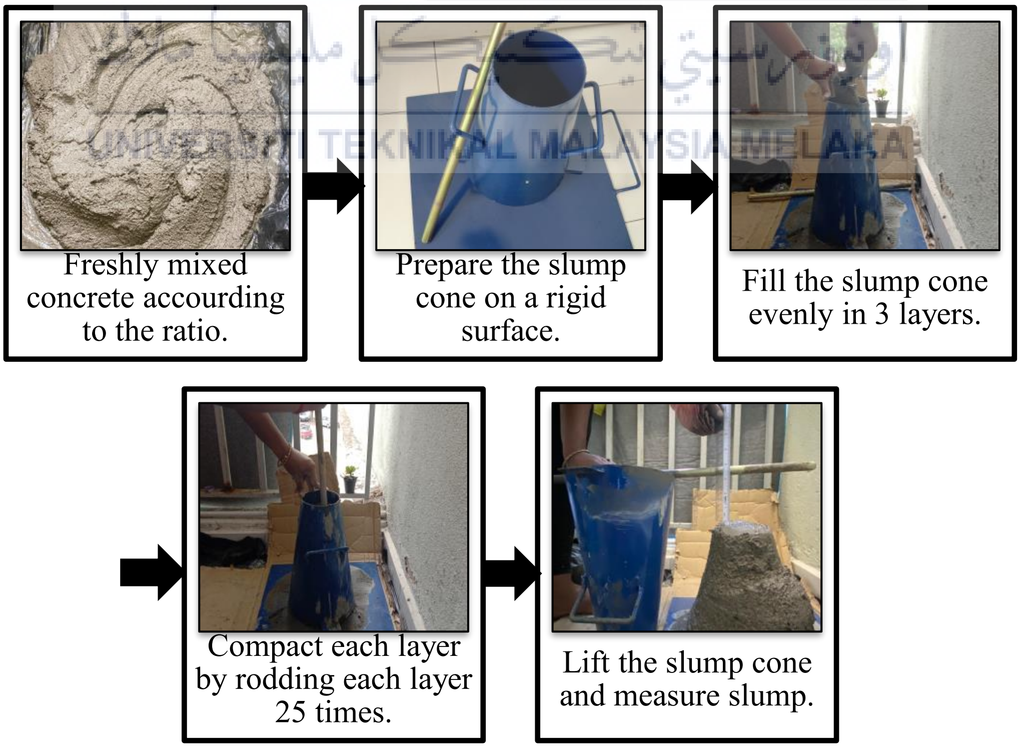


Figure 3.8 Slump test procedure.

3.3.3.2 Compressive Strength

Concrete compressive strength testing is a fundamental test that determines the capacity of concrete to endure compressive forces before failure or breaking. On the Intron machine as shown in Figure 3.10, the compressive strength was tested using the ASTM C39 standard testing procedure. Specimens of the cube shape were tested. The average of all specimens for a given w/c ratio and curing age is 14 days. A total of 12 samples were tested, including RHA 1, RHA 2, and SP 1, each of which had four samples.

At first, cast the concrete into a mold measuring 100mm by 100mm and label them. Cure the cubes for 14 days in an average-temperature environment. Then remove the cured concrete from the cubes. After that, set up the Intron machine and the system on the computer. Place the sample and adjust the machine setting for the desired loading rate, which is 14 MPa per minute. Next, apply the compressive load gradually until the cube fails, and record it. Once failures are observed, take out the cube and give the testing apparatus a thorough cleaning.

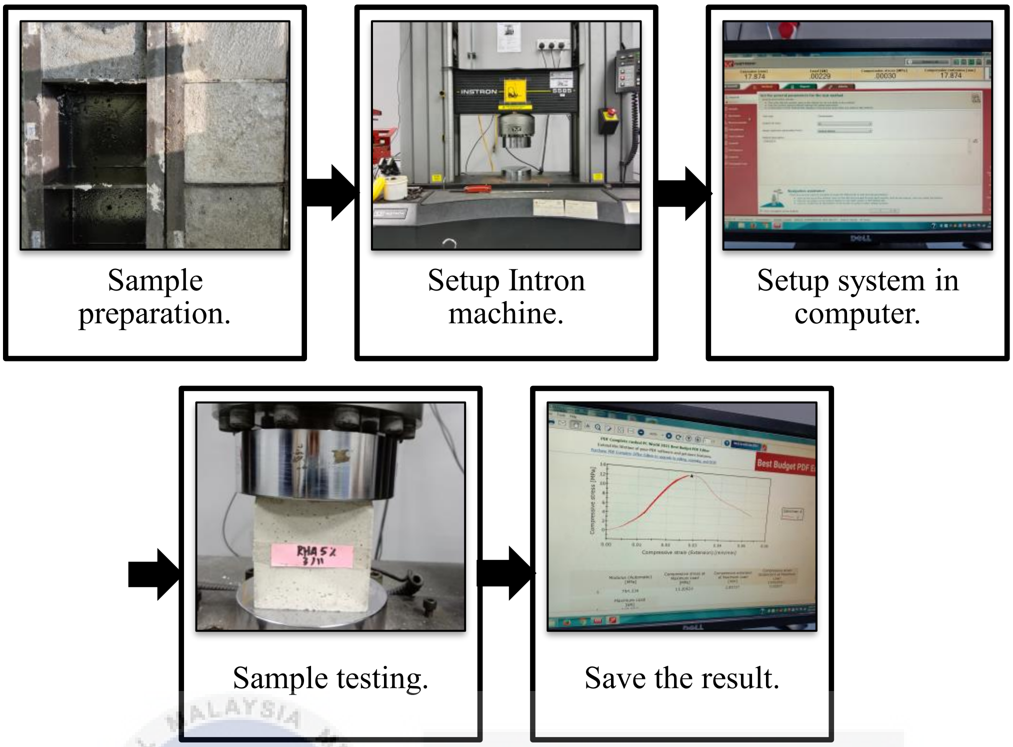


Figure 3.9 Compressive strength test procedure.

