PERFORMANCE OF DOLOMITE WITH DIFFERENT PERCENTAGE AS SAND REPLACEMENT IN FOAM CONCRETE

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Kajian ini dijalankan bagi mengkaji prestasi dolomit dengan peratusan yang berbeza sebagai penggantian pasir dalam pembuatan konkrit berbusa untuk meningkatkan kekuatan mampatan dan mengurangkan penggunaan pasir dalam pembinaan dan dalam masa yang sama dapat mengurangkan pencemaran sungai. Penghasilan campuran konkrit berbusa bergantung kepada jenis bahan, jenis ejen busa dan reka bentuk campuran konkrit. Objektif kajian ini dijalankan adalah untuk mengkaji sifat fizikal (bentuk, saiz, kandungan kelodak) dan komposisi kimia pada dolomit dan juga untuk menentukan kekuatan mampatan konkrit busa. Ciri-ciri fizikal dan kimia pada dolomit telah dikaji dengan menggunakan mikroskop, ujian lumpur, analysis menggunakan ayak, Analisis Pendafloue Sinar-X (XRF), Mikroskop Imbasan Elektron (SEM) dan Analisis Serakan Sinar-X (XRD). Kadar peratusan dolomit yang digunakan adalah 10%, 20%, 30%, dan 40% sementara sampel untuk 0% dolomit digunakan sebagai sampel kawalan. Jumlah specimen adalah sebanyak 45 kiub yang menggunakan acuan bentuk kiub bersaiz 100mm x 100mm x 100mm dengan menggunakan dolomit yang melepasi ayak saiz 600micro dan kepadatan untuk setiap $100mm^3$ ialah $1600kg/m^{3.}$ Nisbah air busa ialah 1:25. Ujian untuk menentukan kekuatan mampatan konkrit busa dijalankan untuk 7 hari, 14 hari dan 28 hari semasa proses pengawetan di dalam air. Keputusan menunjukkan bahawa 30% daripada dolomit telah meningkatkan kekuatan mampatan konkrit busa. Hasil yang diperolehi dianalisis dan sifat fizikal dan kimia dolomit direkod.

ABSTRACT

This paper investigate the performance of dolomite with different percentage as sand replacement in production of foam concrete to increase the compressive strength and reduce the uses of sand in construction while reducing river pollution. The production of foam concrete mix depend on material section, selected foaming agent and mixture design strategies. The objective of this study are observed the physical properties (shape, size, silt content) and chemical composition of dolomite and also to determine the compressive strength of foam concrete. The physical and chemical properties of the dolomite was tasted using microscope, silt test, sieve analysis, X-Ray Fluorescence (XRF), Scanning Electron Microscopy (SEM) and X-Ray Diffraction Analysis (XRD). The percentage rate of dolomite are 10%, 20%, 30% and 40% meanwhile the sample for 0% of dolomite was used as the control sample. The total of specimen are 45 cubes using form cube size 100mm x 100mm x 100mm with using dolomite that passing through 600micron sieve size and the density for $100mm^3$ is $1600kg/m^3$. Foam water ratio is 1:25. The test for determined the compressive strength of foam concrete was conducted for 7 days, 14 days and 28 days during curing processed. Results indicate that 30% of dolomite significantly improved the compressive strength of foam concrete. The obtained results are analysed and the other physical and chemical properties of dolomite are recorded.

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LIST OF ABBREVIATIONS

AAC	Autoclaved Aerated Concrete
CLSM	Cement Lime Sand Mortar
LWC	Lightweight Concrete
NWC	Normal Weight Concrete
SEM	Scanning Electron Microscopy
XRD	X-Ray Diffraction
XRF	X-Ray Fluorescence

CHAPTER 1

INTRODUCTION

1.1 Introduction

In the construction industry, especially in the construction of housing is the longest industry in the world. The need of shelter makes people strive to provide shelters or be known as house. At the beginning of human life, construction of houses only uses the materials found around their homes. Among them is by using natural resources that are readily available and can continue to be used, such as wood. While resident in a limited wood resources, they began to build a house using building materials such as sludge which is the basis of concrete development.

Concrete is a building material that has been widely used in the construction industry. History record show that concrete has begun to be used as a building material as early as the 1850s. This is evident when older Egyptians use unpaved gypsum ash as a cement material, while the Greeks and Roms have long used the limestone ash in the preparation of concrete. This can be seen at the construction of the Coliseum in Rome and Pont du Gard near Nimes which remains to this day (Neville, 1994).

The development of concrete technology around the world has shown how concrete-based building materials have been take over building materials sourced from natural materials. This change is due to the strength and durability of concrete is better than other building materials that are important features of a building. The main basic of concrete preparation is mixing of cement, aggregate and water mixtures. The use of additives and other materials is also commonly used in concrete mixes to produce high quality concrete or produce specific concrete according to user requirements.

Demand for concrete use in the construction industry which is rapidly expanding to the need for various types of concrete properties to meet its requirements. This condition makes the concrete industry often produce a variety of new products. This product covers the process of innovation in the use of new raw materials, methods of production and use of chemicals in concrete mixes, producing more economical concrete and diversifying concrete products. Among the interesting concrete innovation process is low lightweight concrete production.

Lightweight concrete initially has been defined as concrete produced using lightweight aggregate to replace ordinary aggregates. The development of lightweight concrete technology has succeeded in producing lightweight concrete without the use of aggregates, which is to use chemicals to produce stable foam in concrete or mortar. Foam concrete is a highly aerated mortar because it mostly no coarse aggregate is used for it production. Foam concrete typically consists of a slurry of cement, sand and water with the foaming agent. Foam concrete is a lightweight concrete which is lighter than conventional concrete. The production of stable foam concrete mix depends on many factors such as selecting of foaming agent, material section and mixture design strategies and production of foam concrete.

According to the draft International Standard Model Code for Concrete Construction (1977), has classified lightweight concrete having a density of between 1200 kg/m^3 to 2000 kg/m^3. However, the use of foam in lightweight concrete makes lightweight concrete can be provided with a density as low as 300 kg/m^3. Generally, ordinary concrete is provided with a density of 2240 kg/m^3 to 2400 kg/m^3.

Dolomite can be defined as natural aggregates consisting of one or more minerals that are sedimentary rocks resulting from the deposition of river or sea that lasted for millions of years. The raw dolomite is extracted in Chuping, in the state of Perlis, Malaysia. Dolomite as a mineral has very few uses. Dolomite is used as a source of magnesia (MgO), a feed additive for livestock, a sintering agent and flux in metal processing, and as an ingredient in the production of glass, brick, and ceramics. According to Zainal H, Director Department of Mineral and Geoscience Malaysia said, “If the dolomite is processed into magnesia, the extract is useful for reducing the rate of chemical contamination radiation, durable and light brick, furniture, tiles and concrete”. It is recently used in 2011. Dolomite will use as a replacement a part of sand in foam concrete. The smaller size of dolomite can be uses as a filler in foam concrete.

1.2 Problem Statement

In this modern age, development is growing for fulfilling population capacity. Low density concrete has some special features as building materials. One of the important features of the concrete is lighter. With low density make this concrete lighter than ordinary concrete. In the construction industry the dead load factor is the one of the main factor. Therefore, the reduction of concrete density will reduce the overall weight of building structure.

Lightweight Foam Concrete has low strength compared to normal concrete. Lightweight concrete has strength about 15kN/m^3 – 17.5kN/m^3 and normal concrete has strength about 21kN/m^3 – 23kN/m^3, (Wan, 2013). The strength of foam concrete is lower, so the use of foam concrete will decrease. The ways to control Lightweight Foam Concrete is using density. By using different quantities of foamed agent will affect the strength and quality of foamed concrete. The compressive strength of concrete depends on the water to cement ratio, degree of compaction, ratio of cement to aggregate, bond between mortar and aggregate, and grading, shape, strength and size of the aggregate (Abdullahi, 2012).

To increase the strength of foam concrete by using material for filler to fill up the bubble in the concrete. Through this problem, one of the solution suggested is the use of dolomite as a replacement a part of sand. This is because dolomite has a size smaller than sand. Dolomite also have a potential to be used in construction. Besides that, the uses of dolomite can also reduce the uses of sand in construction.

The use of river sand will also increase as well with the development being carried out. This is because sand is one of the main materials in the construction. As reported in the newspaper after an interview people who are living near the river by Nur (2014) has stated that the effects of sand extraction activities among them are presence of dust, river water is getting polluted and lack of clean water supply as show in Figure 1.1. Muaz (2014) an engineer living in the area near the river also said that “before the sand dredging activity, he was dig a well for daily use, but now the water getting dry”. In addition, water strings are also small and river water is also polluted by the effects of this activity.

Figure 1.1 One of river where sand was taken

Source: Nur (2014).

It is impossible to reduce the construction, so the other alternative is to reduce the uses of sand in construction and at the same time can reduce river pollution is by using dolomite as a part of sand. To reduce the use of sand, the study on evaluation using dolomite with different percentage as a replacement a part of sand for foam concrete will be conduct. The value compressive strength of foam concrete as a lightweight concrete if use dolomite in the mixture was analysed.

1.3 Objective of Study

The main objective of evaluation performance of dolomite with different percentage as sand replacement in foam concrete are:

i) To observe the physical properties of fine aggregate in term of shape, size and silt content.

ii) To identified the chemical composition of dolomite.

iii) To determine the compressive strength of foam concrete using different percentage of dolomite as a sand replacement.

1.4 Scope of Study

This studied mainly focuses on the compressive strength of foam concrete that was mixed with different percentage of dolomite in its mixture. Dolomite was used from Quarry Northern Dolomite Sdn. Bhd. at Perlis. The physical properties of fine aggregate was observed by using dolomite that passing through 600micron sieve size by sieve analysis method. The silt and size of fine aggregate was observed by silt test and using electronic microscope. The chemical properties of dolomite was tested using X-Ray Fluorescence (XRF), Scanning Electron Microscopy (SEM - EDX) and X-Ray Diffraction Analysis (XRD).

The compressive strength of foam concrete was conduct at age 7 days, 14 days and 28 days during curing process. The percentage rate of dolomite will prepare for 10%, 20%, 30% and 40% are partial from weight of sand in mixture for each sample. Meanwhile, the sample for 0% of dolomite was used as the control sample. There are five mixture. The size of foam concrete cube is 100mm x 100mm x 100mm. The total of specimen are 45 cubes with target density at 1600kg/m^3 for each cubes. The standards used for this experiment are BS 1881:Part1 16:1983. Foam water ratio is 1:25. The specimen is conduct immediately after the removal of specimen from curing tank, with three hardened concrete specimens shall be used in the measurement of concrete strength at the design age. The trial mix design are refer to past research design on foam concrete.

1.5 Significant of Study

With using dolomite as a sand replacement in production of foam concrete, it was increase the compressive strength. Besides that, the uses of sand in construction was reduced and can avoid the contaminant of river. It also increase the uses of dolomite in industry.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This thesis is to produce foam concrete and test the foamed concrete at laboratory to identify the physical properties, chemical composition and compressive strength. All properties about foamed concrete are describe in this chapter. Fines aggregate that used in this study is silica sand and dolomite.

2.2 Concrete

Concrete is a building material that has been widely used in making architecture structure, foundation, highways and runways, parking structure, pools/reservoir, pipes and concrete making in construction. History record show that concrete has begun to be used as a building material as early as the 1850s. According to research by (Rameshwar et al., 2017), concrete consists of mainly sand which is about 35%. It may be natural sand made from river or artificial sand.

In construction industry natural sand is used as an important building material and world consumption of sand in concrete is around 1000 million tons per year making it scarce and limited. Further, it has cause environment degradation like removal of mineral from top soil due to erosion and change in vegetative property leading to soil infertility problem thereby effecting agricultural productivity.

Concrete is a heterogeneous composite material consisting of aggregates (sand, crushed rock or gravel), a binding medium made of Portland cement, and water. These constituents are available locally and in virtually unlimited quantities. Primary materials can be replace by aggregates made from recycled concrete and by-products from other industries. For example fly ash and slag can be used to replace Portland cement and it was stated by Thomas Concrete Group.

Special types of concrete can be defined as those with extraordinary properties, or as those produced by unusual techniques. There are dozens of special concrete types, including architectural concrete, fibre concrete, self-compacting concrete and high-strength concrete. The areas and industries where concrete is used are diverse from the construction of buildings and infrastructure, to agriculture, architecture and energy production. Concrete is versatile building material and is of highest importance to modern society.

The characteristics of concrete can vary greatly depending on the choice of cement and cement-aggregate ratio, the type of aggregate used, the inclusion of additive and other more. The way of concrete are used and surface treated can also have an impact on their performance. Concrete is a carefully balanced mix of cement, aggregates and water. Cement acts as the binder and modifies the characteristics and uses of concrete.

According to researched by Abdullahi,(2012) has stated that concrete can be visualized as a multi-phase composite material made up of three phase, namely the mortar, mortar/aggregate interface, and the coarse aggregate phase. The coarse aggregate in normal concrete are mainly from rock fragment characterised by high strength. Therefore, the aggregate interface is not a limiting factor governing the strength requirement. The onset of failure is manifested by crack growth in concrete. For normal concrete the crack growth is mainly around the cement paste or at the aggregate/cement paste interfacial zone. The strength of concrete at the interfacial zone essentially depends on the integrity of the cement paste and the nature of the coarse aggregate.

Working with concrete is relatively save, however, like all construction materials. It should be treated with care and respect. When handling concrete, ensure the correct equipment for the task is being used, and that approved safety clothing is worn. In its early life, the fresh concrete must be protected from the detrimental effects of drying due to hot sun, dry air and drying winds. It also needs to be protected from frost and precipitation. In order to achieve the required durability and strength of any concrete, care must be given to curing. Always remember that concrete is a specialised product and handling it safely and correctly requires experience.

