MECHANICAL PROPERTIES OF CONCRETE CONTAINING 5% AND 10% OF BATIK PRODUCTION WASTE

MOHD SYAZWAN BIN RAMLI

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Faculty of Civil Engineering and Earth Resources
University Malaysia Pahang

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ABSTRACT

Concrete is a man-made materials in use since the 16th century ago. Until now almost all of the main building structure in the world is made of concrete. Concrete is a material that consisting of cements, aggregates, sand and water which can be a structure that becomes stronger in terms of compression pressure and durability at a time. Many research has been done to produce concrete that is affordable, high quality and profitable. The environmental regulation have initiated in increasing interest in using waste disposal as a construction materials partially replacing the water in concrete with wastewater from industries. In this study, the idea of using waste product that is batik production waste as replacement by weight for normal water. The objective of this study concentrates on mechanical properties that are compressive and flexural strength of concrete with batik production waste. There are two different percentages in using batik production waste which are 5% and 10% that ware used to replace the normal water by weight and was tested at 7 and 28 days of ages. The strength of normal concrete play as a control mix which has been compared with the concrete containing batik production waste. The result revealed that the concrete containing 5% of batik production waste present the highest compressive and flexural strength and followed by normal concrete and concrete with 10% of batik production waste. As a conclusion, 5% of batik production waste is the optimum percentage for replacing the normal water by weight according to increase value of compressive and flexural strength.

ABSTRAK

Konkrit adalah bahan buatan manusia yang digunakan sejak kurun ke-16 lagi. Sehingga kini hampir semua struktur utama bangunan di seluruh dunia diperbuat daripada konkrit. Konkrit adalah bahan yang terdiri daripada campuran simen, batu baur, pasir dan air yang menjadikan struktur itu lebih kuat dari sudut tekanan mampatan dan ketahanlasakan pada sesuatu masa. Ramai penyelidik telah berusaha untuk menghasilkan konkrit yang murah, berkualiti tinggi dan menguntungkan. Selain itu penguatkuasaan peraturan alam sekitar juga telah menerapkan minat dan usaha ke atas penggunaan bahan buangan sebagai bahan ganti di dalam industri binaan terutamanya dengan mengantikan pengunaan air di dalam campuran konkrit. Dalam kajian ini, idea penggunaan sisa air batik adalah sebagai pengganti air di dalam campuran konkrit. Tujuan kajian ini adalah tertumpu pada sifat mekanikal iaitu kekuatan mampatan dan lenturan konkrit yang menggunakan sisa air batik sebagai penganti air biasa di dalam bancuhan konkrit. Terdapat dua kategori kuantiti peratusan pengunaan sisa air batik yang digunakan bagi mengantikan air biasa iaitu 5% dan 10% yang diuji ketika konkrit mencapai umur 7 dan 28 hari. Kekuatan bancuhan konkrit biasa dijadikan sebagai bancuhan kawalan untuk dibandingkan dengan konkrit yang mengandungi 5% dan 10% sisa air batik. Daripada keputusan yang diperolehi, konkrit yang menunjukkan nilai kekuatan mampatan dan lenturan yang tertinggi adalah konkrit yang mengandungi 5% sisa air batik dan diikuti oleh konkrit biasa serta konkrit yang mengandungi 10% sisa air batik. Secara kesimpulannya, penggunaan 5% sisa air batik adalah nilai optima dalam meningkatkan kekuatan mampatan dan kekuatan lenturan. Penggunaan selebihnya akan menyebabkan penurunan terhadap kekuatan mampatan dan lenturan konkrit.

