EFFECT OF SHREDDED RECYCLED POWDER FREE LATEX GLOVES ON THE PROPERTIES OF HOLLOW CONCRETE BLOCK

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By

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LIST OF ABBREVIATIONS

PFLG	Powder Free Latex Gloves
PL	Polymer Latex
NR	Natural Rubber
PC	Polymer Concrete
UP	Unsaturated Polyester
SBR	Styrene Butadiene Rubber
SAE	Styrene Acrylic Ester
NLWA	Normal Lightweight Aggregate
NS	Natural Sand
FA	Fly Ash

KESAN SARUNG TANGAN GETAH KITAR SEMULA YANG DICINCANG KE ATAS SIFAT-SIFAT KONKRIT BLOK BERLUBANG

ABSTRAK

Malaysia adalah salah satu pengeluar dan pengeksport sarung tangan pemeriksaan dan pembedahan terbesar di dunia dan industri sarung tangan menguasai lebih kurang 70% daripada semua eksport produk getah di negara ini, membekalkan hampir 60% daripada penggunaan dunia. Walau bagaimanapun, industri pembuatan produk getah masih berhadapan dengan mengurangkan dengan sarung tangan yang ditolak seperti sarung tangan tidak memenuhi spesifikasi yang diperlukan. Untuk menyelamatkan sarung tangan getah dari tapak pelupusan sampingan dengan menilai kaedah penggunaan semula sisa yang mampan seperti kitar semula, kompos dan penyusupan semula. Atas sebab-sebab ini, kajian tentang kesan penggunaan sarung tangan lateks diperlukan untuk melihat potensinya untuk menggantikan sarung tangan getah sebagai agregat halus dalam konkrit. Blok konkrit disediakan pada 5% tahap penggantian sarung tangan getah tanpa serbuk (PFLG) dengan menggunakan nisbah air 0.5. Campuran yang digunakan dalam kajian ini adalah campuran kering. Beberapa ujian dijalankan ke blok konkrit iaitu kekuatan mampatan, penyerapan air, kadar sedutan awal, ujian ketumpatan dan dimensi dan toleransi. Akibatnya, penggantian PFLG 5% dicincang, mengurangkan kekuatan blok konkrit. Telah didapati bahawa blok konkrit PL menyerap lebih banyak air berbanding dengan blok konkrit kawalan. Ketumpatan blok konkrit PL lebih ringan daripada blok konkrit kawalan kerana penggantian PFLG yang dicincang dalam blok konkrit.

EFFECT OF SHREDDED RECYCLED POWDER FREE LATEX GLOVES ON THE PROPERTIES OF HOLLOW CONCRETE BLOCK

ABSTRACT

Malaysia is one of the biggest producer and exporter of examination and surgical glove in the world and glove industry dominates approximately 70% of all rubber products exports in the country, supplying close to 60% of the world consumption. However, latex products manufacturing industry is still faced with mitigating with rejected glove such as glove does not meet specifications required. In order to save latex glove from landfills sustainable methods of waste disposal such as recycling, composting and upcycling are being evaluated. For these reasons, study on the effects of using latex glove is needed to observe the potential to replacing latex glove as a fine aggregate in concrete. Concrete blocks were prepared at 5% of shredded powder free latex gloves (PFLG) replacements levels using water to cement ratio of 0.5. The mix used in this research is dry mix. Several tests were conducted to concrete block namely, compressive strength, water absorption, initial rate of suction, density test and dimensions and tolerances. As a result, the replacement of 5% shredded PFLG, reduce the strength of the concrete block. It was found that the PL concrete block absorb more water compared than the control concrete block. The density of PL concrete block lighter than control concrete block due to the replacement of shredded PFLG in the concrete block. The replacement of shredded PFLG in concrete block decreases the initial suction rates because PFLG do not absorb water.