2.3 Lightweight Concrete

The term “lightweight concrete” which is preferred by the American Concrete Institute (ACI) will be used rather than the more scientifically correct term of lower density concrete. Lightweight concrete initially has been defined as concrete produced using lightweight aggregate to replace ordinary aggregates. Among the interesting concrete innovation process is low lightweight concrete productions.

The development of lightweight concrete technology has succeeded in producing lightweight concrete without the use of aggregates, which is to use chemicals to produce stable foam in concrete or mortar. Lightweight aggregates used in structural lightweight concrete are typically expanded shale, clay or slate materials that have been fires in a rotary kiln to develop a porous structure. Other product such as air-cooled blast furnace slag are also used. There are other classes of non-structural lightweight concrete with lower density made with other aggregate materials and higher air voids in the cement paste matrix, such as in cellular concrete.

2.3.1 Classification of Lightweight Concrete

It is convenient to classify the various types of lightweight concrete by their method of production. There are by using porous lightweight aggregate of low apparent specific gravity such as lower than 2.6. This type of concrete is known as lightweight aggregate concrete. Besides that, by introducing large voids within the concrete or mortar mass. These voids should be clearly distinguished from extremely fine voids produced by air entrainment. This type of concrete is variously known as aerated, cellular, foamed or gas concrete.

Other than that, the classification of lightweight concrete is by omitting the fine aggregate from the mix so that a large number of interstitial voids is present. Normal weight coarse aggregate is generally used. These concrete as no fines concrete. Lightweight concrete can also be classified according to the purpose for which it is to be used. It can distinguish between structural lightweight concrete (ASTM C 330-82a), concrete used on masonry units (ASTM C 338-81), and insulating concrete (ASTM C 332-83). Gopal, (2011) state that the density of such concrete that determined in dry state should be not exceed 1840kg/m3, and is usually between 1400 and 1800 kg/m3. On the other hand, masonry concrete generally has density between 500 and 800 kg/m3 and a strength between 7 and 14 MPa.

2.3.2 Types of Lightweight Concrete

Lightweight concrete can be prepared either by injecting air in its composition or it can be achieved by omitting the finer sizes of the aggregate or even replacing them by a hollow, cellular or porous aggregate. Particularly, lightweight concrete can be categorized into three groups. There are lightweight aggregate concrete, aerated concrete and no fines concrete.

2.3.2.1 Lightweight Aggregate Concrete

In the early of 1950s, the use of lightweight concrete blocks was accepted in the UK for load bearing inner leaf of cavity walls. There are several types of lightweight aggregates that suitable for structural reinforced concrete such as pumice, foamed slag, expanded clays and shales, and sintered pulverised (fuel ash aggregate).

2.3.2.2 Aerated Concrete

Aerated concrete has the lowest density, thermal conductivity and strength. Like timber it can be sawn, screwed and nailed, but there are non-combustible. For works in-situ the usual methods of aeration are by mixing in stabilized foam or by whipping air in with the aid of an air entraining agent. The precast products are usually made by the addition of about 0.2% aluminium powder to the mix which reacts with alkaline substances in the binder foaming hydrogen bubbles.

Aerated concrete is a lightweight, cellular material consisting of cement and/or lime and sand or other siliceous material. It is made by either a physical or chemical process during which generally contains no coarse material. Aerated concrete used as a structural material is usually high-pressure steam cured. It is thus factory made and available to the user in precast only, for floors, walls and roofs. Block for laying in mortar or glue are manufactured without any reinforcement.

2.3.2.3 No Fines Concrete

The term no fines concrete generally means concrete composed of cement and a coarse (9-19mm) aggregate only (at least 95% should pass the 20mm BS sieve size), and the product so foamed has many uniformly distributed voids throughout its mass. No-fines concrete is mainly used for load bearing, cast in situ external and internal wall, non-load bearing wall and under floor filling for solid ground floors (CP III: 1970, BSI). No-fines concrete was introduced into the UK in 1923, when 50 houses were built in Edinburgh, followed a few years later by 800 in Liverpool, Manchester and London.

No-fines concrete is thus an agglomeration of coarse aggregate particles, each surrounded by a coating of cement paste up to about 1·3 mm (0·05 in.) thick. There exist, therefore, large pores within the body of the concrete which are responsible for its low strength, but their large size means that no capillary movement of water can take place. Although the strength of no-fines concrete is considerably lower than that of normal-weight concrete, this strength, coupled with the lower dead load of the structure, is sufficient in buildings up to about 20 storeys high and in many other applications.

2.3.3 Types of Lightweight Concrete Based on Density and Strength

Lightweight concrete can be classified as low density concrete, moderate strength concrete and structural concrete.

2.3.3.1 Low Density Concrete

These are employing chiefly for insulation purposes. With low unit weight, seldom exceeding 800 kg/m^3, heat insulation value are high. Compressive strength are low, regarding from about 0.69 to 6.89 N/mm2.

2.3.3.2 Moderate Density Concrete

The use of these concrete requires a fair degree of compressive strength, and thus they fall about midway between the structural and low density concrete. These are sometimes designed as 'fill' concrete. Compressive strength are approximately 6.89 to 17.24 N/mm² and insulation values are intermediate.

2.3.3.3 Structural Concrete

Concrete with full structural efficiency contain aggregates which fall on the other end of the scale and which are generally made with expanded shale, clay, slates, slag, and fly-ash. Minimum compressive strength is 17.24 N/mm². Most structural lightweight concrete are capable of producing concrete with compressive strength in excess of 34.47 N/mm². Since the unit weight of structural LWC are considerably greater than those of low density concrete, insulation efficiency is lower. However, thermal insulation values for structural LWC are substantially better than NWC.

2.3.4 Uses of Lightweight Concrete

The uses of lightweight concrete are:

i) Screeds and thickening for general purposes especially when such screeds or thickening and weight to floors roofs and other structural members.

ii) Screeds and walls where timber has to be attached by nailing.

iii) Casting structural steel to protect it against fire and corrosion or as a covering for architectural purposes.

iv) Heat insulation on roofs and insulating water pipes.

v) Construction of partition walls and panel walls in frame structures.

vi) Fixing bricks to receive nails from joinery, principally in domestic or domestic type construction.

vii) General insulation of walls.

viii) Surface rendered for external walls of small houses.

ix) Used for reinforced concrete.

2.3.5 Advantage of Lightweight Concrete

The advantages of lightweight concrete are:

i) Reduced dead load of wet concrete allows longer span to be poured un-propped. This save both labour and circle time for each floor.

ii) Reduction of dead load, faster building rates and lower haulage and handling costs. The eight of the building in term of the loads transmitted by the foundations is an important factor in design, particular for the case of tall buildings.

iii) The use of LWC has sometimes made it possible to proceed with the design which otherwise would have been abandoned because of excessive weight. In frame structures, considerable savings in cost can be brought about by using LWC for the construction floors, partition and external cladding.

iv) Most building materials such as clay bricks the haulage load is limited not by volume but by weight. With suitable design containers much larger volumes of LWC can haul economically.

v) A less obvious but nonetheless important characteristics of LWC is its relatively low thermal conductivity, a property which improves with decreasing density in recent years, with the increasing cost and scarcity of energy sources, more attention has been given the formerly to the need for reducing fuel consumption while maintaining, and indeed improving, comfort conditions buildings. The point is illustrated by fact that a 125 mm thick solid wall of aerated concrete will give thermal insulation about four times greater than that of a 230 mm clay brick wall.

2.3.6 Durability of Lightweight Concrete

Durability is defined as the ability of a material to withstand the effect of its environment. In a building material as chemical attack, physical stress, and mechanical assault. Chemical attack is as aggregate ground-water particularly sulphate, polluted air, and spillage of reactive liquids LWC has no special resistant to these agencies: indeed, it is generally move porous than the ordinary Portland cement. It is not recommended for use below damp-course. A chemical aspects of durability is the stability of the material itself, particularly at the presence of moisture.

Physical stresses to which LWC is exposed are principally frost action and shrinkage and temperature stresses. Stressing may be due to the drying shrinkage of the concrete or to differential thermal movements between dissimilar materials or to other phenomena of a similar nature. Drying shrinkage commonly causes cracking of LWC if suitable precautions are not taken. Mechanical damage can result from abrasion or impact excessive loading of flexural members. The lightest grades of LWC are relatively soft so that they subject to some abrasion were they not for other reasons protected by rendering.

2.4 Foam Concrete

Ding Y et al. stated that foam concrete is a lightweight material, in which pore structure created by introducing foaming agent through mechanical means. Foam concrete is a highly aerated mortar because it mostly no coarse aggregate is used for it production. A foamed concrete is described as having an air content of more than 25% which distinguishes it from highly air entrained materials. Foam concrete typically consists of a slurry of cement, sand and water with the foaming agent. This action incorporates small enclosed air bubbles within the mortar there by making concrete lighter.

Foam concrete is a lightweight concrete which is lighter than conventional concrete. The production of stable foam concrete mix depends on many factors such as selecting of foaming agent, material section and mixture design strategies and production of foam concrete. According to the draft International Standard Model Code for Concrete Construction (1977), has classified lightweight concrete having a density of between 1200 kg/m^3 to 2000 kg/m^3. However, the use of foam in lightweight concrete makes lightweight concrete can be provided with a density as low as 300 kg/m^3. Generally, ordinary concrete is provided with a density of 2240 kg/m^3 to 2400 kg/m^3.

The stable of foam is the most important gradient in the production of foamed concrete. The foaming generator made foam, where is blend of sand, cement, water and foaming agent either protein or synthetic are mixed and produced stable foam is foamed. According to a study by Norasykin (2009) state that foams from protein foaming agent comes from natural sources and has a weight of around 80g/litre and expansion of about 12.5 times using port form foam generator. It also give a higher strength of concrete compared to synthetic foams. This is suitable for densities from 400 kg/m^3 to 1600 kg/m^3.

Figure 2.1 Foamed Concrete

Figure 2.1 are formed concrete with density 1600kg/m^3. Mydin et al (2011) has stated that foamed concrete is a lightweight material with low densities of between (400-1800) kg/m^3 incorporating a high volume of air, highly workable, self-flowing, self-compacting and self-levelling with fire resisting, thermal insulating and sound proofing properties.

According to research by Aswathy (2017) was stated that foam concrete have an easy handling and low workmanship. It helps in reduction of dead load that will increase the progress of building, and lower transport and handling cost. Therefore foam concrete block is environmentally better than the other ordinary concrete blocks.

2.4.1 History of Foam Concrete

The history of foam concrete dates back to the early 1920s and the production of autoclaved aerated concrete, which was used mainly as insulation. A detailed study concerning the composition, physical properties and production of foamed concrete was first carried out in the 1950s and 60s. Following this research, new admixtures were developed in the late 1970s and early 80s, which led to the commercial use of foamed concrete in construction projects. Initially, it was used in the Netherlands for filling voids and for ground stabilisation. Further research carried out in the Netherlands helped bring about the more widespread use of foam concrete as a building material.

2.4.2 Type of Foam Concrete

According to a study by Norasyikin (2009) state that foam concrete have two types. There are wet foam and dry foam.

2.4.2.1 Wet Foam

Wet foam is produced by spraying a solution of foaming agent (usually synthetic) and water over a fine mesh. This action causes a drop in pressure across the mesh allowing air to be sucked from atmosphere to equal the pressure. This equalization of pressure causes the solution to expand into what can best be described as a foamed similar in appearance to bubble bath foam. The foam has a large loose bubble structure and although relatively stable it is not recommended for the production of low density (below 1100kg/m^3) foamed materials. It is also not suitable for pumping long distance or pouring to any great depth.

2.4.2.2 Dry Foam

Dry foam is produced by forcing a similar solution of foaming agent and water through a series of high density restrictions whilst at the same time forcing compressed air into a mixing chamber. The action of forcing this pressurized air into the solution expands the solution into thick, tight foam, similar in appearance to shaving foam. The bubble size is typically less than 1mm in diameter and of an even size. The type of foam is extremely stable and these stable properties are passed onto the foamed materials when the foam is blended with the base materials.

2.4.3 Properties of Foam Concrete

Foam concrete is a versatile building material with a simple production method that is relatively inexpensive compared to autoclave aerated concrete. Lighter density products may be cut into different sizes. While the product is considered a form of concrete (with air bubbles replacing aggregate), its high thermal and acoustical insulating qualities make it a very different application than conventional concrete. There are a few properties of foamed concrete.

2.4.3.1 Air Void

The pore structure of cementitious material, predetermined by its porosity, permeability and pore size distribution, is a very important characteristic as it influence the properties of the material such as strength and durability. The pore parameter could therefore be a primary factor influencing the material properties of foam concrete and an in depth look into this aspect is required to establish relationships between this and material properties.

According to the research by Wee et al., (2011), the air-void size and frequency, and hence spacing factor, of the foamed concrete varied with different w/c ratios and air contents, which in turn affected the mechanical properties of the concrete. For the different w/c ratios and air contents adopted, it was found that an air-void system with a spacing factor of about 0.05 mm, air-void size of 0.15 mm and air content of 40% was optimal in terms of achieving a high strength to weight ratio.

The compressive strength of foamed concrete seems to be influenced by the spacing factor, w/c ratio and air content in relation to density. The results also indicated that the inclusion of air-voids in foamed concrete had a greater effect on compressive strength than the modulus of elasticity and it increases with increase of w/c ratio. Wet foam is produced by spraying a solution of foaming agent (usually synthetic) and water over a fine mesh.