3.3.3.3 Water Absorption

The ASTM C1585 standard specifies the rate of water absorption by concrete samples due to capillary forces under unsaturated circumstances. The test uses block concrete specimens as shown in Figure 3.11 that are conditioned in a temperature and relative humidity setting for three days before being sealed for 15 days and weighed. The concrete sample is then placed in a water-filled pan, and its weight is measured after 7 days. A total of 12 samples were tested, including RHA 1, RHA 2, and SP 1, each of which had four samples. (Mohammadi, 2013)

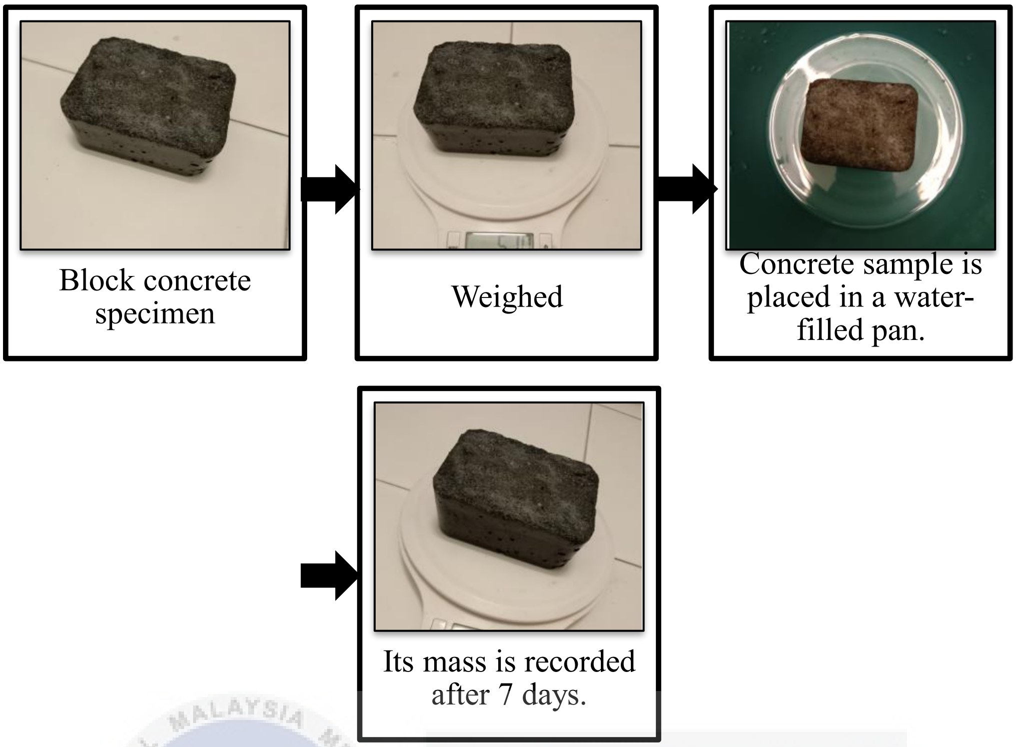


Figure 3.10 Water absorption test procedure.

3.3.3.4 Scanning Electron Microscopy (SEM)

ASTM C856 is a standard for analyzing hardened concrete using scanning electron microscopy (SEM) for microstructural analysis. To examine the samples under a scanning electron microscope (SEM), first gather all the prepared samples to be analyzed. Make sure it is appropriately labeled. Break the sample as shown in Figure 3.12 to expose a fresh surface, and the surface should be flat and smooth.

Then, prepare the spatter coater equipment and small samples of the material. After positioning the sample in the middle of the apparatus and turning on the vacuum, the platinum coating process will begin and last for 30 seconds. When the thirty seconds of coating are done, turn off the machine. After the coating is finished, place the sample in an appropriate holder before SEM examination. Accurate analysis and a dust-free, clean surface for the sample are ensured by this procedure.

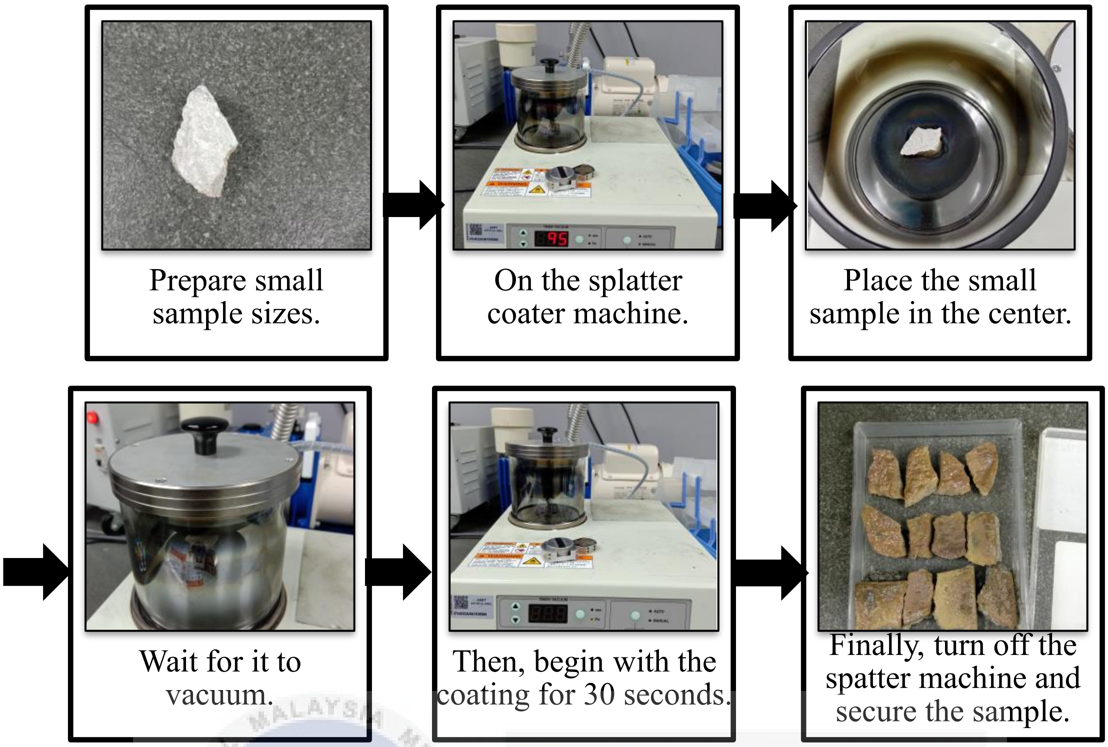


Figure 3.11 Platinum coating procedure.

After the platinum coating, attach the sample securely to the sample holder of the SEM machine using the tape as shown in Figure 3.13. In a round, four samples were placed according to the particular concrete mixture. Then on the SEM machine to warm up and create a vacuum within the SEM chamber to reduce unwanted molecules from the air. After vacuuming, calibrate the SEM for optimal imaging by adjusting the settings. Then capture the images with different magnifications by using different imaging modes. Lastly, process the captured images using SEM software and save the folder.

