COMPRESSIVE STRENGTH OF CONCRETE USING GLASS POWDER AS A FILLER REPLACEMENT

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ABSTRACT

A lot of researches have been done to improve the quality of concrete that can be used in long term period and design a more economic concrete for the construction. Using waste glass as a construction material is a good way to help the environment. The purpose of this study focused on the physical properties of concrete in terms of workability and compressive strength after added the glass powder as a sand replacement. 27 samples of concrete including control samples were prepared for this study. Concrete were designed based on grade 30 at a 28 days and water cement ratio is 0.55. Glass powder was used as a replacement material for sand in proportion 10 % and 20 %. Control samples are used as a guide and the result will be compared with the data of control samples. The average result of slump test for control samples is 30 mm in a range 30-60 mm. The average value of compression test for control samples is 34.10 N/mm^2 at a 28 days and it's achieve the target value for concrete grade 30. The experimental results are compared with the control samples have the lower strength with the increasing of the glass powder that replace in sand. Average workability value for samples 10 % and 20 % is 115 mm and 120 mm respectively which is the higher workability. Concrete utilizing glass powder demonstrated a higher mod failure pattern with the lower strength that may caused from the Alkali Silica Reaction in concrete.

ABSTRAK

Banyak kajian telah dilakukan untuk menaikkan kualiti konkrit yang boleh digunakan dalam tempoh jangka masa yang lama. Dengan menggunakan kaca sebagai bahan terbuang adalah cara yang baik untuk membantu alam sekitar. Kajian ini dijalankan bertujuan untuk mengetahui sifat fizikal konkrit dengan menggunakan serbuk kaca sebagai pasir terhadap kebolehkerjaan dan kekuatan konkrit. Sebanyak 27 buah sampel telah disediakan dalam kajian ini. Konkrit telah direkabentuk mengikut gred 30 pada umur 28 hari dengan nisbah air simen sebanyak 0.55. Serbuk kaca digunakan sebagai bahan pengganti pasir dalam peratusan 10 % dan 20 %. Sampel kawalan digunakan sebagai panduan dan keputusan yang diperolehi akan dibandingkan dengan sampel kawalan tersebut. Purata ujian penurunan untuk sampel kawalan pula ialah 30mm di mana ia berada dalam lingkungan penurunan yang telah dihadkan sebanyak 30-60mm. Nilai purata kekuatan mampatan sampel kawalan pula ialah 34.10 N/mm^2 pada umur 28 hari dan ini menunjukkan telah mencapat gred 30. Hasil eksperimen menunjukan pertambahan jumlah serbuk kaca yang diganti dalam pasir adalah berkurang dibandingkan dengan sampel kawalan. Purata kebolehkerjaan untuk sampel 10 % dan 20 % adalah 115 mm dan 120 mm masing-masing adalah kebolehkerjaan yang tinggi. Konkit menggunakan serbuk kaca menunjukkan corak mod kegagalan yang lebih tinggi dengan kekuatan lebih rendah yang mungkin disebabkan dari tindak balas alkali silikat dalam konkrit.

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CHAPTER 1

PREFACE

1.1 Introduction

Concrete is an artificially engineered material that formed from combining aggregates such as sand or gravel that is bonded together by Portland cement and water. It is the most commonly used for construction material. It is strong, cheap and durable. Furthermore, if using the waste material for concrete construction will give advantageous as the production cost will cheaper.

The glass powder was selected as a filler replacement in concrete because of it contain a type of cement that called "pozzolan cement" which according to Neville (1995) The characteristics of glass powder is a lightweight and their properties have a good beneficial in concrete mixing such as its high mechanical strength, low water absorption and high chemical and frost resistance. Regarding the use of glass in concrete from the previous research, the chemical reaction between the silica glass particles and the alkalies present in the concrete may cause the Alkali Silica Reaction (ASR) to occur. It will give implication of the surface cracking because of the results, there will be form a gel and increase the volume as it absorbs water, expands and therefore exerts internal pressures. The long term implication may cause the loss of strength. So, preventative actions could be achieved in the concrete mix at appropriate proportions and to lowering the cracks that resulting from the

ASR by incorporating of pozzolonic material such as fly ash, silica fume, or ground blast furnace slag.