2.4.3.2 Density

The properties of foamed concrete are critically dependent upon the quality of the foam concrete. Measurements of foam density should be taken as a matter of routine because density can vary according to the volume of the surfactant solution in the containment vessel and also with the time of storage. Furthermore the level of expansion of the surfactant solution to foam varies according to the type and details of the equipment, such as the type of the foaming gun, and with the valve settings controlling the flow and feed pressure of the surfactant and air. The density of a foam can be determined, quite simply, through weighing a known volume of foam.

2.4.3.3 Water Absorption and Porosity

The study had shown that 5 % and 10 % eggshell powder as partial cement replacement has lower water absorption than control concrete whereas further increased replacement shows same water absorption with control concrete 14 (Yerramala, 2014). Furthermore, it also observed that the water absorption increases with increased porosity as shown in Figure 2.2 (Yerramala, 2014).

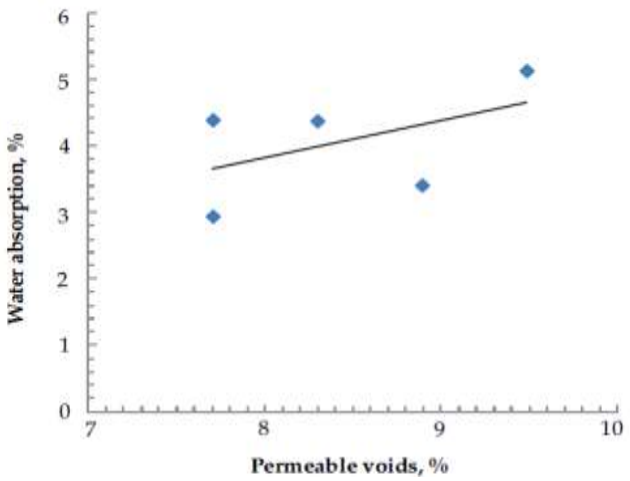

Figure 2.2 Relationship between Water Absorption and Porosity

Source:Yerramala, (2014).

2.4.3.4 Stability

The stability of foam concrete is the consistency at which the density ratio is nearly one (the measured fresh density/design density), without any segregation and bleeding. This ratio is higher than unity at both lower and higher consistencies due to either stiffer mix or segregation. The stability of test mixes can also be assessed by comparing the calculated and actual quantities of foam required to achieve a plastic density within 50 kg/m3 of the design value and calculated and actual w/c ratios. The additional free water contents resulting from the foam collapse corresponded to an increase in actual w/c ratio. Thus the consistency of the base mix to which foam is added is an important factor, which affects the stability of mix. This consistency reduces considerably when foam is added and depends on the filler type also as stated by (Ramamurthy, 2009).

Hence there is a need for determining the water–solids ratio, which would satisfy both stability and consistence of the mix. Regression equations based on the experimental results, for predicting the spread flow value of foam concrete, knowing the proportion of the other ingredients, will help in arriving at this water content for the production of a stable and workable foam concrete mix. For typical materials used, an appropriate workability value has been arrived at as 45% of spread at which a foam concrete mix of good stability and consistency can be produced.

2.4.3.5 Compressive Strength

The compressive strength of concrete depends on the water to cement ratio, degree of compaction, ration of cement to aggregate, bond between mortar and aggregate, and grading, shape, strength and size of the aggregate that was stated in research by Rocco and Elices (2009). The compressive strength decreases exponentially with a reduction in density of foam concrete. The specimen size and shape, the method of pore formation, direction of loading, age, water content, characteristics of ingredients used and the method of curing are reported to influence the strength of cellular concrete in total.

Compressive strength can be measured at 28 and/or 56 days essentially in accordance with BS 1881: Part 116:1983. But, because the strength of foamed concrete is relatively low, 150 mm cubes might be required to ensure reasonably accurate measurements. Disposable polystyrene moulds are widely used for foamed concrete: these can be supplied with lids so that a specimen can be left in the mould until immediately prior to testing. Steel moulds can be used but they should be lined with a non-stick plastic film. Mould release oil should not be allowed to come into contact with the foamed concrete because it can affect the properties of the concrete.

Other parameters affecting the strength of foam concrete are cement–sand and water-cement ratios, curing regime, type and particle size distribution of sand and type of foaming agent used. For dry density of foam concrete between 500 and 1000 kg/m3, the compressive strength decreases with an increase in void diameter. For densities higher than 1000 kg/m3, as the air-voids are far apart to have an influence on the compressive strength, the composition of the paste determines the compressive strength. It has been reported that small changes in the water–cement ratio does not affect the strength of foam concrete as in the case of normal weight concrete.

At higher water–cement ratios (within the consistency and stability limit) was increase in strength is observed with an increase in water–cement ratio, just opposite to the trend usually noted for conventional concrete/mortar where the entrapped air content is only a few percentage by volume. It has been concluded by Ramamurthy et al. (2009), that the strength of moist-cured foam concrete depends on water–cement ratio and air–cement ratio and the combined effect should be considered when volumetric composition of air-voids approaches that of water voids.

2.4.3.6 Resistance to Aggressive Environment

Foam concrete mixture designed at low density taking into consideration of depth of initial penetration, absorption and absorption rate, provided good freeze-thaw resistance. Sulphate resistance of foam concrete, that was stated by studied by Ramamurthy et al. (2009), reveals that foam concrete has good resistance to aggressive chemical attack. Comparing the performance of mixes with sand and fly ash, mixes with fly ash exhibited higher carbonation than that with sand. An accelerated chloride ingress tests suggested that foam concrete performance is equivalent to that of normal concrete, with enhanced corrosion resistance at lower density. The cell-like structure of foam concrete and possible porosity of cell wall do not necessarily make the foam concrete less resistant to penetration of moisture than dense concrete; the air-voids appears to act as a buffer preventing rapid penetration.

2.4.3.7 Workability

According to McGovern (2000), for most applications the slump of the base mix should be between about 75 and 100 ram. The workability of the base mix could be assessed using a test developed for low-strength materials. As described by Brewer (1996), workability can be quantified by the 'spread ability' of a 76.2 mm (3 inch) diameter, 152.4 mm (6 inch) long cylinder of material. This could also be used to assess the workability of the foamed concrete mix. Workability or 'flow ability' can be also assessed from the efflux time of a litre sample through a modified Marsh cone

2.4.3.8 Segregation

Segregation of foamed concrete in the fresh state can be detected through foam rising to the surface of the mix (noticeable in a ready-mix truck or in recently poured concrete), or by the formation of a separate paste/sand mortar at the bottom of the mixer (noticeable when mixing). Segregation can be quantified through differences in the density of cores of hardened concrete taken from various depths, or, as proposed by Dhir et. al (1999), by comparison of the oven-dry densities of 100 mm diameter, 25 mm thick slices obtained from the top and bottom of a core.

2.4.3.9 Soundness

The 'soundness' or 'hardness' of the surface of foamed concrete can be used to assess whether it has developed sufficient strength to allow additional lifts to be poured, or further site works to commence. The screed tester developed by the Building Research Establishment (BRE), and as shown in Figure 8, can be used to assess the 'soundness' of a surface. The rig comprises a weight that slides along a bar and which is allowed to fall freely onto an expansion ring connected to a 6 mm diameter pin. In testing foamed concrete the penetration of a single drop of the weight should be measured (multiple drops are normally used with other materials).

2.4.4 Advantage of Lightweight Foam Concrete

In recent years, more attention has been paid to the development of lightweight aggregate concrete. Lightweight concrete reduces building costs, eases construction and has the advantage of being relatively “green” building material (Lo et al., 2007).

Lightweight concrete can be used in structural frames, but it proves to be more suitable for wall system structures, where the local ductility demand (in seismic zones) and the required strength of the materials are reduced and the dead load to live load ratio was very high. As stated by Hamad, (2014), according to the lightweight concrete is very advantageous as it has higher strength-weight ratio, better tensile strain carrying capacity, lower coefficient of thermal expansion, and better heat and sound insulation characteristics due to air voids present in the concrete. By using Autoclaved Aerated Concrete (AAC) we can get reduction in the dead load of the construction materials which could result in a decrease in cross-section of concrete structural and Subsequently, reinforcement can be reduce due to the lightweight of the concrete.

2.4.4.1 Thermal Insulation

Foamed concrete with a density of 1200kg/m^3, for instance, can produce a monolithic wall five times thinner, requires ten times raw material(by weight) and possesses five times more superior thermal insulation properties compared to that of conventional concrete. The amplitude-ratio and phase-displacement of a 15cm thick wall with a density of 1100kg/m^3 causes the outside temperature of a building to take between 10-12 hours to reach the inside. Such a duration, which is much longer than that of conventional concrete wall, results in a more energy-efficient enclosure.

2.4.4.2 Sound Insulation or Acoustical Properties

Sound insulation is a kind of measure to prevent the sound waves from permeating. It is demonstrated by the sound transmission loss which is expressed by the difference of decibels between the incident sound and permeated sound. The higher the numeral is, the better the sound insulating property is. According to the way of transmittance, the sound that people would like to insulate can be divided into air-borne sound (due to the vibration of the air) and solid-borne sound (due to the impact on solids or solid vibration). The sound permeation complies with the “mass law” in acoustics.

The sound insulation property of wall or plate depends on its mass area ratio. The greater the mass is, the harder it is to vibrate this material, thus the better the insulating property will be. Therefore, it is better to choose dense and heavy material (clay brick, reinforced concrete, steel plate) as sound insulating material. The best way to insulate the solid-borne sound is to use the unconnected structure. That means to fill in elastic liner between wall and spandrel girder, as well as between the frame of the building and the wallboard. The elastic liner can be chosen from felt, cork, rubber, and elastic carpet.

The sound insulation effect of polymer foams comes into play in the following two ways that are the porous body absorbs sound wave energy to terminate the reflection and transferal of the sound waves and the porous body eliminates resonance and decreases noise. When the sound wave arrives at the cell wall of a pore in polymer foams, it will strike the pore and make the gas within it to be compressed. This causes hesitation, so the impact energy of the sound wave will dissipate. In addition, increasing the rigidity of the polymer foams can eliminate or decrease the resonance and noise caused by the sound wave hitting the pores.

2.4.4.3 Fire Resistance

Aerated concrete is a non-combustible, fire-resistant material, has the first class of fire-resistance, which exceeds the one of ordinary concrete. Foam concrete is extremely fire resistant and well suited to applications where fire is a risk. According to other research test have shown that in addition to prolonged fire protection, the application of intense heat, such as a high energy flame held close to the surface, does not because the concrete to spall or explode as is the case with normal dense weight concrete.

2.4.4.4 Saving in Construction Material

The low cost of materials, as well as the large dimensions of blocks which have less weight ensure construction cost reduction. Foam concrete is an economically viable solution particularly in large volume application. Its use can also have an effect on other aspects of construction.

2.4.4.5 Ease of Removal

Foam concrete can be design for specific strengths to allow the future removal for maintenance of utilities or excavations. Sometimes excavations of cement lime sand mortar (CLSM) or other flow able fill material can be susceptible to unpredictable gains in strength due to delivery and production methods. Foam concrete is produced on site to exact requirements, can be easily excavated with common construction equipment.

2.4.4.6 Time Saving

The application of Foam Concrete can be a great time saver over conventional ground treatment method for settlement free construction.

i) No waiting period for consolidation of subsoil and reduce or eliminate the need of pilling

ii) Minimal amount of soil removed to be placed with foam concrete and can be applied directly on existing marginal ground

iii) Deeper placement of lifts, due to reduced lateral loading and no compaction steps

iv) Eliminate the need to correct completed construction which has settled

2.4.4.7 High Durability

Foam concrete, which differs from mineral wool and various materials such as foam plastic, improves the thermal insulation and mechanical characteristics inherent in it over time. This is due to his prolonged internal maturation. The production of modern building materials is not necessarily a large production hall, high pipes and clouds of contaminants. And the equipment for this production, too, need not necessarily be produced by the giants of the machine-building industry. The scarcity of staff and the almost complete absence of overheads make the cost of our equipment 30-40% lower than the cost of similar facilities for foam concrete sold on the market of construction equipment today. The number of parts and automation equipment is minimized, therefore in the installation there are no nodes that create the danger of any frequent breakdown.

2.4.4.8 High Strength with Low Density

Typical cast densities range from 350-1600kg/m^3, with compressive strength of 0.2 to 12+ MPa respectively. With its low density. Foam concrete imposes little vertical stress on the substructure, a particularly important issue in areas sensitive to settlement. Due to its low density, foam concrete is a viable solution for reducing loading on burden soil. Additionally, foam concrete is less susceptible to differential settlement. Heavier density foam concrete with higher strengths is produced and used for speciality applications.

2.5 Dolomite

Rocks can be defined as natural aggregates consisting of one or more minerals. Research on rocks or known as Petrographic science means the study and scientific interpretation of genesis, evolution and thermodynamic study of the process of forming a type of rock. The rock is a term given by the people of Perlis to name a kind of brightly coloured rock. This rock is believed to be abundant around Chuping area, Perlis. This rock is widely used to create a base layer road before paved with tar. For example, the

Limestone Forest Cooperative Quarry supplying 80% of its rocks to use for the construction of the Kuala Perlis-Changlun.

Initial statistics show that the state of Perlis has a limestone deposit a lot of 540 million tons compared to Selangor which is more than 530 million tons. According to collection of rock material extraction reports from the source of the State Department of Land and Mines of Perlis, the quantity of limestone produced in the state of Perlis exceeds 1 million tonnes of matrix per year. However, limestone around Mata Ayer is suitable for use cement industry while limestone found in Kubang Tiga, Chuping is found contains high Magnesium Oxide content which is not suitable for cement industry. The limestone of this type is known as rock decomposed by local communities.