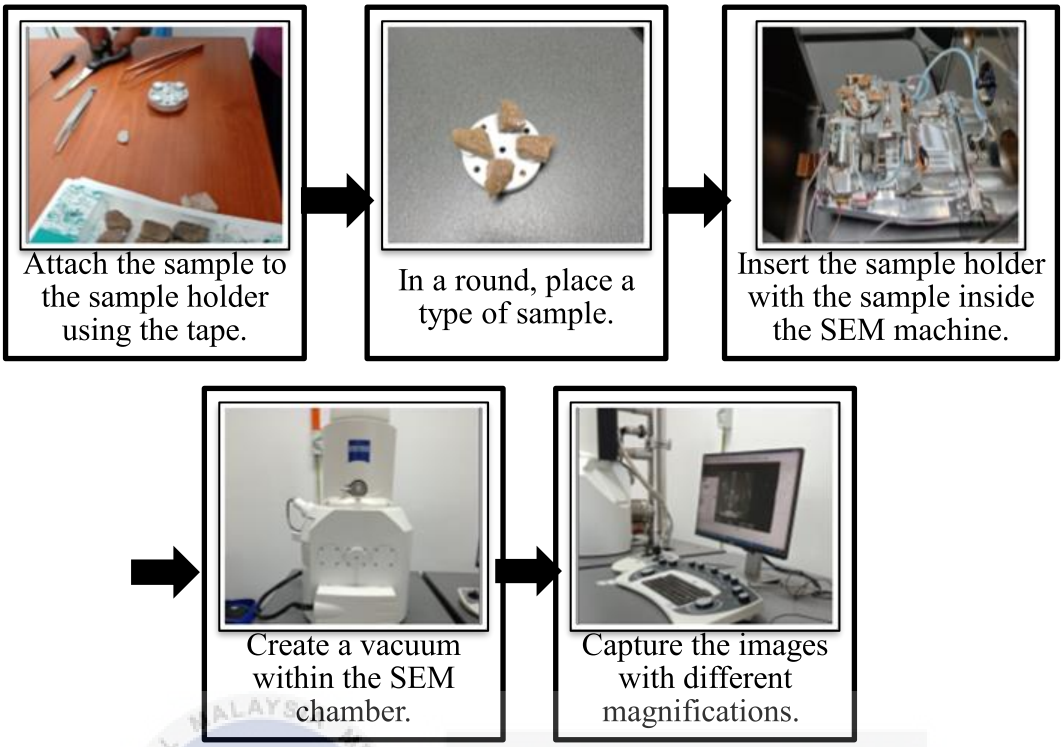


Figure 3.12 Scanning Electron Microscopy (SEM) test procedure.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

In this chapter it analyzed various concrete mixtures, including rice husk ash, silica, cement, aggregates, water, and admixtures, to understand their impact on key properties as workability, compressive strength, water absorption, and microstructural characteristics. Experiments included slump tests, compressive stress tests, water absorption tests, and scanning electron microscopy (SEM) analysis. It is to understanding of how different material compositions affect concrete properties, revealing potential applications, strengths, and limitations for construction purposes.

4.2 Workability – Slump Test

Table 4.1 shows four samples named A1, A2, A3, and A4 for the concrete mixture of different volumes of cement, fine sand, water, and rice husk ash for each sample. The workability results for RHA 1 show A1 95mm, A2 98mm, A3 102mm, and A4 101mm. A1 and A2 achieved medium workability, and A3 and A4 achieved high workability. Slump values with higher values often indicate greater workability.

Table 4.1 Workability results for RHA 1.

Type	Samples	Slump Value (in mm)	Degree of Workability
RHA 1	A1	95	Medium workability
	A2	98	Medium workability
	A3	102	High workability
	A4	101	High workability

Table 4.2 shows the RHA 2 type concrete mixture with 4 samples, named B1, B2, B3, and B4. For all the samples, the amount of cement, fine sand, and water was the same but differed in the percentage of rice husk ash. The slump value obtained is 92mm for B1, 96mm for B2, 94mm for B3, and 90mm for B4. The workability obtained for all the samples is medium.

Table 4.2 Workability results for RHA 2.

Type	Samples	Slump Value (in mm)	Degree of Workability
RHA 2	B1	92	Medium workability
	B2	96	Medium workability
	B3	94	Medium workability
	B4	90	Medium workability

Table 4.3 shows a SP 1 type concrete mixture with 4 samples, which are C1, C2, C3, and C4. For all the samples, the volume of cement, fine sand, and water is the same but different in percentage of silica, which is 0%, 5%, 10%, and 15%. The slump values obtained are 102mm, 101mm, 103mm, and 105mm. It shows high workability for all four samples, which indicates consistent workability.

Table 4.3 Workability results for SP 1.

Type	Samples	Slump Value (in mm)	Degree of Workability
SP 1	C1	102	High workability
	C2	101	High workability
	C3	103	High workability
	C4	105	High workability

The tables 4.1, 4.2, and 4.3 provide workability results for various concrete mixtures. In Table 4.1, A1 and A2 showed medium workability with slump values of 95mm and 98mm, while A3 and A4 showed high workability with slump values of 102mm and 101mm. Table 4.2 showed medium workability with slump values of 92mm, 96mm, 94mm, and 90mm for all RHA 2 samples. Table 4.3 showed consistent workability across all SP 1 samples with high slump values, suggesting that varying silica percentages did not significantly affect the workability of the concrete mixtures.

According to Siddika, Mamun, et al., 2021 RHA contains macro and mesopores that absorb water, reducing free water and lowering slump value and Tayeh et al., 2021 mentioned higher reactivity of RHA can also lower concrete flow.

The Figure 4.1 reveals that the higher the rice husk ash percentage, the higher the slump value, even with reduced cement and sand content. RHA enhances workability even with reduced cement content. The SP 1 shows consistently increasing the degree of workability which is considered as high workability.

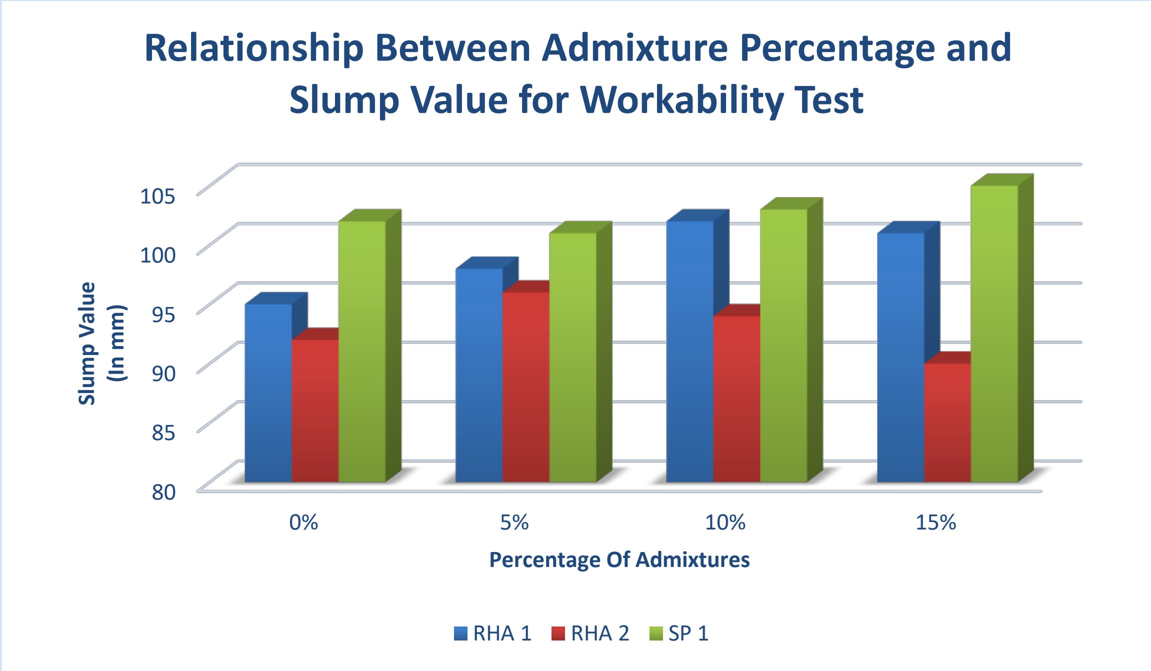


Figure 4.1 Admixture percentage and slump value graph.

