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SAND BRICK USING CRUSHED WASTE GLASS TO REPLACE SAND PARTIALLY

EE EN QI

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DEPARTMENT OF CIVIL ENGINEERING

SESSION I: 2022/2023

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This Report Is Submitted to The Civil Engineering Department as Part Of The Conditions For Awarding A Civil Engineering Diploma

DEPARTMENT OF CIVIL ENGINEERING

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CONFIRMATION OF PROJECT

The report entitled " **SAND BRICK USING CRUSHED WASTE GLASS TO REPLACE SAND PARTIALLY**" has been submitted, reviewed, and confirmed as meeting the requirements and requirements of project writing as prescribed. We acknowledge that this work is the result of our own work except for excerpts from each of which we have sourced.

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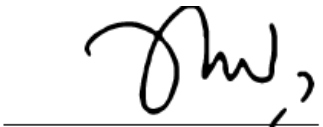

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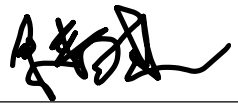

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ABSTRACT

The making of a sand brick using crushed waste glass is to recycle the waste material such as glass to replace partial sand in sand brick. This project focuses on the waste material in the production of sand brick to go eco-friendlier, cheaper, and strong. The substitution of waste glass as the sand in the sand brick is based on the problem that occurs which is objects from glass will no longer be used and cause increased waste. The main material for making this sand brick is cement, crushed waste glass, sand, and water using the ratio of (1:1:6) composition of (water: cement: sand). The waste glass will be crushed and added into the mixture of sand brick with amounts of 5%, 15%, and 25% and it will be molded into a size 200x 100x 60 mm for 24 samples. It will have dried for 24 hours and cured for 7, 14, and 21 days. The final product will be run with several laboratory tests such as a crushing strength test and water absorption test to determine its strength and ability. The test result of each sample will be evaluated and analyzed based on the standard for sand brick which is BS 6073. Thus, we gained the best average value of crushed waste glass from the compressive strength test which is 14.8N/mm² from the sand brick that contains 5% of crushed waste glass. For the water absorbing test, the best average percentage that we obtained which is the lowest percentage that sand brick absorb is 7.93% which is also the sand brick that contains 5% of crushed waste glass. In conclusion, all the data on the sand bricks that we obtained in the test passed the standard normal sand brick value especially 5% of crushed waste glass in the sand brick is categorized as a high-quality sand brick.

Keywords: *Sand brick, crushed waste glass, eco-friendly, compressive strength test, water absorption test*

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Malaysia has three glass bottle facilities, each producing 600 tons of new bottles per day. Only 10% of these bottles will be returned to the factory to be used in the production of new ones. Now, some of the companies of waste management no longer accept glass bottles and jars to process them because there is no demand for recycled glass and glass has a lower value compared to other waste materials such as plastic, paper, metal, and more. Glass bottles could go as low as RM0.10/kg. Based on the search that has been made, the volume difference between glass and plastic recycling is one of the key reasons behind the imbalance. One of the reasons is glass is more expensive to transport since it is heavier and bulkier. There's also the issue of glass's limited end-market application. Glass must be heated to 1,500 degrees to be recycled, whereas plastic does not. Also, glass can last a million years in a landfill, but plastic takes 1,000 years to decompose, depending on temperature and other factors.

Cement sand brick is produced with a mixture of cement, sand, and water according to a predetermined ratio in a set standard. The brick mixture will be molded under pressure and cured under steam. Yet even though the production of cement sand brick is low cost, it is depending on the economic profile. The cost of the raw material might be increased due to high demand. Not only that, the use of raw materials such as fine aggregate is also likely to decrease in the near term due to insufficient natural resources. Most impact assessment methods assume that at a global worldwide scale, the stock for bulk resources, such as the sand and gravel used for concrete manufacture is so important that it could be considered unlimited. To avoid this thing happening many studies focus on the waste

the material used in construction. Due to a variety of factors, commercial production of waste-derived bricks is still quite limited.

The raw material of sand brick can be replaced to waste material which is environment-friendly, strong, low-cost, and available. For environmental protection and sustainable development, extensive research has been conducted on the production of bricks from waste materials. Using glass waste in sand brick can be used as a replacement material for partial sand. Waste glass has a lot of potential in the concrete construction industry. While using waste glass (WG) in the sand brick as partial sand improves some of the concrete properties, it also negatively affects others. The main material in glass is sand (silicon dioxide or, SiO_2), limestone (calcium carbonate or $CaCO_3$), and sodium carbonate (Na_2CO_3). Finding alternative methods for reusing waste glass can cut disposal costs while ensuring the longevity of landfills and natural resources.

1.2 PROJECT BACKGROUND

The production of a larger quantity of concrete causes serious problems in the construction industry. It increases the consumption of natural aggregates as the largest concrete component [Mirjana et al,2010]. Not only that but the consumption of natural resources is also limited in terms of the raw materials used in packaging or construction. From that situation, many innovative ideas are made on bricks by using waste materials such as sand this is to reduce the consumption of natural resources in construction materials as the fast-paced urbanization and population growth have boosted construction activity around the world. So, the sand demand is getting higher day by day. As the consumption of natural resources is limited in terms of the raw materials used in construction, there is another alternative to recreate new brick with some material that has good potential to replace the sand which is waste glass. Waste glass provides a readily available resource for use partially substituting sand in the sand brick mix.

1.3 PROBLEM STATEMENT

In the civil engineering construction industry, the most basic building material of houses is conventional brick. Conventional brick is one of the main components manufactured from natural resources such as sand and cement. There is an issue in producing brick especially in developing areas where manufacturers find it difficult to locate adequate sources of natural aggregate supply. As the price of sand increased, it affected the price of cement and sand bricks (Kubissa et al.,2015)

The production of a larger quantity of concrete causes serious problems in the construction industry. It increases the consumption of natural aggregates as the largest concrete component and creates an enormous amount of waste material from construction and demolition activities. Demolition of old and deteriorated buildings is a frequent phenomenon today (Mirjana et al.,2010)

One of the major challenges of our present society is the protection of the environment. Some of the important elements in this respect are the reduction of the consumption of energy and natural raw materials and the consumption of waste materials. These topics are getting considerable attention under sustainable development nowadays. The use of recycled aggregates from construction and demolition wastes is showing the prospective application in construction as an alternative to primary (natural) aggregates. It conserves natural resources and reduces the space required for landfill disposal. (Haliza 2010)

Nowadays, glass products are largely utilized and therefore they contribute to an increase in solid waste volume. One of the glass products is glass bottles. Glass bottles have remained abandoned, and a considerable amount of them are dumped on the roadside, and bank of the river, which blocks the flow of water in the drain and leads to environmental problems.

1.4 OBJECTIVE PROJECT

This study aims to promote sustainable materials in brick production using crushed waste glass to replace sand partially. To achieve the above goals, the following objectives are outlined as follows:

1. To reduce the use of natural resources of sand brick by replacing it with crushed waste glass
2. To investigate the characteristics of sand brick containing finely crushed waste glass.
3. To investigate the durability properties of composite brick by water absorption test and strength test.

1.5 ISSUE PROJECT

To achieve the objectives project, the issues the project depends on it. The following are the issues of the project:

1. Is the glass can replace the partial sand and achieve a high-strength sand brick?
2. Is the sand brick of the project suitable used in construction?
3. Is the sand brick of the project more durable than the normal sand brick?

1.6 PROJECT SCOPE

The engineering characteristics of cement sand brick using crushed glass waste as sand are the focus of this research. Sand, cement, crushed waste glass, and water are the primary ingredients in the sand brick mix. The waste glass is collected from post-consumer in the housing area and shops. Before adding to the brick mix, the waste glass was to investigate the characteristics of sand brick containing finely crushed waste glass is crushed manually and will be sieved and graded through a below 4.75mm sieve which is the size range between 4.75mm to 0.075mm. 21 samples will be made by adding 0%, 5%, 15%, and 25% of the crushed waste glass into the sand brick mix. Ordinary Portland Cement (OPC) had been used as a binder in cement sand bricks. The specimen size of the bricks

is 200x100x60 mm and had been tested for engineering properties which are compressive strength and water absorption test in. The findings of the study will assist in the use of crushed waste glass as an aggregate substitute, hence improving the characteristics of sand cement bricks. This study looked at the density, and strength of the sand-cement bricks when they were loaded, as well as the water absorption of the sand-cement bricks with crushed waste glass substitution. So, the result of the study will determine the desired percentage of crushed waste glass in each sample to obtain the best strength.

1.7 SIGNIFICANT PROJECT

The recycling of waste in concrete is becoming ever more popular and it can lead to many environmental benefits. Normally, natural sand is used in producing sand cement brick, but nowadays manufacturing itself finds it difficult to obtain the sources due to the shortage of supply. In this study, a new alternative concept to reduce this problem is to utilize glass waste in the manufacturing of construction materials such as brick. The production of brick involves recycling materials from construction and demolition waste. Glass is a widely available and extremely cheap resource. In this study, this waste is used as the main material to replace natural sources in the production of composite brick.

Since the demand for concrete manufacturing is increasing day by day, the utilization of stone chips as coarse aggregate leads to the exploitation of natural resources. Recent research findings have shown that brick made with recycled glass aggregate is capable to provide better long-term strength and better thermal insulation due to the better thermal properties of the glass aggregates. The use of recycled glass as aggregate can also greatly enhance the aesthetic appeal of brick. Glass is a unique inert material that could be recycled many times without changing its chemical properties. The major aim of environmental authorities is to reduce, as far as possible, the disposal of post-consumer glass in landfills and diversion to economically viable glass product streams.

I. For the Malaysian citizen

According to the research, Malaysian wastes 1.21kg per capita per day. Can you imagine how much glass will be wasted by this population about 32.78 million people in Malaysia? In the meaning of the other, using waste glass in the sand brick is very eco-friendly, this action can save our earth by reducing the waste glass andthe next generation can grow in a good environment.

II. For the construction companies

In construction, sand brick is the most important material. According to the research, about 4500-6000 bricks will be used in a 1200sqf home. So, with the high amount of usage of sand bricks in the construction, the sand brick that replaces partial sand with crushed waste glass needs to be considered. This action not only will save the budget for theconstruction, but also save the environment.

1.8 DEFINITION OF OPERATING TERMS

Waste-Glass (WG)

Waste glass is another waste material that is produced in large quantities and is difficult toeliminate.

Sand Brick

A type of brick made from a mixture of cement and sand, molded under pressure, and cured under steam. Cement bricks apply fly ash, coal cinder, coal gangue, slag, chemical residue or natural sand, mud as raw material, and cement as a coagulant, without high temperaturethen form a new type of wall material.

Water cement ratio

The water-cement ratio (w/c ratio, or water-to-cement ratio, sometimes also called the water-cement factor, *f*) is the ratio of the mass of water (*w*) to the mass of cement (*c*) used in a concrete mix:

$$f = \frac{mass_{water}}{mass_{cement}}$$

The water-cement ratio of the fresh concrete mix is one of the main, if not the most important, factors determining the quality and properties of hardened concrete, as it directly affects the concrete porosity, and good concrete is always a concrete as compact and as dense as possible. A good concrete must be therefore prepared with as little water as possible, but with enough water to hydrate the cement minerals and to properly handle it.

A lower ratio leads to higher strength and durability but may make the mix more difficult to work with and form. Workability can be resolved with the use of plasticizers or superplasticizers. A higher ratio gives a too-fluid concrete mix resulting in a too-porous hardenedconcrete of poor quality.

1.9 RESULTS EXPECTATIONS OF THE PROJECT

We believe that glass bottles can be processed into construction-grade cullet using any convenient mechanical method. For cullet-aggregate blends, the glass cullet can be blended with natural aggregates by any convenient mechanical method. Normal precautions should be followed to prevent segregation. Typical aggregates for construction include sand, crushed rock, and recycled concrete. The glass cullet and cullet aggregate blends should be compared with these standard specifications for each specific application. This research intends to encourage regulatory departments to amend specifications to allow glass cullet and cullet aggregate blends as an alternative to conventional aggregate in numerous applications.