Decomposed rocks are defined as sedimentary rocks that result from deposition processes a river or sea that takes millions of years. It has more than 20 percentage of mineral content of Magnesium Oxide. There are six quarries involved in the production of deciduous rock in Perlis state of Kuari Felda Rimba Mas Cooperative, Indera Consortium Quarry, Quarry Salleh bin Hassan, Quarry

Integrated Company, Kuari Kesuma Abadi Sdn. Bhd. and the Farmers Organization Quarantine. However, the biggest production of rock decay in Perlis is from Quarry Felda Rimba Mas Cooperative and Indera Consortium Quarry. Detection of rock decomposed using imaging scanning electron microscopy showcase and clarify the shape of crystal and phase-phase mineral distribution with more precise. X-rays are used to calculate the elemental content and its concentration and translated into an image with the colour segmentation method of the image concerned according to the delegated element.

2.5.1 Physical Properties of Dolomite

The physical properties of dolomite that are useful for identification are presented in the table on this page. Dolomite has three directions of perfect cleavage. This may not be evident when the dolomite is fine-grained. However, when it is coarsely crystalline the cleavage angles can easily be observed with a hand lens. Dolomite has a Mohs hardness of 3 1/2 to 4 and is sometimes found in rhombohedral crystals with curved faces. Dolomite produces a very weak reaction to cold, dilute hydrochloric acid; however, if the acid is warm or if the dolomite is powdered, a much stronger acid reaction will be observed. (Powdered dolomite can easily be produced by scratching it on a streak plate.)

Dolomite is very similar to the mineral calcite. Calcite is composed of calcium carbonate ($CaCO_3$), while dolomite is a calcium magnesium carbonate ($CaMg(CO_3)_2$). These two minerals are one of the most common pairs to present a mineral identification challenge in the field or classroom. Dolomite ($CaMg(CO_3)_2$) is a common sedimentary rock forming mineral. It can be found in ancient rocks as massive layers. It is an end-member mineral consisting of alternate layers of calcite $CaCO_3$ and magnesite $MgCO_3$. Divalent Fe can replace Mg++ in dolomite to form solid solutions toward anchorite ($CaFe(CO_3)_2$).

Other dolomites include those bearing manganese, zinc, lead, strontium as well as cobalt and nickel. These minerals have attracted considerable attention on account of their interesting thermodynamic properties and because they possess potentially important environmental functions. Dolomite is used to produce magnesia (MgO), the most important product of the magnesium compound industry as state in research by Hossain, (2011).

Dolomite may be used as a raw material to make an MgO based expansive agent to compensate for the shrinkage of cement and concrete. Dolomite is effective also as a parent-sorbent for high temperature CO_2 capture. It has many other applications such as a functional construction material and as a source of magnesium for the glass and ceramics manufacturing industries.

The best way to tell these minerals apart is to consider their hardness and acid reaction. Calcite has a hardness of 3, while dolomite is slightly harder at 3 1/2 to 4. Calcite is also strongly reactive with cold hydrochloric acid, while dolomite will effervesce weakly with cold hydrochloric acid. Table 2.1 is a physical properties of dolomite with their specification.

Table 2.1 Physical Properties of Dolomite

Characteristics	Specification
Chemical Classification	Carbonate
Colour	Colourless, white, pink, green, grey, brown, black
Streak	White
Luster	Vitreous, pearly
Diaphaneity	Transparent to translucent
Cleavage	Perfect, rhombohedral, three directions
Mohs Hardness	3.5 to 4
Specific Gravity	2.8 to 2.9
Diagnostic Properties	Rhombohedral cleavage, powdered form effervesces weakly in dilute HCl, hardness
Chemical Composition	$CaMg(CO_3)_2$
Crystal System	Hexagonal
Uses	Construction aggregate, cement manufacture, dimension stone, calcined to produce lime, sometimes an oil and gas reservoir, a source of magnesia for the chemical industry, agricultural soil treatments, metallurgical flux

Source: Hobart (2015-2019)

2.5.2 Chemical Composition of Dolomite

Ferrous iron commonly substitutes for some of the magnesium in dolomite, and a complete series very likely extends between dolomite and ankerite $CaFe(CO_3)_2$. Manganese also substitutes for magnesium, but typically only to the extent of a few percent and in most cases only along with iron. Other cations known to substitute albeit in only relatively minor amounts within the dolomite structure are barium and lead for calcium and zinc and cobalt for magnesium.

Dolomite effervesces with dilute hydrochloric acid, but slowly rather than vigorously as calcite does; in general, it appears to smoulder slowly, and in some cases it does so only after the rock has been powdered or the acid warmed, or both. This difference in the character of the effervescence serves as the test usually used to distinguish dolomite from calcite in the field. In the laboratory, staining techniques, also based on chemical properties or typical compositions, may be used to distinguish between these minerals. The stains generally employed are especially valuable for investigating rocks made up of alternate lamellae of dolomite and limestone composition. Table 2.2 is a chemical composition of dolomite.

Table 2.2 Chemical Properties of Dolomite

Source Element (%)	Northern Dolomite Sdn. Bhd	Ferlab Sdn. Bhd.	Perlis Dolomite	Ipoh Dolomite	Perlis Dolomite Industries	Geoscience Meneral Department
CaO	32 – 35	31 – 38	31.5	30.0	30.6	32.3
MgO	19 – 23	15 – 18	23.7	21.0	21.3	20.1
Fe_2O_3	< 0.01	< 0.1	0.06	0.46	0.04	0.04
SiO_2	0.01	< 0.2	0.08	0.42	0.10	-
Al_2O_3	0.01	-	0.08	0.28	-	-
LOI	-	-	4.62	48.0	-	48.4
$CaCO_3$	-	-	-	-	54.6	57.6
$MgCO_3$	-	-	-	-	44.5	42.0

2.5.2.1 Cristal Structure

In a somewhat simplified way, the dolomite structure can be described as resembling the calcite structure but with magnesium ions substituted for calcium ions in every other cation layer. Thus, the dolomite structure can be viewed as ideally comprising a calcium layer, a CO3 layer, a magnesium layer, another CO3 layer, and so forth. However, as described for the potassium feldspars, dolomites unlike calcites may also exhibit order-disorder relationships. This results because the purity of some of the cation layers may be less than ideal such as some of the “calcium layers” may contain magnesium, and some of the “magnesium layers” may contain some calcium. The term protodolomite is frequently applied to Holocene dolomites (those formed during approximately the last 11,700 years) that have less than ideal dolomite structures. Most dolomites of ancient dolostones, however, appear to be well ordered. Modifications that may reflect diverse calcium-versus-magnesium layering aberrations are treated extensively in professional literature.

2.5.3 Uses of Dolomite

Dolomite as a mineral has very few uses. However, dolomite has an enormous number of uses because it occurs in deposits that are large enough to mine. The most common use for dolomite is in the construction industry. It is crushed and sized for use as a road base material, an aggregate in concrete and asphalt, railroad ballast, rip-rap, or fill. It is also calcined in the production of cement and cut into blocks of specific size known as "dimension stone."

Dolomite's reaction with acid also makes it useful. It is used for acid neutralization in the chemical industry, in stream restoration projects, and as a soil conditioner. Dolomite is used as a source of magnesia (MgO), a feed additive for livestock, a sintering agent and flux in metal processing, and as an ingredient in the production of glass, bricks, and ceramics.

Dolomite serves as the host rock for many lead, zinc, and copper deposits. These deposits form when hot, acidic hydrothermal solutions move upward from depth through a fracture system that encounters a dolomitic rock unit. These solutions react with the dolomite, which causes a drop in pH that triggers the precipitation of metals from solution.

Dolomite also serves as an oil and gas reservoir rock. During the conversion of calcite to dolomite, a volume reduction occurs. This can produce pore spaces in the rock that can be filled with oil or natural gas that migrate in as they are released from other rock units. This makes the dolomite a reservoir rock and a target of oil and gas drilling.

2.6 Silica Sand

Silica is the name given to a group of minerals composed of silicon and oxygen, the two most abundant elements in the earth's crust. Silica is found commonly in the crystalline state and rarely in an amorphous state. It is composed of one atom of silicon and two atoms of oxygen resulting in the chemical formula SiO2.Sand consists of small grains or particles of mineral and rock fragments.

Although these grains may be of any mineral composition, the dominant component of sand is the mineral quartz, which is composed of silica (silicon dioxide). Other components may include aluminium, feldspar and iron-bearing minerals. Sand with particularly high silica levels that is used for purposes other than construction is referred to as silica sand or industrial sand.

For a particular source of sand to be suitable for glassmaking, it must not only contain a very high proportion of silica but also should not contain more than strictly limited amounts of certain metallic elements. Silica sand is also normally required to be well-sorted, to have grains of an approximately uniform size. Most sources of sand used by the construction industry do not satisfy these requirements and are not, therefore, suitable for glassmaking.

Industrial uses of silica sand depend on its purity and physical characteristics. Some of the more important physical properties are: grain size and distribution, grain shape, grain strength and refractoriness. Industrial sand is a term normally applied to high purity silica sand products with closely controlled sizing. It is a more precise product than common concrete and asphalt gravels. Silica is the name given to a group of minerals composed solely of silicon and oxygen, the two most abundant elements in the earth’s crust. In spite of its simple chemical formula, SiO2, silica exists in many different shapes and crystalline structures. Found most commonly in the crystalline state, it also occurs in an amorphous form resulting from weathering or plankton fossilization.

For industrial and manufacturing applications, deposits of silica yielding products of at least 95% SiO2 are preferred. Silica is hard, chemically inert and has a high melting point, attributable to the strength of the bonds between the atoms. These are prized qualities in applications like foundries and filtration systems. Quartz may be transparent to translucent and has a vitreous lustre, hence its use in glassmaking and ceramics. Industrial sand’s strength, silicon dioxide contribution and non-reactive properties make it an indispensable ingredient in the production of thousands of everyday products.

Some silica sand deposits may cater for the used primarily as metallurgical sand. The copper and zinc at some smelter uses the sand as a fluxing agent which, in the molten state, reacts with various impurities in the ore and produces a slag. The slag is drawn off with the impurities, leaving a more refined metal behind. Silica sands have a large number of other industrial uses depending on their characteristics. There are production of glass, foundry sand, ceramics, sandblasting and other abrasives, building products, water filtration, filler and extender, production of silicon and silicon carbide, pigments, hydraulic fracturing and propping in the oil industry, ultra-high silica products in the electronic and fibre optic industries, fused silica and silicone product.

2.7 Ordinary Portland Cement (OPC)

Ordinary Portland Cement (OPC) is the most common cement used in general concrete construction when there is no exposure to sulphates in the soil or groundwater. OPC manufactured by Lafarge Malaysia exceeds the quality requirements specified in the Malaysian Standard MS 522: Part 1: 1989 Specifications for Ordinary Portland Cement. Our OPC is manufactured under an effective system of testing, control and monitoring, conforming to requirements under SIRIM's product Certification License.

2.7.1 History

Portland cement was developed from natural cements made in Britain beginning in the middle of the 18th century. Its name is derived from its similarity to Portland stone, a type of building stone quarried on the Isle of Portland in Dorset, England. The development of modern Portland cement (sometimes called ordinary or normal Portland cement) began in 1756, when John Smeaton experimented with combinations of different limestones and additives, including trass and pozzolanic ash, relating to the planned construction of a lighthouse, now known as Smeaton's Tower.

In the late 18th century, Roman cement was developed and patented in 1796 by James Parker. Roman cement quickly became popular, but was largely replaced by Portland cement in the 1850s. In 1811, James Frost produced a cement he called British cement. James Frost is reported to have erected a manufactory for making of an artificial cement in 1826. In 1811 Edgar Dobbs of Southwark patented a cement of the kind invented 7 years later by the French engineer Louis Vicat. Vicat's cement is an artificial hydraulic lime, and is considered the 'principal forerunner' of Portland cement.

2.7.2 Manufacture

The raw materials required for the manufacture of OPC are calcareous material such as limestone or chalk and argillaceous materials such as shale or clay. A mixture of these materials is burnt at a high temperature of approximately 1400 0C in a rotary kiln to form clinker. The clinker is then cooled and grounded with a requisite amount of gypsum into fine powder known as Portland cement. OPC is a grey coloured powder. It is capable of bonding mineral fragments into a compact whole when mixed with water.

This hydration process results in a progressive stiffening, hardening and strength development.

2.7.3 Chemical Composition of Portland Cement

Generally, the actual chemical compositions and proportions of Portland cement are varying due to different manufacturers. A general composition of Portland cement is shown in Table 2.3, which indicates the oxide composition limits of Portland cements.

Table 2.3 General Composition Limits of Portland Cement

Oxide	Content %
CaO	60 – 77
SiO_2	17 – 25
Al_2O_3	3 – 8
Fe_2O_3	0.5 – 6.0
MgO	0.5 – 4.0
Na_2O	0.3 – 1.2
SO_3	2.0 – 3.5

Source: Neville (2010).

2.7.4 Compound Composition of Portland Cement

Generally, four major raw materials used in manufacturing Portland cement mainly are lime, silica, alumina and iron oxide, which usually regarded as major constituents of cement.

2.8 Foaming Agent

According to Nambiar and Ramamurthy (2007), the introduction of pores inside lightweight foamed concrete can be achieved mechanically either by pre-foaming method (produce the foam before adding it to the mix) or mix foaming method (mixing in a foaming agent). In mixed foaming, base mix with low water content is too dry, causing the burst out of the bubble in foamed concrete and hence affect the density and strength of the lightweight foamed concrete (Ramamurthy et al., 2009).