4.3 Compressive Strength Test

Table 4.4 shows the impact of the RHA 1 type concrete mixture on the mechanical properties of a cement aggregate composite. The tables come with cross-sectional area in mm², maximum load in kN, and compressive stress at maximum load in MPa. It reveals that the higher the cement and fine sand levels in the mixture, the greater the compressive stress at maximum load, while higher rice husk ash and water levels lower these properties. This is because the pores and voids in samples A3 and A4 are too large, according to the SEM test image. The higher the voids and pores, the lower the load-bearing capacity and compressive stress.

Table 4.4 Compressive stress results for RHA 1.

Type	Samples	Cross-sectional area (in mm²)	Maximum Load (kN)	Compressive stress at Maximum Load (Mpa)
RHA 1	A1	10000	140.017	14.00167
	A2	10000	140.008	14.00078
	A3	10000	76.222	7.62218
	A4	10000	24.873	2.48731

Table 4.5 shows compressive stress results for RHA 2, which shows the mechanical properties of the concrete mixture, which comes with the same amount of cement, fine sand, and water but a different percentage of rice husk ash. The compressive stress results reveal that none of the samples from B1, B2, B3, and B4 achieved the maximum compressive stress of 14 MPa. Even through the SEM test, it shows cracks, pores, and voids for all the samples.

Table 4.5 Compressive stress results for RHA 2.

Type	Samples	Cross-sectional area (in mm²)	Maximum Load (kN)	Compressive stress at Maximum Load (Mpa)
RHA 2	B1	10000	132.062	13.20624
	B2	10000	119.777	11.97769
	B3	10000	105.196	10.51960
	B4	10000	85.414	8.54142

Table 4.6 shows the impact of 0% to 15% of the silica percentage on the same amount of cement, sine sand, and water ratio. It shows that the higher the silica, the higher the compressive stress at the maximum load, except for sample C4, which contains 15% silica. Through the SEM test, we can understand that the sample C4 has some cracks.

Table 4.6 Compressive stress results for SP 1.

Type	Samples	Cross-sectional area (in mm²)	Maximum Load (kN)	Compressive stress at Maximum Load (Mpa)
SP 1	C1	10000	140.001	14.00013
	C2	10000	140.002	14.00022
	C3	10000	140.009	14.00090
	C4	10000	132.526	13.25262

The Figure 4.2 examines the impact of different concrete mixtures on the mechanical properties of cement aggregate composites, focusing on compressive stress at maximum load. Results show that higher levels of cement and fine sand increase compressive stress, while elevated rice husk ash and water decrease it. This is due to larger voids and pores in which can observe through SEM test images. For RHA 2 type samples, none achieved the maximum compressive stress of 14 MPa, because it consists cracks, pores, and voids when observe through SEM test images. For SP 1 samples, higher silica percentages generally lead to increased compressive stress, except for sample C4 with 15% silica.

A study found that the strength of concrete made with part replacement of cement by RHA is due to higher w/c ratios. (Dharmaraj et al., 2023) Yan et al., 2022 mentioned the unconfined compressive strength of the mixture increases slower with higher RHA content and higher with longer curing age.

Based on the Figure 4.2 it reveals that higher silica in concrete mixtures increases mechanical strength. Abhilash et al., 2021 found that even a small dose of silica can significantly enhance compressive strength due to its high pozzolanic activity. High reactivity with CH during hydration can increase compressive and tensile strengths. Mehta & Ashish, 2020 found silica addition improves the bond between aggregate and paste, enhancing bond at the matrix interface.

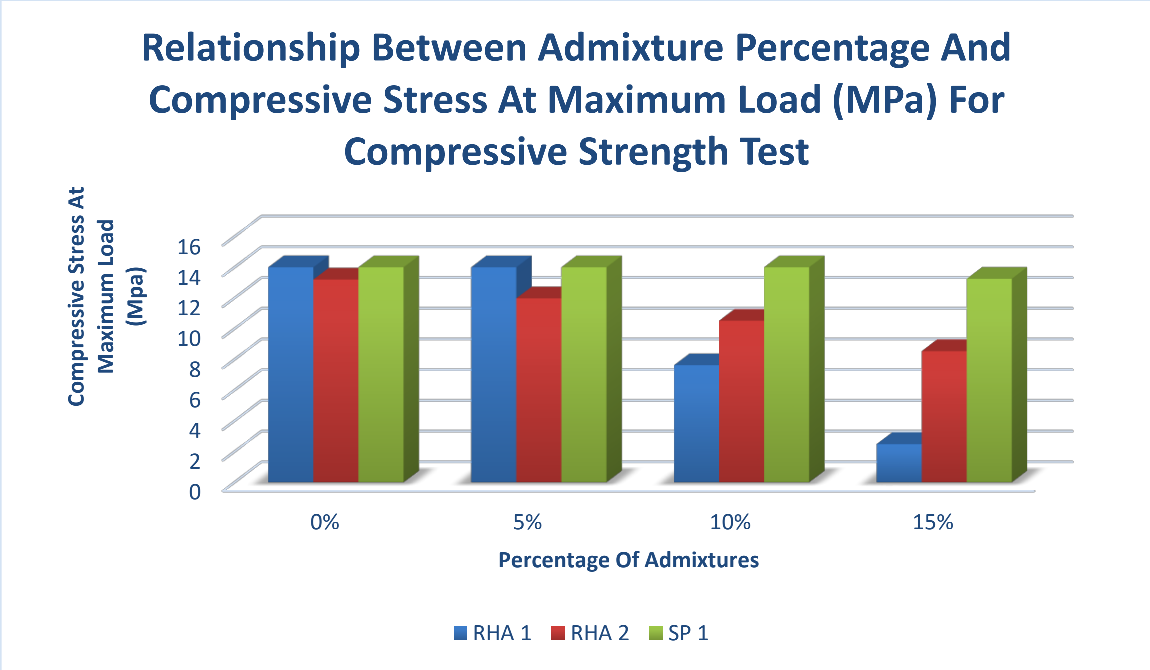


Figure 4.2 Admixture percentage and compressive stress at maximum load (MPa) graph.