CHAPTER 1

INTRODUCTION

1.1 Background

One of the major sources of economic growth, development and economic activities are construction sector and construction activities. Construction sector/industry also play an important role in developing and enhancing the economic sector. Growth of economic has been influencing the construction industry through the increasing demand of construction materials lately. In order to overcome the high demand of resources, new innovation need to be planned if not upgrading the available structure to establish the stability in economics. The most common construction material that have been used in construction since a long time ago are cement and aggregates.

Currently, many researches focus mainly on the utilization of the by-product in concrete industries. From the past researches, many investigations were conducted regarding the use of polymer latex as a partial cement replacement in concrete as they had used polymer in powder form. In this research, the chosen material that will be mixed together with sand and cement to produce concrete block is shredded form of Powder Free Latex Gloves or known as latex disposable gloves that offer excellent performance in a variety of application across a broad range of industries. Powder Free Latex Gloves are used broadly in applications in dental and medical, child care, food processing and food service, janitorial and sanitation, automotive and manufacturing industries. From the previous research, latex in concrete block can improve the flexural and tensile strength. Latex also can act as a binder in concrete block.

A concrete block is a product made from mixture of cement, sand and water which is primarily used as a building material in the construction of the walls. It is also called a concrete masonry unit (CMU). A concrete block is one of precast concrete products used in construction. The meaning of precast refers to the fact that the blocks are formed and hardened before they are brought to the job site. The uses of sand as a part of mixture in concrete block subsequently contribute to the heavy weight of structure itself. Concrete block can be hollow or solid or three cores or voids. Concrete block are easy to handle, light and common in various types as shown in Figures 1.1 and 1.2.

Figure 1.1 Hollow Concrete Block (http://www.ecobuildcambodia.com)

Figure 1.2 Solid Concrete Block (https://www.goodwins.ie)

1.2 Problem Statement

Malaysia is one of the biggest producer and exporter of examination and surgical glove in the world and glove industry dominates approximately 70% of all rubber products exports in the country, supplying close to 60% of the world consumption (MRB, 2012). However, latex products manufacturing industry is still faced with mitigating the rejected glove such as glove that does not meet specifications and requirements. In order to reduce latex glove from being dumped to the landfills there is a sustainable methods of waste disposal such as recycling, composting and upcycling. For these reasons, study on the effects of using latex glove is needed to observe its potential to replace latex glove as a fine aggregate in concrete. Besides, this research will present whether shredded form of polymer latex can have the same properties compared to powder form of polymer latex.

1.3 Objectives

The followings are the objectives set out for this research:

1. To determine the properties of hollow concrete block with shredded recycled powder free latex gloves.
2. To evaluate and compare the differences in properties between ordinary hollow concrete block and hollow concrete block with shredded recycled powder free latex gloves.

1.4 Scope of Work

This study will focus on assessing the potential of polymer latex as replacement of natural fine aggregate in concrete block. The conventional concrete block was designed with a proportion of 1:6 (Cement: Sand) as control sample to be compared with the polymer latex concrete block. The performance of each mix in terms of strength, water absorption and density will be compared and discussed.

1.5 Layout of Dissertation

- This dissertation consists of five different chapters. Chapter 1 will introduce the research background, problem statement as to introduce the reader to the importance of the topic being studied and the significance of the study. Also, the objectives of this research in order to set the desired target of work while the scope of work will explain the work flow during research.
- Chapter 2 will present the literature review about the research title, polymer latex and its effectiveness as the replacement of natural aggregates in concrete block mixes.
- Chapter 3 will focus on methodology undertaken to achieve the research objectives. The methods, test conducted and standard references will be viewed in detail to facilitate understanding on the execution of the project.
- Chapter 4 will present the research results and discussion to ensure the stated objectives are accomplished and have produced substantial result to facilitate future studies or to be used in real projects.
- Chapter 5 will provide a brief summary of the finding in this research and recommendations for future research based on this thesis.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

