THE EFFECT OF WASTE WASH WATER ON CONCRETE PROPERTIES

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ABSTRACT

Recycling is the act of processing the used material to create new product. The usage of tap water is getting more intense with the advanced development in manufactory industry included in concrete ready mix plant. In order to reduce the tap water consumption, waste wash water can be used as substitute in concrete mixture. Normally, in concrete ready-mixed plant they using 700 to 1300 liters of tap water to wash the truck after delivery the concrete in every day. Therefore, new alternative to recycle and reuse the waste wash water is important to avoid the environmental problem and wastage. Several researches have been developed a new way to reuse this water in concrete and it was found that the use waste wash water in the concrete mix is a possible. It was shown certain properties of concrete have been improved and there is no adverse effect to the concrete quality. In this study, wash water is used as a replacement of tap water in order to study the concrete compressive strength and it micro properties. Tests conducted by 100% replacing the tap water with waste wash water in concrete mixture. It was shown, the using of waste wash water has improved performance of concrete in terms of concrete strength, water absorption and porosity.

ABSTRAK

Kitar semula merupakan pemprosesan bahan terpakai untuk dijadikan produk baru. Penggunaan air dirawat (air paip) semakin hari semakin meningkat dengan kemajuan di dalam semua bidang. Untuk mengurangkan penggunaan air paip, air kitar semula boleh digunakan sebagai bahan gantian. Kilang bancuhan konkrit memerlukan 700 hingga 1300 litter air setiap hari untuk membasuh lori bancuhan konkrit yang digunakan bagi menghantar konkrit. Oleh itu, penggunaan semula air basuhan ini adalah perlu bagi mengelakkan ianya menjadi pembaziran dan masalah alam sekitar. Keadaan menjadi lebih teruk apabila air basuhan tersebut terus disalurkan ke dalam saliran tanpa rawatan. Beberapa penyelidikan telah dijalankan untuk mengkaji penggunaan semula dan mendapati bahawa penggunaan air basuhan dalam konkrit tidak menurunkan kualiti konkrit malah memperbaiki ciri-ciri kejuruteraan konkrit. Dalam kajian ini air basuhan digunakan sebagai penggantian air paip untuk mengkaji kesannya terhadap kekuatan mampatan dan kesan terhadap 'microstructure' konkrit. Ujian dilakukan dengan penggantian air basuhan dengan nilai yang sama iaitu 100% penggantian. Kajian mendapati bahawa penggunaan air basuhan ini meningkatkan prestasi konkrit dari segi kekuatan konkrit, resapan air dan pengurangan jumlah liang udara.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Malaysia is one of the developing countries. During this era of globalization, there are a lot of extreme construction works all over the world. Nowadays, the environmental pollution in Malaysia is increased same as the development of our country. As a Malaysian, to make sure that our environment is safe for all citizens and also the development of our country will go on as usual, something must be done in order to overcome and fixed this problem before it become more critical.

It has been calculated that about 9-m^3 ready-mixed concrete truck contains, at the end of each working day, approximately 200–400 kg of returned plastic concrete. this material can be left overnight in the truck with the addition of hydration control admixtures or washed out. When washed out, with the addition of about 700–1300 L of water, the material can be mechanically separated into aggregates ready for reuse and water containing amounts of suspended fine particles. Consequently, partial and complete recycle of waste wash water are usually adopted in the manufacturing plants. By the former method, water is collected in sedimentation basins: hence, clarified water is reused in the production, while sediment must be disposed of in authorized landfills; on the contrary, full recycle represents an environmentally safe and cheap procedure, because wash water is totally reused as mixing water in the production and no disposal procedure is involved. Therefore, I choose this title " Waste wash water recycling in ready-mixed concrete plants" for my thesis. For me to reuse water from the plant can reduce water wastage and in this way can also safe environment.

1.2 Problem statement

after daily work, employees need water to 150 to 300 gallons of clean water to wash the concrete truck drum and wash water allowed to flow directly into rivers. in this way can lead to wastage. if no action determination, residual moisture will cause pollution that can affect the health of people, plants and animals near the area

1.3 Objectives of study

The objectives of the study are:

i. To study properties of wash water in ready-mixed concrete plants.

ii. To study the effect of waste wash water from ready-mixed concrete plants in concrete microstructure.

iii. To study compression behavior of concrete by using waste wash water.