4.4 Water Absorption Test

Table 4.7 shows water absorption results for the RHA-1 type. The mixture contains lower cement, fine sand, and higher water and rice husk ash. It shows that the higher the amount of rice husk ash and water in the mixture, the higher the water absorption for 7 days.

Table 4.7 Water absorption results for RHA 1.

Type	Samples	m_t(g)	$a\ (mm^2)$	Water Absorption $I = \frac{m_t}{a.d}$
RHA 1	A1	34	44.18	772
	A2	53	44.18	1203
	A3	75	44.18	1703
	A4	115	44.18	2611

According to Table 4.8, even with the same amount of cement, fine sand, and water in the mixture, the water absorption rises from 681 to 1022 because of the increased percentage of rice husk ash, which is from 0% to 15%.

Table 4.8 Water absorption results for RHA 2.

Type	Samples	m_t(g)	$a\ (mm^2)$	Water Absorption
				$I = \frac{m_t}{a.d}$
RHA 2	B1	30	44.18	681
	B2	37	44.18	840
	B3	40	44.18	908
	B4	45	44.18	1022

Table 4.9 results show different results when the water absorption is maintained between 636 and 749 for the SP 1 type. It shows silica absorbs less volume of water compared to rice husk ash.

Table 4.9 Water absorption results for SP 1.

Type	Samples	m_t(g)	$a\ (mm^2)$	Water Absorption
				$I = \frac{m_t}{a.d}$
SP 1	C1	28	44.18	636
	C2	30	44.18	681
	C3	31	44.18	704
	C4	33	44.18	749

Table 4.7 shows water absorption results for the RHA-1 type, which contains lower cement, fine sand, and higher water and rice husk ash. The higher the amount of rice husk ash and water, the higher the water absorption for 7 days. Even with the same amount of cement, fine sand, and water, the water absorption increases from 681 to 1022 due to the increased percentage of rice husk ash. Table 4.9 shows silica absorbs less water compared to rice husk ash.

Figure 4.3 shows the impact of different percentages of admixture on concrete mixtures. An increase in RHA percentage leads to greater water absorption. Even with the same cement, sand, water, and rice hush ash ratio, the trend shows an increase in water absorption, with significant differences for each percentage. Tayeh et al., 2021 researched water absorption in concrete increases with RHA substitution ratio, but this increases surface water absorption, causing moisture attack and affecting the durability of reinforced concrete structures.

The silica mixture in concrete exhibits consistent water absorption values between 636 and 749. According to Abhilash et al., 2021, silica when added to concrete, has been found to decrease water absorption by reducing the connection between cellular pores.

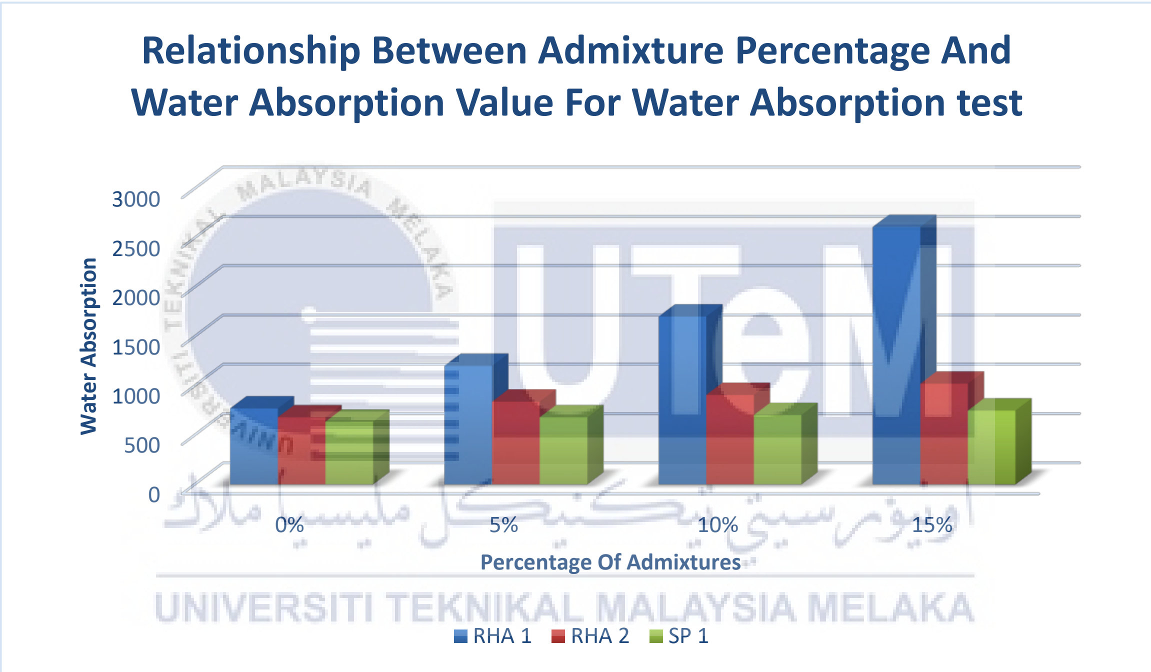


Figure 4.3 Admixture percentage and water absorption value graph.

4.5 Scanning Electron Microscopy (SEM) Test

The RHA 1, RHA 2, and SP 1 concrete samples analyzed using a scanning electron microscope (SEM), using a ZEISS EVO 18 model and selected magnifications of 100x and 500x µm. The samples were coated with a thin platinum layer for conducting layer scanning.

Table 4.10 shows SEM test results for the RHA 1 sample, revealing that a decrease in cement volume and fine sand, but an increase in rice husk ash and water volume, affects concrete composition. Results show that 5% of rice husk ash contains pores and cracks, 10% has larger pores, and 15% has many voids.

Table 4.10 Scanning Electron Microscopy (SEM) test results for RHA 1.