Construction industry is one of the biggest supplier for the natural aggregates such as natural sand. Natural sand is widely used and is also a key ingredient for concrete block mixture but over exploiting sand will give negative impact such as extensive sand extraction physically alters rivers and coastal ecosystems, increase suspended sediments and cause erosion. Natural sand also contributes a lot to the weight of concrete block which is not sustainable in long term performance. Therefore, there is a need to have new innovation in producing concrete block with lesser use of natural sand. In this research, in order to produce concrete block, potential material that will be used is shredded Powder Free Latex Gloves and from this research we will know whether this polymer latex is suitable and can enhance the properties of concrete block or not.

2.2 Hollow Concrete Block

Short and Kinniburgh (1978) described concrete block as the following:

" In order to form a relatively open structure particles off aggregate should be bonded together by cement paste and concrete is being compacted only partially under the influence of vibration. By vibrating the concrete, the cement paste, being thixotropic, liquefies and flows to form menisci at the point of contact with the aggregate particles and bonds. Cement paste gels or becomes virtually solid when vibration stops and the whole structure becomes firm enough to permit the block to be extruded from the mould and to be handled to another place of curing".

Practitioners and contractors have chosen blocks in their construction industries for several reasons. The use of concrete block could be economical than clay bricks. Completion of construction work according to schedule can be accomplished on time whereas; large dimension of block contributes to faster time for blocks to be laid. Labour cost involves in the construction can also be reduced and material cut down resulted in lower production cost. This is convenient in construction and gives plus points to the simplicity in production technology (Goodings and Thomas, 1995).

Dry mixing also known as no-slump mixes is normally used in the production of concrete block. It is important that the concrete is thoroughly mixed, either in a high efficiency mixer or for a longer period in a larger ordinary mixer due to the relatively lower water cement ratio (w/c) of the mix and the need for the cohesive mix. By ordinary standards, these mixes would be considered as harsh and unworkable.

Dynamic compaction is currently being used recently to obtain a more uniform compaction and sufficient strength. Various methods of compaction are being used by manufacturers in the production of blocks and different strengths could be achieved. If compaction is not properly done, problems of lower density block may arise. Density contributes to the strength achievement and the improvement with regard to resistance to sulphate and chloride attack. Besides that, hydrostatics conditions may be generated if too much water is added and does not result in densification and uniform particle arrangement (Goodings and Thomas,1995)

2.2.1 Block Types, Dimension and Size

2.2.1.1 Types of block and block specification

According to Short and Kinniburgh (1978), blocks are classified into two types; i.e composed of aggregate concrete and aerated concrete. For aggregate concrete block, it is divided into two groups as follows:

1. Those made from organic material, which is chemically stabilized sawdust or wood meal.
2. Those employing mineral aggregates.

Meanwhile, according to BS 2028: Part 1, blocks are classified into three types as follows:

1. Type A: Dense aggregate blocks with density of not less than 1500 kg/m^3.
2. Type B: Lightweight aggregate blocks for load bearing wall.
3. Type C: Lightweight aggregate blocks for non-load bearing partitions.

Type A density should be 1500 kg/m^3 but for type B and C density should be less than 1500 kg/m^3 but not less than 650 kg/m^3. Figure 2.1 shows typical application of concrete block in building for basement, below ground, external wall, partition walls and suspended floor. Depending on the properties of blocks, design and construction requirements and their usage can be classified as the following (http://www.cba-blocks.org.uk/tech/datasheets/tech_datasheets.html).

1. Type A: generally used in buildings including usage below the ground level damp proof course.
2. Type B: generally used in buildings including below the ground level damp proof course and in the outer leaf of external walls.
3. Type C: primarily for internal non-load bearing wall.

2.2.1.2 Dimension of blocks and sizes

There are various dimensions of blocks are available in the market. The block dimensions very depending on popular demands among practitioners and contractor to facilitate different types of construction. BS 6073: Part 2: 1981 provided the standard format for blocks as a guideline.