We investigate the effects of using recycled glass bottles as an alternative fine aggregate. We will use recycled bottles from junkshops. These bottles will be cleaned to prevent foreign materials or chemicals from contaminating the specimens. After cleaning, they will be crushed manually and sieved to ensure uniformity in particle size. We will use Class A mix which has a 1:1:6 proportion of cement, water, and sand respectively. Some percentage of sand will replace by the crushed waste glass (0%, 5%, 15%, and 25%) and a control mixture will also make available. Three (3) specimens were collected from each

mixture using 200x100x60mm of rectangular molds and these specimens were tested for compressive strength and absorption test upon the 7th, 14th, and 21st day of its curing. Then, the results can be evaluated.

1.10 CONCLUSION

Overall, the making of a sand brick using crushed waste glass to replace aggregate is an idea that can be applied to produce products that are environmentally friendly and suitable for new building materials. However, this study needs to be done by considering a lot of matters in terms of materials, method, cost, and information retrieval in detail and specifically to achieve the main objectives at the end of the study. Furthermore, this sand brick can be solved based on the statement of the problem mentioned when these bricks are successfully produced well. It also has a positive impact on consumers and the environment which can reduce production costs on the use of and can reduce the amount of waste glass.

CHAPTER 2

FIELD RESEARCH

2.1 INTRODUCTION

This chapter discusses the past research related to this project which is sand brick using crushed waste glass as aggregate as a source of reference. This literature review is done mostly on Google Scholar. The content is including specific information reviews made by past researchers. All the data from the different authors will be collected and analyzed as guidance to generate an idea to solve the problem issue in this project. The data included in the literature review is about the advantages and disadvantages of using crushed waste glass in sand brick.

2.2 BRICK

Brick is one of the oldest manufactured materials for building worldwide. There are numerous types of brick, including clay brick, cement sand brick, concrete brick, sand lime brick, and many more. Each type of brick has its own purposes, and also advantages and disadvantages.

According to Wikipedia, brick is generally used in masonry construction, a brick can be defined as a block or a single unit from different types such as concrete material or sand and lime, clay-bearing soil, and air-dried fire-hardened. Generally, bricks will be produced in huge quantities and can be classified into many classes, materials, sizes, and types and of course, vary with time and region or area.

2.2.1 Burnt Clay Bricks

Burnt clay bricks are the classic form of brick, created by pressing wet clay into molds, then drying and firing in kilns. This is a very old building material and is found in many of the ancient structures of the world. In appearance, these bricks are solid blocks of hardened clay, usually reddish in color.

Burnt clay bricks are typically sold in four classes, with the first class offering the best quality and most strength. These high-grade burnt clay bricks have no noticeable flaws and naturally cost more than lower classes.

When burnt clay bricks are used in walls, they require plastering or rendering with mortar. Uses for burnt clay bricks include masonry walls, foundations, and columns.

From the search, the details of burnt clay bricks are below:

1. Burnt clay bricks are made by flint clay clinker and binder, Crushing, Mixing, Shaping, drying, and high-temperature Sintering.
2. Al_2O_3 content is 30%-48%, SiO_2 content is 50%-65%, and a small number of alkali metals, alkaline earth metal oxides TiO_2, Fe_2O_3, etc.
3. Mineral composition is usually mullite, quartz, and glass phase.
4. Refractoriness is 1580-1750°C, refractoriness under load is 1250-1450°C, line expansion coefficients are low, with good thermal shock resistance, and a strong ability to resist erosion acid slag.
5. Working temperature: less than 1350°C.

The characteristics of burnt clay bricks are good resistance to abrasion and corrosion, good thermal shock resistance, good volume stability at high temperatures and burnt clay brickshave high mechanical strength.

The application of burnt clay bricks is Iron and steel making of blast furnaces, hot blast stoves, hot metal ladles, tundish, soaking pits, heat treatment furnaces, refining furnaces, reheating furnaces, metal mixer furnaces, and cupola furnaces. Besides that, burnt clay bricks are non-ferrous metals such as smelting furnaces, and reverberatory furnaces. The

burnt clay bricks also use in building materials which are cement kilns, glass kilns, ceramic kilns, lime kilns, kilns cars, tunnel kilns, and rotary kilns. Furthermore, burnt clay bricks also use in energy and Incineration such as coke ovens boilers, power generation boilers, CFB boilers, electric furnaces, carbon roasting furnaces, and waste incinerators.

2.2.2 Sand Lime Bricks

Sand lime bricks (also known as calcium silicate bricks) are made by mixing sand, fly ash, and lime. Pigments may also be added for color. The mixture is then molded under pressure to form bricks. Sand lime bricks are not fired in kilns in the same manner as burnt clay bricks; instead, the materials bond together by a chemical reaction that occurs as the wet bricks dry under heat and pressure.

The properties of sand lime brick are:

-It is a very smooth and uniform finish and has an attractive appearance.

-They are dense, strong, and tough.

-They are porous and therefore free from indigestion.

-Also, uniform in size, shape, and finish, and no plastering is required.

-When required, the amount of plaster is significantly less.

-Essential materials are quite common in the event and can be used as an alternative to claybricks

Sand lime bricks offer advantages such as:

-Their shape is uniform and presents a smoother finish that doesn’t require plastering.

-They offer excellent strength for load-bearing structures.

-They are gray instead of the regular reddish color. Different pigments can be added for ornamental purposes.

-Less mortar is required during construction.

-Edges are straight and precise, making construction easier.

-They do not effloresce salts and minerals.

Sand lime bricks are most often used in structural foundations and walls, exposed brick and pillars, and, when the pigment is added, for ornamental uses.

A pigment is often added to the mix to impart different colors to the brick, which would otherwise be a grey white – off white color. Common pigments and their corresponding colors are shown below in Table 2.1:

Table 2.1: Common pigments of Sand Lime Bricks

Pigment	**Color**
Carbon Black	Black, Grey
Chromium Oxide	Green
Iron Oxide	Red, Brown
Ochre	Yellow

2.2.3 Engineering Bricks

Engineering bricks are used primarily in civil projects where strength and resilience against the elements are essential. They are clay-based and can be mixed with many other materials. What sets engineering bricks apart from other types is their extreme durability: They are fired at excessively high temperatures to produce a brick as hard as iron. They also have very low porosity and are used in places like sewers, retaining walls, manholes, foundational work, and underground tunnels, where resistance to water and frost is crucial.

There are 2 different classes of Engineering bricks, Class A and Class B. Class A engineering bricks have a compressive strength greater than 125N/mm² and water absorption less than 4.5% while Class B engineering bricks have a compressive strength greater than 75N/mm² and water absorption less than 7%.

Class A Solid is the ideal engineering brick. The bricks themselves are engineered to the highest of standards and comply with exacting British & European standards. The Class A's have been approved and are being used in several railways and civil engineering projects. These bricks are available in 65mm, 73mm and 80mm sizes.

These bricks are currently available in two colors, red and blue-black, which are an extension of our Westminster Blue Black and Richmond Smooth Red family of bricks, so both brick types are also available in Class B and with perforated versions of each brick type, thus giving greater choice and convenience.

Crest Class B Engineering bricks are of exemplary quality, they comply with all the latest British and European Standards. These bricks are red/brown in color, durable against frost attack, and ideal for use below The DPC level.

2.2.3 Concrete Bricks

Concrete bricks are made from solid concrete poured into molds. They are traditionally used in internal brickwork but are more frequently used in exterior work, such as facades and fences, to provide a modern or urban aesthetic. Concrete bricks can be manufactured in different colors if pigments are added during production.

Due to their durability, concrete bricks can be used in almost any type of construction, except underground, since they tend to be porous.

The properties of cement bricks are below:

- Concrete bricks will initially shrink after manufacturing due to the loss of moisture.

- Clay bricks will typically expand after manufacturing due to the addition of moisture. Most of this expansion occurs during the first few weeks but will continue at a much slower rate for several years. This expansion of clay bricks is not reversible.
- Both concrete and clay bricks experience expansion and contraction due to heat gain and loss.
- Clay bricks typically have core holes while concrete bricks are usually frogged. Cores and frogs are designed to reduce weight and aid in the drying and firing process.
- A concrete brick typically weighs more than a clay brick due to its higher density.
- The higher density of concrete brick is correlated to fewer air pockets and consequently to a lower water absorption rate.
- Concrete bricks will typically have a higher compressive strength than clay bricks.

2.2.4 Fly Ash Clay Bricks

Fly ash clay bricks are manufactured with clay and fly ash—a byproduct of coal burning— fired at about 1,832°F. This type of brick is sometimes described as self-cementing since it contains a high volume of calcium oxide and therefore expands when exposed to moisture. This tendency to expand, however, can also produce pop-out failure. Fly ash clay brick hasthe advantage of being lighter in weight than clay or concrete brick.

Typical uses for fly ash clay brick include:

-Structural walls
-Foundations
-Pillar
-Anywhere that improved fire resistance is required

The advantages of fly ash bricks are:

1. Strength of Fly Ash Bricks

- As compared to regular fire clay bricks, fly ash bricks have greater compressive strength.
- The compressive strength of fly ash brick is near about 9-10N/mm2.
- The thickness of those bricks is low, so it reduces cracks in plaster.
- It has a good earthquake-resisting property.
- It increases the strength of the structure.

2. Durability of Fly Ash Bricks

- These fly ash bricks are highly durable but less permeable.
- Due to lower permeability, it reduces the efflorescence effect on brick.
- These bricks prevent dampness on the wall because it is less porous, and that's why it does not absorb more water.
- It's highly resistive against acid, water, and sulfate.

3. Appearance of Fly Ash Bricks

- The key thing about these fly ash bricks is their appearance.
- Fly ash bricks are cement-like in color, smooth, even surface, and uniform finish.
- Due to the smooth surface, the amount of plaster is reduced to 40% than common plastering.
- Plaster of Paris or putty can be applied directly to this.
- Those bricks are free from organic matter, pebbles, etc.

4. Thermal Property of Fly Ash Bricks

- Fly ash bricks have excellent thermal properties because the thermal conductivity of fly ash brick is 0.9-1.05 W/mm^2, so it absorbs minor heat. For this reason, the building is cool in the summer.

5. Sound Insulation of Fly Ash Bricks

- Fly ash bricks have decent sound insulation property than ordinary bricks.

6. Fire Resistance of Fly Ash Bricks

- Fly ash bricks are good in fire-resisting than regular fire clay bricks.

7. Sustainability of Fly Ash Bricks

- The main ingredient of fly ash bricks is fly ash, and it comes from the thermal power plant. So, it doesn't damage the environment again; that's why it's an environmentally friendly product.

8. Availability of Fly Ash Bricks

- Those bricks are generally available near the thermal power station areas, but now days, it's nearly available in all the places.

Disadvantages of Fly Ash Bricks

There are not so many disadvantages of fly ash bricks, but some are also there. Those are the following-

- All fly ash bricks are not suitable for construction. It's necessary to use high-quality fly ash bricks to resist harmful effects.
- If the fly ash bricks are not appropriately prepared, then it has no strength and not suitable for construction.
- These bricks are only available in modular size. Larger size bricks are not produced due to cracks.
- Bonding is less due to a smooth finish; that's why we need to care about when masonry work is running.
- In plastering work, plaster doesn't make a suitable bond with those bricks due to the smooth surface.

- Fly ash bricks are not suitable in the winter area region.

2.3 CEMENT

According to (Somayaji, 2001), cement can be defined as any material that unites or binds, essentially like glue. In civil engineering, cement or cementitious materials are always related to the ingredients in concrete, mortar, and grout. Meanwhile, according to (BS EN197-1:2000), cement is a hydraulic binder; more specifically, an inorganic material which finely grounded. After it mixes with water, it will form a paste which then sets and hardens because of the hydration reactions and processes. Eventually, it will preserve stability and strength even under the water. There are two types of cement that are commonly used in building construction: hydraulic and non-hydraulic cement. Hydraulic cement is actually the cement that turns into a solid form where water is present and resulting a material that does not degenerate in water. Meanwhile, non-hydraulic cementdoes not need water to transform into a solid form.

2.3.1 Ordinary Portland Cement (OPC)

Ordinary Portland cement is the most widely used type of cement, which is suitable for all general concrete construction. It is the most produced and used type of cement around the world, with annual global production of around 3.8 million cubic meters per year. This cement is suitable for all kinds of concrete construction.

2.3.2 Portland Pozzolana Cement (PPC)

Portland pozzolana cement is prepared by grinding pozzolanic clinker with Portland cement. It is also produced by adding pozzolana with the addition of gypsum or calcium sulfate or by intimately and uniformly blending Portland cement and fine pozzolana.
This cement has a high resistance to various chemical attacks on concrete compared with ordinary Portland cement, and thus, it is widely used. It is used in marine structures, sewage works, sewage works, and for laying concrete underwater, such as bridges, piers, dams, mass concrete works, etc.