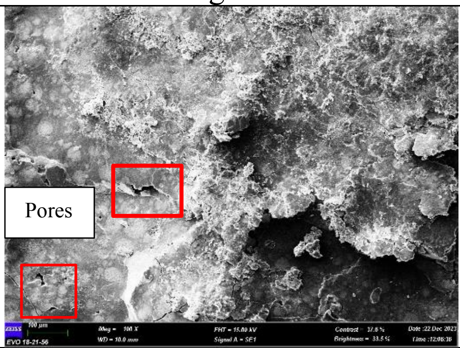
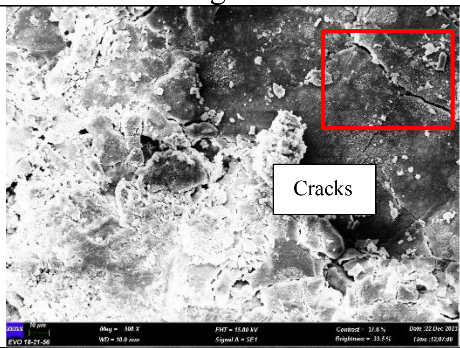
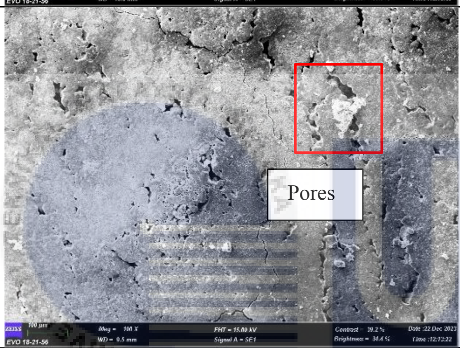
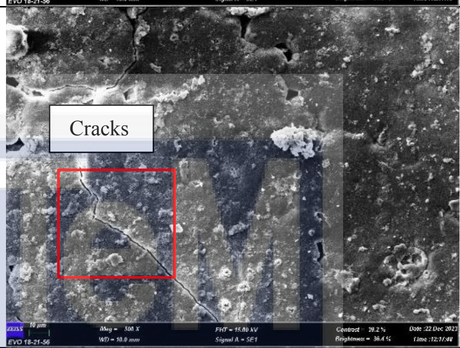
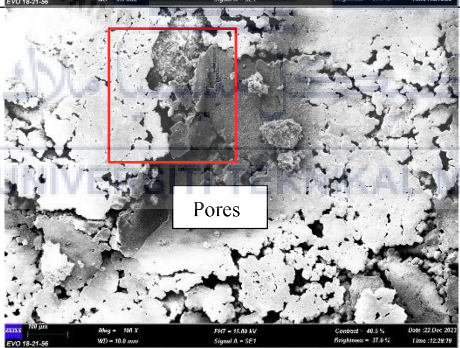
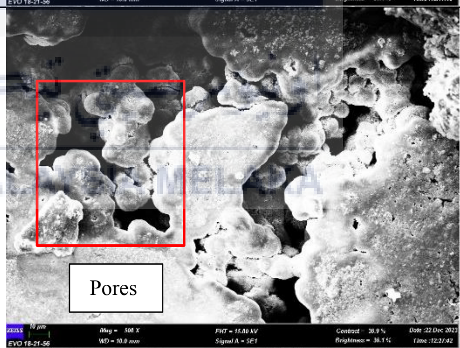
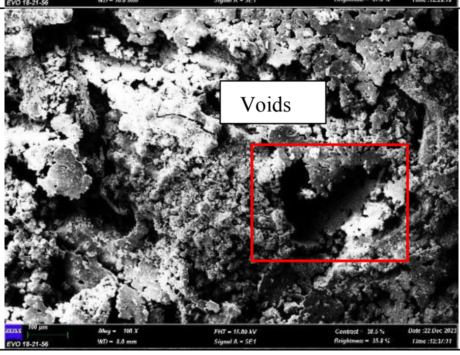
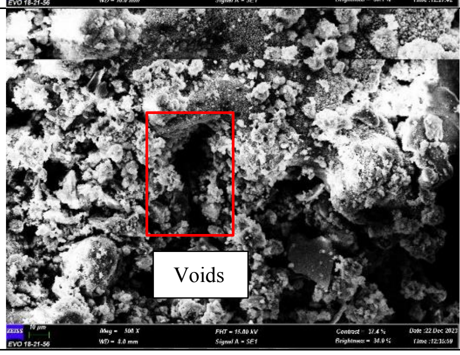
%	Mag: 100x	Mag: 500x
0		
5		
10		
15		

Table 4.11 shows SEM test results for the RHA 2 sample, revealing consistent amounts of cement, aggregates, water, fine sand, and rice husk ash in different percentages (0%, 25%, 50%, 75%). Rice husk ash usage results in micro cracks and pores in 5% and 10% of RHA, while 15% shows a rough surface with many micropores.

Table 4.11 Scanning Electron Microscopy (SEM) test results for RHA 2.

