THE EFFECT OF WASTE WASH WATER ON THE CONCRETE PROPERTIES

SUHAYA BT SEKERI

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Faculty of Civil Engineering and Earth Resources
University Malaysia Pahang

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ABSTRACT

The disposal of leftover concrete and waste wash water from ready-mix concrete trucks is becoming an increasingly greater environmental concern. When an empty $9m^3$ ready-mix truck returns to the batch plant from the construction site, there is still approximately 200 to 400 kg of concrete adhering to the inside of the drum and mixing blades. It takes approximately 700 to 1300 L of water to wash this concrete out before it hardens inside the drum. Then this waste wash water is directly distributed to the drainage without any treatment that could bring environmental problems. The alternative solution is to recycle the waste wash water and use it as batch water to make fresh concrete. In this study analyzes the quality of this waste wash water. Then, tests were conducted on mortar. The waste wash water meets the ASTM C94 requirements on mixing water for ready-mix concrete. The aim of this study is to determine the compressive strength and drying shrinkage of the mortar. The specimens for compressive strength test were cured under water with different curing duration of 7, 28 and 60 days. For drying shrinkage the specimens were cured on air for 4, 11, 18 and 25 days. The results revealed the development of compressive strength were increase with increases of curing days. While the value of drying shrinkage that recorded is less during the curing durations. It was shown that the mortar using waste wash water produce better results than mortar using tap water. Thus, the use of waste wash water from ready-mix truck should be considered for use in concrete mix which is to improve the properties of concrete at the same time reducing the environmental pollution.

ABSTRAK

Pembuangan sisa konkrit dan juga air basuhan lori bancuhan konkrit siap menjadi satu kebimbangan yang semakin serius kepada persekitaran. Apabila $9m^3$ lori bancuhan konkrit siap yang kosong kembali ke kilang bancuhan konkrit siap daripada tapak pembinaan, sekurang-kurangnya masih terdapat 200 hingga 400 kg konkrit yang tertinggal di dalam drum dan pada bilah campuran. Ini memerlukan penggunaan air sebanyak 700 hingga 1300 liter untuk membasuh dan membuang konkrit ini sebelum konkrit mengeras di dalam drum lori bancuhan konkrit siap tersebut. Kemudian air basuhan ini akan di salurkan ke dalam saliran tanpa sebarang rawatan yang akan mengundang pencemaran kepada alam sekitar. Penyelesaian alternatif ialah dengan mengitar semula air basuhan dan menggunakannya sebagai air bancuhan untuk menghasilkan konkrit. Dalam kajian ini kualiti air di analisa dan digunakan ke atas penghasilan mortar. Air basuhan ini telah memenuhi syarat-syarat yang ditetapkan dalam ASTM C94 untuk digunakan dalam bancuhan konkrit siap. Matlamat kajian ini ialah untutk menentukan kekuatan mampatan dan nilai susut pengeringan mortar. Spesimen untuk ujian kekuatan mampatan diawet di dalam air dalam tempoh pengawetan yang berlainan pada 7, 28 dan 60 hari. Bagi nilai susut pengeringan, spesimen dibiarkan terdedah kepada udara selama 4, 11, 18 dan 25 hari. Keputusan menunjukkan kekuatan mampatan meningkat dengan peningkatan hari pengawetan. Manakala, nilai susut pengeringan yang direkodkan turut berkurang semasa tempoh pengawetan. Mortar yang menggunakan air basuhan lori bancuhan konkrit menunjukkan keputusan yang lebih baik berbanding mortar yang menggunakan air paip. Oleh yang demikian, penggunaan air sisa basuhan lori bancuhan konkrit perlu dipertimbangkan untuk digunakan dalam bancuhan konkrit yang mana ia dapat memperbaiki sifat-sifat konkrit dan dalam pada masa yang sama dapat mengurangkan pencemaran alam sekitar.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Concrete is an incredibly useful and flexible building material which contributes to the construction world where modern architecture becomes not possible. Composed of cement, sand and coarser aggregates, concrete can easily be poured into forms and molds to create any number of shapes, and then hardens to become a durable stone like material. In Malaysia, most of the construction activity at site they used ready-mix concrete to build the main structures of the building. Ready-mixed concrete is a type of concrete that is manufactured in a factory or batching plant, according to a set recipe, and then delivered to a work site, by truck mounted transit mixers. Then at the end of each working day, it is common practice for the ready-mixed concrete industry to thoroughly clean the inside of a concrete trucks drum and it produces large amounts of waste wash water that leads to problem of environmental impact.