2.3.3. Rapid Hardening Cement

Rapid hardening cement attains high strength in the early days; it is used in concrete where formworks are removed at an early stage and are like ordinary Portland cement (OPC).

This cement has increased lime content and contains higher c3s content and finer grinding,which gives higher strength development than OPC at an early stage.

The strength of rapid hardening cement at the three days is like 7 days strength of OPC with the same water-cement ratio. Thus, the advantage of this cement is that formwork can be removed earlier, which increases the rate of construction and decreases the cost of construction by saving formwork cost.

Rapid hardening cement is used in prefabricated concrete construction, road works, etc.

2.3.4. Quick setting cement

The difference between the quick setting cement and rapid hardening cement is that quick- setting cement sets earlier. At the same time, the rate of gain of strength is similar to Ordinary Portland Cement, while quick-hardening cement gains strength quickly. Formworks in both cases can be removed earlier.

Quick setting cement is used where works is to be completed in a very short period and for concreting in static or running water.

2.3.5. Low Heat Cement

Low heat cement is produced by maintaining the percentage of tricalcium aluminate below 6% by increasing the proportion of C2S. A small quantity of tricalcium aluminate makes the concrete to produce low heat of hydration. Low heat cement suitable for mass concrete construction like gravity dams, as the low heat of hydration, prevents the cracking of concrete due to heat.

This cement has increased power against sulfates and is less reactive and the initial

setting time is greater than OPC.

2.3.6. Sulfates Resisting Cement

Sulfate resisting cement is used to reduce the risk of sulfate attack on concrete and thus is used in the construction of foundations where the soil has high sulfate content. This cement has reduced the contents of C3A and C4AF.

Sulfate resisting cement is used in construction exposed to severe sulfate action by water and soil in places like canals linings, culverts, retaining walls, siphons, etc.7. Blast FurnaceSlag Cement

Blast furnace slag cement is obtained by grinding the clinkers with about 60% slag and resembles more or less in properties of Portland cement. It can be used for works where economic considerations are predominant.

2.3.7 White Cement

It is prepared from raw materials free from Iron oxide and is a type of ordinary Portland cement, which is white. It is costlier and is used for architectural purposes such as precast curtain wall and facing panels, terrazzo surface, etc. and for interior and exterior decorative work like external renderings of buildings, facing slabs, floorings, ornamental concrete products, paths of gardens, swimming pools, etc.

2.4 GLASS

Glass is an inorganic solid and non-crystalline material that is transparent in appearance. Using archaeological evidence, we can trace the usage of glass in the stone age period too. Some of the weapons and tools were made of naturally occurring volcanic glass. These four types of glasses, they are:

- Annealed Glass
- Heat Strengthened Glass
- Toughened Glass
- Laminated Glass

The properties of the glass are below:

- It is a material made of natural products.
- It is an inorganic solid material.
- Glass can withstand high temperatures.

With these properties, glass is the best option use in construction especially the characteristics good fire resistance of the glass.

2.4.1 Composition of Glass

Sand, the common form of silica, is easily available in nature. It is the main component ofglass making along with the chief component silicon dioxide (SiO_2).

There are a few types of glass in the industrial, first is soda lime glass. It is produced by combining silica, calcium carbonate and sodium carbonate. Soda lime glass is the most prevalent type of glass, used for windowpanes and glass containers (bottles and jars) for beverages, food, and some commodity items. Some glass bakeware is made of soda-lime glass, as opposed to the more common borosilicate glass.[1] Soda–lime glass accounts for about 90% of manufactured glass.

The second type of glass is lead crystal glass and it is manufactured by mixing silica with cerium oxide. Lead glass is thus more fluid and easier to work with and fabricate than soda glass because it can be worked on at a wider temperature range while still being more malleable and less brittle than ordinary glass. In the medical and research fields where visibility is required during procedures or experiments that involve radiation, lead glass can achieve the same radiation attenuation as the surrounding walls or barriers while allowing visibility to the operator. A typical example is the viewing window of an X-ray room or a laboratory experimenting with radioactive materials. The high refractive index of lead glass is useful to produce lenses as thinner lenses can be crafted to achieve similar focal lengths to ordinary ophthalmic glass. Lead glass is thus used for special medical glasses, binoculars, microscopes, and telescopes. Lead glass is used in laser optics for printing and photocopying technologies.

The third type of glass are flint glass. Flint glass, also called Crystal, or Lead Crystal, heavy and durable glass characterized by its brilliance, clarity, and highly refractive quality. Developed by George Ravenscroft (*q.v.*) in 1675, it ushered in a new style in glassmaking and eventually made England the leading glass producer of the world. Ravenscroft's experimentation was supported by the Worshipful Company of Glass Sellers, a body of English retailers long dissatisfied with the quality of glass from Isola (island) di Murano, Venice. In the optical glass industry, flint glass is any highly refractive lead-containing glass used to make lenses and prims. Because it absorbs most ultraviolet light but comparatively little visible light, it is also used for telescope lenses. The light-dispersive power of flint glass can be made twice as high as that of crown glass (of conventional soda- lime composition), and the two complementary types of glass are cemented together to make lenses corrected for chromatic aberration. In the container glass industry, flint glass is any clear glass free of coloring.

2.5 SAND

Sand is a granular material composed of finely divided mineral particles. Sand has various compositions but is defined by its grain size. Sand grains are smaller than gravel and coarser than silt. Sand can also refer to a textural class of soil or soil type, i.e., a soil containing more than 85 percent sand-sized particles by mass.

The composition of sand varies, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica (silicon dioxide, or SiO_2), usually in the form of quartz.

Calcium carbonate is the second most common type of sand, for example, aragonite, which has mostly been created, over the past 500 million years, by various forms of life, like coral and shellfish. For example, it is the primary form of sand apparent in areas where reefs have dominated the ecosystem for millions of years like the Caribbean. Somewhat more rarely, sand may be composed of calcium sulfate, such as gypsum and selenite, as is found in places like White Sands National Park and Salt Plains National Wildlife Refuge inthe U.S.

Sand is a non-renewable resource over human timescales, and sand suitable for making concrete is in high demand. Desert sand, although plentiful, is not suitable for concrete. 50 billion tons of beach sand and fossil sand is used each year for construction.

2.6 COMPRESSIVE STRENGTH TEST

The compressive strength test is also known as the crushing strength test which is an important type of laboratory test conducted on bricks to determine the load-carrying capacity of bricks when subjected to a compressive load. This test is performed utilizing a compression testing machine. The crushing or compressive strength of normal building bricks should not be below 3.5 N/mm². The bricks of high quality should not have strength below 14 N/mm².

According to the journal by Hathaichanok Warnphen. The compressive strength of concrete bricks with different replacement amounts of waste glass at 7, 14, and 28 days are presented in Fig. 1. It was found that all the samples had the same trend; as the best result, at 28 days, a compressive strength value of 48.49 MPa was obtained from concrete bricks with 20% waste glass as an aggregate replacement, representing a 7.61% increase in compressive strength compared with the control mix (45.06 MPa); replacement up to 20% gave a high compressive strength value. Adaway and Wang reported that the increase in compressive strength above the control mix may be attributed to the angular nature of glass aggregate, which has a gr

eater surface area than the naturally rounded sand particles. In contrast, the compressive strength of concrete bricks decreased with the increase of waste glass up to 30%, caused by the weak bond between waste glass and cement paste due to the surface of waste glass is smoother than sand causing poorly mechanical anchorage between cement paste and waste glass

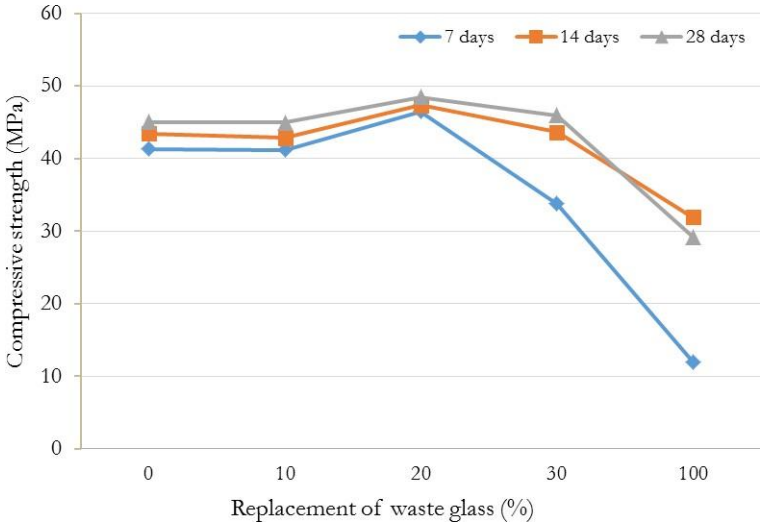

Fig 2.1: Compressive strength of concrete bricks with different replacement of waste glass.

2.7 WATER ABSORPTION TEST

Water Absorption test on brick is conducted to determine the moisture absorbed by the brick when subjected to extreme conditions like rain. The absorption test can be used as an indicator of the durability properties of the brick such as quality, degree of burning, and behavior of brick in weathering.

From the research of the construction in Year 2010, it states that water absorption test on bricks is conducted to determine durability property of bricks such as degree of burning, quality, and behavior of bricks in weathering. A brick with water absorption of less than 7% provides better resistance to damage by freezing. The degree of compactness of bricks can be obtained by water absorption test, as water is absorbed by pores in bricks. The water absorption by bricks increases with increase in pores. So, the bricks, which have water absorption less than 3 percent can be called as vitrified. Not only that, but water absorption shall also not be more than 20% by weight up to class 12.5 and 15% by weight for higher classes.

From the research of Gharpedia in Year 2018, bricks are dry and porous; therefore, it can release and absorb moisture inherently from the weather/mortar/concrete. If the brick dry, absorbs moisture from water when laid, the mortar will become weak and poor. It fails to make the bond between bricks and mortar due to insufficient water for the hydraulic reaction of cement in the mortar and overall reduces the strength ofconstruction.

Also, if the brick absorbs more water than the recommended result, it gives adverse effects on the strength of brick as well as the durability of the structure. The porous bricks will allow absorption of rainwater thereby giving rise to dampness in the wall. Even it cannot be grouted like concrete. So, water absorption of bricks is a significant and useful property of bricks. Water absorption is found out by the water absorptiontest of bricks.

According to the journal by Hathaichanok Warnphen, the water absorption and density of concrete bricks with different replacements of waste glass at 7, 14, and 28 days are presented in Fig. 2. The results show that all the samples exhibited the same trend. The increase of curing time decreased the water absorption and increased the density of concrete bricks because of the pore filling of the hydration reaction. The results showed that concrete bricks of 20% waste glass as aggregate replacement had the lowest value of water absorption at 14 and 28 days (5.91 and 5.35) and the highest compressive strength. This is consistent with Du and Tan, who observed compressive strength correlate well with the reduced porosity of concrete.

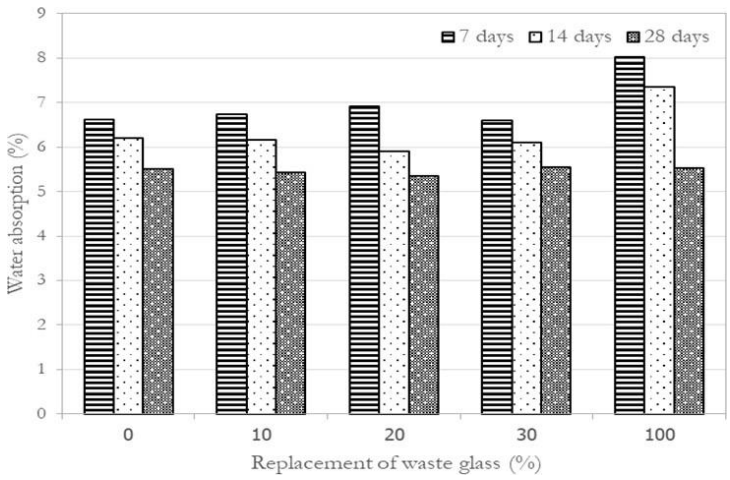

Fig 2.2: Water absorption of concrete bricks with different replacement amounts of wasteglass.