1.2 Research Background

Pozzolanic materials are often found in concrete mixes as the hardness of the concrete is fully hydrated then combined with calcium hydroxide that called pozzolanic reaction. However, water is essential for pozzolanic reaction to occur and form secondary C-S-H gel. Furthermore, the finely glass powder particle also contain the pozzolanic characteristics when mixed with Ordinary Portland Cement (OPC) that have a properties of the cementing material.

Researches perform from Bazant et al. (1998) determining that glass particle size that caused the expansion for 1.5 mm, whereas particles < 0.25 mm caused no expansion on concrete. Further studies performed by Jin, Meyer and Baxter (2000) found that glass particles and the increasing the quantity of glass effect on ASR to occur. They found that when glass particles formed 100 % of the aggregate the largest expansion occurred. The green glass that containing more than 1.0 % chromium oxide had a beneficial suppressive effect on ASR. According from Carpeneter and Cramer (1999), powdered glass was effective in reducing ASR expansion in accelerated mortar bar tests, similar to the effects of other pozzolanic materials like fly ash, silica fume and slag. From research that performed by Shayan and Xu, (1998), shown that concrete mixes using glass as fine and coarse aggregate could suppress the ASR expansion that caused by natural reactive aggregates and coarse glass particles itself.

In the previous research, there were proving that glass could be used in concrete in three forms, as coarse and fine aggregate, and in powder form. The coarse and fine glass aggregates could cause ASR in concrete because of the size of pieces and particle that attributes to a larger surface area and made it contact with the

alkaline cement, but the glass powder could suppress their ASR tendency, that similar to supplementary cementitious materials (SCMs).

1.3 Problem Statement

It is to present invention to provide a glass material suitable for use in concrete that does not absorb water and which may be fabricated as having a small particle size, thereby allowing its use as a replacement to larger porous rocks and sand and which minimizes ASR within the resultant cement product.

1.4 Objective of the Study

The main objectives of the study are to check the compressive strength of conventional concrete due to different percentation of glass powder replacement within the different curing age.

The size of aggregate will give influence for the strength of the concrete. Using the glass powder as a filler replacement in sand, it also influence the workability when added more glass powder, the workability is increasing but later it will decreases because of the alkali silica reaction occur during the curing age increases.

1.5 Scope of Study

The study will focus on determining the value of concrete strength with the size recommended by previous research and workability as well when used the glass powder as replacement for sand. 27 samples of cube including the control sample will be prepared.

For at least three differ mixture sample as a proportion 0 %,10 % and 20 % replacement of the glass powder were tested after 7,28 and 56 days of curing. To gain of the early strength, 7 days compressive strength test results are often used and they are estimated to be about 64 % to 70 % of the 28 days strength. 28-day test results for a normal concrete structure are adopted as the concrete mixing were get strength follow the grade mix design and achieve the target value. However, to produce high strength concrete, compressive strengths based on 56 or 91 days compression test results are commonly used instead. Moreover, with later ages of test results, other cementing materials can be incorporated into the concrete mixture which improves the durability of concrete in terms of heat generation in hydration and also increase the strength.

1.6 Expected Outcomes

This study was conducted the strength of concrete depend on the particle size of filler. Use as glass powder as filler, which is very fine particle. This research should increase the strength of concrete in term due to different percentage of glass dust replacement. The uses of waste glass in concrete in several forms, including fine aggregate, coarse aggregate and glass powder hope will give a great potential to prevent expansive ASR in the presence susceptible aggregate. The important of the study is to use the recycle material or waste material as will give benefit and significant to the society and environment. The waste material also can give benefit in construction which the glass powder as filler will also can decrease the pollution of the environment.