It has been calculated that a $9m^3$ ready-mixed concrete truck contains, at the end of each working day, approximately 200 to 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 to 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 authorised landfills. (Franco and Elisa, 2001)

The quality of waste wash water from the ready-mixed concrete operations is derived from the source of the water itself. Wash water discharge from truck wash contains cementitious materials and chemical admixture residue. Because of that, the wash water cannot be run out from the ready-mix concrete plant to the environment as effluent without adequate treatment. Moreover, the treatment process for this case is relatively expensive process for ready-mix concrete producer.

Stabilising admixture systems were introduced in 1988 to overcome the potential problems of recycled wash water and plastic concrete in new concrete. The use of these admixtures avoids the necessity to remove any wash water from concrete truck drums, permitting its reuse for mixing new concrete, so long as there is no visible oil. These systems consist of two phases, stabilisation and activation. The stabilisation phase slows or stops the hydration of the individual cement grains, while the activation phase allows the hydration process to proceed normally. Dosage of retarder and accelerator depend on the application, the desired length of stabilisation, the age and cement content of the concrete, the required set time, and concrete temperature. Although these stabilising admixtures have been commercially available for several years, their novelty and perceived difficulties have limited their general use in the ready-mixed concrete industry.

Concrete producers encounter a significant problem when faced with the prospect of disposing of waste wash water in an environmentally acceptable manner. Ideally, this water would be reusable, avoiding the environmental issues and the expense of disposal. Therefore, this present study will use the recycled waste wash water for the production of new concrete and make a comparison between the tap water in terms of properties, compression behavior and drying shrinkage.

1.2 Problem Statement

The ready-mixed concrete industry used approximately 150 to 300 gallons water per day to clean the inside of a concrete truck's drum and this wash water is discharge directly to the lands. When concrete waste wash water is dumped on land, materials such as chemical additives harm the natural structure and destroy habitats. The negative impacts of these are the unbalancing of environmental values, thus the adverse effects on human health. The wastage at the ready-mixed concrete plants also increases same as the cost of the production.

1.3 Objectives of study

The objectives of the study are:

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

ii. To study the effect of waste wash water towards the compressive strength of the concrete.

iii. To study the effect of waste wash water towards the drying shrinkage of the concrete.

1.4 Scope of study

This present study concentrated on compressive strength and drying shrinkage of the concrete after we replaced the tap water with concrete waste wash water. The cube specimen's for compression test is 50mm x 50mm x 50mm. The methods of testing are according to ASTM C109M-07, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50mm cube specimens). The specimen's for drying shrinkage is 25 mm x 25 mm x 285 mm. The method of testing for drying shrinkage is according to ASTM C596-07, Standard Test Method for Drying Shrinkage of Mortar Containing Hydraulic Cement.

Waste wash water is the main substant for this present study. Waste wash water were taken from the concrete plantation in the Kuantan. This waste wash water was used 100% in the specimens without any other admixtures. Specimens containing with waste wash water is compared with the specimens that contained tap water known by control specimens.

The specimens were cured under water with different curing duration of 14, 28 and 60 days for all mixes. The compressive strength tests were conducted after curing period. The specimen for drying shrinkage will be placed in air storage for 25 days. The length comparator reading is obtained for each specimen after 7, 14 and 25 days on air storage.

1.5 Significant of Study

This experimental study was conducted the new way to the concrete production in our country by using the waste wash water. This will become the new achievement to reduce the cost of the concrete production by using waste wash water of the concrete-mixed in replacing the tap water, and also one of the ways to save our country from pollution.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Ready-mix concrete is a type of concrete that is manufactured in a factory or batching plant, according to a set recipe, and then delivered to a work site, by truck mounted transit mixers. This results in a precise mixture, allowing specialty concrete mixtures to be developed and implemented on construction sites. The first ready-mix factory was built in the 1930s, but the industry did not begin to expand significantly until the 1960s, and it has continued to grow since then.