1.4 Scope of study

Scopes of this study include the following procedures:

i. waste wash water is a key ingredient in this study. Waste water were taken from three plants in the Kuantan. Waste wash water is used 100% in the mixture without addition with other types of water. Mixture containing with waste wash water compared with distilled water and tap water

ii. 50 x 50 x 50 of mould is used to form a cube. everything will be done at FKASA laboratory UMP.

1.5 Significant of study

The experimental study conducted is a step towards the new mixture by using waste wash water. The mixture shall be in construction industry and will create a new environment which help in reduce pollution from waste wash water.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In the concrete mix, there are four of the most important, namely cement, sand, aggregate and water. Water is also used to wash the concrete truck after finished delivery the concrete. Water used for washing the concrete trucks allowed to flow directly into rivers without any treatment and some of concrete plant have are individual pond but not used or treated the water. Waste wash water or may be known as water from concrete production operations (CPO) – water recovered from processes of hydraulic cement concrete production that includes wash water from mixers or water that was part of a concrete mixture and water that contains quantities of concrete ingredients. The pH value for the waste wash water is above 11, this indicates a high content of alkali in waste wash water. Alkali content in the waste wash water depends on the products manufactured by the factory. The water will be used in this study

2.2 Requirement of quality water in concrete production

Quality of water for mixing and curing concrete indicates that relatively few investigations on this subject have been conducted. It seems to have been generally agreed that water fit to drink was fit to use in concrete mixing, and even fewer limitations were applicable to curing-water quality. Waterways Experiment Station to determine the effects of pH values of water on the strength of concrete and the staining properties of elements found in water. It was found that various contaminants can render distilled water unfit for mixing or curing concrete. It is also indicated that pH does not provide a basis for specifying quality of mixing water. (Mather ,Bryant ; Tye,R. V. 1956)

Excessive impurities in mixing water not only may affect setting time and concrete strength, but also may cause efflorescence, staining, corrosion of reinforcement, volume instability, and reduced durability. Specifications usually set limits on chlorides, sulfates, alkalis, and solids in mixing water unless tests can be performed to determine the effect the impurity has on various properties. A continuous gradation of particle sizes is desirable for efficient use of the paste. In addition, aggregates should be clean and free from any matter that might affect the quality of the concrete. (B.Chatveera and Lertwattanaruk, 2007)

2.3 Effect of water on concrete

Combining water with a cementations material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and allows it to flow more freely.Less water in the cement paste will yield a stronger, more durable concrete; more water will give an free-flowing concrete with a higher slump.Impure water used to make concrete can cause problems when setting or in causing premature failure of the structure.Hydration involves many different reactions, often occurring at the same time. As the reactions proceed, the products of the cement hydration process gradually bond together the individual sand and gravel particles, and other components of the concrete, to form a solid mass.

Reaction:

Cement chemist notation: $C_3S + H \rightarrow C\text{-}S\text{-}H + CH$

Standard notation: $Ca_3SiO_5 + H_2O \rightarrow (CaO)\cdot(SiO_2)\cdot(H_2O)(gel) + Ca(OH)_2$

Balanced: $2Ca_3SiO_5 + 7H_2O \rightarrow 3(CaO)\cdot 2(SiO_2)\cdot 4(H_2O)(gel) + 3Ca(OH)_2$

(Abrams.DA 1942)

2.3.1 Concrete strength

The first rarely mentioned fundamental assumptions for the strength versus water-cement ratio relationship are discussed, namely, that: (a) the strength of structural concrete is controlled by the strength of the cement paste in it; (b) the strength of a cement paste depends strongly on the porosity in it; and (c) the porosity (capillary) is a function of the water-cement ratio. This is the foundation of the relationship between concrete strength and water-cement ratio. Numerous empirical formulas, so-called strength formulas, have been developed for this relationship; the Abrams' formula for instance.(Abrams.DA 1942)

Water is the key ingredient, which when mixed with cement, forms a paste that binds the aggregate together. The water causes the hardening of concrete through a process called hydration. Hydration is a chemical reaction in which the major compounds in cement form chemical bonds with water molecules and become hydrates or hydration products. Details of the hydration process are explored in the next section. The water needs to be pure in order to prevent side reactions from occurring which may weaken the concrete or otherwise interfere with the hydration process. The role of water is important because the water to cement ratio is the most critical factor in the production of "perfect" concrete. Too much water reduces concrete strength, while too little will make the concrete unworkable. Concrete needs to be workable so that it may be consolidated and shaped into different forms (i.e.. walls, domes, etc.). Because concrete must be both strong and workable, a careful balance of the cement to water ratio is required when making concrete. (Kuhl H August 1928)

Water is a key reactant in cement hydration. The incorporation of water into a substance is known as hydration. Water and cement initially form a cement paste that begins to react and harden (set). This paste binds the aggregate particles through the chemical process of hydration. In the hydration of cement, chemical changes occur slowly, eventually creating new crystalline products, heat evolution, and other measurable signs.