1.7 Conclusion

This chapter was introduced about the using of glass powder in concrete. Based from the previous research, the glass powder have the properties that need to be consider for gain the strength, improved the workability and durability. From that

problem, it needs to investigate what the factor that influences for the physical properties. The objective is for compare the compressive strength with the different percentage replacement of glass powder. By the objective, the scope of study as a guide to fulfill the research objective is achieved. So, the research need to be done based from the scope of study and the result as the expected outcome when added the glass powder will gain the increasing strength compared with the control concrete

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Since the increasing demand on building materials in the last decade, and the increasing of the waste material, it will give opportunity for the civil engineers to convert the industrial wastes into useful building and construction materials. In addition to the use of binder replacement materials from waste, the glass is considered to be a material which could be used as binder and also as aggregate replacement. This study outlines the physical properties when use of glass powder as a sand replacement and give influence for their performance in workability also the strength.

2.2 Glass as aggregate for concrete

Recent studies, the use of glass in concrete as a replacement in aggregate may cause the excessive expansion (Shao et al, 2000, Johnson, 1974) then make the concrete cracking. It is because of the chemical reaction that takes place between the silica-rich glasses that produce the ASR reaction occur Karamberi & Moutsatsou, (2005). It depends on particle size of glass that will give influence for the factor that ASR reaction to occur. To induced expansion for reduce the ASR, use the particle size 300 μm or smaller (Meyer et al.1996).

Besides that, from the research by Ahmad Shayan and Xu's, it proves that the glass is suitable use to mix with concrete whether to replace in coarse or fine aggregate. In this research, the additives material such as fly ash as well as superplasticizer be used to ensure the strength and improve the workability.

According from G.D Perkins research, the concrete that containing glass as a fine aggregate can achieve the good strength to that natural sand aggregate. It compare with the control concrete at 28 days achieved a compressive strength of 49.1N/mm^2, whereas the concrete containing glass aggregate achieved a compressive strength of49.5N/mm^2. It can conclude that the glass is suitable material for use as 100% replacement for fine aggregate.

2.2.1 Glass

There are many types of glass that make the glass different from each other because of the different in physical and chemical properties. All waste glass may be used as a fine aggregate substitute in concrete according from specific glass waste materials. Sheet Glass Powder (SGP) is using in concrete for the green environment also conservation of natural resources and it give benefit for economy as the waste material reported by Mageswan and Vidivelli (2010). The applications that already use waste glass concrete are footpaths, bike paths and similar non-structural work. To prevent the problems due to alkali silica reaction between cement paste and glass aggregate, clean glass aggregate in concrete must be used which for a long time the concrete can lead to weakened and decrease the durability.

The glass from green bottles tends to reduce ASR because of the chemical properties from the chromium oxide, as specified by Bluemenstyk (2003). Milled waste glass use as a cement replacement gain the higher strength as a result of formation a denser microstructure based from the research Nassar and Soroushian (2011).

2.3 Pozzolan

According to the Neville ("Properties of Concrete",1995) the glass dust was selected as a filler replacement in concrete because it contain a type of cement that called pozzolan. Gordon and Breach Publisher(1996) state that a pozzolan in defined as a siliceous of aluminious material, which in themselves possesses little or no cementing property, but will in a finely divided form in the presence of moisture, these material can react with calcium hydroxide of concrete at ordinary temperatures to form compounds of cementitious properties. This reaction is called pozzolanic reaction. The pozzolanic reaction only occur when the availability of calcium hydroxide that been produced through the hydration process. However, the water is important for pozzolanic reaction to occur and that may form secondary C-S-H gel. Therefore, water curing is essential to ensure the hydration process become fast to create a large amount of lime for the occurrence of pozzolanic reaction as well. The benefit of formation the additional C-S-H gel, that would fill the existing voids in concrete thus make the concrete denser. Furthermore, the amount of CaOH may reduce during this pozzolonic reaction, which is vulnerable to aggressive environment then improves the durability of concrete and finally increases the strength.

In a hardened concrete without pozzolans, the lime that produced from the cement will slowly react with the aggregate, producing gels. These gels are expansive, and it fill the voids with a lower pressure thus avoiding water penetration and leaching. When too large a volume of gels form after the concrete has hardened, the lime that produced only react with the aggregate that only have small total surface area, it give the possible pressure increase and slow destruction of the concrete. So, to ensure the gels are formed before the hardening, the pozzolan has to very fine. From the researcher Yixin Shao, Thibaut Lefort, Shylesh Moras and Damian Rodriguez, the glass having a particle size finer than 38 μm did exhibit a

pozzolanic behavior that led the higher reactivity with lime then give the higher compressive strength in concrete also lower expansion.