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LIST OF ABBREVIATIONS

ACI	-	American Concrete Institute
APHA	-	American Public Health Association
ASTM	-	American Society of Testing and Materials
BOD	-	Biological Oxygen Demand
BPW	-	Batik Production Waste
BS	-	British Standard
COD	-	Chemical Oxygen Demand
DOE	-	Department of Environment
EPA	-	Environmental Protection Agency
G30	-	Normal Concrete
G30+5%	-	Concrete with 5% of Batik Production Waste
G30+10%	-	Concrete with 10% of Batik Production Waste
kN	-	Kilo Newton
MPa	-	Mega Pascal
mg/L	-	Milligram per Liter
N/mm^2	-	Newton per Millimeter square
ppm	-	parts per million
TSS	-	Total Suspended Solid
UK	-	United Kingdom

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Momentum in the economy has been making all over the world compete to make their country more progressive and make their country a place in the public know. Progress of a country depends on the efficiency of leaders and the rapid development of economic and healthy competition. In addition, the competition at present is the construction of building structures that scratch the sky like that happened in Asia. For example in Dubai, the construction of the highest tower in the world and also the construction of the largest artificial islands in the world. In such construction, it requires a lot of energy work such as building designers, laborers, architects, project managers and also the materials to build these structures.

Generally, the most widely used construction material is concrete, commonly made by mixing Portland cement with sand, crushed rock, and water. Last year in the U.S. 63 million tons of Portland cement was converted into 500 million tons of concrete, five times the consumption by weight of steel. In many countries the ratio of concrete consumption to steel consumption exceeds ten to one. The total world consumption of concrete last year is estimated at three billion tons, or one ton for every living human being. Man consumes no material except water in such tremendous quantities. Today, the rate at which concrete is used is much higher than it was 40 years ago. It is estimated that the present consumption of concrete in the world is of the order of 11 billion metric tons every year (Kumar and Paulo, 2006).

Water quality plays an important role in the strength of concrete. Impurities in the water may interfere with the settling of the cement, may adversely affect the strength of concrete or cause staining of its structure and may also lead to corrosion of the reinforcement. Mixing water should not contain undesirable organic substance or inorganic constituent in excessive proportion. However, no standard explicitly prescribing the quality of mixing water are available, partly because quantitative limits of harmful constituent are not known, but mainly because unnecessary restrictions could be economically damaging (Neville, 2002).

Wastewater reuse can be defined as the use of treated wastewater for a beneficial use, such as agricultural, irrigation and industrial cooling. The term water reuse is used synonymously with water reuse.

In fact, industrial waste water and sanitary sewage can be used in concretes. After sewage passes through a good disposal system, the concentration of solids is usually too low to have any significant effect on concrete. Waste waters from tanneries, paint factories, coke plants, chemical plants, and galvanizing plants, and soon may contain harmful impurities. As with all questionable water sources, it pays to run the comparative strength tests before using such water in concrete manufacturing (Theodore, 2002).

Therefore, treated wastewater can also be used for industrial purposes if suitable industries are not far from the treatment plant. Industry's requirement for water quality ranges widely, from very pure water for boilers of electricity generation to lower water quality for cooling towers. Treated wastewater can fulfils the lower range of this requirement, such as water for cooling towers. Secondary-treated wastewater after chlorination may be adequate for this purpose. In the other hand, the wastewater can also be potentially used in the construction sector. The suitable wastewater which is fulfill the requirement needed can replace the potable water function as the concrete mixing water. In this situation the clean water source can be reserved for the other important usage.

1.2 Problem Statement

Water scarcity and water pollution are some of the crucial issues in the world. One of the ways to reduce the impact of water scarcity and pollution is to expand water and wastewater reuse.

A water supply and a sanitation system are the primary infrastructure need of any community, particularly in mega cities, playing a key role in providing amenities to the people, protecting the environment and eliminating water borne diseases. This a well functioning urban drainage and wastewater treatment system is the most effective solution to sewage and urban runoff problems as well as to maintaining and enhancing healthy living condition in mega cities (Juha, 2003).

The decision to develop reuse applications is often economic and may be the result of viewing wastewater from a disposal perspective or as a water resource. From a disposal perspective, the level of treatment is required for discharge to surface water is questionable. A measure of indirect reuse occurs when effluents that have been discharge and diluted in a river are withdrawn downstream for irrigation or as a public water supply.