Furthermore, Ramamurthy et al. (2009), mentioned that the importance of air-void influencing the strength of foamed concrete and concluded that foamed concrete with a narrower air-void size distribution shows higher strength. Prior to produce of foamed concrete, stable foam with density of 45 kg/m3 is produced by using dry pre-foaming method. The foam must be stable in order to resists the pressure of the mortar and hold until a strong skeleton of concrete is built up around the void filled with air.

2.9 Water

Water is an important raw material for mixing concrete. It gives an important role in cement hydration process which helps the production of C-S-H gel. Water is the most abundant fluid in nature which exists in various states. Regardless of its significant role, the water is an agent of deterioration which permeates concrete (Mehta et. al 2014).

Water molecules are very small which enable it to penetrate into very fine pores and cavities. Furthermore, water is possessed of the highest heat of vaporization among the common fluids. At ambient temperature, water tends to exist in liquid state in a porous material rather than vaporizing and leaving the material dry. The internal movement of moisture and structural transformation of water within porous solids are known to inflict disruptive volume changes.

For instance, the mechanism of water freezing into ice, development of osmotic pressure due to concentration gradient, and hydrostatic pressure build up by differential vapour pressure can lead to high internal stress. Hence, high internal stress leads to the expansion inside the concrete. In this study, water was used as a testing agent for initial surface absorption test, sorptivity test, porosity and water absorption test (Mehta & Monteiro, 2014).

CHAPTER 3

METHODOLOGY

3.1 Introduction

The experiments were carried out in the laboratory in accordance to the relevant British Standard (BS) for each part of the process. Sets of 100x100x100 mm plastic cube moulds were used to cast the concrete specimens. The research methodology is carefully planned after accessing the objective. Main materials to produce foam concrete are mortar and foam. Mortar is normally fresh concrete which contains a mix of cement, fine sand and water. Silica sand and dolomite was used as fine aggregate. The crushed dolomite was taken at Quarry Northern Dolomite Sdn. Bhd. Dolomite that was dried in over for one night. After that, it was sieve using sieve analysis method BS Standard to get the dolomite that passing 600micron sieve size and used it in this research. The percentage of dolomite was prepared for 10%, 20%, 30% and 40% from the weight of silica sand. The density of foam concrete is 1600kg/m^3. Figure 3.1 show the flow chart of this research study.

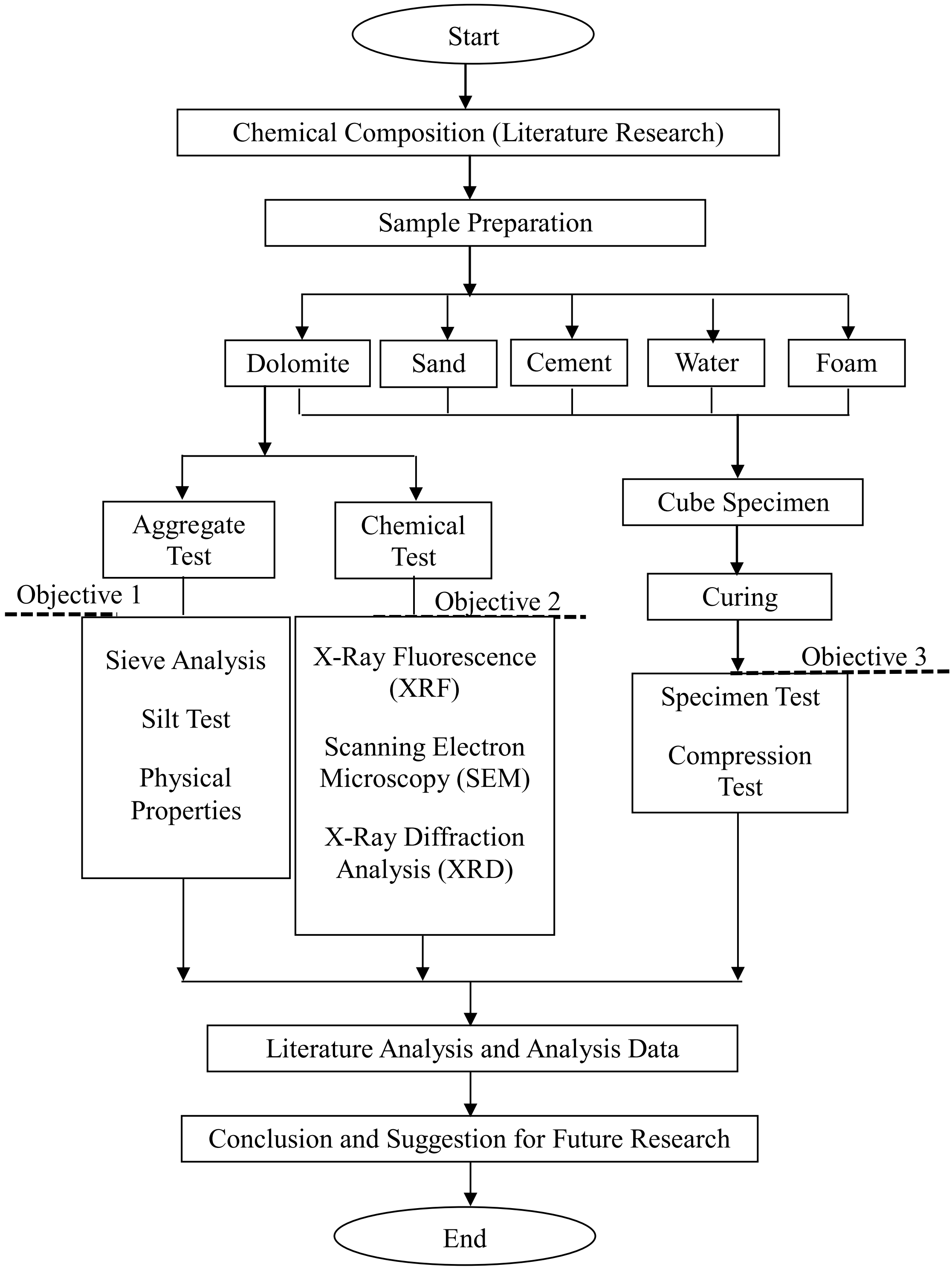

Figure 3.1 Flowchart Researh Methodology

3.2 Material

Material that used in this study are cement, silica sand, dolomite, foaming agent and water.

3.2.1 Cement

Ordinary Portland Cement (OPC) is the most common cement used in general concrete construction when there is no exposure to sulphates in the soil or groundwater. Ordinary Portland cement (OPC) of “ORANG KUAT” as shown in Figure 3.2 branded from YTL Cement Sdn. Bhd. was used throughout the study.

Figure 3.2 Ordinary Portland Cement

3.2.2 Silica Sand

In this study, silica sand was used as a fine aggregate. The using of silica sand because in testing it need to uses a smaller size. The preparation of silica sand is easy than river sand is one of the factor it used in this foam concrete. The figure 3.3 show the image of silica sand.

Figure 3.3 Silica Sand

3.2.3 Dolomite

Dolomite is a carbonate material composed of calcium magnesium carbonate $CaMg(CO_3)_2$. Raw crushed dolomite was taken at Quarry Northern Dolomite Sdn. Bhd. at Perlis. First, dolomite was dry in over at the temperature ± 100 °C for one night to remove its uncertain moisture. Dolomite was sieved through 600µm opening of sieve after oven dried. The sieving method of sand either by hand or mechanically is described in BS 410 Standard Sieve. Figure 3.4 show the packaging of dolomite after sieve.

Figure 3.4 Dolomite

3.2.4 Foaming Agent

The foam can be originated from an agent made of natural surfactants or synthetic materials, and can be added to the concrete mix either as pre foamed (where the foam is prepared in advance by the foaming machine and added later) or as mixed foaming (the foam is added to the mix at the same time as it is prepared) as stated in research from Shawnim and Mohammad (2018).

The foam, an air entraining agent which consists of stable bubbles produced by mixing foaming agent and water in foam generator, was introduced into the plastic mix of mortar in order to produce a material with a cellular structure containing voids between 0.1 and 1 mm for this study. The foam generator was operated under the pressure of 0.4 MPa. The purpose of introducing foam is to control the density of lightweight foamed concrete. The ratio of foaming agent to water is 1:25 by volume.

Figure 3.5 show the foaming agent was measure for 1Litre. Figure 3.6 is the foam generator and Figure 3.7 shown the form of foam after generating.

Figure 3.5 Foaming Agent

Figure 3.6 Foam Generator

Figure 3.7 Foam After Generating

3.2.5 Water

Water needs to be free from impurities and maintain a neutral pH else the impurities may affect the hydration of cement and its durability. The water for curing purpose is 25 renewed regularly in order to avoid staining on the surface of concrete. According to ASTM C1602 (2006), potable and non-potable water is permitted to be used as mixing water in concrete. Concrete performance requirements for mixing water are compressive strength and time of set. Water was used in three parts of preparing specimen in this study, which were mixing concrete for the production of LFC, curing purpose and agent for absorption testing.

3.3 Physical Properties Test

To find the physical properties of dolomite, the sieve analysis and silt test was conducted. With using microscope, the shape of dolomite was observed.

3.3.1 Sieve Analysis Test

Dolomite was sieve using BS 410 Standard Sieve. The size of sieve that used are 3.35mm, 2.36mm, 1.18mm, 600µm, 425µm, 300µm, 150µm and 63µm. The dolomite was sieve after dry in oven for one night. Figure 3.8 show the sieve for sieve analysis. First, all size of empty sieve was weighted. Next, arranged sieve starting smaller size until the biggest size. Weighted 3kg of dolomite. Carefully poured the dolomite sample into the top sieve and place the lid to cover it. All sieve was place in sieve analysis equipment as shown in Figure 3.9. After that, set up the sieve for 10 minutes. After 10 minutes, remove sieve from the apparatus and weight all sieve. All the data was recorded.

Figure 3.8 Sieve

Figure 3.9 Sieve Analysis Apparatus

3.3.2 Silt Test

The silt content of fine aggregate was calculate after conduct the silt test. The test was conduct using 250ml measuring cylinder. The 1% of salt solution was added with 50ml of water in the measuring cylinder. Then the fine aggregate was pour onto cylinder until it up to 100ml. After that the solution was added until the volume up to 150ml. Shake the cylinder and allow to settle for three hours. After three hours, the silt content settled down over the sand layer. Measure the height of silt as shown on Figure 3.10.

Figure 3.10 Silt Test

3.3.3 Microscope Test

Dolomite and silica sand was observed using microscope. The cable at microscope was connected to the laptop. The image under the microscope appear in the laptop as shown in Figure 3.11.

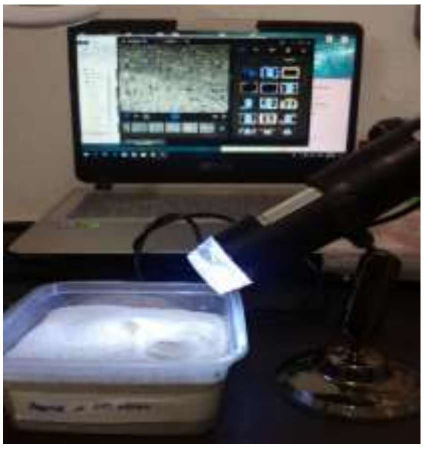

Figure 3.11 Microscope Setup

3.4 Chemical Composition Analysis

The chemical composition of dolomite was tested at the FIST Laboratory, Centre Laboratory and CHARIFF Laboratory. Three test for chemical composition are X-ray Fluorescence (XRF), Scanning Electron Microscopy (SEM - EDX) and X-Ray Diffraction Analysis (XRD).

3.4.1 X-Ray Fluorescence (XRF)

The characterization of dolomite was identified using X-ray Fluorescence (XRF). This methods is to determine the chemical composition in which it were able to identify the elements and compounds present in dolomite. X-ray loggers are able to analyse samples with grades up to 100 bpj (parts per million). This equipment also has the ability to identify boron elements (5B) so that uranium elements (92U). For sample preparation for XRD analysis, 0.6g samples were blended up to 75μm, mixed with 6.0g fluxes in platinum crucibles and burned in fossil fittings. The glass beet produced from the combustion has been analysed. This analysis is derived from the laser beam that is focused on the sample and the results obtained are recorded. The machine for this test are shown in Figure 3.12.

Figure 3.12 Machine for X-ray Fluorescence (XRF)

3.4.2 Scanning Electron Microscopy (SEM)

SEM is an electron microscope that constructs its image as a network of dots as in television and uses electrons in place of light to produced image. SEM uses a very fine detector electron flow through the entire surface of specimen to transmit various signal variations directly proportional to the amount of radiation. These points will quickly connect to each other so that the image of each point becomes a line, and this line moves underneath the screen quickly until it is seen as a perfect image with the naked eye.

The images are recorded in the whole by allowing point info with points built in sequence on photographic films. The SEM also contains high resolution, so samples can be focused on high levels. Examining the surface of the rock decomposed is carried out using a light scanning microscope, the SEM JEOL JSM-6460LA model. It was done to study the morphology of sample fracture and sample surface condition using 12kV acceleration voltage and 1-3nA radiation current. Figure 3.13 show the machine that use for Scanning Electron Microscopy (SEM - EDX)

Figure 3.13 Machine for Scanning Electron Microscopy (SEM – EDX)

3.4.3 X-Ray Diffraction Analysis (XRD)

Dolomite were carried out on samples by using X-Ray Diffraction Analysis (XRD) method to determine the mineral phase present in the sample. The analysis is based on the information of the mineral crystal structure. This method can only detect crystalline material while amorphous materials such as glass can't be determined. The model which uses fixed monochromator. The scan state is set at 30 kV, 15 mA and scan rate is 0.625 ° C / second. The radiation diffusion slots are fixed at 2 mm and 3 mm while the receiving slip is 0.3mm. The peak angle range (2θ) is in the range of 5.0 ° to 60.0 °. The Figure 3.14 shown the machine that used for X-Ray Diffraction Analysis (XRD).