2.2.1.3 Block shapes

There are variety of shapes and patterns to suit to the modern demands in construction. The typical shape of concrete block illustrated by Richard (2004). The shape names given are fairly well established by common usage in different localities. Basically, there are large numbers of shapes that can be produced from both hollow and solid from aggregate concrete rather than aerated concrete.

2.3 Shredded Powder Free Latex Gloves

Powder free latex gloves are made from natural rubber latex. Polymer latex gloves that will provide a barrier of protection from infectious organisms are an essential feature of medical practice for the protection of both patients and medical personnel. Natural rubber latex has constantly been the most satisfactory raw material for the manufacture of gloves. Certain latex proteins, carried over into the finished product by inadequate manufacturing processes, may pose a risk of provoking allergic reactions in some patients and medical workers. As with any allergy, the risk depends on the route of exposure and dosage. Hence, the methodology of manufacture, including the means used to coat gloves to make donning easy, can influence the eventual exposure of sensitive people to latex allergens.

NR products are come from *Hevea brasiliensis* latex, a milky fluid obtained by tapping the bark of *Hevea* trees. Like all plant materials, latex contains growth-related substances such as proteins, carbohydrates, and other organic and inorganic constituents. The rubber hydrocarbon particles (the elastic component sought in all NR products) comprise 25% to 45% of the latex system. The non- rubber substances constitute only a small percentage of the latex system. When subjected to ultracentrifugation at approximately 59,000 *g*, latex can be separated into 3 main fraction; top rubber hydrocarbon particle phase, ambient C-serum in which all latex particles are suspended and denser bottom fraction of non-rubber particles, particularly lutoids, which contain yet another serum (B-serum) (Yip et al., 2002).

2.4 Concrete with polymer

Turan and Gesog (2004)studied the properties of rubberized concretes containing silica fume. Two types of tire rubber, crumb rubber and tire chips, were used as fine and coarse aggregate, respectively, in the production of rubberized concrete mixtures which were obtained by partially replacing the aggregate with rubber. The results show a systematic reduction in compressive strength with the increase in rubber content for the concretes with and without silica fume.

Further, Sivakumar. M.V.N (2011) investigated the effect of polymer modification on mechanical and structural properties of concrete. In this study, two different types of polymers are used at different dosages to modify the cement concrete matrix. The experimental results evidently show that the characteristic compressive strength of polymer modified concrete increases with the increase of polymer dosage from 5% to 15%, after reaching its optimum percentage dosage around 15% it started decreasing.

In addition, Ling (2011) performed a study to predict the density and compressive strength for rubberized concrete blocks. In this study, the influence of rubber content within the range of 5–50% as the replacement for sand volume and water/cement (w/c) ratio (0.45–0.55) on the density and compressive strength of concrete blocks was investigated. The density and compressive strength of rubberized concrete blocks is affected differently depending on the rubber content and w/c ratio. If the rubber content increases in the mixture, a systematic reduction in density and compressive strength takes place. It is suggested that the rubber substitution used in concrete blocks should not exceed 10% volume for structural and 40% volume for non-structural applications.

Besides, Sutan and Mohamed (2011) was study on the effects of polymer additives namely polyvinyl acetate (PVAc) on water absorption and compressive strength of mortar. The findings from this study are PVAc mortar mixes absorbed more water than control mix. They were potentially less durable than control mortar mix. PVAc mortar mixes had the highest strength at the end of 28 days for all different w/c ratios.

Next, M. Ismail et al. (2011) was study on the behaviour of concrete with polymer additive at fresh and hardened state. Materials that had been used as an additive in concrete in this study comes from paint factory (waste latex paint). In this study state that the polymer additive does not help in enhancing the compressive strength of the concrete. Although the polymer particles have filled up the void space in the concrete, they are not totally integrated into the concrete mix. This causes the bonding between the concrete particles become weak. Besides, the water absorption of concrete is decreasing when the polymer content was increasing. This was due to the pore-blocking effect of the polymer particles (Abdulrahman.et. al., 2008). In addition, polymer is a water- impermeable material, so the polymer particles which distribute in the concrete pores will block the water to infiltrate through the concrete particles.