Ready-mix concrete is sometimes preferred over on-site concrete mixing because of the precision of the mixture and reduced work site confusion. However, using a pre-determined concrete mixture reduces flexibility, both in the supply chain and in the actual components of the concrete. Ready Mixed Concrete is also referred as the customized concrete products for commercial purpose. The Ready-mix Concrete Company offer different concrete according to user's mix design or industrial standard. The Ready mixed concrete company is required to equip themselves with up-to-date equipments, such as transit mixer, concrete pump, and Concrete Batching Plant, which needs visualized production management software and also PLC controller.

Ready Mixed Concrete, or RMC as it is popularly called, refers to concrete that is specifically manufactured for delivery to the customer's construction site in a freshly mixed and plastic or unhardened state. Concrete itself is a mixture of Portland cement, water and aggregates comprising sand and gravel or crushed stone. In traditional work sites, each of these materials is procured separately and mixed in specified proportions at site to make concrete. Ready Mixed Concrete is bought and sold by volume, usually expressed in cubic meters. RMC can be custom-made to suit different applications.

However, disposal of waste water from Ready Mixed Concrete (RMC) operations is a great concern of the ready-mixed concrete producers. Most of the traditional disposal systems are no longer environmentally acceptable. Alternative solution is to recycle the waste water and use it as batch water to make fresh concrete. (S. Abdol Chini and William J. Mbwambo, 2000). In this present chapter, reviews about waste wash water were presented.

2.2 Water Usage at Ready Mix Concrete

There is a common practice in the ready-mixed concrete industry to thoroughly clean the inside of a concrete trucks drum at the end of each day using approximately 150-300 gallons of water. According to the Water Quality Act (part 116), truck wash water is a hazardous substance (it contains caustic soda and potash) and its disposal is regulated by the Environmental Protection Agency (EPA). In addition, a high pH makes truck wash water hazardous under EPA definition of corrosivity. These regulations require accurate and precise record keeping of each waste water disposal, retention of the records for three years, and submission of the records to EPA. (S. Abdol Chini and William J. Mbwambo, 2000)

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. (Franco Sandrolini and Elisa Franzoni, 2000)

The ready mixed concrete industry is faced with the challenge of managing about 3% to 5% of its estimated annual production of 300 million cubic meters (400 million cubic yards) as returned concrete. In addition, about 80,000 truck mixers are washed out using about 750 to 1,500 liters (200 to 400 gallons) each of water daily. (Colin Lobo, 2004)

2.3 Disposal of Waste Wash Water at Ready Mix Concrete

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. 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 ramfall in excess of a designated 10-year, 24-hour ramfall 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. (S. Abdol Chini and William J. Mbwambo, 2000)

Another practice is to dump concrete wash water into wash-out pits or mechanical reclaiming units at the ready-mix plant. Batch plant facilities have developed a variety of operational configurations to control pollution related to waste water. This includes settling ponds, storm water detention/retention facilities and water reuse systems. Wash pits are used for settling and aggregate recovery. Unlined ponds are used for effluent evaporation and percolation to ground water. For facilities where most of the suspended solids are removed by sedimentation in a basin or tank, the water as discharged from the treatment system is fairly clear with the suspended solid level of about 100 ppm. However, the dissolved material will remain relatively high in the range of 500 ppm to 2500 ppm (normal drinking water contains 100 to 500 ppm dissolved solids). Operationally, the treatment and control systems function as follows. The wash water from the truck wash is collected in the washout (settlement) pit, The washout pit is used for settling and aggregate recovery. The supernatant from the wash pit is either reused for truck washing or discharged to a retention pond. (S. Abdol Chini and William J. Mbwambo, 2000)