2.8 PREVIOUS STUDY

Waste glass may open a new path of economic and pollution-free concrete construction if desired strength can be achieved (T. S. Serniabat, M. N. N Khan, and M. F. M. Zain, 2014)

Waste glass can be used as a partial fine aggregate for producing concrete bricks, and it can be employed as an alternative material for waste glass management. (Nur liza Rahim, Norlia Mohamad Ibrahim, Roshazita Che Amat, Shamshinar Salehuddin, 2014)

The influence of size in aggregate replacement (fine and coarse aggregates, separately or simultaneously); they found that the optimum replacement amounts of waste glasses as fine and coarse 28 (separately) were 20% and 5–10%, respectively, but simultaneous replacement of waste glass as fine and coarse aggregates had the worst value. (S. D. Castro, and J. D. Brito, 2014)

Incorporating waste glass into cement-based materials has the potential for creating a more sustainable future. Currently, trials of waste glass being used in cement-based materials on the commercial scale are limited (Edward Harrison, Aydin Berenjian, and Mostafa Seifan,2020)

The ground waste glass was used as aggregate for mortars and no reaction was detected with fine particle size, thus indicating the feasibility of the waste glass reuse as fine aggregate in mortars and concrete (S.P. Gautam, Vikas Srivastava, and V.C. Agarwal, 2018)

Synthesis of alkali-activated materials using waste glass cullet is considered a potential way to reduce the negative environmental effects related to the use of OPC and natural sand (Md. Nabi Newaz Khan and Prabir Kumar Sarker,2020)

2.7 CONCLUSION

In summary, based on the previous research have been done, many opinions state that waste glass has the potential to replace partial sand in construction materials that are more economical and environmentally friendly. This is because waste glass is a sustainable future when compared to the sand or aggregate that is taken from natural resources which are likely to be limited in the future. However, there is criticism from past researchers who say that mixing glass waste with cement will cause an alkaline reaction that can reduce the strength and bonding between cement and other material. Yet, the previous study found out that glass waste can be used, and no reaction was detected with the fine size of aggregate past researchers also determined the optimum percentage of waste glass that should be added in. Overall, waste glass can be used for sand and aggregate replacement with a certain amount and finer size as recommended by past researchers to obtain the required strength in making sand brick.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Regarding the objectives, laboratory works need to be done to obtain the data and information related to the project. The data is the reference for the study experiment that must be done. After discussion of study objectives in the introduction part, some experiments need to be done to achieve that objective is given such as compressive strength and water absorption. Information and material from the experiment will help to collect the information regarding the study and can help to achieve the study objective. Several planned before laboratory work will make sure our work is more regulated nicely and systematic. The step that must take before laboratory works such as:

I. Preparing a flow chart regarding the experiment that must be done as a reference to laboratory keeper to facilitate a preparing regarding experiment needs.
II. List all the materials and equipment that needs in a laboratory experiment. This is important to make sure the work is complete and arrangeable.
III. Inform the technician about the experiment works that have been planned to do.

3.2 PROJECT DESIGN

3.2.1 Method/ Process of Project/ Project Production Technique

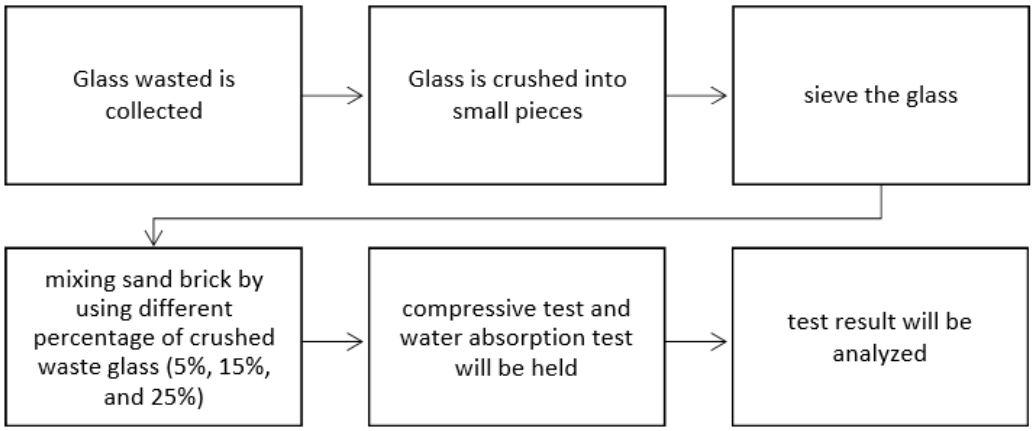

Figure 3.1: flow chart of sand brick using crushed waste glass

In the process of producing sand brick using crushed waste glass, some methods and techniques need to be considered. In terms of material, consumption is cement, water aggregate, and water according to the ratio of sand brick which is 1:1:6 (water: cement: sand). In the preparation of making sand brick, waste glass is also the main material for this project. Waste glass is collected from post-consumer usually in recycle center in MBSA U2. Those collected waste glass will be crushed manually using a hammer with great care. We decide to crush the waste glass manually because crush waste glass use machine is too expensive. While crushing the waste glass we need to wear appropriate and safe clothing and equipment to avoid any injuries such as hand gloves. The crushed glass will go through a sieving process (4.75mm, 2.36mm, 1.18mm, 300µm, 150µm, and 75µm) to determine the size and grade of the crushed particles. The size 1.18mm, and 300µm of waste glass is be used in making sand brick. That crushed waste glass will be mixed into cement and sand to form a sand brick by adding amount of water. The amount of crushed waste glass to substitute some sand is 5%,15%, and 25%. Besides that, we also need to do 6 control sand brick which is no add any crushed waste glass. A total of 24 samples will be molded into relevant standard brick size, 200 x 100 x 60 mm, dried for 24 hours. After that, three of each percentage waste glass of brick will take into compressive strength test, and three of each percentage waste glass will run the water absorption test for 7 days, 14 days, and 21 days. The compressive strength test will be tested at Reliable Testing Laboratory in Subang Murni, Selangor while the water

absorption test will be weighted respectively in the 7th days, 14th days, and 21st days.

Figure 3.2: the results of crushed waste glass after sieving

Figure 3.3: the materials of cement, sand, and 15% of crushed waste glass

Figure 3.4: Process of putting the mixture into the mold

3.2.2 MATERIAL AND EQUIPMENT

The materials used in this study are cement, sand, crushed waste glass as substitute for sandpartially, and water.

3.2.2.1 Cement

Ordinary Portland Cement will be used in the study is the Castle brand manufactured by YTL Cement Corporation Berhad, according to Malaysian Standard MS 522, which is based on the British standard BS 12 and European Union standard EN 196. The chemical composition of the cement is existing in the table 3.1.

Table 3.1: Chemical composition of cement

Chemical composition	
Oxide	**Content %**
CaO	63.17
SiO2	19.98
Al2O3	5.17
Fe2O3	3.27
MgO	0.79
SO3	2.38
Total Alkalis	0.9

L. O. I.	1.88
I. R.	1.47
L. S. F.	0.87
Main Compounds (Bogue's equations)	
C3S	59.09
C2S	12.71
C3A	8.18
C4AF	9.94

3.2.2.2 Sand

Good quality sand will be taken in the project. The sand will be subjected to specific gravity and sieve analysis tests and the test will be carried out at the workshop of PSA. The specificsize of the sand will be used in the project.

3.2.2.3 Crushed waste glass

Glass is formed by melting silica, soda ash, and lime followed by supercooling to achieve a solid which does not crystallize but rather retains the amorphous structure of the molten liquid. Silicate glasses, rich in silica are commonly referred to as "glass" in the industry. The main types of glass are soda glass, lead crystal glass, borosilicate glass, and electric glass. Broken glass or waste glass is usually referred to as a 'cullet'. A cullet can be either internal cullet or external cullet. Internal cullet is not considered waste because they usually reject within the industry that does not meet the quality control and is absorbed as raw materials in the manufacturing process. External cullet is the waste glass that is collected and reprocessed for recycling. External cullet is further classified as pre-consumer and post-consumer cullet depending upon whether the cullet is generated in the industry using glass as a componentor is generated after use by the consumer.

The crushed waste glass that be used in the project are clear and colored glass. After crushed the glass using hammer manually, we sieve the glass with the different size of sieving which is 4.75mm, 2.36mm, 1.18mm, 300µm, 150µm, and 75µm

3.2.2.4 Water

The Water used for the concrete mix for this experiment was taken from the pipe in the laboratory in the apartment of civil engineering, Politeknik Sultan Salahuddin Abdul Aziz Shah. The water was ensured to be clean and free from impurities or reactive agents.

3.3 METHOD OF DATA ANALYSIS

After the brick test is done, all the data obtained will be valued according to the British Standard for Precast concrete masonry units (BS 6073-1981). From that reference, the result obtained can be determined in terms of minimum and maximum performance permissible for compressive strength and water absorption for bricks.

3.3.1 Compressive Strength Test

For the compressive strength test, 12 bricks in figure 3.5 that contain 0% (control brick), 5%, 15%, and 25% of crushed waste glass with a size specimen of 200x 100x 60 mm by using the digital compressive machine in Reliable Testing Laboratory which located in Subang Murni, Selangor. The results will be evaluated and analyzed using graphs of compressive strength (N/mm^2) vs percentage of waste glass (%). According to the British Standards Institution, bricks should have a compressive strength of at least 7 N/mm^2. From the resulting graph, we can determine which brick has the highest strength.

Figure 3.5: The compressive test by using the machine

3.3.2 Water Absorption Test

To determine the percentage of water absorption, three bricks of each percentage of the crushed waste glass which is 5%, 15%, and 25% will be weighed after dried and it must be submerged in clean water as shown in figure 3.6 at room temperature for 7 days, 14 days, and 21 days. After that, the brick will be weighted on the 7^{th} day, 14^{th} day, and 21^{st} day respectively. The brick then will be determining its percentage of water absorption by using this calculation:

(Wet brick mass – dry brick mass)/dry brick mass x 100

The quantity of water absorption in a good-grade brick should not exceed 20%.

Figure 3.6: the place to put the sand brick in water absorption test

3.4 CONCLUSION

Through Chapter 3, we designed the flow chart of the project and explained all the processes of the project. Six main steps need to be taken to undertake the project. All the materials and equipment that will be used in the project are also listed in chapter 3 with details explanations such as cement, sand, and many more. The compressive test and water absorption test are also our methods of data analysis.

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

After all the data and information sand bricks with different percentage of crushed waste glass are obtained, analysis is done to see the effectiveness of sand brick has been in accordance with the scope of the study. The results obtained in this chapter are the results obtained from the test conducted in the study area which is compressive strength test and water absorption test. The data resulting from the tests in the study area were analyzed in more detail such as in format graph. So that we can draw conclusions based on the objectives of the study that have been stated.

4.2 COMPRESSIVE STRENGTH TEST

Compressive strength of bricks is the capacity of brick to resist or withstand under compression when tested on Compressive testing machine [CTM]. The Compressive strength of a material is determined by the ability of the material to resist failure in the form of cracks and fissure. In our project, the compressive strength test was run in the Reliable Testing Laboratory, Subang Murni Shah Alam. Three bricks of each percentage of the sand brick which is 0%, 5%, 15%, and 25% are test. Figure 8 which is line graph shows the compressive strength against percentage of crushed waste glass shows the result test of the sand bricks.