2.4 ASR (Alkali Silicate Reaction)

The problem of ASR is not restricted to glass aggregate concrete. According to the definition of ACI Committee 116, it can occur also in conventional concrete, if the aggregate contains certain siliceous rocks and minerals. However, deleterious alkali-silica reaction (ASR) might occur in glass concrete due to its high silica constituent. ASR is caused by an internal chemical reaction between the alkalies present in the concrete and certain forms of silica found in concrete aggregates. It may cause the severe deterioration of a structure by expansion of the concrete and may cause the concrete to crack. It happen because of this reaction form a gel which the volume is increases as it absorb water. Then the expansion creates an additional of pressures which the results in failure if it left without reinforcement. Some solutions have been formed to reducing ASR as the precautionary methods in order for provide stability to new concrete mix that use glass for the lessen the cracking, but these solutions have some limitations which made it still particularly important to investigate the utilisation of glass in concrete.

2.5 Compressive Strength

Compressive strength defined as the measured maximum resistance of a concrete specimen from axial loading. The compression strength test is the most familiar test and is used as the standard method of measuring compressive strength for quality control purposes by Neville (1994).The concrete strength is proportional with ground glass size reported by Zdenek et.al. (2000) and typically controlled by the bond strength between cement and aggregate. According from Meyer et.al, to achieve the higher strength, use the size below 45 μm glass which is the pozzolanic reactivity. The strength decreases as the size of particle is increases.

For increase the strength of concrete, use the low water cement ratio and requires the use of superplasticizers as additives. It also may improve the workability of concrete, control rate of hardening also improved durability.

2.6 Conclusion

From that article, it can be conclude that the glass contain silica properties may cause the cracking because of the reaction of Alkali Silica Reaction (ASR). The ASR cannot to avoid but it will reduce with use finer aggregate to be form as pozzolanic material that may bind together with cement, for lowering of crack then it will gain the high strength because of the reduce of CaOH that already use during the pozzolanic reaction, and also improve the durability of concrete. The workability of concrete that contain glass powder may increase because of the properties of glass that low absorb water and for improve the workability use the additives such as fly ash.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will discuss in detail the activities and planning of necessary work in carrying out the experimental work and laboratory test to achieve the objective as set in this project. The main objective is to check the compressive strength of concrete using glass dust as a filler replacement due to different percentage. The process of sample preparation according to British Standard 8110:1995. Comparison of sample concrete will be made with the control concrete by the grade 30 at age 28 days.

To achieve objective and goals, all activities that carried out must have thorough a planning. For this study, the flows of activities involved are as shown in Figure 3.1.