Figure 3.14 Machine for X-Ray Diffraction Analysis (XRD)

3.5 Mix Proportion

Trial mixed design was calculate refer to research by Rokiah (2019). All the weight of material was tabulated in Table 3.1. The mix design was calculate for one mixer which is prepared for nine specimens with including 20% wastage.

Table 3.1 Total Mix Proportion

Sample Designated	% of Dolomite	Cement (kg)	Sand (kg)	Dolomite (kg)	Water (L)	Foam (kg/m³)
D_0	0	5.79	8.68	0	2.89	0.27
D_{10}	10	5.79	7.81	0.87	2.89	0.27
D_{20}	20	5.79	6.94	1.74	2.89	0.27
D_{30}	30	5.79	6.08	2.61	2.89	0.27
D_{40}	40	5.79	5.21	3.47	2.89	0.27
Total (kg)		28.95	34.72	8.69	14.45	1.35

Table 3.2 below show the mix proportion of the sample for one specimen with including 20% wastage.

Table 3.2 Mix Proportion for One Specimen

Sample Designated	% of Dolomite	Cement (kg)	Sand (kg)	Dolomite (g)	Water (L)	Foam (kg/m³)
D_0	0	0.64	0.96	0	0.32	0.03
D_{10}	10	0.64	0.87	96.67	0.32	0.03
D_{20}	20	0.64	0.77	193.33	0.32	0.03
D_{30}	30	0.64	0.68	290.00	0.32	0.03
D_{40}	40	0.64	0.58	385.56	0.32	0.03

All the materials was prepared before start the mixing process.

3.6 Mixing and Casting

Firstly, all the materials such as cement, sand, dolomite and water was weighed. Then prepared the generator to generate foam. The cement and fine material were put into a mixer as shown in Figure 3.15. Figure 3.16 show the type of mixer was used. It was mixed until become homogeneous. After that, a small amount of water was pour and blended for two minutes. While mixer continues rotate, the remaining water was added. The weight the foaming agent. The foaming agent was added until the required density was achieve. After the required density was achieved, the concrete mix was poured into mould size 100mm x 100mm x 100mm as shown in Figure 3.17. Before pour concrete into the mould, the oil was applied at the mould. It is must because for easy process to remove dried concrete from mould. Concrete was pour by three layer into the mould. After that, the mould that contain concrete was vibrate on the vibrator to remove bubble in mix concrete. After that, leave the mix concrete in the mould at dry surface for 24 hours or until the concrete was hardened as shown in Figure 3.18 and Figure 3.19.

Figure 3.15 Cement and Fine Material in Mixer

Figure 3.16 Mixer

Figure 3.17 Mould size 100mm x 100mm x 100mm

Figure 3.18 Place the Mould Contains at Dry Surface

Figure 3.19 Hardened Concrete

3.7 Curing

Before curing process, the hardened concrete was labelled and remove from mould as in Figure 3.20 and Figure 3.21. The dried foam concrete was weight and record all the data as in Figure 3.22. Then all the foam concrete was pun into water tank such in Figure 3.23 for water curing process. The foam concrete was placed in the water for 7 days, 14 days and 24 days before compression test. Water curing is to prevent the water loss from the concrete surface by uninterrupted wetting of the exposed surface of concrete.

Figure 3.20 Labelled Foam Concrete

Figure 3.21 Remove Foam Concrete from Mould

Figure 3.22 Weighted Hardened Foam Concrete

Figure 3.23 Water Curing Process

3.8 Compression Test

Compression test was conduct Concrete Laboratory. Before start the testing for compression test, the foam concrete was remove from water tank. Dry the concrete using any fabric. Then weighed the foam concrete. After record all the data, compression test was conduct. The compressive strength was determined as accordance to BS 1881: Part 117:1983. Figure 3.24 show the foam concrete ready to tested. Figure 3.25 show process of compression test. Load was applied gradually till the specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete are recorded. The specimens are tested by compression testing machine after 7 days, 14 days and 28 days immediately after removing foam concrete from curing process.

Figure 3.24 Foam Concrete Ready for Compression Test

Figure 3.25 Compression Test

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter discusses the result of physical properties dolomite, chemical composition of dolomite and compressive strength of foam concrete. The foam concrete was namely D_0, D_{10}, D_{20}, D_{30} and D_{40}. All the specimens were water cured for 7 days, 14 days and 28 days ages before testing. The control density for foam concrete is 1600kg/m^3. All the result was tabulated and present in graph. The performance of dolomite in foam concrete as sand replacement was discussed in this chapter.

4.2 Physical Properties

The physical properties of dolomite was conduct to study in term of size, silt content and shape. The test for physical properties is sieve analysis, silt test and with using microscope.

4.2.1 Sieve Analysis Result

To check the size distribution of dolomite, sieve analysis test was run. The data for sieve analysis was in Table 4.1. The percentage dolomite that passing for each sieve size was present in semi-log graph as shown in Figure 4.1

Table 4.1 Data Sieve Analysis

BS Size	Weight of Sieve (g)	Weight of Sieve + sample (g)	Weight of Sample (g)	Percentage Retain on Sieve (%)	Cummulative Retain (%)	Passing (g)	Cummulative Passing (%)
3.35	542.42	544.54	2.12	0.07	0.07	3021.07	99.93
2.36	531.41	573.23	41.82	1.38	1.45	2981.37	98.55
1.18	485.70	758.05	272.35	9.01	10.46	2750.84	89.54
0.600	483.76	1054.76	571.00	18.89	29.35	2452.19	70.65
0.425	454.29	650.53	196.24	6.49	35.84	2826.95	64.16
0.300	448.43	645.61	197.18	6.52	42.36	2826.01	57.64
0.150	426.28	1094.62	668.34	22.11	64.47	2354.85	35.53
0.063	308.09	1264.60	956.51	31.64	96.11	2066.68	3.89
Pan	364.14	481.77	117.63	3.89	100.00	2905.56	0.00

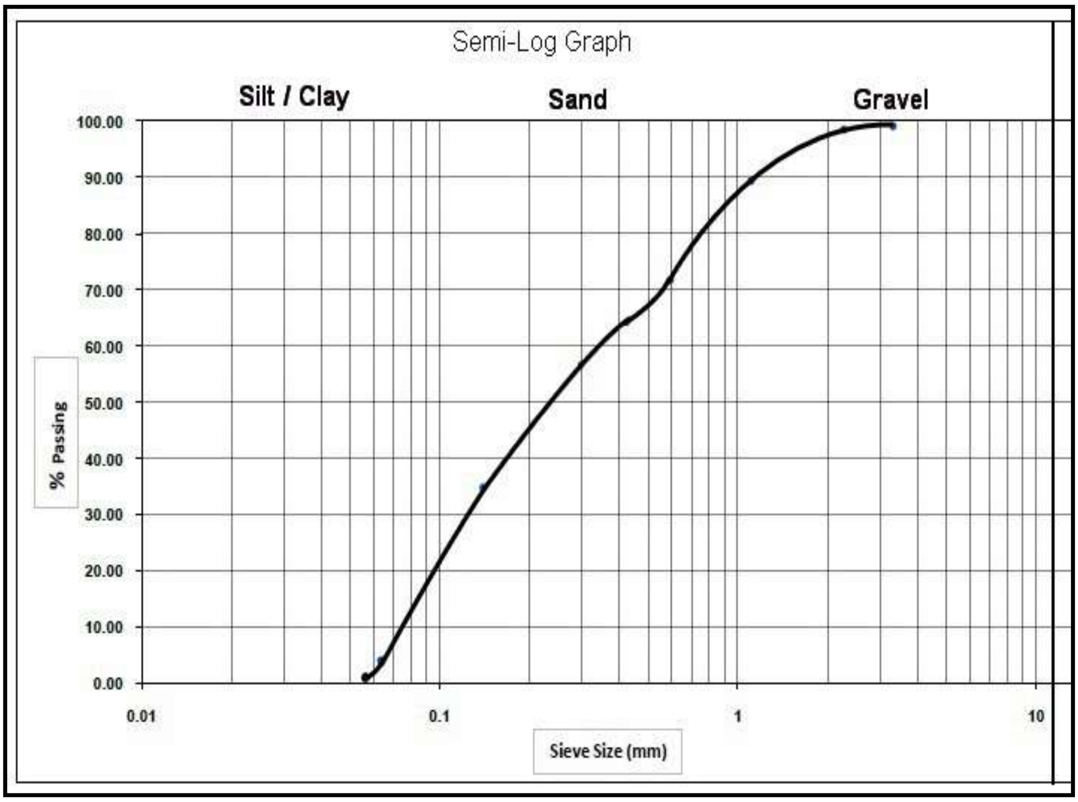

Figure 4.1 Semi-log Graph

The data of sieve analysis was present in semi-log graph. Based on the graph in Figure 4.1, the distribution of dolomite can be concluded as a sand type. This is because the total of dolomite after run sieve analysis test is about 66.76% locate at sand type.

4.2.2 Silt Content Test

Silt content is a fine material which is less than 150 micron. BS 882 and ASTM C40 recommends that no more than a maximum of 6% silt content for fines aggregates be used in concrete structure (Cho, 2013). The strength of concrete was reduce if used silty sand for bonding.

$$\% \text{ of Silt} = \frac{\text{Height of silt layer}}{\text{Height of sand}} \times 100$$

$$\% \text{ Silt in Silica Sand} = \frac{4}{94} \times 100 = 4.2\ \%$$

$$\% \text{ Silt in Dolomite} = \frac{3.5}{92} \times 100 = 3.8\ \%$$

From the test had occur, percentage of silt in silica sand and dolomite are 4.2% and 3.8%. From the results, this fine aggregate can be use in concrete mixture because it’s not a silty sand. According to Gokul, (2017). The silt or clay content can be effect to compressive strength. The Figure 4.2 show the silt content of dolomite and silica sand in bar graph.

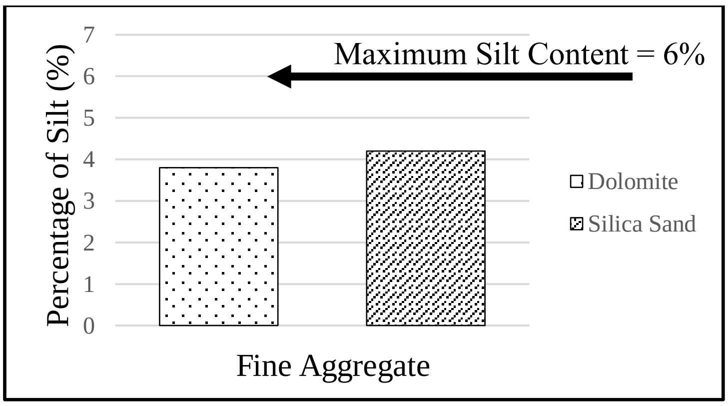

Figure 4.2 Percentage of Silt Content

4.2.3 Image Under Microscope

The shape of fine aggregate was observed using microscope. Microscope that used is namely OTEK. The image of dolomite and silica sand under this microscope was shown in Figure 4.3 and Figure 4.4. The dolomite and silica sand was observed at 40 magnification under microscope. Dolomite has a fine size like silica sand. Both are angular shape. The finer aggregate is the best material as a filler in foam concrete.

Figure 4.3 Dolomite under Microscope

Figure 4.4 Silica Sand under Microscope

4.3 Chemical Composition Result

The chemical composition of dolomite was tested at the FIST Laboratory, Centre Laboratory and CHARIFF Laboratory. Three test for chemical composition are X-ray Fluorescence (XRF), Scanning Electron Microscopy (SEM - EDX) and X-Ray Diffraction Analysis (XRD).

4.3.1 Composition Using X-Ray Fluorescence (XRF)

Chemical composition of dolomite was analysed using X-Ray Fluorescence (XRF). Table 4.2 shows the result of chemical composition analysis for the element found in dolomite. SQX Calculation result for XRF shown in Appendix A.

Table 4.2 Chemical Composition in Dolomite using XRF

Component	Chemical Composition (mass %)
CaO	35.7
MgO	15.5
Fe_2O_3	0.099
SiO_2	0.192
Al_2O_3	0.184

Based on XRD analysis, the main component in dolomite is CaO with chemical composition about 35.7% and MgO is 15.5%.

4.3.2 Composition Using Scanning Electron Microscopy (SEM)

Analysis using Scanning Electron Microscopy (SEM)-EDX can analyse the image of microstructure and quantitative of specimen surface. Table 4.3 show the chemical composition of dolomite using SEM.