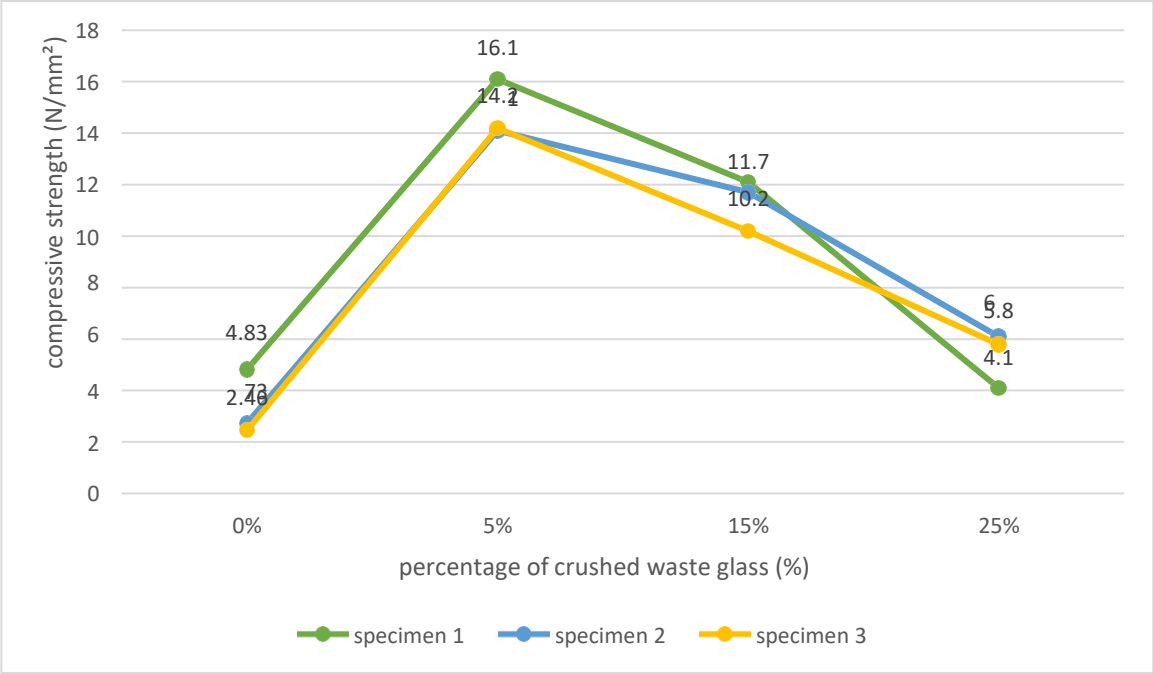

Figure 4.1: A line graph that compressive strength against percentage of crushed waste glass

From the figure 4.1, we can see that the 5% percentage of crushed waste glass in each specimen are the maximum value of compressive strength which is 16.1N/mm² in specimen 1, the maximum load that can it sustain is 322800N. The compressive strength and the maximum load that can sustain in specimen 1 is the highest in all the specimen. The average of the value compressive strength in three specimen sand brick that contains 5% of crushed waste glass is 14.8N/mm² and its average of maximum load that can sustain for three specimen sand brick is 294233.33N. The second highest average value of compression strength is the sand brick that contains 15% crushed waste glass which is 11.33 N/mm² while the average maximum load that can it sustain is 212633.33N. The third highest average value of compression strength is the sand brick that contains 25% of crushed waste glass which is 5.33N/mm² while its average maximum value load that able to sustain is 106700N. The control brick which is contain 0% of crushed waste glass is the lowest average value of compression strength in all the sand brick which is just 3.34 N/mm² and the average maximum load that can sustain is 66600N.

From the graph, we can clearly see the lowest value compressive strength is 2.46N/mm² which is the 3rd specimen control brick that no waste glass inside and the maximum load that can it sustain 49100N.

From the research, the crushing or compressive strength of normal bricks should not be below 3.5 N/mm². If it is less than 3.5N/mm², then it is not suitable useful in construction. The bricks of high quality should not have strength below 14 N/mm². So, the 5% of crushed waste glass substitution performed a high compression strength which is in categories high quality bricks. In the other hand, the control brick which contain no waste glass had an average compressive strength that less than 3.5 N/mm². In the conclusion that can make through the graph is the more the percentage of waste glass in the sand brick that over than 15%, the less the compressive strength in the sand brick.

4.3 WATER ABSORPTION TEST

Brick for external use must be capable of preventing rainwater from passing through them to the inside of walls of reasonable thickness. Water absorption test on bricks is conducted to determine durability property of bricks such as degree of burning, quality and behavior of bricks in weathering. In our project, the water absorption test in conducted at the laboratory concrete in Polytechnics Shah Alam. Three bricks of each percentage of the sand brick which is 0%, 5%, 15%, and 25% are test. The figure 9 is bar graph shows the average percentage of water absorption by sand bricks against the percentage of the crushed waste glass that had been used in sand bricks.

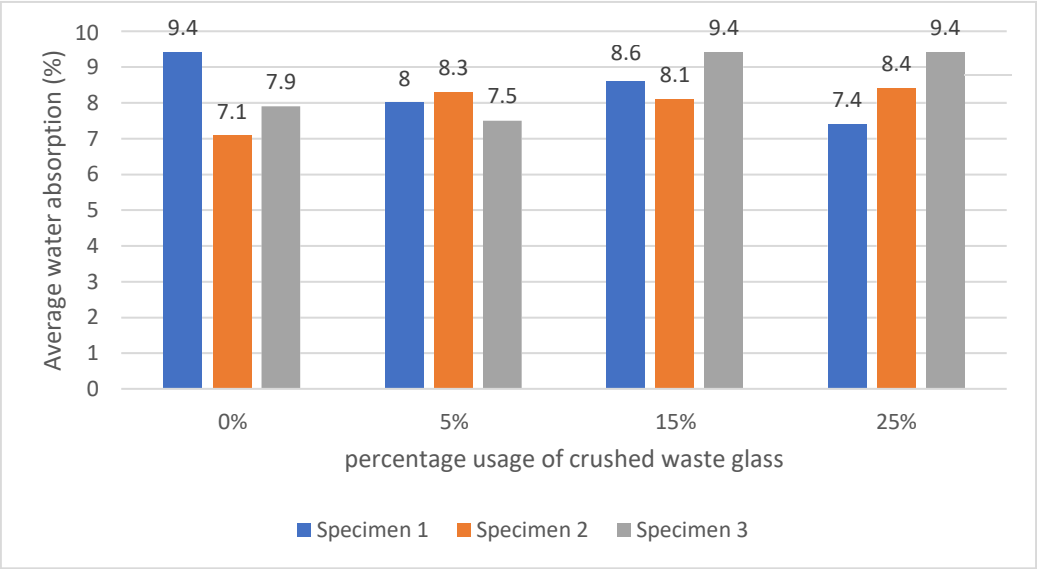

Figure 4.2: A bar graph of the average percentage of water absorption against percentage of the crushed waste glass

From the bar graph, we can see that the average water absorption of specimen 2 which is no contains of crushed waste glass in 7th days, 14th days, and 21st day is the lowest than others which is 7.1%. If we analyze more deeply, its weight in dry condition is 1.82kg while after soak in the water for 7 days, 14 days, and 21 days, the average weight for that three days are 1.95kg. The weight before and after just different 0.13kg only. However, the average percentage of the water absorption for the three specimen sand bricks that contain 0% crushed waste glass is 8.13% is more than average percentage of the water absorption for the three specimen sand bricks that contain 5% of crushed waste glass in the sand brick which is 7.93%. From the data obtained, we can conclude that the characteristic water absorption for sand brick that contains 5% of waste glass is better than sand brick that contains 0% of crushed waste glass. The second high percentage of water absorption is the sand brick that contains 25% of crushed waste glass which is 8.4% while the highest percentage water absorption in all bricks is the sand bricks that contain 15% of crushed waste glass which is 8.7%.

From the research, the percentage water absorption of the sand brick should not more than 20% and our data of the percentage water absorption successfully shows that all the sand bricks that we make are the quality sand bricks. In conclusion, the higher the

percentage usage of crushed waste glass in the sand brick, the higher the percentage of water absorptionin the sand brick.

4.4 CONCLUSION

In conclusion, we successfully obtained the data of all sand bricks through the compressive strength test and water absorption test. In compressive strength test, the first conclusion that can be concluded through the data obtained is the higher the usage of waste glass, the higher the compressive strength but when the usage of waste glass is more than 5%, the higher the usage of waste glass more than 5%, the lower the compressive strength. The second conclusion of compressive strength test is the usage of 15% waste glass in the sand brick is categories high quality sand brick while the 5% and 25% usage of waste glass in the sand brick is categories normal sand bricks. Lastly, the control bricks which is no waste glass substitute inside is not suitable for using in construction.

In water absorption test, the conclusion that we learned from the data obtained is the higher the usage of waste glass, the higher the water absorption. This can sure that the percentage water absorption of contains 15% waste glass in sand brick is higher than the sand brick that contains 5% of waste glass. Besides that, all the bricks that we tested are the normal brick because all the percentage water absorption did not more than 20%.

CHAPTER 5

DISCUSSION AND CONCLUSION

5.1 INTRODUCTION

This chapter reviews the research that has been carried out. First, a brief review of the research is presented. In this part, all issues such as the research objectives, the framework and research methodology are briefly discussed. Subsequently, the major findings of the study are discussed. In this section, the findings from the empirical test derived from data analysis are presented. Then, the implications of the current study are discussed. Next, the contributions of the study are presented. Finally, the discussion on the limitations and directions for future research are presented.

5.2 DISCUSSION PROJECT

From the data and graph that we done for the compressive strength test and water absorption test, we can make some discussion about it so that the data and the results that we gained are more possible and logically.

First discussion topic is the compressive strength test. From the research, the reason that we choose the crushed waste glass as our substitute materials because the sand is the main component of glass as the glass have the same characteristics with the sand which is contains component of silicon dioxide. So, the sand brick that contains crushed waste glass gave the higher compressive strength value than the sand brick that no contains any crushed waste glass. In our project, the highest compressive strength value is the sand bricks that contains 5% of crushed waste glass which is 16.1N/mm^2. From the research in chapter 2, the crushing or compressive of the high-quality bricks should not have strength below 14 N/mm^2 while the compressive strength of normal bricks should not be below 3.5 N/mm^2. If it is less than 3.5N/mm^2, then it is not suitable useful in construction. In our compression strength test, which contain crushed waste glass 5% to 25% are more than

3.5N/mm². The compressive strength test that below in 3.5N/mm² in our project are the bricks that contain 0% waste glass. It considers to there are not enough of silica in the sand brick, the strength of the bond between the cement sand mixture particle in the sand brick is weak. In the conclusion, it seems that the sand brick that contain 5% to 25% of crushed waste glass in the sand brick is suitable use in construction especially 15%.

The second discussion topic is water absorption test. From the data obtained, we can see that our percentage water absorption from sand brick that contain 0% to 25% of waste glass are ups and downs. The average percentage water absorption sand brick contains 0% of crushed waste glass is 8.13%, the 5% of crushed waste glass sand brick is 7.93%, the 15% of crushed waste glass sand brick is 8.7%, and the last 25% of crushed waste glass sand brick is 8.4%. The reason that percentage water absorption in 0% of crushed waste glass sand brick higher than 5% of crushed waste glass sand brick is there are fully sand and cement in the sand brick. As we known, the water absorption of sand is higher than the crushed waste glass. The percentage water absorption of crushed waste glass 5% and 15% in sand brick are increase constantly. This is because water absorption by bricks increases with increase in pores. The higher the amount crushed waste glass in the sand brick, the bigger the gap between glass and cement sand particle, and the bond between particle crushed glass and cement sand particle are weak, that's the reason the increase of percentage water absorption. From the research, the good quality of sand brick has the percentage water absorption that not more than 20%, so all the bricks that we make is good quality bricks. In conclusion, all the bricks in water absorption test are passed and suitable use in construction.

Overall, all the test we done is gained the data logically, and the data obtained may consider to error of humanity which is unequal of the mixture when we mix the sand, cement, and glass.

5.3 CONCLUSION PROJECT

The conclusion that can make after studying and analyzing the findings for this project especially from the data compression strength test and water absorption test that we obtained is we found that our sand brick with substitute partial crushed waste glass has great potential for future extend the scope. This is because the scope for our project is construction. Nowadays, the construction improving constantly, and our sand brick are suitable used in all construction. In conclusion, what we can conclude through this project is our sand brick with substitute partial crushed waste glass as sand has achieved the objectives that we targeted which is reduce the use of natural resources (sand) in the sand brick. In fact, this sand brick can reduce the amount of waste glass at the same time save our environment. As we known, our country produces 600 tons of glass bottles per day and this glass will take 1000 years to decompose. Therefore, the idea substitute crushed waste glass into the sand brick can reduce the pollution of our environment. Besides that, all bricks in our projects successfully shows that it is accordance with the characteristic of the sand brick which is have a properties high durability in water absorption test and compressive strength test after the data through the tests is obtained.

In this study, the effectiveness of the sand brick with substitute partial crushed waste glass is more focused on the value compressive strength and value percentage of water absorption of the sand bricks. The bricks that contain crushed waste glass is more high strength than the bricks that no contain crushed waste glass. From the data obtained, brick that contains 5% of crushed waste glass had compressive strength attain 14.8N/mm² while the sand brick that contain no crushed waste glass just only 3.34N/mm². In the water absorption test, the average water absorption sand brick that contains 5% crushed waste glass which is 7.93% is lower than the sand brick that no contain any crushed waste glass. Based on the research, sand brick with 5% of crushed waste glass had achieve the high-quality sand brick standard.