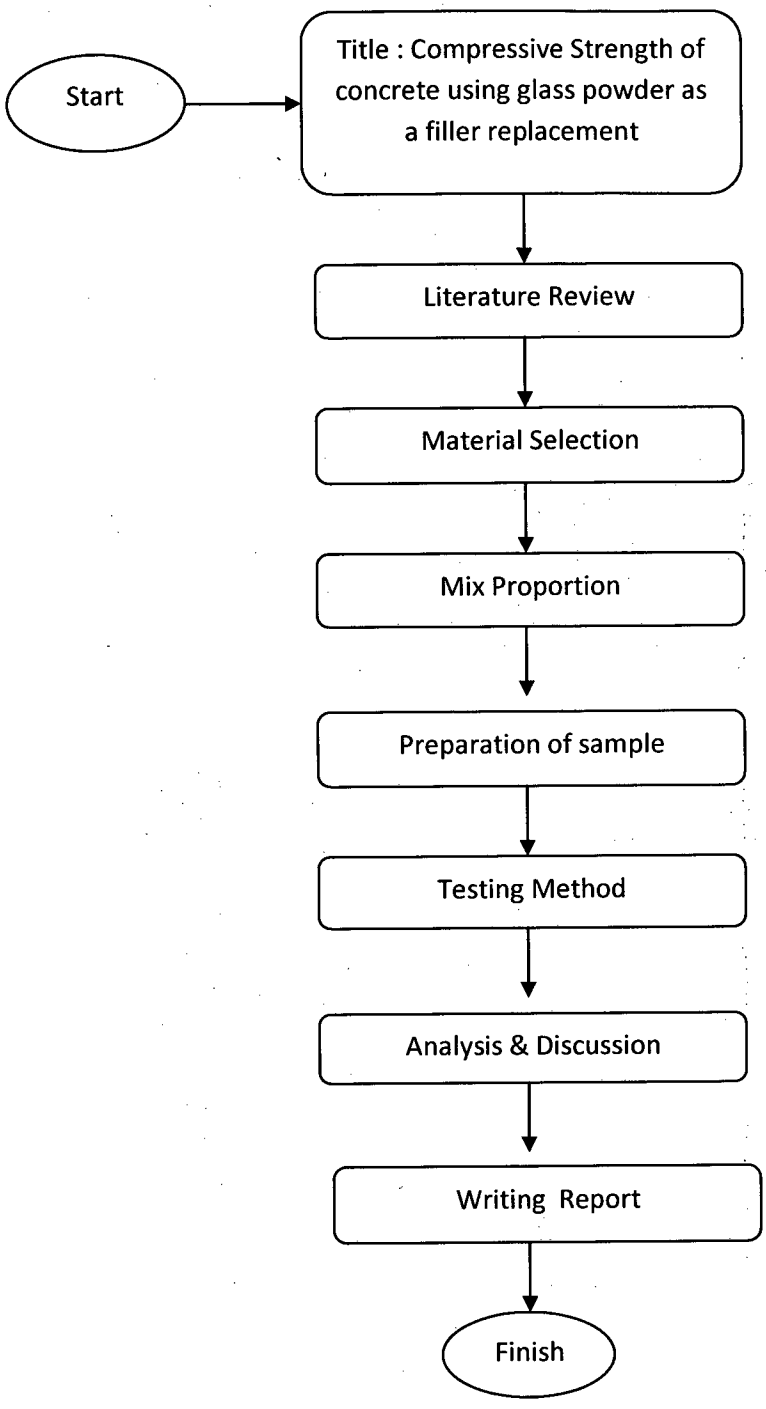

Figure 3.1: Flowchart of Project

To determine of this objective achieve, the laboratory testing should be done as show in Table 3.1 that involves three types of tests which will be carried out upon the completing of this study.

Table 3.1: Different Types of Test Conducted in the Project

Category of Test	**Types of Test**
Aggregate Test	Sieve Analysis
Fresh Concrete Test	Slump Test
Hardened Concrete Test	Compressive Strength Test

3.2 Materials and Instrument

The materials may be used in this research is cement as raw material, fine aggregate and water. Then the important material is a waste material which is glass powder. The instrument to do the testing is compression test machine because need to check the compressive strength. The research will be done in laboratory UMP.

3.2.1 Portland Cement

There is a variety of Portland cement currently available in the market. In this project, ordinary Portland cement is chosen to produce concrete. This is because this kind of cement is widely used; furthermore, ordinary Portland cement is readily available in the laboratory. Cement is cohesive upon mixing with water. It is a binder to bind the coarse aggregate as well as fine aggregate so as to produce quality concrete.

3.2.2 Coarse Aggregate

Fine aggregate is readily available in the laboratory. Before it can be used in concrete mixing, it has to be cleaned from any impurities and organic matter which might later affect the properties of the hardened concrete. It also needs to be sieved so as to obtain the particle size distribution. As in this project, the aggregate size required is of 20mm.

To obtain a quality mix concrete, the aggregate used should not be having in access of water. It should be in the saturated surface dry stage so that the amount of water used in mixing concrete can cater the hydration process of cement properly, thus the producing a denser and stronger concrete.