F. Pacheco-torgal et al. (2012) was study on the properties and durability of concrete containing polymeric waste (tyre rubber and polyethylene terephthalate bottles). This study reveals that tyre waste concrete is specially recommended for concrete structures located in areas of severe earthquake risk and also for applications submitted to severe dynamic actions like railway sleepers. This material can also be used for non-load-bearing purposes such as noise reduction barriers. Investigations about rubber waste concrete show that concrete performance is very dependent on the waste aggregates.

Diab et al. (2013) performed a study on the experimental investigation of the effect of latex solid/water ratio on latex modified co-matrix mechanical properties summarizes that compressive strength of modified concrete is improved with the increase in SBR solid/water cement ratio up to a limit of 0.20.

Besides, R. Bedi et al. (2013) was study on the mechanical properties of polymer concrete. Polymer concrete is prepared by mixing a polymeric resin with aggregate mixture. Micro fillers are also employed sometimes to fill the voids contained in the aggregate mixture. Enhancement in compressive strength up to 30% has been reported for addition of 15% fly ash (micro filler) in polymer concrete.

Moreover, Maria et al. (2015) was study on the investigation on the properties of concrete tactile paving blocks made with recycled tire rubber. In this study, concrete with replacement of 10–50% of natural sand for tire rubber reduce the compressive strength of concrete. The density of concrete containing crumb rubber tends to decrease due to lower density of rubber compared to natural aggregate. The rubber aggregated did not significantly alter the water absorption and porosity, all concrete mixes containing tires rubber had low water absorption and porosity.

Nelson Flores Medina et al. (2017) was study on mechanical and thermal properties of concrete incorporating rubber and fibres from tyre recycling. In this study, concrete compressive strength is reduced in proportion to the increase of rubber content.

Besides that, Nadrah et al. (2017) was study on fresh hardened state of polymer modified concrete summarizes that the utilization of polymer waste micronized poly ethylene vinyl acetate (EVA) in mortar. Though the compressive strength decreased due to the application, EVA waste contributed to producing more lightweight floor. This lightweight characteristic is due to the rises in void index through the use of EVA waste. Besides, this also contributed to noise attenuation transmitted through the floors and offer better acoustic comfort for residents if used inside a building.

Wang et al. (2018) performed a study on the influence of polymer latex on the setting time, mechanical properties and durability of calcium sulfoaluminate cement mortar. In this study, three different types of polymer latexes (styrene butadiene rubber (SBR), styrene acrylic ester (SAE) and polyacrylic ester (PAE)) with three different dosages (0%, 10% and 20%) were employed to prepare polymer latex modified calcium sulfoaluminate (CSA) cement mortar based on the same workability. Polymer latex tends to reduce water demand of CSA cement mortar. The water-reduction rate is markedly increased when the polymer to cement ratio is increased from 10% to 20%. Among these three polymer latexes, SAE latex has the lowest water-reducing rate while SBR latex shows similar water-reducing rate as PAE latex. Addition of polymer latex decreases strength when subjected to extreme conditions.

Andayani et al. (2018) was study on copolymer natural latex in concrete: dynamic evaluation through energy dissipation of polymer modified concrete summarizes the polymers interaction gave positive and negative effect to concrete properties. Types of polymers affect the concrete properties.