Water reuse supplies may be considered part of an overall water supply during water resources master planning. Recycled water may be used instead of some potable water uses where additional potable water supplies are more costly or not available, thus freeing an equivalent amount of potable water for other uses. Use of recycled water should not adversely affect downstream water rights, degrade water quality, or injure plants, fish, and wildlife. Withdrawal of a treatment plants effluent from stream discharge may be limited by a quantity of water necessary to maintain an established habitat along the stream. Treatment requirements for discharge depend on the beneficial uses associated with the stream (Hammer, 2005).

Hammer (2005) also noted that, in many project specifications, the quality of water is covered by a clause saying that water should be fit for drinking. Such water very rarely contains dissolved inorganic solids in excess of 2000 parts per million (ppm), and as a rule less than 1000 ppm. For a water/cement ratio of 0.5, the latter content corresponds to a quantity of solids representing 0.05 per cent of the mass of cement, and any effect of the common solids would be small. While the use of potable water as mixing water is generally satisfactory, there are some exception for instance in some arid areas, local drinking water is saline and may contain an excessive amount of chlorides. Also, some natural mineral waters contain undesirable amounts of alkaline carbonates and bicarbonates which could contribute to the alkaline silica reaction.

Ultimately, after appropriate treatment, wastewater collected from cities must be returned to the land or water. The complex question of which contaminants in urban wastewater should be removed to protect the environment, to what extent and where they should be placed must be answered in light of an analysis of local condition, environmental risk, scientific knowledge engineering judgment and economic feasibility. Providing these infrastructures is however costly. For example, the total 20 year capital cost to upgrade US municipal sewerage systems is estimated to be US$110 billion (for design year of 2010 in 1990 dollar) according to the 1990 Needs Survey Report to the Congress. The cost for constructing conventional secondary (US$37.3 billion) and advanced (US$11.79 billion) wastewater treatment systems totals US$49.0 billion (National Research Council, 1993).

Therefore, Malaysia as a developing country should be aware about this issue from now on and start to consider the alternative of wastewater reuse to avoid any possible effect to human health and the environment in the future besides to preserve the clean water supply. Industrial sector is one of the potential sectors to apply this option. Industrial water use accounts for approximately 20% of global freshwater withdrawals. So industries should be encouraged to invest in better water efficiency, more recycling and management for freshwater conservation. The inclusion of planned wastewater reclamation, recycling, and reuse in water resources management systems reflect the increasing scarcity of water sources to meet societal demands, technological advancement, public acceptance and improved understanding of public health risk (Juha, 2003). Commonly, the wastewater is usually used for cooling process. However, the usage can be expanding for construction field. The wastewater can be possibly used as concrete mixing water as long as the requirement for the water for concrete mixing is fulfill.

1.3 The Objective of Study

The study is carried out to achieve the following objective:

i) To determine the value of compressive strength and flexural strength of concrete with different percentage of BPW.

ii) To compare the value of compressive strength and flexural strength between normal concrete and concrete containing BPW.

1.4 The Scope of Study

The scope of this study covers the behavior of concrete grade 30 according to the Standard Department of Environmental (DOE), UK. The three types of concrete that will be mix and test are normal concrete, concrete with containing 5% and 10% of BPW. The sizes of specimen is 150mm × 150mm × 150mm cube for compressive strength test and 100mm × 100mm × 500mm prism for flexural strength test, respectively. The testing will be carried out at the age 7 and 28 day for all specimens of concrete. The scope is related to the material and equipments that involved in this study and fulfill the requirement according to standard BS 1881: Part 116:1983: Concrete Compression Test and BS1881: Part118: Concrete Flexural Test and BS 3148:1980: Method of parameter test for Water for making Concrete (including note on the suitability of the water).

1.5 Significant of Study

Although the wastewater reuse is already known, but in the construction area especially in Malaysia the application is still cannot be extensive. The effective treatment of wastewater to meet water quality objectives for water reuse application and to protect public health is a critical element of water reuse systems. Conventional municipal wastewater treatment consists of a combination of physical, chemical, and biological processes and operation to remove solids, organic matter, pathogens, toxic metal, and sometimes nutrient form wastewater. Therefore, by conducting this study the potential of the wastewater reuse can be further investigated and contribute to expand the application of the wastewater reuse. Besides, the study can help to promote the new alternatives to use the wastewater in the industrial sector thus; will probably lead to water pollution diminution. Therefore wastewater reuse has a big potential to bring about environmental, economic and financial benefits. Finally, the data obtained during the research can be applied or used as a reference in future research to improve the outcome obtained.