3.2.3 Fine Aggregate

Fine aggregate as used in concrete normally refer to sand. It is a filler replacement in a sample of concrete mix to fill up all possible voids which appear in the mix. This result in a denser concrete, thus when the concrete hardened, it gives higher compressive strength. Fine aggregate before added to produce a concrete mix also need to be sieved to ensure the uniformity of the particle size.

3.2.4 Glass Powder

Glass powder is a pozzolanic material that may use as a filler replacement in concrete. As glass powder generally increases the strength and workability of concrete which use the fine particle size of glass dust. The type of glass powder is from waste material. Figure 3.2 show the glass powder that used for this research.

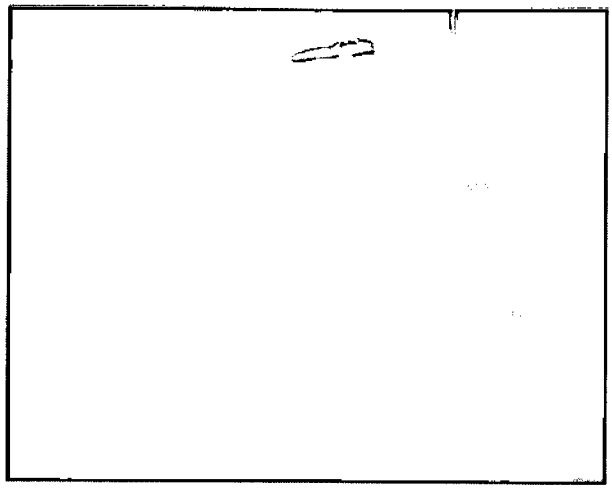

Figure 3.2: Glass powder

3.2.5 Water

Water play major role in the mixes and any particle or contaminant in the water must avoid. Water in concrete is needed to initiate the cohesive properties of the binder Portland cement through hydration process. It is important to have sufficient water but not excessive or insufficient water used in mixing concrete. This is because insufficient water results in incomplete hydration process of the Portland cement in forming Calcium Hydrate gel (C-S-H gel). And in the presence of excessive water, the hardened concrete will lose its strength. Tap water is chosen to mix the concrete where the quality is accordance MS28:1985 or BS 314 8:1959 has been specified by the Public Work Department of Malaysia.

3.3 Concrete Mix Design

Design of concrete is most importance in obtaining the desire strength. In this project will be designed to achieve Grade 30 using the British method of concrete mix design. Size of each cube sample will be of (150 x 150 x 150) mm and the procedure for the concrete mix design was attached in Appendix A.

3.4 Concrete Mix Proportion

Mix design of concrete is very important in order to produce a batch of concrete. Properties of compressive strength and workability can be altered through the design process. The concrete mix proportion of cement:sand:coarse: 1:1:2 was considered. A concrete mix with different proportions of glass powder ranging from 0 % (for the control mix), 10 % and 20 % need consider to observed the effect of glass powder on the mechanical properties of concrete. The slump of the fresh concrete need to determine to ensure that it would be within design value (30-60 mm) and to study the effect of glass powder replacement on the workability of concrete. The specimens demould after 24h, cure in water and then test at room temperature with the require age.

3.5 Laboratory Testing

The tests that involved in this project are sieve analysis, slump test and compressive strength test.

3.5.1 Sieve Analysis

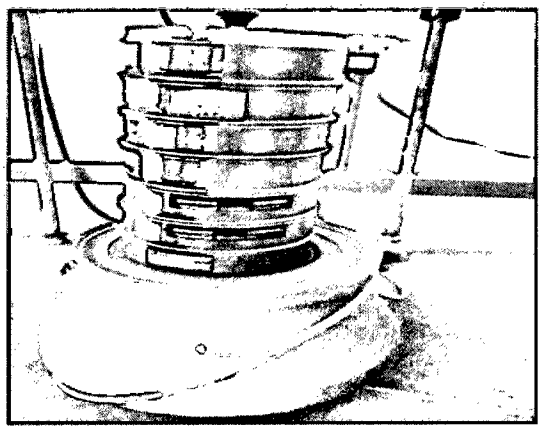

Figure 3.3: Mechanical Sieve Shaker