Also, N F Ariffin et al. (2018) was study on mechanical properties of polymer-modified porous concrete summarizes that Use of the polymer latex and redispersible polymer powder could produce acceptable porous concrete with adequate strength properties and water permeability. Strength properties of polymer-modified porous concretes are significantly improved by the polymer modification and There is no significant change in void ratio of polymer-modified porous concretes compared to unmodified (normal) porous concrete. That means without changing void ratio of porous concrete, the strength can be improved by the polymer-modification. Polymer powder show high compressive strength than liquid polymer and coefficient of permeability is directly proportional to void ratio.

Finally, Hameed and Hamza (2019) was study on the characteristics of polymer concrete produced from wasted construction materials summarizes the polymer concrete (PC) produced from unsaturated polyester (UP) has better properties than the other one which was prepared ordinary Portland cement. Bulk density results show decreasing the values with increasing the percentage of the added polymer resin for the all types of aggregates. The results of tests under work show increasing the values of these mechanical properties with increasing the percentage of polymer resin were added to the all types of aggregates. Also, it can be concluded that the prepared mortars could be used as precast have good properties with low cost.

CHAPTER 3

MATERIALS AND EXPERIMENTAL DETAILS

3.1 Overview

In this chapter 3 will describes the method that will be done to accomplish the objectives of this research as stated in chapter 1. The steps of preparing the sample of concrete block with polymer latex and conventional concrete block will be discussed further. The testing methods that will be followed for all the tests are in accordance to the American Society for Testing and Materials (ASTM), British Standard (BS) and International Organization of Standardization (ISO) test procedures.

3.2 Experimental Design

Flow chart of research methodology and testing that going to be done will be presented in Figure 3.1.

3.3 Materials

The materials that have been used to produce concrete block with polymer latex and the conventional concrete block in this research are:

i. Ordinary Portland Cement (OPC)