CHAPTER 2

LITERATURE REVIEW

2.1 Concrete

Concrete is a construction material composed of cement, aggregate, water, and chemical admixtures. Concrete solidifiers and hardens after mixing with water and placement due to a chemical process known as hydration. The water reacts with the cement, which bonds the other component together, eventually creating a stone-like material. Concrete grows stronger with increasing of age. Quality concrete is related to the quality of materials that used to mix it. If materials have high quality, the concrete also will have a quality. It is can be increase the strength of the concrete (Lomborg, 2001).

2.2 Material of concrete

2.2.1 Cement

Cement is a hydraulic bonding agent used in building construction and civil engineering. It is fine powder obtained by grinding the clinker of a clay and limestone mixture calcined at high temperatures. When water is added to cement it become slurry that gradually hardens to a stone like consistency. Cement must be sound, it must not contain excessive quantities of certain substance such as lime, magnesia, calcium sulphate that may expand on hydration or react with other substance in the aggregate and cause the concrete to disintegrate (Surahyo, 2002).

2.2.2 Aggregate

Aggregate are inert granular materials such as sand, gravel or crushed stone that are an end product in their own right, which account for 70 to 80 percent of the total volume of concrete. They are also the raw materials that, along with water and hydraulic binders, are an essential ingredient in concrete. For a good concrete mix, aggregate need to be clean, hard, strong particles free of absorbed chemicals or coating of clay and other fine materials that could cause the deterioration of concrete.

Aggregate are divided into two types which are fine aggregate such as natural or manufactured slag. Another type of aggregate is coarse aggregate such as gravel, crushed stone or blast furnace slag.

2.2.2.1 Fine Aggregate

Based on ASTM-C33 and BS-882 grading requirement, fine aggregate can be defined as material that will pass a No.4 sieve and will, for the most part, be retained on a No.200 sieve or it lower than 5mm. In other word, particles in between 0.075mm and 5mm (Surahyo, 2002).

2.2.2.2 Coarse Aggregate

Based on ASTM-C33 and BS-882 grading requirement, coarse aggregates are particles greater than 4.75mm, but generally range between 9.5mm to 37.5mm in diameter (Surahyo, 2002).

Aggregates selected for use should be clean, hard, strong, and durable properties, free of chemical, coating of clay, or other material that will affect the bond of the cement paste. Aggregates containing shale or other soft and porous organic particles should be avoided because they have poor resistance to weathering. Coarse aggregates can usually be inspected visually for weakness. Any aggregates that do not have adequate service record should be tested for compliance with requirements. Most concrete aggregate sources are periodically checked to ensure that the aggregates being produced meet the concrete specification (Marotta, 2002).

2.2.3 Water

Combining water with a cementitious 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 easily. Less water in the cement paste will yield a stronger, more durable concrete and more water will give an easier 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.

Water containing large quantities of chlorides tends to cause persistent dampness and surface efflorescence. Such water should, therefore, not be used where appearance of unreinforced concrete is of importance or where a plaster finish is to be applied. In much more importantly, the presence of chlorides in concrete containing embedded steel can lead to its corrosion (Neville, 2002).

2.3 Properties of Concrete

2.3.1 Strength

Strength of concrete is commonly considered its most valuable property, although, in many practical cases, other characteristic, such as durability and permeability, may in fact be more important. Nevertheless, strength usually gives an overall picture of the quality of concrete because strength is directly related to the structure of the hydrated cement paste.

Concrete has relatively high compressive strength, but significantly lower tensile strength. It is fair to assume that a concrete samples tensile strength is about 10% - 15% of its compressive strength. As a result, without compensating, concrete would almost always fail from tensile stresses even when loaded in compression (Katz, 2002). The practical implication of this is that concrete elements subjected to tensile stresses must be reinforced with materials that are strong in tension.