The properties of this hardened cement paste, called binder, control the properties of the concrete. It is the inclusion of water (hydration) into the product that causes concrete to set, stiffen, and become hard. Once set, concrete continues to harden (cure) and become stronger for a long period of time, often up to several years.

The strength of the concrete is related to the water to cement mass ratio and the curing conditions. A high water to cement mass ratio yields a low strength concrete. This is due to the increase in porosity (space between particles) that is created with the hydration process. Most concrete is made with a water to cement mass ratio ranging from 0.35 to 0.6. (Neville 1997, p734)

2.3.2 Workability

Workability depends on water content, aggregate (shape and size distribution), cementitious content and age (level of hydration), and can be modified by adding chemical admixtures. Raising the water content or adding chemical admixtures will increase concrete workability. Excessive water will lead to increased bleeding (surface water) and/or segregation of aggregates (when the cement and aggregates start to separate), with the resulting concrete having reduced quality. The use of an aggregate with an undesirable gradation can result in a very harsh mix design with a very low slump, which cannot be readily made more workable by addition of reasonable amounts of water. (Lobo C and Mullings GM 2003)

Workability is the ability of a fresh (plastic) concrete mix to fill the form/mold properly with the desired work (vibration) and without reducing the concrete's quality. Workability depends on water content, aggregate (shape and size distribution), cementitious content and age (level of hydration), and can be modified by adding chemical admixtures. Raising the water content or adding chemical admixtures will increase concrete workability. Excessive water will lead to increased bleeding (surface water) and/or segregation of aggregates (when the cement and aggregates start to separate), with the resulting concrete having reduced quality. The use of an aggregate with an undesirable gradation can result in a very harsh mix design with a very low slump, which cannot be readily made more workable by addition of reasonable amounts of water.Workability can be measured by the concrete slump test, a simplistic measure of the plasticity of a fresh batch of concrete following the ASTM C 143 or EN 12350-2 test standards. (H. Roper, D. Baweja, 1992)

2.3.3 Durability

Durability is a very important concern in using concrete for a given application. Concrete provides good performance through the service life of the structure when concrete is mixed properly and care is taken in curing it. Good concrete can have an infinite life span under the right conditions. Water, although important for concrete hydration and hardening, can also play a role in decreased durability once the structure is built. This is because water can transport harmful chemicals to the interior of the concrete leading to various forms of deterioration. Such deterioration ultimately adds costs due to maintenance and repair of the concrete structure. The contractor should be able to account for environmental factors and produce a durable concrete structure if these factors are considered when building concrete structures. (Cebeci OZ and Saatci 1989)

2.4 Water usage at concrete plants

It has been calculated that a 9-m^3 ready-mixed concrete truck contains, at the end of each working day, approximately 200–400 kg of returned plastic concrete this material can be left overnight in the truck with the addition of hydration control admixtures or washed out. When washed out, with the addition of about 700–1300 l of water, the material can be mechanically separated into aggregates ready for reuse and water containing amounts of suspended fine particles. (Cebeci OZ and Saatci 1989)

Water is an important material in the mixing of concrete. Water always plays a big role in the life of concrete. First, water is always a component of fresh concrete—sometimes an excessive component. Second, water can be retained by concrete (dams, pipes) or restrained by it (walls). And third, water can go into concrete but generally not through it.As a component of paste, about 20 percent water by weight is needed to hydrate all the cement (w/c, 0.20), and about 15 to 20 percent more to provide space for the cement hydration products. And then, usually more water is needed to make the mix workable. At about 0.65 to 0.70 w/c the permeability of concrete increases exponentially, so it is usually best to limit the w/c to 0.60 if that is tolerable with respect to other concrete properties. (Su N, Miao B and Liu FS 2002)