ii. River Sand

iii. Water

iv. Shredded Polymer Latex

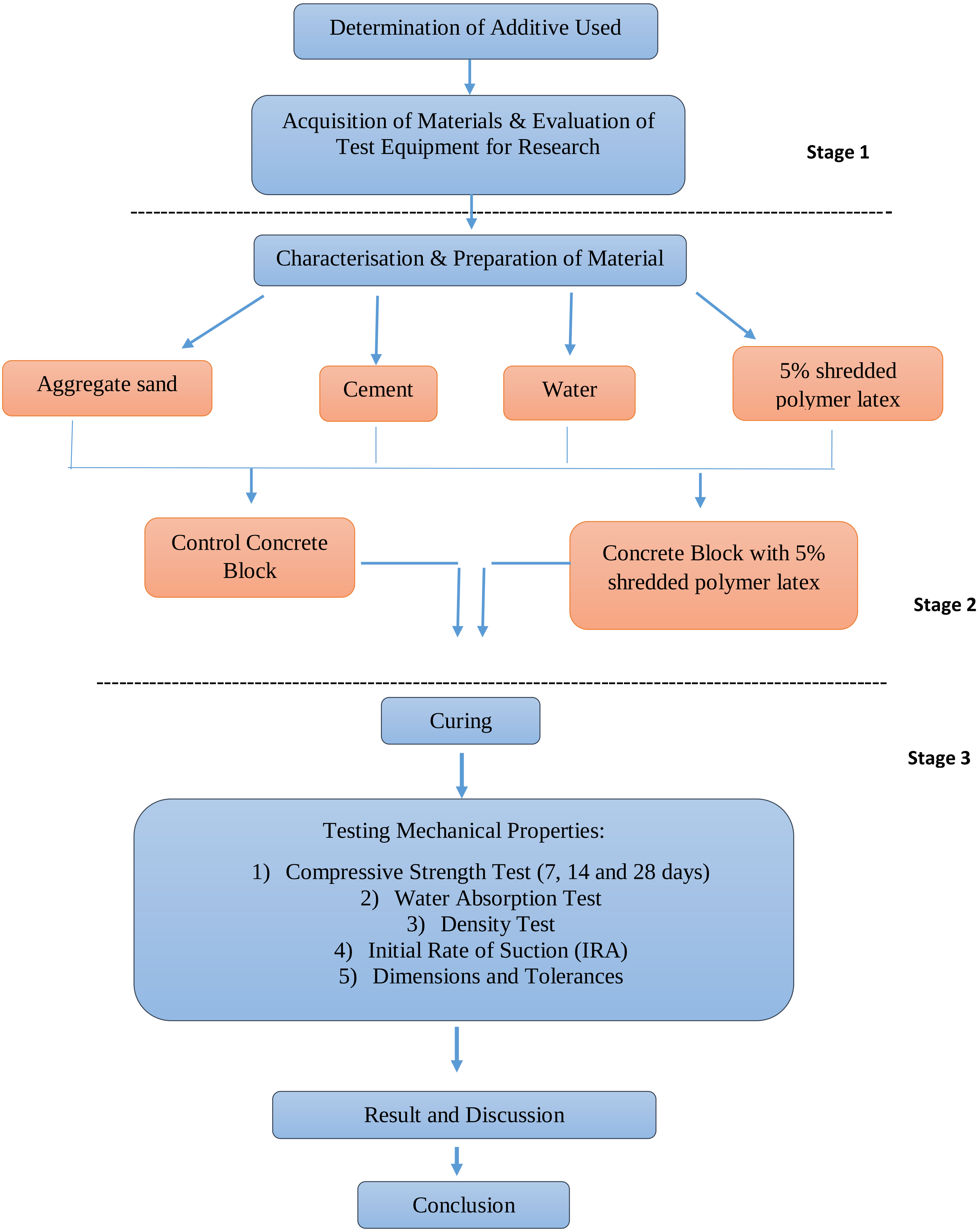

Figure 3.1: Flow chart of research methodology

3.3.1 Ordinary Portland Cement

Cement is a material with adhesive and cohesive properties or any material that binds or unites sand and coarse aggregate which is essentially like glue. Besides, cement fill voids in between sand and coarse aggregate particle to form a compact mass. Ordinary Portland Cement (OPC) as shown in Figure 3.2 was used as binder for this research which conformed to BS EN 197-1. This OPC was manufactured by Tasek Corporation Berhad. The cement should not exceed three months of storage after production.

Figure 3.2: Ordinary Portland Cement

3.3.2 River Sand

Natural river sand as shown in Figure 3.3 was used as fine aggregate in concrete mix to produce concrete block in this research. The sand was washed using water in order to remove clay, silt and other impurities. The fine aggregate complied with the requirement of ASTM C136 (ASTM, 1996b), with specific gravity of 2.62, water absorption of 0.6% and fineness modulus of 3.3.

Figure 3.3: River sand

3.3.3 Water

In this research, tap water was used to produce concrete block. Tap water sourced from domestic water supply available in the concrete laboratory was used to mix concrete throughout this investigation.

3.3.4 Shredded Polymer Latex

PFLG as shown in Figure 3.4 were dried until the surface of each glove completely dry. After that, PFLG was shredded until it become half powder. PFLG was shredded by using shredder machine.

Figure 3.4: Shredded PLFG

3.4 Mix Proportions

Table 3.1 shows two types of mixes which are conventional concrete block and concrete block with shredded polymer latex glove. Conventional concrete block is designed with normal procedure while concrete block with polymer is designed by replacing partial shredded polymer latex with natural fine aggregate which is river sand.

Table 3.1 Mix proportion of the concrete block

Mix	Batched Quantity			
	OPC (kg)	Water (Litre)	River Sand (kg)	Polymer Latex(Litre)
Control concrete block	1	1	6	0
Polymer latex concrete block	1	1	5.8	0.2

3.5 Mixing, Casting and Curing

Procedure how to preparing mixing, casting the mixing into concrete block, and curing process also will be explained in this section.