Finally, the things that can we conclude from the assessment made is all the percentage especially substitution of 5% to 15% into the sand brick is found to be effective and meet

the specified characteristics of the sand brick and required the low cost and used materials. This is because the reused waste glass in the sand brick is used the concept of eco. The concept project of reused the crushed waste glass in sand brick is an environmentally friendly, safety, and reliability product. Therefore, this concept of reused the crushed waste glass in the sand brick can save the environment from becoming a more pressing environmental pollution problem. Overall, it seems that our sand brick project brings a lot of benefits to us so I hope that more construction company in Malaysia can consider our project for the better environment.

5.4 Recommendation

After finished the project, there are some things that are proposed to further enhance the study that will be done on sand brick to find out the level of effectiveness. The first recommendation for this project is using the same percentage of crushed waste glass but using difference ratio of crushed waste glass in the project. From the results obtained, the best percentage that we obtained is 5% of crushed waste glass in sand brick. So, the recommendation for this 5% of crushed waste glass is using different ratio of size crushed waste glass which is 1.18mm and 300µm. For example, using 5:5 of 1.18mm and 300µm size of crushed waste glass, using 8:2 of 1.18mm and 300µm size of crushed waste glass in the sand brick.

The second recommendation is using the crushed waste glass machine. In this project, we crushed the waste glass manually which is using hammer. Although the cost usage of hammer to crush the waste glass in this project are very cheaper, but it took a long time to achieve the weight of the waste glass that we need, and this action is very dangerous because the glass is a sharp and fragmented material. In my opinion, we can use crushed waste glass machine, not only the machine is safer than manual, the usage of crush waste glass machine also can crush the glass into the small size equally in a short time, but the only downside of usage machine is the cost is too expensive. So, the usage of the crushed waste glass machine can save the time of the project.

The third recommendation is using the mixture machine. In this project, we mix the materials which is sand, cement, crushed waste glass and water just on the tray manually. A most inconspicuous problem is whether the material is evenly mixed? So, through

using the mixture machine, we not only can make sure that the mixture had mix equally but also can save our time.

5.5 Conclusion Chapter

The results of this project that can be conducted on this substitute partial crushed waste glass as the sand in the sand brick can be concluded that this project has achieve the objectives that we have targeted and solve the problem statement that we had state in chapter 1. The result obviously shows that the sand brick that contains a few of crushed waste glass can achieve a standard strength value in compression strength test. Besides that, this project also successfully shows that reduction the use of natural resources which is sand by replace partial sand with crushed waste glass. Impact, the sand brick that substitute the crushed waste glass can save our environment and reduce the waste glass in the world. Let us work together with promote our project which is substitute partial waste glass in the sand brick to the others so that we able to ensure the quality of the environment is preserved to ensure the development of the country and future generations!

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Appendix 1 Data of Water Absorption Test

0% of crushed waste glass

	7 days	14 days	21 days	Average
Specimen 1 (1.71kg)	8.8% (1.86kg)	9.4% (1.87kg)	9.9% (1.88kg)	9.4% (1.87kg)
Specimen 2 (1.82kg)	6.6% (1.94kg)	7.1% (1.95kg)	7.7% (1.96kg)	7.1% (1.95kg)
Specimen 3 (1.78kg)	7.3% (1.91kg)	7.9% (1.92kg)	8.4% (1.93kg)	7.9% (1.92kg)

5% of crushed waste glass

	7 days	14 days	21 days	Average
Specimen 1 (2.00kg)	7.5% (2.15kg)	8.0% (2.16kg)	8.5% (2.17kg)	8.0% (2.16kg)
Specimen 2 (1.92kg)	7.8% (2.07kg)	8.3% (2.08kg)	8.9% (2.09kg)	8.3% (2.08kg)
Specimen 3 (1.86kg)	7.0% (1.99kg)	7.5% (2.00kg)	8.1% (2.01kg)	7.5% (2.00kg)

15% of crushed waste glass

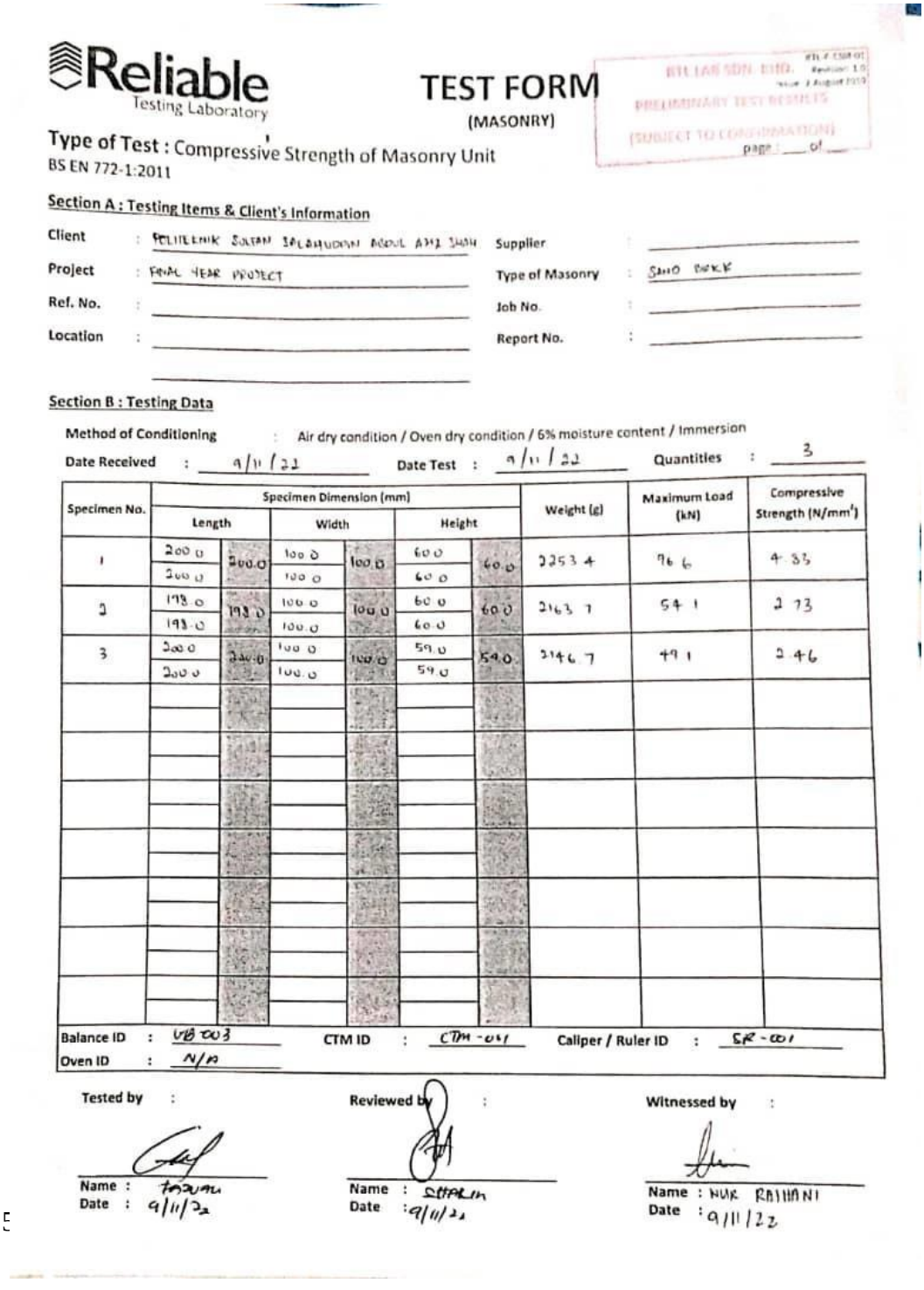
	7 days	14 days	21 days	Average
Specimen 1 (1.97kg)	8.1% (2.13kg)	8.6% (2.14kg)	9.1% (2.15kg)	8.6% (2.14kg)
Specimen 2 (1.98kg)	7.6% (2.13kg)	8.1% (2.14kg)	8.6% (2.15kg)	8.1% (2.14kg)
Specimen 3 (1.92kg)	8.9% (2.09kg)	9.4% (2.10kg)	9.9% (2.11kg)	9.4% (2.10kg)

25% of crushed waste glass

	7 days	14 days	21 days	Average
Specimen 1 (1.90kg)	6.8% (2.03kg)	7.4% (2.04kg)	7.9% (2.05kg)	7.4% (2.04kg)
Specimen 2 (1.91kg)	7.9% (2.06kg)	8.4% (2.07kg)	8.9% (2.08kg)	8.4% (2.07kg)
Specimen 3 (1.81kg)	8.8% (1.97kg)	9.4% (1.98kg)	9.9% (1.99kg)	9.4% (1.98kg)

Appendix 2 Data of Compression Strength Test

0% of crushed waste glass in sand brick:



Reliable Testing Laboratory

TEST FORM
(MASONRY)

BTL LAB SDN. BHD. PRELIMINARY TEST RESULTS (SUBJECT TO CONFIRMATION) page 1 of 1

Type of Test : Compressive Strength of Masonry Unit
BS EN 772-1:2011

Section A : Testing Items & Client's Information

Client : POLITEKNIK SULTAN SALAHUDDIN ABDUL AZIZ SHAH
Project : FINAL YEAR PROJECT
Ref. No. :
Location :
Supplier :
Type of Masonry : SAND BRICK
Job No. :
Report No. :

Section B : Testing Data

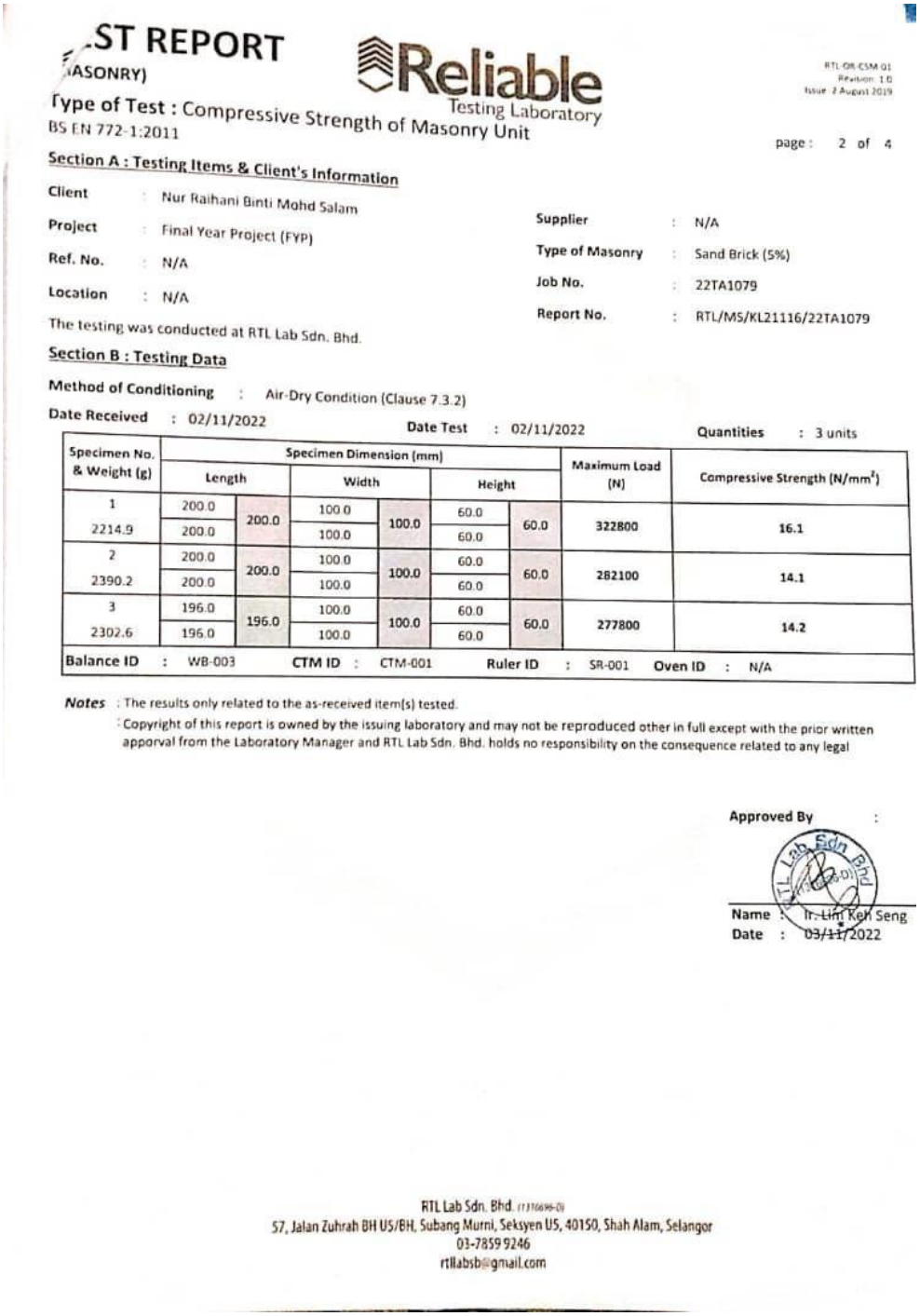
Method of Conditioning : Air dry condition / Oven dry condition / 6% moisture content / Immersion
Date Received : 9/11/22 Date Test : 9/11/22 Quantities : 3