There are basically four options for disposing unused concrete and wash water for ready-mix producers: at the ready-mix plant yard, at the construction site, at a landfill, or at a reclamation unit. The first two options are becoming limited because of the 1987 revisions to the Clean Water Act. In addition to point sources of water pollution, these revisions include diffuse sources of water pollution such as storm water runoff from ready-mix plant yards and construction sites. Since October 1, 1992, all ready-mix plant yards and construction sites have been required to obtain a National Pollutant Discharge Elimination System permit. This includes monitoring storm water that leaves the yard, and installing any necessary control systems that will reduce the level of pollutants in the water. A third way to dispose of the waste materials is to deposit them at an authorized landfill or disposal site. However, with the development of environmental regulations and the increased demand on landfill, the availability of authorized disposal sites has decreased significantly over the last 15 years. Finally, a ready-mix truck can dispose of wash water and leftover concrete at a wash-out pit, or a mechanical reclaiming unit. These options require a high capital investment and are expensive and labor intensive to maintain. (Jeff Borger, Ramon L. Carrasquillo, and David W. Fowler, 1994)

2.4 Alternative Solutions to Disposal of Waste Wash Water

Recent developments in admixture technology have made significant progress to control the hvdration of cement. This control has enabled concrete producers and users to stop cement hydration for a desired period and be able to restart it at any time, allowing the concrete to set normally, without sacrificing any of the properties of the hardened material. These types of admixtures, defined as extended-set control admixtures, not only have a significant influence on the production, transportation, and placement of concrete, but have also had a positive impact on the environment. With this technology, in fact, it is possible to eliminate or greatly reduce the amount of waste in the production and use of concrete. (Marco Paolini & Rabinder Khurana, 1998)

The use of these admixtures circumvents the necessity to remove any wash water from concrete truck drums, and allows wash water to be reused for mixing more concrete. The admixture is added in a dosage dependent on the amount of waste water present in the drum of the concrete truck, and on the time span desired for the reuse of the water.

The use of such admixtures offers the benefits of:

- Decreasing environmental problems associated with the disposal of residual wash water
- Saves labor, equipment and freight costs by eliminating the need to dispose of wash water
- Eliminates the need for expensive reclaimer/recycler units and their high-maintenance costs
- Reduces labor costs required for chipping set concrete out of mixer drums when used after each load
- Reduces amount of water required for wash down

(S. Abdol Chini and William J. Mbwambo, 2000)

2.5 Quality of Waste Wash Water from Ready Mix Concrete

The quality of waste water from the Ready mix Concrete operations is derived from the source of the water itself. Wash water discharge from truck wash contains cementitious materials and chemical admixture residue. Due to the high content of dissolved limestone solids the wash water is caustic and has a high pH value ranging between 11 and 12. In general the waste water contains dissolved solids which include: sulfates and hydroxides from cement, chlorides from the use of calcium chloride as an admixture, oil and grease from the equipment, and small quantities of other chemicals associated with hydration of Portland Cement and derivatives from chemical admixtures. The most common derivatives of chemical admixtures are: ethanolamine, diethanolamine, formaldehyde, K-naphthalene sulfonate, and benzene sulfonic acid. (S. Abdol Chini and William J. Mbwambo, 2000)

2.6 Effect of Waste 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. (Nan Sua, Buquan Miaob and Fu-Shung Liuc, 2001)

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. (Franco Sandrolini and Elisa Franzoni, 2000)

2.7 The Suitability of Waste Wash Water for use in Concrete

The traditional criterion widely employed to define the suitability of mix water has been to compare its quality with fitness for drinking. However, specifications have been developed giving limits of acceptable chemical impurities and their effects on certain concrete properties. These major criteria are given in ASTM C 94 in which the 7-day or 28-day compressive strength of concretes or mortars incorporating waste wash water must achieve at least 90% of the strength of control samples made with municipal or distilled water. For mixes containing waste wash water, ASTM C 94 allows deviations of 1 h and 1.5 h for the initial and final sets respectively. (Stephen Ekolu and Amit Dawneerangen, 2010)

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this present chapter, the details explanations about methodology of the effect of waste wash water on concrete were discussed. The basic approach of this study is to evaluate the compressive strength and drying shrinkage of the concrete after we replaced the tap water with concrete waste wash water. Compressive strength test was conducted to determine the physical properties of concrete with waste wash water. Water curing was taken into consideration for the compressive strength.

The experimental plan and the implementation of the experiment that has been carried out through the study were discussed. This chapter also consists of explanation on material used and brief on testing method. The laboratory works need to be done to