3.5.1 Samples Preparation

The sample needed for each type of concrete block mixes is 18 block with dimension length × width × depth is 40 cm × 9.5 cm × 20 cm for compressive strength test, water absorption, density, initial rate of suction (IRA) and dimensions and tolerances. The total numbers of samples for each test are provided in Table 3.2.

Table 3.2 Total number of concrete block each test

Mix	Compressive strength test	Water absorption	Initial rate suction	Density test and dimension and tolerances
Control Concrete Block	9	3	3	3
Polymer Latex Concrete Block	9	3	3	3

3.5.2 Mixing

Mixing process of control concrete block was started with pouring sand and cement into concrete mixer in dry condition for 2 minutes as shown in Figure 3.5. Next, water was added part by part and continued mixing for 10-15 minutes. For polymer latex concrete block, the process started with pouring the sand and cement into the concrete mixer. After that, 5% of shredded PFLG was added into the mix. Next, water was added part by part for 10-15 minutes. In this mix, dry mix was used to produce concrete block.

Figure 3.5: Dry mixing of concrete prior to addition of water

3.5.3 Casting and Curing

The fresh mix was cast into the mould as shown in Figure 3.6. Then, the sample was left 24 hours for hardening process and demoulded on the next day. All the blocks were cured in curing room as shown in Figure 3.7 after the first day of production until the testing date.

Figure 3.6 Casting of concrete block

Figure 3.7: Concrete block sample under curing

3.6 Testing Procedures

This section discusses about the testing procedures and method used to test the concrete block sample to obtain the required data and information for further analysis. This test was carried out to determine the mechanical properties of block in this research work such as compressive strength, water absorption, initial rate of suction and etc.

3.6.1 Compressive Strength Test

The most important part in concrete is the compressive strength which represents the overriding factor of concrete performance. Neville and Brooks, (1993) stated that the major factors influencing concrete strength are water/cement ratio, degree of compaction, age and temperature. However, other factors also affect strength such as aggregate/cement ratio and also the quality of the aggregate in terms of grading.

The sample was tested at age of 7, 14 and 28 days. Before testing was carried out, the samples were immersed in water for not less than 24 hours. The main objective of immersing the block in the water at room temperature is to reach the minimum value of the strength in the weakest state. Five minutes were needed to remove and to allow water to drain and then the sample was wiped off. Concrete block was tested by using compression machine as shown in Figure 3.8. The sample was placed at the centre of the bearing surface. The maximum load applied on the sample measured by the testing machine will be recorded. The compressive strength of the sample was calculated based on the Equation 3.1 below.

$$f_m = \frac{P}{A} \qquad \text{………….. Equation 3.1}$$

Where,

fm = Compressive Strength (MPa)

P = Maximum Load (kN)

A = Surface Area of applied load (m^2)

Figure 3.8: Compressive strength testing machine

3.6.2 Water Absorption

Water absorption test was conducted to measure the quantity of water absorbed. The concrete block sample was tested at 28 days. Two alternative standard methods were specified in MS 76:1972; the 5-hour boiling test and the vacuum test. In this study, the 5-hour boiling test were adopted. Before the test were conducted, concrete block was dried at least for 48 hours at 110°C. The concrete block the was then cooled to room temperature and weighed.

The concrete block was placed into a water tank as shown in Figure 3.9 and heated up to one hour and continuously to be boiled for 5 hours. The concrete block was cooled to room temperature by natural loss of heat which was not less than 16 hours or not more than 19 hours. The concrete block was removed and the surface was wiped with a damp cloth. Within two minutes after its removal from water, the concrete block should be weighed.

For control tests, MS76:1972 prescribed 24-hour cold immersion test. However, the results obtained by this method always lower than the standard method which was mentioned earlier. Amount of water absorption in percentage was calculated using Equation 3.2.

$$\text{Water absorption,\%} = 100\left(\frac{wetmass - drymass}{drymass}\right) \qquad \text{.......Equation 3.2}$$

Figure 3.9: Boiling water absorption testing machine