Specimen No.	Specimen Dimension (mm)						Weight (g)	Maximum Load (kN)	Compressive Strength (N/mm²)
	Length		Width		Height				
1	200.0	200.0	100.0	100.0	60.0	60.0	2253.4	96.6	4.83
	200.0		100.0		60.0				
2	198.0	198.0	100.0	100.0	60.0	60.0	2163.1	54.1	2.73
	198.0		100.0		60.0				
3	200.0	200.0	100.0	100.0	59.0	59.0	2146.7	49.1	2.46
	200.0		100.0		59.0				

Balance ID : VB 003 CTM ID : CTM-001 Caliper / Ruler ID : SR-001
Oven ID : N/A

Tested by : Name : FAZURA Date : 9/11/22
Reviewed by : Name : SITI ARLIN Date : 9/11/22
Witnessed by : Name : NUR RAIHANI Date : 9/11/22

5% of crushed waste glass in sand brick:



ST REPORT
ASONRY)

Reliable
Testing Laboratory

RTL-QR-CSM 01
Revision: 1.0
Issue: 2 August 2019

Type of Test : Compressive Strength of Masonry Unit
BS EN 772-1:2011

page : 2 of 4

Section A : Testing Items & Client's Information

Client	: Nur Raihani Binti Mohd Salam	Supplier	: N/A
Project	: Final Year Project (FYP)	Type of Masonry	: Sand Brick (5%)
Ref. No.	: N/A	Job No.	: 22TA1079
Location	: N/A	Report No.	: RTL/MS/KL21116/22TA1079

The testing was conducted at RTL Lab Sdn. Bhd.

Section B : Testing Data

Method of Conditioning : Air-Dry Condition (Clause 7.3.2)

Date Received : 02/11/2022 Date Test : 02/11/2022 Quantities : 3 units

Specimen No. & Weight (g)	Specimen Dimension (mm)						Maximum Load (N)	Compressive Strength (N/mm²)
	Length		Width		Height			
1	200.0	200.0	100.0	100.0	60.0	60.0	322800	16.1
2214.9	200.0		100.0		60.0			
2	200.0	200.0	100.0	100.0	60.0	60.0	282100	14.1
2390.2	200.0		100.0		60.0			
3	196.0	196.0	100.0	100.0	60.0	60.0	277800	14.2
2302.6	196.0		100.0		60.0			

Balance ID : WB-003 CTM ID : CTM-001 Ruler ID : SR-001 Oven ID : N/A

Notes : The results only related to the as-received item(s) tested.
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Approved By :

RTL Lab Sdn Bhd

Name : Ir. Lim Kek Seng
Date : 03/11/2022

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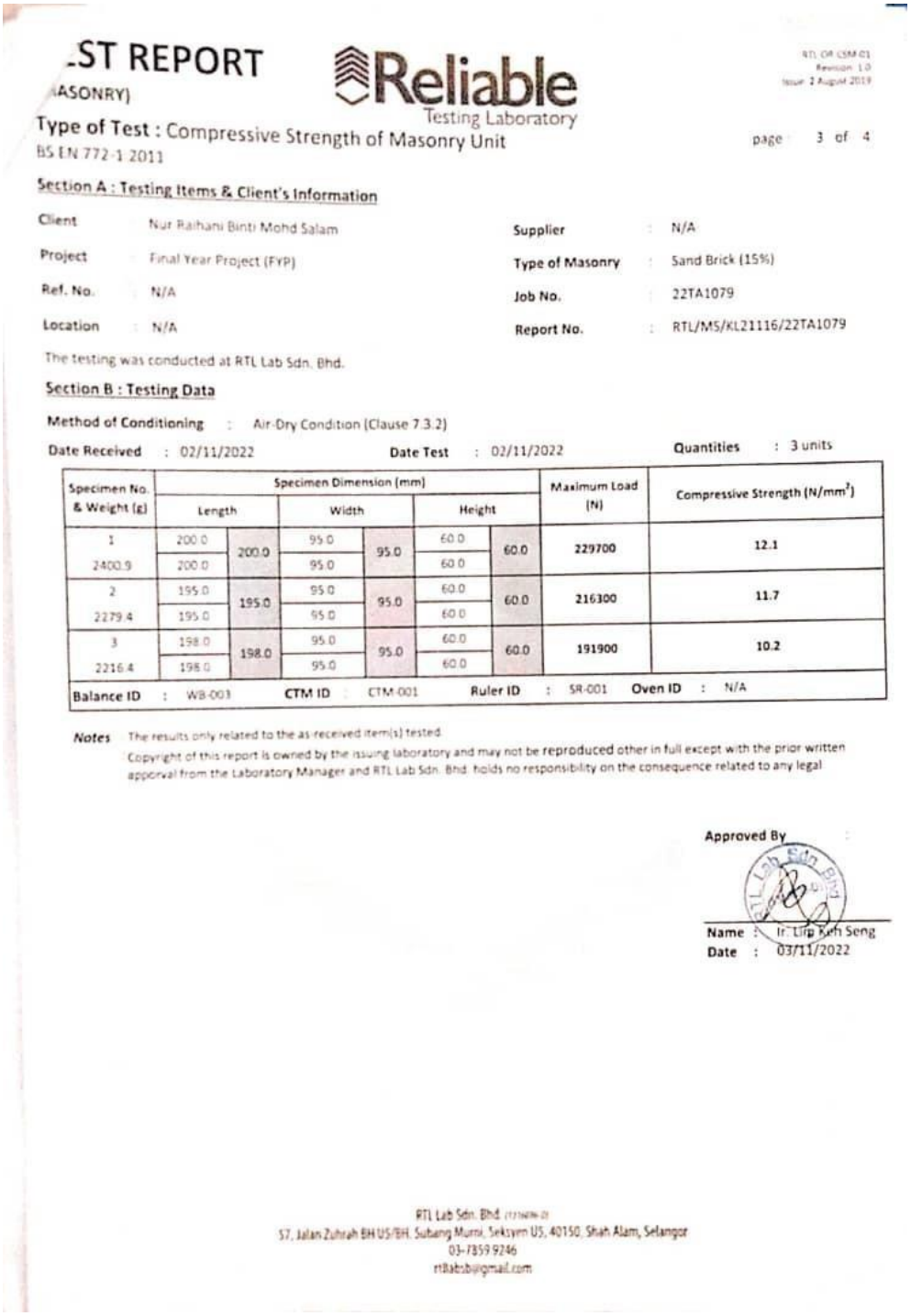
15% of crushed waste glass in sand brick:



.ST REPORT
ASONRY)

Reliable
Testing Laboratory

RTL QR CSM-01
Revision 1.0
Issue 2 August 2019

Type of Test : Compressive Strength of Masonry Unit
BS EN 772-1 2011

page 3 of 4

Section A : Testing Items & Client's Information

Client	: Nur Raihani Binti Mohd Salam	Supplier	: N/A
Project	: Final Year Project (FYP)	Type of Masonry	: Sand Brick (15%)
Ref. No.	: N/A	Job No.	: 22TA1079
Location	: N/A	Report No.	: RTL/MS/KL21116/22TA1079

The testing was conducted at RTL Lab Sdn. Bhd.

Section B : Testing Data

Method of Conditioning : Air-Dry Condition (Clause 7.3.2)

Date Received : 02/11/2022 Date Test : 02/11/2022 Quantities : 3 units

Specimen No. & Weight (g)	Specimen Dimension (mm)						Maximum Load (N)	Compressive Strength (N/mm²)
	Length		Width		Height			
1	200.0	200.0	95.0	95.0	60.0	60.0	229700	12.1
2400.9	200.0		95.0		60.0			
2	195.0	195.0	95.0	95.0	60.0	60.0	216300	11.7
2279.4	195.0		95.0		60.0			
3	198.0	198.0	95.0	95.0	60.0	60.0	191900	10.2
2216.4	198.0		95.0		60.0			

Balance ID : WB-003 CTM ID : CTM-001 Ruler ID : SR-001 Oven ID : N/A

Notes The results only related to the as-received item(s) tested.

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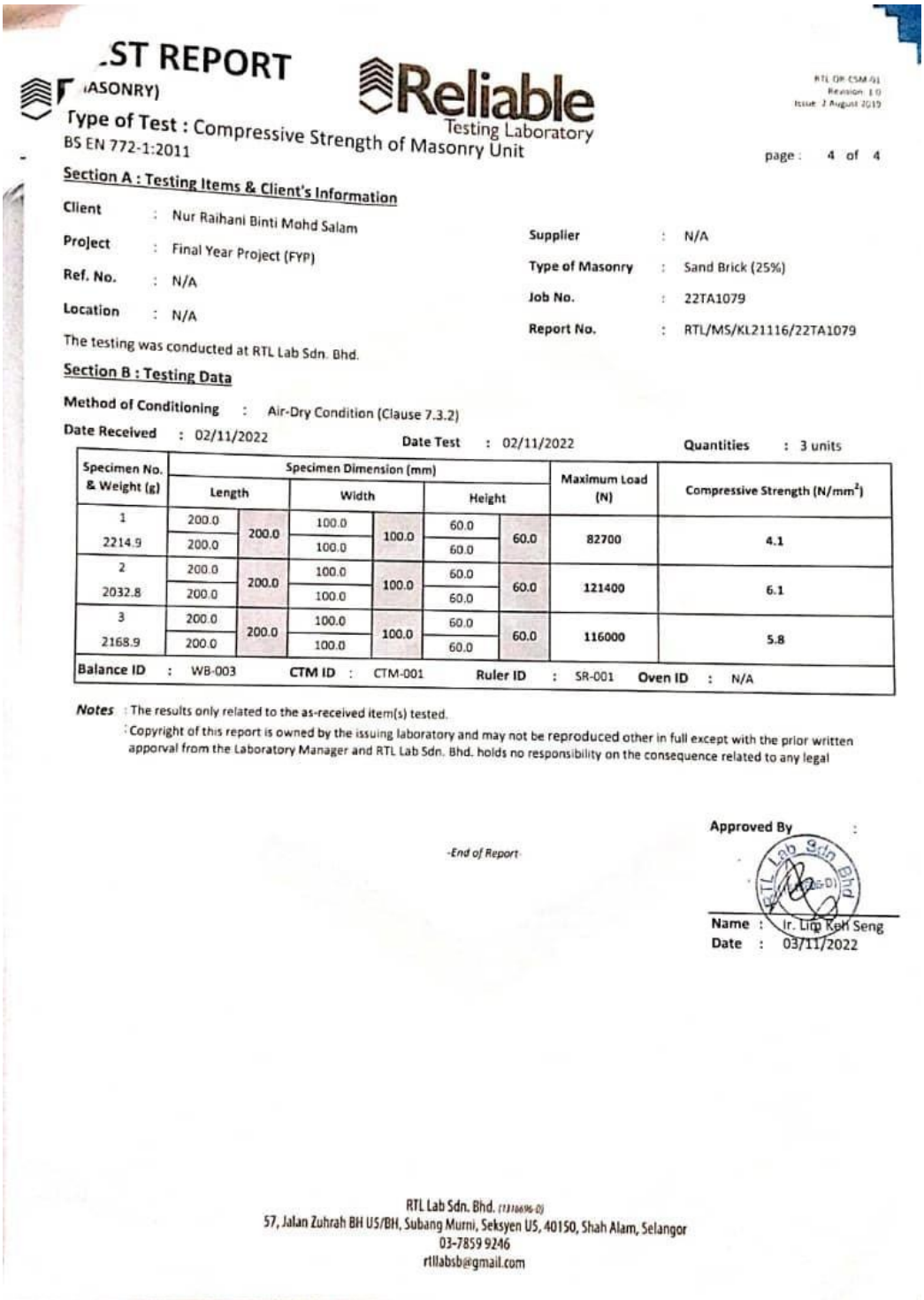
25% of crushed waste glass in sand brick:



.ST REPORT

(ASONRY)

Reliable Testing Laboratory

RTL QF CSM-01
Revision 1.0
Issue 2 August 2019

Type of Test : Compressive Strength of Masonry Unit
BS EN 772-1:2011

page : 4 of 4

Section A : Testing Items & Client's Information

Client : Nur Raihani Binti Mohd Salam
Project : Final Year Project (FYP)
Ref. No. : N/A
Location : N/A

Supplier : N/A
Type of Masonry : Sand Brick (25%)
Job No. : 22TA1079
Report No. : RTL/MS/KL21116/22TA1079

The testing was conducted at RTL Lab Sdn. Bhd.