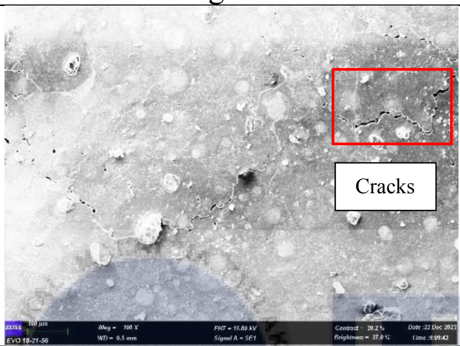
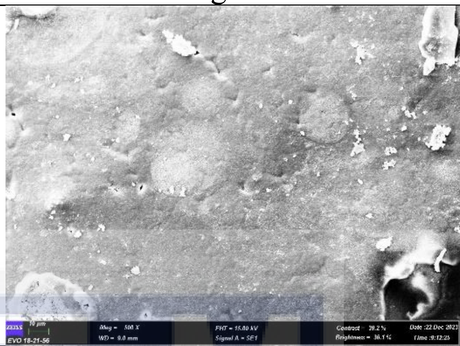
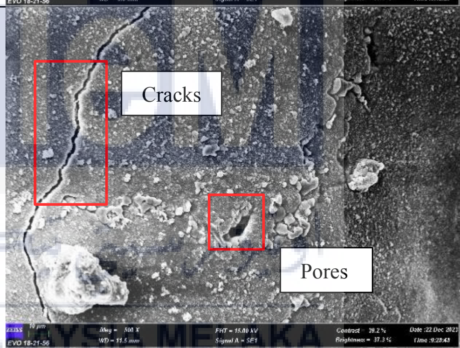
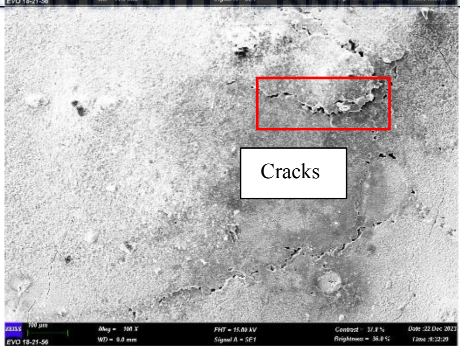
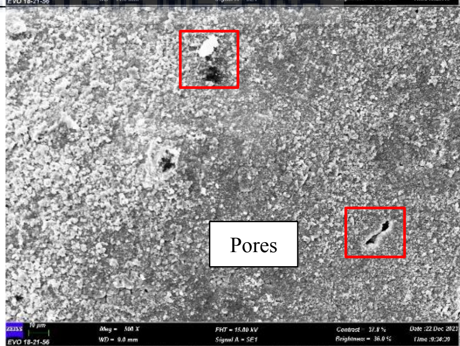
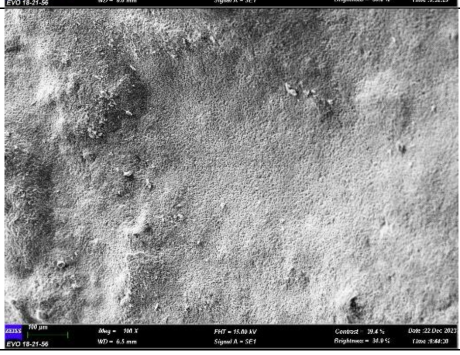
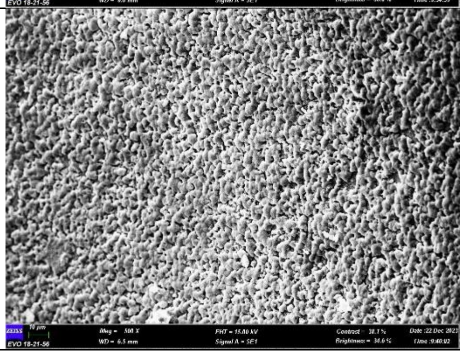
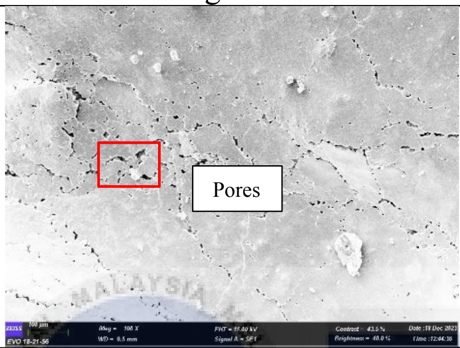
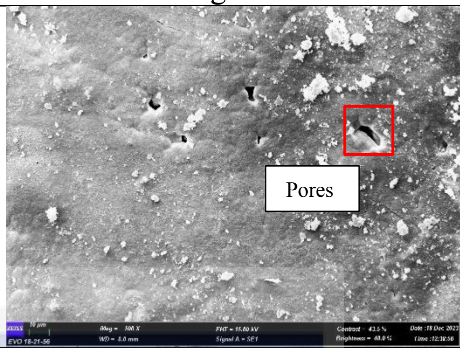
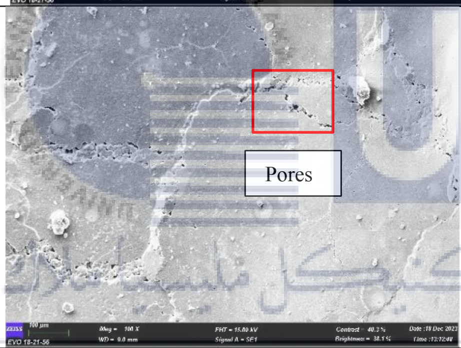
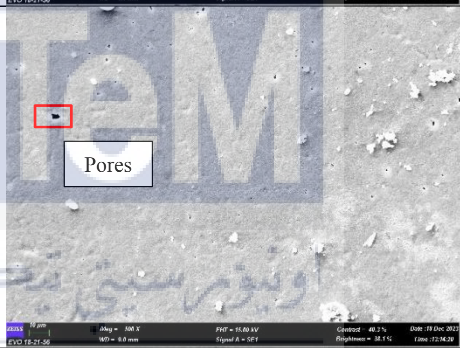
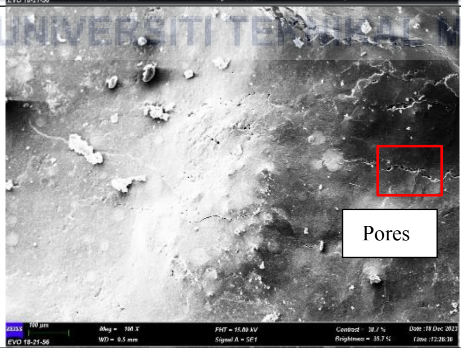
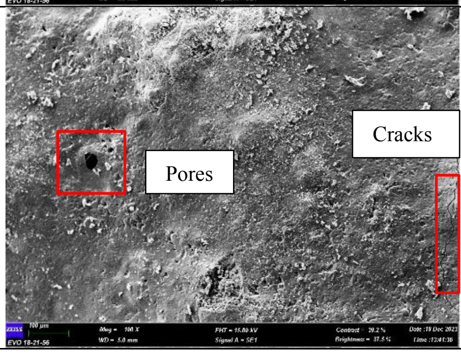
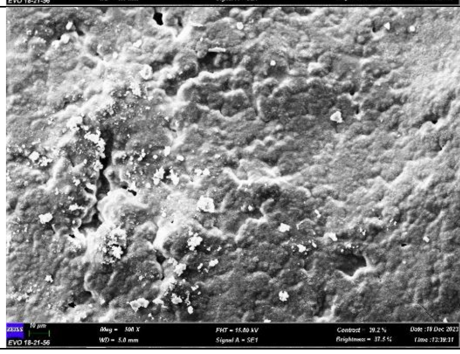
%	Mag: 100x	Mag: 500x
0		
5		
10		
15		

Table 4.12 shows SEM test results for the SP 1 sample, revealing consistent amounts of cement, aggregates, water, fine sand, and silica in different percentages (0%, 25%, 50%, 75%). The 5% and 10% silica used showed pores and smooth surfaces, while the 15% SP showed pores and cracks.

Table 4.12 Scanning Electron Microscopy (SEM) test results for SP 1.

%	Mag: 100x	Mag: 500x
0		
5		
10		
15		

As depicted in the SEM image in table 4.10 and 4.11 the RHA content increases the voids form due to the increased water absorption by RHA particles. Selvaranjan et al., 2021 research suggests that as water evaporates, more voids form, increasing porosity, and filling these voids with air reduces thermal conductivity due to low thermal conductivity.

Researcher Farid & Zaheer, 2023 found that Rice Hush Ash (RHA) has good compatibility with cement and high pozzolanic activity. Increasing the quantity of C-S-H and decreasing Ca(OH)2 can improve the pore structure of concrete mix. Adding more RHA to cement decreases density and aids in progressive hydration and pozzolanic reaction which is shown in Table 4.10 as the percentage of RHA increases and the amount of cement and sand decreases, more pores or voids and cracks appear. Table 4.11, containing 15% rice husk ash, demonstrates many micropores in RHA 2, a rough surface texture on the concrete surface.

Abhilash et al., 2021 found silica application to concrete reduces pore size, porosity, and structure, while improving pore volume. Its pozzolanic actions create a compact, homogeneous microstructure. However, according to Table 4.12 over 10% Silica increases air voids and porosity, as noted by other researchers.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The thorough research into the impact of rice husk ash (RHA) and silica as admixtures on the properties of concrete for building applications produced valuable insights into the workability, compressive strength, water absorption, and microstructural characteristics of various concrete mixtures. The technique used in this study, as described in Chapter 3, provides an organized way to investigate these important characteristics.