Table 4.3 Chemical Composition in Dolomite using SEM

Element	Line Type	Apparent Concentration	k Ratio	Wt %	Wt % Sigma	Standard Label	Factory Standard
Mg	K series	0.79	0.00523	30.27	1.36	MgO	Yes
Ca	K series	1.58	0.01413	69.73	1.36	Wollastonite	Yes

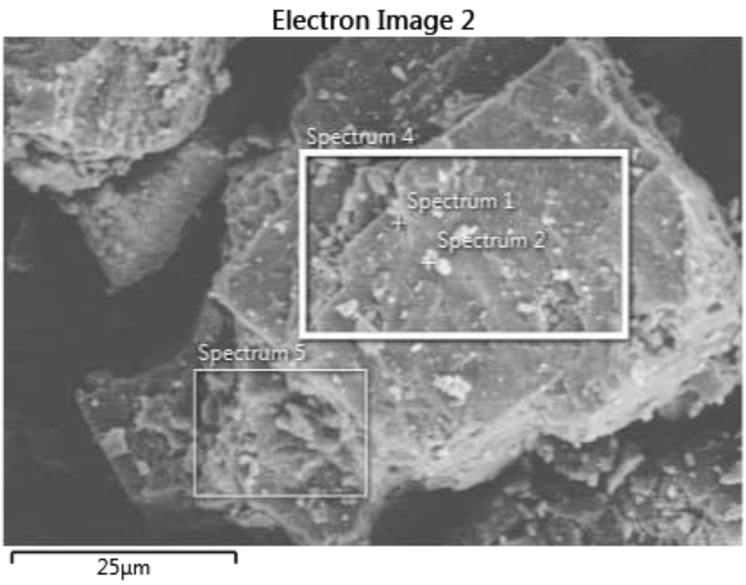

Figure 4.5 Electron Image

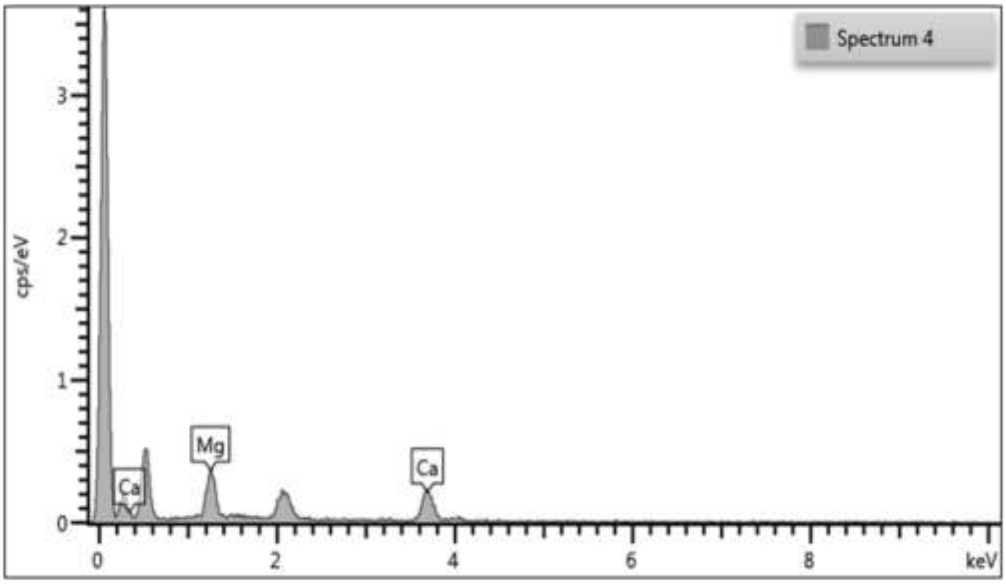

Figure 4.6 Graph of Element Appear under SEM

Figure 4.5 and Figure 4.6 was shown the appearance of element under Scanning Electron Microscopy.

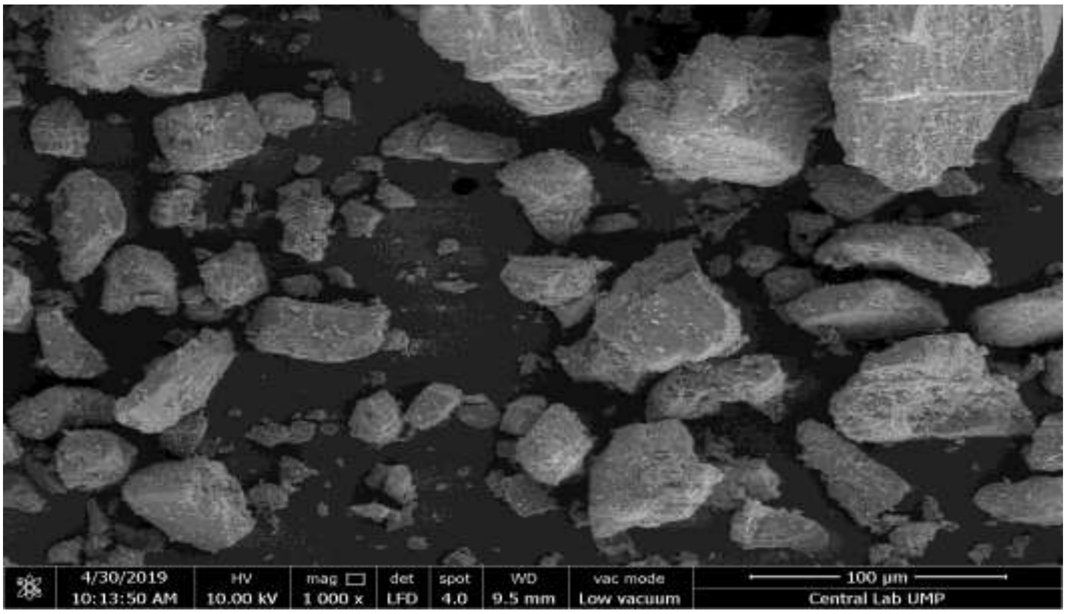

Figure 4.7 Image of Dolomite under SEM

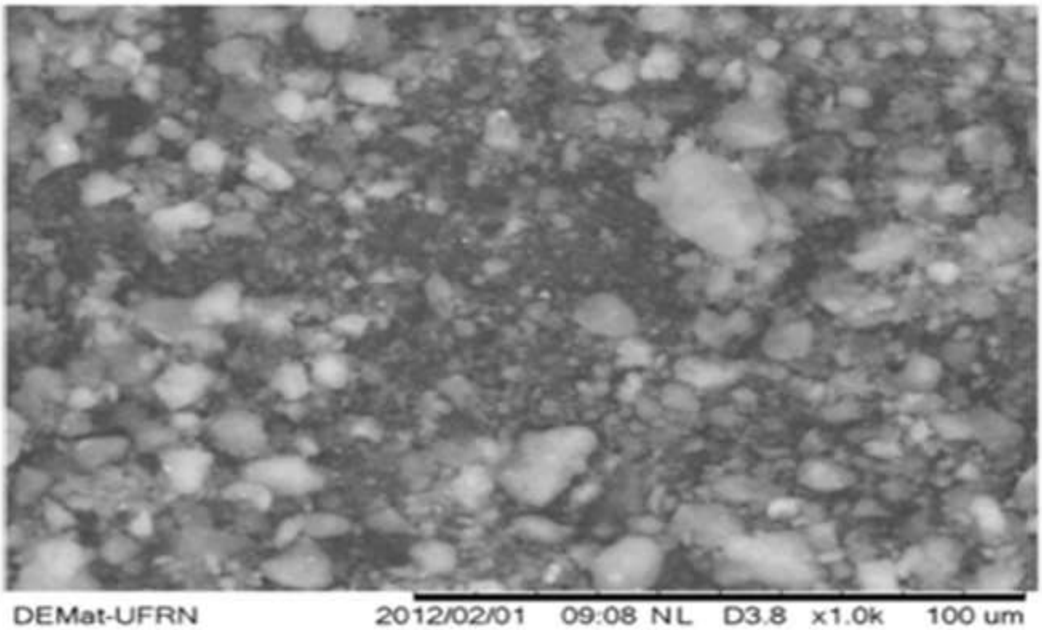

Figure 4.8 Image of Silica Sand under SEM

The Figure 4.7 and Figure 4.8 is the image of dolomite and silica sand under SEM with 1000 magnification. The shape of both fine aggregate are angular shape which is suitable to use in concrete.

4.3.3 Composition Using X-Ray Diffraction Analysis (XRD)

The X-Ray Diffraction Analysis (XRD) in Figure 4.9 show the diagram that showing the intensity and angular 2θ is obtained and it is matched with the standard peaks for inorganic. Figure 8 shows the results of the standard roll-outs of inorganic materials with the peak obtained from dolomite samples. The present mineral phase is dolomite, C, $Ca_{0.5}$, $Mg_{0.5}$, and O_3. The peak obtained from this XRD analysis is matched with the data contained in the software showing the chemical formula is Calcium Magnesium Carbonate, $CaMg(CO_3)_2$. Detail peak list for XRD is in Appendix B.

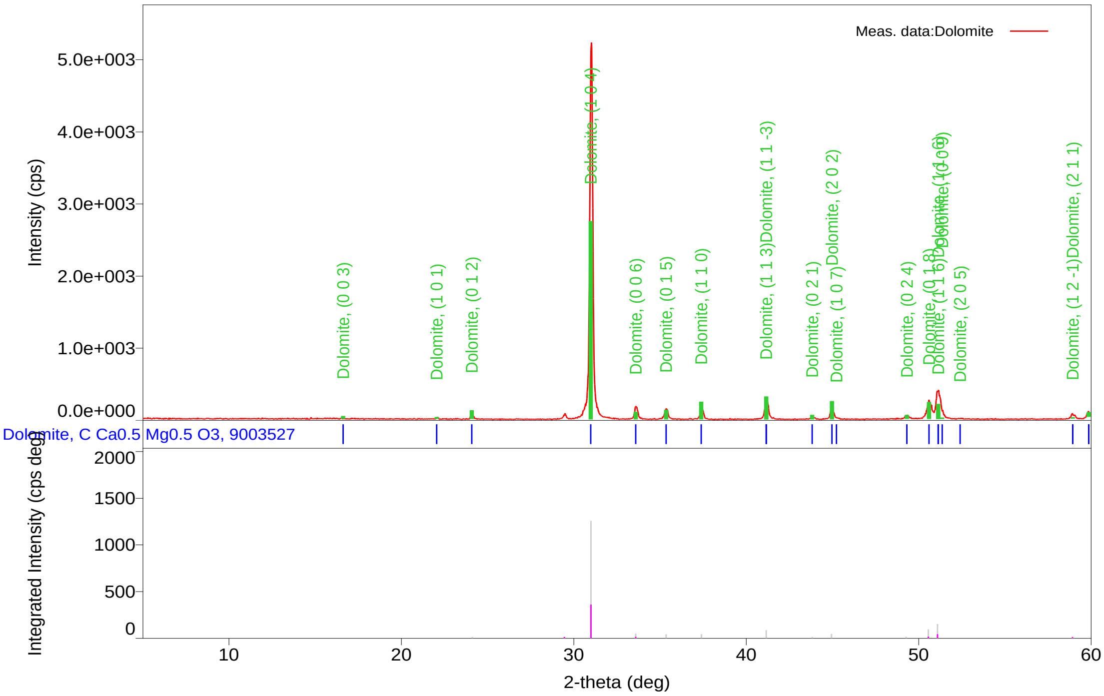

Figure 4.9 Mineral Present using XRD Analysis

4.4 Compression Test Result

The foam concrete was namely D_0, D_{10}, D_{20}, D_{30} and D_{40}. All the specimens were water cured for 7 days, 14 days and 28 days ages before testing. The control density for foam concrete is 1600kg/m^3. All the data of compressive strength was record in Table 4.4. Figure 4.10, Figure 4.11 and Figure 4.12 present the graph of compressive strength for 7 days, 14 days and 28 days respectively. Figure 4.13 shown the graph of compressive strength for all designated.

Table 4.4 Compressive Strength

Ages (Day)	7	14	28
Designated	Compressive Strength (N/mm^2)		
D_0	6.31	6.35	6.37
D_{10}	7.30	8.33	9.43
D_{20}	10.4	10.8	11.0
D_{30}	10.6	11.2	12.39
D_{40}	8.24	8.69	9.87

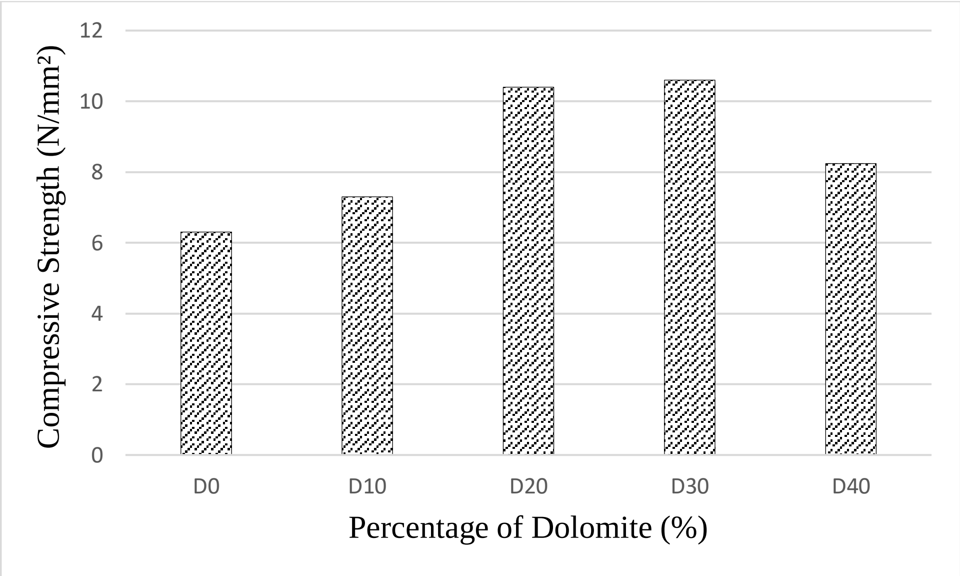

Figure 4.10 Graph of Compressive Strength at Age 7 Days

From the figure above the compressive strength of foam concrete for D_0, D_{10}, D_{20}, D_{30} and D_{40} are 6.31N/mm^2, 7.30N/mm^2, 10.4N/mm^2, 10.6N/mm^2 and 8.24N/mm^2 respectively.