2.3.1.1 Factors that Influence The Strength of Concrete

In engineering practice, the strength of concrete at a given and cured in water at a predescribed temperature is assumed to depend primarily on several factors such as water cement ratio, degree of compaction, type of cement and type of aggregate.

a) Water Cement Ratio

Water cement ratio is of weight of water to the weight of cement used in concrete mix. It has an important influence on the quantity of concrete produced. A lower water cement ratio leads to higher strength and durability, but may make the mix more difficult to place. The water cement ratio is independent of the total cement content and the total water content of a concrete mix.

From time to time, the water cement ratio rule has been criticized as not being sufficiently fundamental. Nevertheless, in practice the water cement ratio is the largest single factor in the strength of fully compacted concrete (Neville, 2002).

b) Degree of Compaction

The aim of the concreting process is to achieve a homogeneous mass free from void, and the planner must ensure that the concrete mix and compaction method are selected giving due consideration to the placing conditions. Besides that, normally to gain the fully of free from voids the assistance of internal and external vibration must be done in correctly and the strength is increase.

2.3.2 Types of Strength

2.3.2.1 Compressive Strength

One of important properties of concrete is its strength in compression. The compressive strength of concrete is its property commonly considered in structural design but for some purposes the tensile strength is of interest, example of these are the design of highway and airfield slabs, shear strength, and resistance to cracking. The strength in compressive has a definite relationship with all the other properties of concrete. In other word, compressive strength is the capacity of a material to withstand axially directed pushing forces. When the limit of compressive strength is reached, materials are crushed. Concrete can be made to have high compressive strength of concrete is the most common performance measure used by the engineer in designing building and other structure.

2.3.2.2 Flexural Strength

It is the ability of a beam or slab to resist failure in bending. Flexural testing is used to determine the flexure or bending properties of a material. Sometimes referred to as a transverse beam test, it involves placing a sample between two knife-edge points and initiating a load at the midpoint of the sample. The flexural strength is expressed as modulus of rupture (MR) in psi. Flexural MR is about 12% to 20% of compressive strength. However, the best correlation for specific materials is obtained by laboratory test (Santon and Bloem, 1999)

2.3.2.3 Tensile Strength

The tensile strength of a material is the maximum amount of tensile stress that it can be subjected to before failure. It has long been known that concrete materials have low tensile strength compared to their compressive strength. The practical implication of this is that concrete elements subjected to tensile stresses must be reinforced with materials that are strong in tension. Concrete is most often constructed with the addition of steel or fiber reinforcement. The reinforcement can be by bars (rebar), mesh, or fibers, which provide the required tensile strength to concrete producing reinforced concrete.

The tensile strength determined from the frame specimens has been compared with the cylinder splitting strength. Tensile testing is commonly used to determine the maximum load (tensile strength) that a material or a product can withstand. Tensile testing may be based on a load value or elongation value.

2.3.2.4 Relationship between Compressive Strength and Flexural Strength

The relationship between compressive strength and flexural strength are close related. The level of both strength is depending on general level of the concrete strength. If the compressive strength was increase, the flexural strength also will increase but at a decreasing rate. The flexural strength will increase slowly than compressive strength and beside that, flexural strength is sensitive to inadequate curing than compressive strength.

2.3.3 Shrinkage and Expansion

Shrinkages of concrete is caused by the settlement of solids and the loss of free water for, the plastic concrete (plastic shrinkage), by the chemical combination of cement with water (autogenously shrinkage) and by the drying of concrete (drying shrinkage). Where movement of the concrete is restrained, shrinkage will produce tensile stresses within the concrete which may cause cracking (Neil, 1996).

As concrete matures it continues to shrink, due to the ongoing reaction taking place in the material, although the rate of shrinkage falls relatively quickly and keeps reducing over time (for all practical purposes concrete is usually considered to not shrink any further after 30 years). The relative shrinkage and expansion of concrete and brickwork require careful accommodation when the two forms of construction interface.