Section B : Testing Data

Method of Conditioning : Air-Dry Condition (Clause 7.3.2)
Date Received : 02/11/2022 Date Test : 02/11/2022 Quantities : 3 units

Specimen No. & Weight (g)	Specimen Dimension (mm)						Maximum Load (N)	Compressive Strength (N/mm²)
	Length		Width		Height			
1	200.0	200.0	100.0	100.0	60.0	60.0	82700	4.1
2214.9	200.0		100.0		60.0			
2	200.0	200.0	100.0	100.0	60.0	60.0	121400	6.1
2032.8	200.0		100.0		60.0			
3	200.0	200.0	100.0	100.0	60.0	60.0	116000	5.8
2168.9	200.0		100.0		60.0			

Balance ID : WB-003 CTM ID : CTM-001 Ruler ID : SR-001 Oven ID : N/A

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-End of Report-

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Date : 03/11/2022

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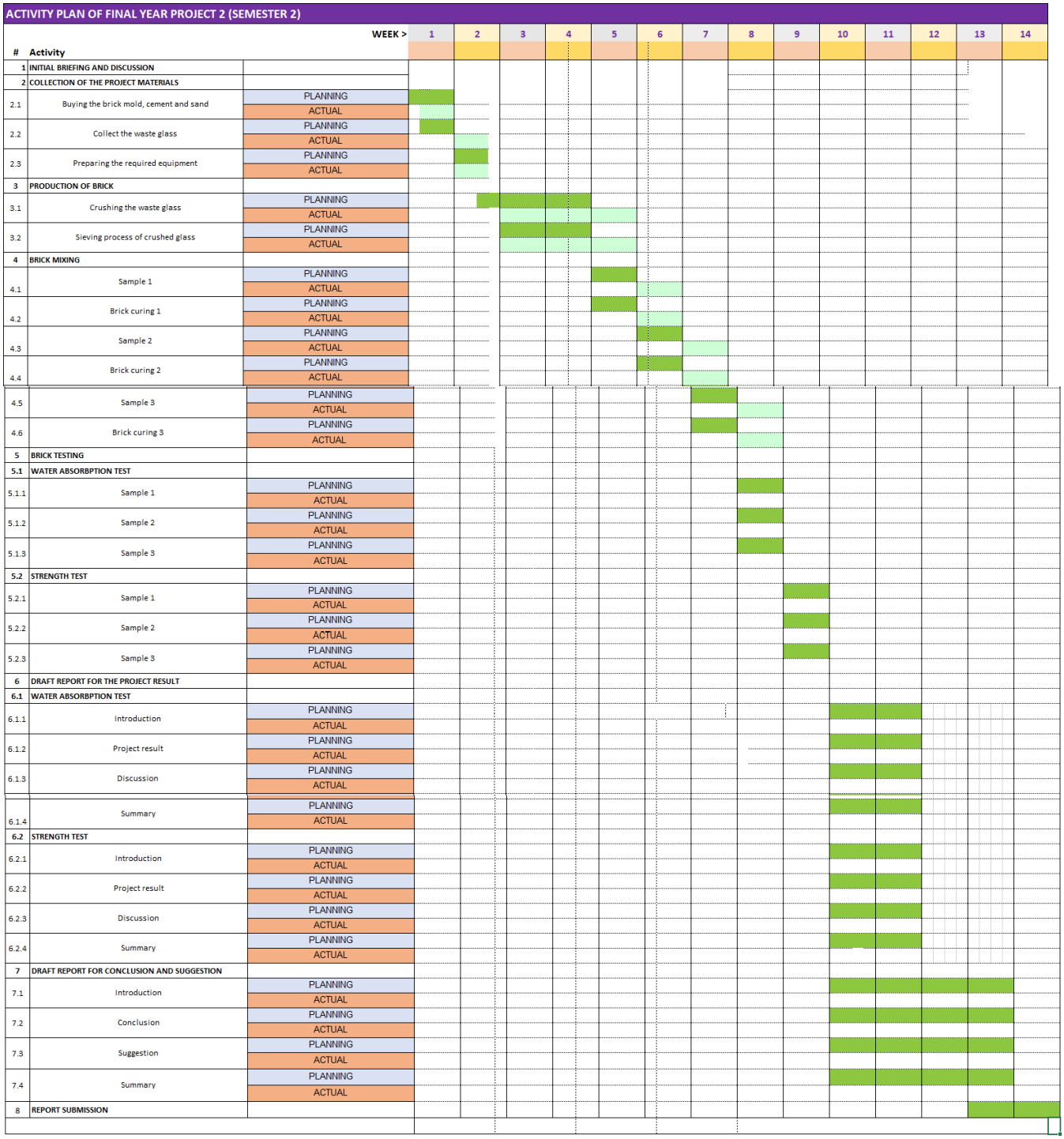
Appendix 3 Gantt Chart (Phase 1)

NO	TASK	ACTIVITY/WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1			SEMESTER 1													
1.1	Project title selection	Planning														
		Actual														
1.3	Project research	Planning														
		Actual														
1.4	Discussion with the supervisor about the project	Planning														
		actual														
1.5	Defense proposal	Planning														
		Actual														
1.6	Logbook update	Planning														
		Actual														
1.7	Proposal presentation 1	Planning														
		Actual														
2	**Draft report chapters 1-3**															
2.1	Introduction	Planning														
		Actual														
2.2	Literature review	Planning														
		Actual														
2.3	Data collection	Planning														
		Actual														
2.4	Research detail about the project	Planning														
		Actual														
2.5	Research detail about material	Planning														
		Actual														
2.6	Methodology	Planning														
		Actual														
2.7	Presentation 2	Planning														
		Actual														
2.8	Proposal submission	Planning														
		Actual														

Appendix 4 Gantt Chart (Phase 2)



Appendix 5 Cost of Project

Material and Equipment	**Price**	**Unit**	**Total price**
Cement	RM20/Bag	1	RM 20
Rent machine compressive test	RM 7/pc	12	RM 84
Mold of brick	RM 13 /pc	3	RM 39
TOTAL			RM 143

Appendix 6 Photo of The Sand Brick

LAMPIRAN J

BORANG INVENTORI PROJEK PELAJAR

PERKARA	MAKLUMAT
Program:	DIPLOMA KEJURUTERAAN AWAM
Jabatan:	JABATAN KEJURUTERAAN AWAM
Semester/ Tahun:	1: 2022/2023
Tajuk Kajian/Projek:	SAND BRICK USING CRUSHED WASTE GLASS TO REPLACE SAND PARTIALLY
Jenis Kajian/Projek:	KAJIAN NYATA
Kategori Kluster Penyelidikan:	Tanda " / " pada yang berkenaan: [ ] Sains Tulen [ ] Sains Sosial [ ] Sains Gunaan [ ] Sastera & Sastera Ikhtisas [/] Teknologi & Kejuruteraan [ ] Warisan Alam & Budaya [ ] Sains Kesihatan & Klinikal [ ] ICT
Ahli Kumpulan:	1. Nama: EE EN QI No. Pendaftaran Pelajar: 08DKA20F1041 2. Nama: NUR RAIHANI BINTI MOHD SALAM No. Pendaftaran Pelajar: 08DKA20F1059
Penyelia:	Nama: PN. DALIELA BINTI ISHAMUDDIN No. Kad Pengenalan: 820122025606
Penyelia Bersama:	1. Nama: No. Kad Pengenalan: 2. Nama: No. Kad Pengenalan:
Multi-Disiplin:	
Kolaborasi: (Industri/Komuniti)	*Nyatakan maklumat lengkap industri/komuniti yang terlibat dalam pembangunan projek berserta peranan dan sumbangan pihak industri.*

Objektif Kajian/Projek:	1. To reduce the use of natural resources of sand brick by replacing it with crushed waste glass 2. To investigate the characteristics of sand brick containing finely crushed waste glass. 3. To investigate the durability properties of composite brick by water absorption test and strength test.

PERKARA	MAKLUMAT
Skop Kajian/Projek:	The engineering characteristics of cement sand brick using crushed glass waste as sand are the focus of this research. Sand, cement, crushed waste glass, and water are the primary ingredients in the sand brick mix. The waste glass is collected from post-consumer in the housing area and shops. Before adding to the brick mix, the waste glass was to investigate the characteristics of sand brick containing finely crushed waste glass is crushed manually and will be sieved and graded through a below 4.75mm sieve which is the size range between 4.75mm to 0.075mm. 18 samples will be made by adding 5%, 15%, and 25% of the crushed waste glass into the sand brick mix. Ordinary Portland Cement (OPC) had been used as a binder in cement sand bricks. The specimen's size of the bricks is 200x100x60 mm and had been tested for engineering properties which are compressive strength and water absorption test in. The findings of the study will assist in the use of crushed waste glass as an aggregate substitute, hence improving the characteristics of sand cement bricks. This study looked at the density, and strength of the sand-cement bricks when they were loaded, as well as the water absorption of the sand-cement bricks with crushed waste glass substitution. So, the result of the study will determine the desired percentage of crushed waste glass in each sample to obtain the best strength.
Penglibatan Pelajar: (merujuk kepada skop kajian/projek)	-
Abstrak Kajian/Projek:	The making of a sand brick using crushed waste glass is to recycle the waste material such as glass to replace partial sand in sand brick. This project focuses on the waste material in the production of sand brick to go eco-friendlier, cheaper, and strong. The substitution of waste glass as the sand in the sand brick is based on the problem that occurs which is objects from glass will no longer be used and cause increased waste. The main material for making this sand brick is cement, crushed waste glass, sand, and water using the ratio of (1:1:6) composition of (water: cement: sand). The waste glass will be crushed and added into the mixture of sand brick with amounts of 5%, 15%, and 25% and it will be molded into a size 200x 100x 60 mm for 24 samples. It will have dried for 24 hours and cured for 7, 14, and 21 days. The final product will be run with several laboratory tests such as a crushing strength test and water absorption test to determine its strength and ability. The test result of each sample will be evaluated and analyzed based on the standard for sand brick which is BS 6073. Thus, we gained the best average value of crushed waste glass from the compressive strength test which is 14.8N/mm² from the sand brick that contains 5% of crushed waste glass. For the water absorbing test, the best average percentage that we obtained which is the lowest percentage that sand brick absorb is 7.93% which is also the sand brick that contains 5% of crushed waste glass. In conclusion, all the data on the sand bricks we obtained in the test passed the standard normal sand brick value especially 5% of crushed waste glass in the sand brick, which is categorized as a high-quality sand brick.

Infografik Kajian/Projek:	
Peringkat: *(sekiranya ada menyertai pertandingan)*	Jabatan
No. Pendaftaran Harta Intelek (*jika ada*)	

Disemak oleh: _____ Tandatangan Penyelaras Kursus Projek Nama dan Cop:	Disahkan oleh: _____ Tandatangan Penyelaras Projek Pelajar Jabatan Nama dan Cop:

Nota: *Borang ini perlu diisi oleh pelajar dan dihantar kepada Penyelaras Kursus Projek/Jabatan dalam bentuk salinan keras (hardcopy) dan salinan lembut (softcopy) (Borang LAMPIRAN J dan gambar hasil projek dalam format jpeg/bitmap) bersama Laporan Akhir dan hasil projek.*