2.4.1 Waste wash water in ready-mix concrete plant

Recycling waste water in the production of new concrete, but gives some restrictions for its composition and use. In this paper, the use of waste wash water (coming from a medium-size ready-mixed concrete plant) in mixing water for concrete and mortars has been investigated: the effects on physical–mechanical properties and microstructure are investigated as a function of the characteristics of waste water used. The results have shown that mortar and concrete prepared with recycled water exhibit 28-day mechanical strength in no way lower than 96% of the reference materials (90% is the minimum allowed in prEN 1008) and, in some cases, even better. Moreover, the use of wash water in concrete leads to a reduction of the concrete capillary water absorption and mortar microporosity, which surely improves the durability of the material. This effect can be ascribed to the filling action of the fines present in the wash water and to the slight reduction of the actual water/cement ratio. (J. Borger, R.L. Carrasquillo, D.W. Fowler, 1994)

2.4.2 Disposal of wash water at concrete plant

The current practices for the disposal of concrete wash water include dumping at the job site, dumping at a landfill, or dumping into a concrete wash water pit in the ready-mix plant. The dumping of concrete waste water at job sites or at ready-mix plant yards has been curtailed by revisions made to the Clean Water Act in 1987. These revisions encompass sources of water pollution such as storm water runoff from ready-mix plant yards and construction sites. For example, in Florida ready-mix batch plants are only permitted to discharge waste water to surface waters of the state as a result of conditions created by rainfall in excess of a designated 10-year, 24-hour rainfall hydrologic event. In other words, the most economic and easy option for the disposal of concrete wash water has been outlawed, with the exception of rare weather conditions, due to its environmental impact. (M. Orsi, Il riciclo delle acque di lavaggio 1994)

2.4.3 Effect of wash water to the environment

Another problem regarding water in concrete industry is wash water from washing mixers, trucks or chutes. Because of environmental requirements, wash water cannot be run out of ready-mixed concrete plant as effluent without adequate treatment. The treatment process in this case is relatively expensive process for ready-mixed concrete producer. (C. Lobo, W.F. Guthrie and R. Kacker, 1995)

Production of large amounts of waste wash water coming from ready-mixed concrete plants leads to problems of environmental impact. National laws usually prohibit the disposal of such types of water, due to their extremely high pH value and suspended matter amount, and require the water to be treated prior to discharge. prEN 1008 provides for recycling waste water in the production of new concrete, but gives some restrictions for its composition and use. In this paper, the use of waste wash water (coming from a medium-size ready-mixed concrete plant) in mixing water for concrete and mortars has been investigated: the effects on physical–mechanical properties and microstructure are investigated as a function of the characteristics of waste water used. (M. Paolini and R. Khurana,1998)

CHAPTER 3

METHODOLOGY

3.1 Introduction

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

i. Preparing a flow chart regarding the experiment that has to be done as a reference to laboratory keeper to facilitate a preparing regarding experiment needs.

ii. List all of the material and equipment that needs in laboratory experiment. This is important in order to make sure the work complete and arrange able.

iii. Inform the technician about the experiment works that have been planned to do.

3.2.Preparation equipment

3.2.1. Concrete mould

Cube mould is used to produce mortar cube. Standard concrete cube size is 50mm length x 50mm width x 50mm height is show in figure 3.1.

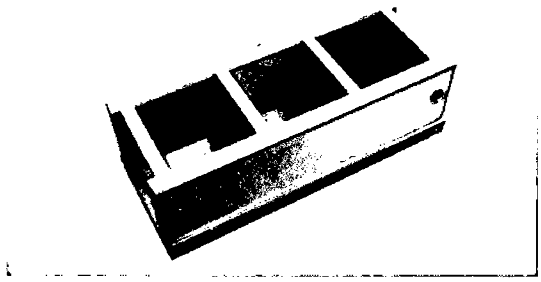

Figure. 3.1 Mould for concrete cube

3.2.2 Vacuum saturated equipment

Figure 3.2 show saturated vacuum equipment. This tool is used to determine amount of air in the cube. This device consists of two parts, a glass jar and pump.

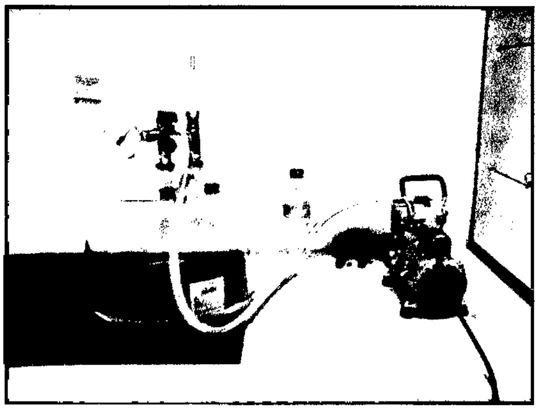

figure 3.2. Vacuum saturated test apparatus