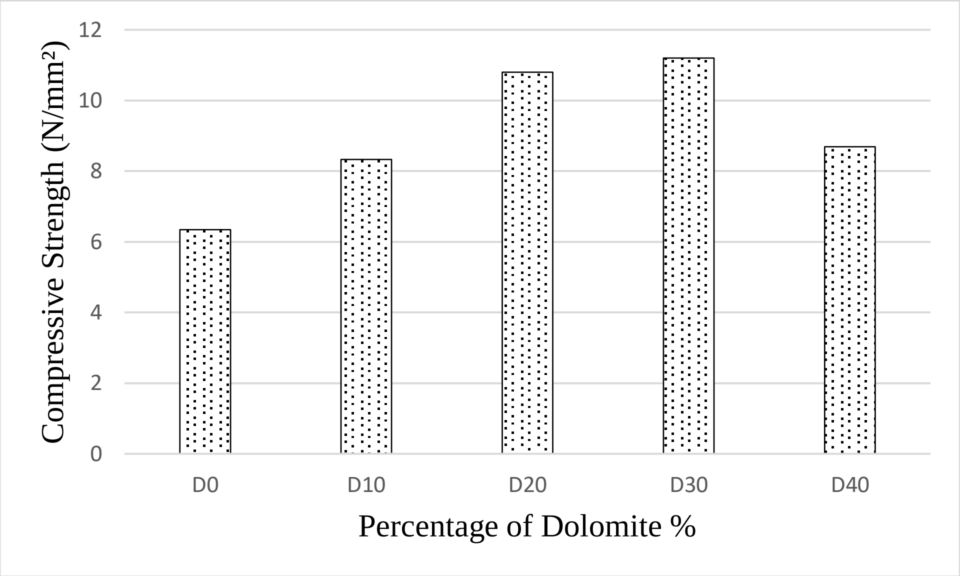

Figure 4.11 Graph of Compressive Strength at Age 14 Days

From the figure above the compressive strength of foam concrete for D_0, D_{10}, D_{20}, D_{30} and D_{40} are 6.35N/mm^2, 8.33N/mm^2, 10.8N/mm^2, 11.2N/mm^2 and 8.69N/mm^2 respectively.

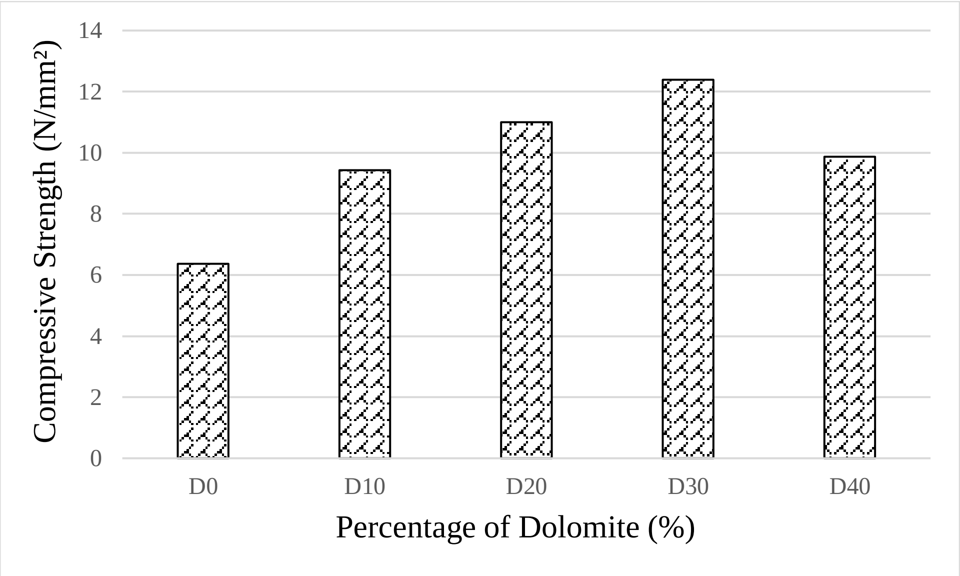

Figure 4.12 Graph of Compressive Strength at Age 28 Days

From the figure above the compressive strength of foam concrete for D_0, D_{10}, D_{20}, D_{30} and D_{40} are 6.37N/mm^2, 9.43N/mm^2, 11.0N/mm^2, 12.39N/mm^2 and 9.87N/mm^2 respectively.

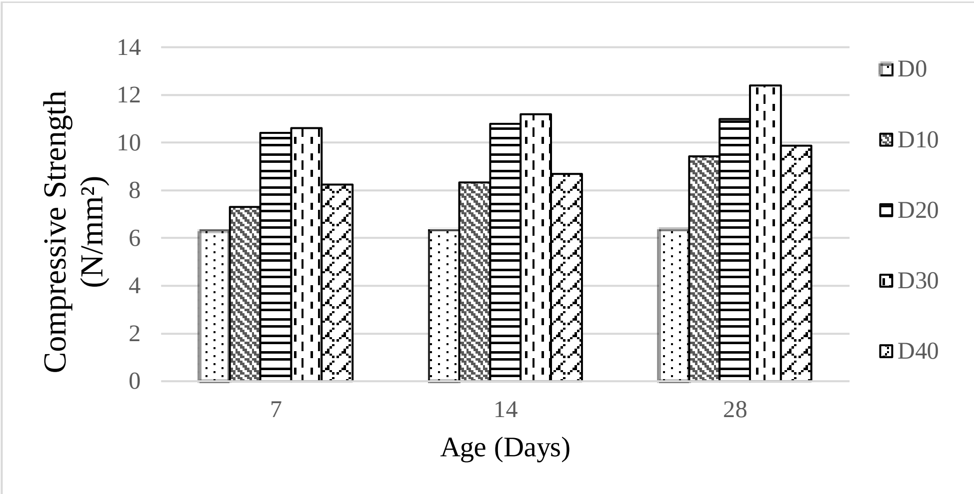

Figure 4.13 Graph (Bar) of Compressive Strength

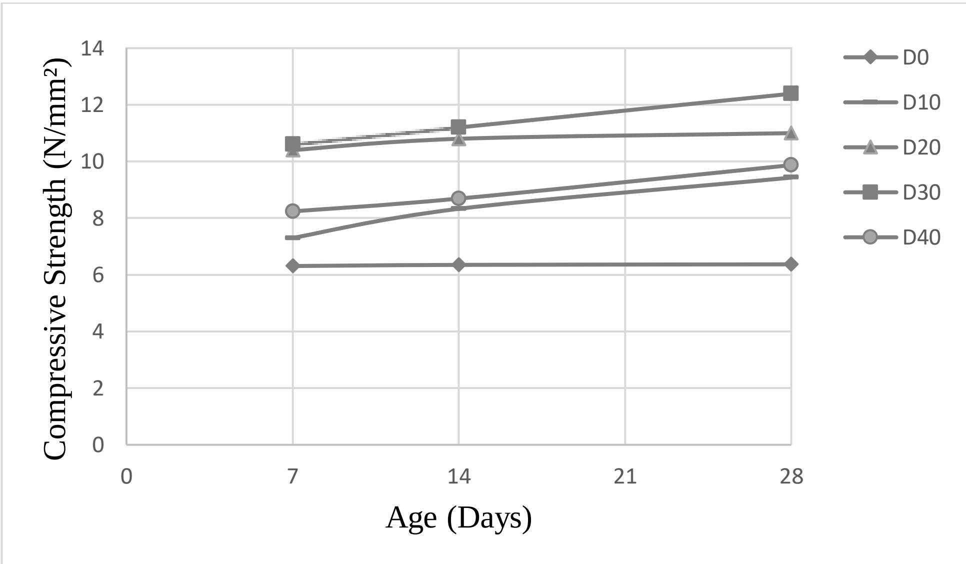

Figure 4.14 Graph (Line) of Compressive Strength

Based on the graph above, the minimum strength is presence from D_0 as a control sample that has the strength about 6.37 N/mm^2 at age 28 days. The strength of foam concrete was increase when used the dolomite in the mixture. The maximum compressive strength of foam concrete that mix with dolomite are 12.39 N/mm^2 that shown in D30 line. The increasing of strength from 0% of dolomite until 30% of dolomite is 48.59%. For D_{40} show that the value of compressive strength was decrease about 20.24%. The strength of dolomite was increase when the curing age increase.

CHAPTER 5

CONCLUSION

5.1 Introduction

In this chapter, there are some conclusion and recommendation that been made. The recommendations are made for further study to obtain a better result.

5.2 Conclusion

Based on the laboratory result obtained, the following conclusions can be drawn corresponding to the objectives that listed out in Chapter 1 of the study.

The first objective is to observe the physical properties of fine aggregate in term of shape, size and silt content. Dolomite is sufficient as a sand replacement because has fine size and has angular shape. According to PP (2018), the compressive strength increased as the fines content increases. Besides that, the silt content in dolomite not over than 6% that can be used in concrete mixture.

Second objective is to identify the chemical composition of dolomite. The element that appeared under the analysis are Magnesium Oxide (MgO) and Calcium Oxide (CaO). Some chemical composition that has in dolomite can make dolomite be used in construction.

The last objective is to determine the compressive strength of foam concrete using different percentage of dolomite as a sand replacement. Dolomite has a significant impact on the compressive strength of foam concrete. It was found that D30 (30%) of dolomite partial replacement of sand provide greater compressive strength of foam concrete. Based on the other research also found that 30% is optimum level of using husk ash to increase compressive strength of foam concrete, Rum (2017). According to research by Rokiah et al. (2019) also found that 30% of Processed Spent Bleaching Earth (PSBE) in foam concrete can increase the compressive strength.

As a conclusion, dolomite can be widely use to making light weight foam concrete in construction project and the used of can be reduce. At the same time, river pollution that cause by river sand extraction activities also can be reduced.

5.3 Recommendation

The study of lightweight foamed concrete incorporate with dolomite as a sand replacement material is innovative and sustainable product among construction and building materials. In order to discover and improve this research work in future, there are a few aspects are suggested for future improvement:

i) Carefully control the foam during mixing process. The extra of foam from the calculate weight can changes the density of foam concrete.

ii) Adopt the different curing methods for the concrete specimens and study the impact on engineering properties such as water absorption, thermal conductivity and sound insulation.

iii) Produce and study its properties on lightweight foam concrete incorporated with not only dolomite but also can add other materials with dolomite partial as a sand replacement to add more compressive strength.

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APPENDIX A
SQX CALCULATION RESULT XRF

2019- 4-29 16:28

SQX Calculation Result

Sample : Dolomite
Application : Oxide
Sample type : Metal & Alloy
Sample film corr. :
Helium corr. : Yes
File : Dolomite
Date analyzed : 2019- 4-29 16:12
Balance :
Matching library :
Impurity corr. :

No.	Component	Result	Unit	Det. limit	El. line	Intensity	w/o normal
1	CO2	48.2	mass%	0.73884	C -KA	1.2045	35.8009
2	MgO	15.5	mass%	0.01202	Mg-KA	75.9636	11.5144
3	Al2O3	0.184	mass%	0.00169	Al-KA	2.2270	0.1366
4	SiO2	0.192	mass%	0.00117	Si-KA	2.3704	0.1423
5	P2O5	0.0055	mass%	0.00064	P -KA	0.1955	0.0041
6	SO3	0.0249	mass%	0.00106	S -KA	0.7697	0.0185
7	Cl	0.0111	mass%	0.00186	Cl-KA	0.2397	0.0082
8	K2O	0.0064	mass%	0.00129	K -KA	0.4293	0.0048
9	CaO	35.7	mass%	0.00562	Ca-KA	1656.7484	26.5075
10	MnO	0.0101	mass%	0.00302	Mn-KA	0.3029	0.0075
11	Fe2O3	0.0990	mass%	0.00285	Fe-KA	4.2040	0.0735
12	SrO	0.0122	mass%	0.00088	Sr-KA	7.9067	0.0091
13	BaO	0.0450	mass%	0.01283	Ba-KA	3.0978	0.0334

APPENDIX B

DETAIL PEAK LIST FOR X-RAY DIFFRACTION ANALYSIS

Peak list

No.	2-theta(deg)	d(ang.)	Height(cps)	FWHM(deg)	Int. I(cps deg)	Size(ang.)	Phase name
1	24.11(2)	3.689(3)	51(7)	0.143(19)	8.6(6)	591(78)	Dolomite(0,1,2)
2	29.455(9)	3.0300(9)	40(6)	0.18(3)	8.5(9)	483(72)	Unknown
3	30.996(3)	2.8828(3)	4266(65)	0.145(2)	839(5)	594(10)	Dolomite(1,0,4)
4	33.588(10)	2.6660(8)	157(13)	0.147(11)	33.2(7)	590(45)	Dolomite(0,0,6)
5	35.358(17)	2.5365(12)	114(11)	0.177(16)	27.7(8)	491(43)	Dolomite(0,1,5)
6	37.405(8)	2.4022(5)	166(13)	0.130(10)	29.5(8)	672(49)	Dolomite(1,1,0)
7	41.162(7)	2.1912(4)	256(16)	0.158(10)	57.4(10)	560(34)	Dolomite(1,1,-3)
8	43.83(2)	2.0639(11)	29(5)	0.18(5)	8.6(6)	488(122)	Dolomite(0,2,1)
9	44.948(10)	2.0150(4)	135(12)	0.155(15)	31.4(9)	580(55)	Dolomite(2,0,2)
10	49.280(9)	1.8476(3)	39(6)	0.22(3)	10.0(8)	420(56)	Dolomite(0,2,4)
11	50.568(9)	1.8035(3)	187(14)	0.243(16)	63(2)	378(25)	Dolomite(0,1,8)
12	51.102(8)	1.7859(3)	328(18)	0.222(10)	101(2)	415(19)	Dolomite(1,1,6)
13	58.925(15)	1.5661(4)	53(7)	0.17(4)	11.1(16)	559(134)	Dolomite(1,2,-1)