Workability tests using slump tests found differing degrees of workability for various concrete mixes. RHA 1 samples showed an effect between increasing RHA percentages and greater slump values, highlighting RHA's capacity to improve workability even with low cement content. Regardless of RHA %, RHA 2 samples consistently showed medium workability, whereas SP 1 samples consistently showed high workability. The workability findings indicate that RHA and silica can both impact the ease of concrete placing, which has consequences for building methods.

The detailed relationship between the concrete mix and mechanical qualities was shown by compressive strength testing. An rise in RHA % correlated with a decrease in compressive stress in RHA 1 samples, indicating the difficulties associated with larger RHA substitution ratios. None of the RHA 2 samples achieved the maximum compressive stress of 14 MPa, indicating possible difficulties in terms of strength and durability. Higher silica percentages were shown to have an advantage with increased compressive stress in SP 1 samples, confirming silica's involvement in improving concrete strength.

The findings of water absorption revealed the effect of RHA and silica on the porosity and moisture resistance of concrete. Higher RHA percentages resulted in greater water absorption in RHA 1 and RHA 2 samples, indicating possible durability issues related with higher RHA substitution ratios. In comparison, SP 1 samples consistently kept water absorption within a range of 636 to 749, demonstrating improved moisture resistance compared to RHA. These findings highlight the need of taking water absorption properties into account when constructing concrete mixes for certain climatic circumstances.

SEM examination revealed precise information about the internal structure of the concrete samples. A rise in RHA % caused with the production of voids, fractures, and pores in RHA 1 and RHA 2 samples, indicating possible problems in the microstructure. The microstructural features of SP 1 samples varied with silica %, indicating the importance of careful admixture selection to produce the desired structural qualities. The SEM findings are consistent with the overall findings, underlining the need of controlling the admixture ratio to minimize negative impacts on the microstructure of the concrete.

Finally, the methodology of the study effectively satisfied the research objectives by offering a systematic and extensive evaluation into the effects of RHA and silica as admixtures on concrete characteristics. Workability, compressive strength, water absorption, and microstructural investigations all contribute to a more detailed knowledge of how these admixtures affect concrete behavior. The findings emphasize the potential benefits and limitations of RHA and silica, providing useful insights for the creation of sustainable and long-lasting concrete mixes adapted to specific applications.

5.2 Recommendations

i) The study recommends adjusting the ratios of rice husk ash and silica in concrete mixes, since different amounts might alter workability and strength.

ii) The study recommends limiting alteration ratios when utilizing greater rice husk ash (RHA) percentages because of the probable water absorption and lower compressive strength concerns.

iii) The study recommends increase the curing days more than 14days for the use of rice husk ash since Yan et al., 2022 said that the mixture's unconfined compressive strength grows slowly with increased RHA content and faster with longer curing age.

5.3 Project Potential

The study finding could be applied to create environmentally friendly concrete methods by optimizing the usage of RHA and silica, hence lowering environmental effect. It will improve construction efficiency by increasing workability, resulting in more cost-effective building practices. The initiative will also give insights into the development of concrete mixes with improved durability, addressing issues such as water absorption and microstructural integrity. It will provide industry recommendations for the appropriate use of RHA and silica as admixtures, encouraging consistent methods for long-term building.

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Chisholm JGibbs T Harrison, Pb. D., & Eng MICE DChisholm BE CPEng IntPE JGibbs BA MICT THarrison C Eng FICT MICE, Pb. C. (2008). Properties of Concrete for use in Eurocode 2. *A Cement and Concrete Industry Publlication*, 59.

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APPENDICES

APPENDIX A Research planning schedule (Gantt Chart) FOR PSM 1 and PSM 2.

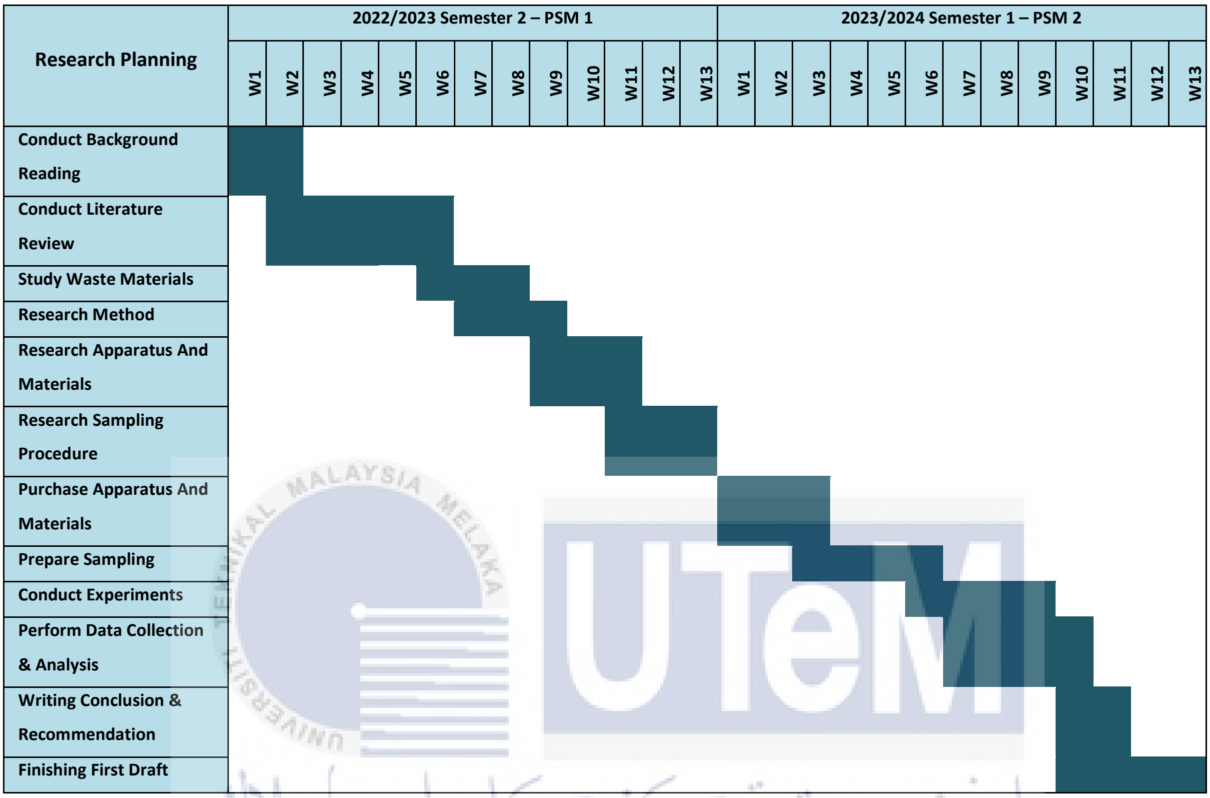

Figure 5.1 Research planning schedule (Gantt Chart).