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PERFORMANCE OF CONCRETE CONTAINING ENGINE OIL

TEE LIAN YONG

A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Civil – Structure)

Faculty of Civil Engineering
Universiti Teknologi Malaysia

MAY, 2008

I declare that this project report entitled "*Performance Of Concrete Containing Engine Oil*" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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To my beloved Father & Mother

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ABSTRACT

This study was conducted to investigate the effect of using engine oil in concrete. Laboratory work was conducted to determine the performance of control sample, concrete with used engine oil, concrete with new engine oil and concrete with superplasticizer. The performance of these types of concrete were determined by the workability test, compressive strength test and durability test. The workability of concrete is determined using slump test and compacting factor test. Meanwhile, compressive strength test is done to determine the strength of concrete. For each type of concrete, a total of twelve 150mm $\times$ 150mm $\times$ 150mm cubes were cast. The cubes were tested at the ages of 3, 7, 28 and 56 days to study the development of compressive strength. The durability test is done by exposing the concrete samples to seawater. Six concrete cubes were cast and used for each type of concrete for the durability test. The results indicate that the concrete with superplasticizer has the highest workability, compressive strength and durability. The use of engine oil either the used engine oil or the new engine oil were able to increase to some extent the workability of the concrete. However, the compressive strength of concrete with used engine oil and concrete with new engine oil is lower than control sample. The durability of concrete with engine oil were also lower than control sample.

ABSTRAK

Projek ini dijalankan untuk mengkaji kesan minyak enjin dalam konkrit. Kerja makmal telah dilaksanakan untuk menentukan prestasi konkrit kawalan, konkrit dengan minyak enjin terpakai, konkrit dengan minyak enjin baru dan konkrit dengan *superplasticizer*. Prestasi keempat-empat jenis konkrit tersebut diuji dengan menggunakan ujian kebolehkerjaan, ujian kekuatan mampatan dan ujian ketahanlasakan. Kebolehkerjaan konkrit diuji dengan menggunakan ujian penurunan dan ujian faktor pemadatan. Manakala, ujian mampatan dijalankan untuk mengetahui kekuatan konkrit. Bagi setiap jenis konkrit, sebanyak duabelas kiub konkrit berukuran 150mm $\times$ 150mm $\times$ 150mm telah dibuat. Kiub konkrit tersebut telah diuji pada hari ke 3, 7, 28 and 56 untuk menentukan kekuatan mampatannya. Ujian ketahanlasakan telah dilakukan dengan mendedahkan sampel konkrit dalam air laut. Bagi setiap jenis konkrit, sebanyak 6 kiub telah disediakan untuk ujian ketahanlasakan. Keputusan yang diperolehi menunjukkan konkrit yang dicampur dengan *superplasticizer* memberikan nilai kebolehkerjaan, kekuatan mampatan dan ketahanlasakan yang paling tinggi. Penggunaan konkrit yang ditambah dengan minyak enjin terpakai dan minyak enjin baru dapat meningkatkan kebolehkerjaan konkrit. Namun begitu, kekuatan mampatan bagi konkrit yang dicampur dengan minyak enjin terpakai dan minyak enjin baru adalah lebih rendah berbanding dengan konkrit kawalan. Konkrit dengan minyak enjin juga menunjukkan tahap ketahanlasakan yang lebih rendah berbanding konkrit kawalan.

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LIST OF ABBREVIATIONS

ACI		American Concrete Institution
BS	–	British Standard
DoE	–	Department of the Environment
OPC	–	Ordinary Portland Cement
RHPC	–	Rapid Hardening Portland Cement
SAE	–	Society of Automotive Engineers
VI	–	Viscosity Index

LIST OF SYMBOLS

C_2S	–	Dicalcium silicate
C_3S	–	Tricalcium silicate
C_3A	–	Tricalcium aluminate
C_4AF	–	Tetracalcium aluminoferrite

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CHAPTER 1

INTRODUCTION

1.1 Background

Concrete is a mixture of cement, aggregates and water together, with any other admixtures which may be added to modify the ultimate physical properties of concrete. The water and cement paste fills the voids between the grains of sand and these will fill the voids between the stones. After a few days the cement paste start to harden or set and at the end of four weeks it gives concrete its nominal ultimate strength, which is as good as that of some of the strongest stones.

Concrete mixtures are "designed" by specialized laboratories and mixed in strictly controlled proportions in concrete plants from which they are carried to the site in the revolving drums of large trucks that keep mixing the concrete. Concrete samples in the shape of cylinders or cubes are taken from each truckload and tested for compressive strength after seven and twenty-eight days. The strength of concrete depends on the ratio of water to cement, and of cement to sand and stone. The finer and harder the aggregates, the stronger the concrete. The greater the amount of water added into the mix, the weaker the concrete.

Unfortunately, even the best concrete has tensile strength barely one tenth of its compressive strength, a property it has in common with all stones. The invention of reinforced concrete remedied this deficiency and produced a structural material that, pound per pound, is the most economical.

In reinforced concrete, steel bars are embedded in the concrete so that the steel takes the tension and concrete takes the compression. For example, the bottom of a beam supported at its ends is always in tension, while its top is in compression. Steel bars set near the bottom of the beam prevent the concrete from cracking under tension and make the beam capable of resisting both kinds of stress.

Reinforced concrete is the most commonly used structural material in construction industry. Combining the compressive strength of concrete and the tensile strength of steel, reinforced concrete can be poured into forms and given any shape suitable to the channeling of loads. It is economical, available almost everywhere, fire-resistant, and can be designed to be lightweight to reduce the dead load [1].

1.2 Research Objective

The main objectives of this work are as follows:

i) To study the effect of engine oil on the properties of fresh concrete.
ii) To study the effect of engine oil on the compressive strength of concrete.
iii) To study the durability of concrete with engine oil when expose to seawater.

1.3 Problem Statement

Water is necessary to life on earth. All organisms contain it; some live in it; some drink it. Plants and animals require water that is moderately pure, and they cannot survive if their water is loaded with toxic chemicals or harmful microorganisms.

The most plentiful sources of water for human activities are surface waters, which include all the lakes, streams and rivers that flow into the oceans that cover approximately 70 percent of the earth's surface. Groundwater, on the other hand, refers to underground water sources – aquifers that retain water percolating through the earth's surface. Surface waters and groundwater become polluted in a variety of ways.

Water pollution is water that has been contaminated with harmful wastes which make the water unusable for drinking, cooking, cleaning, swimming and other activities. If the level of pollution is very severe, this condition can kill large numbers of fish, birds, and other animals. Pollution makes streams, lakes, and coastal waters unpleasant to look at, to smell, and to swim in. People who ingest polluted water can become ill [2].

The major water pollutants are chemical, biological, or physical materials that degrade water quality. Pollutants can be classed into eight categories which are the petroleum products, pesticides and herbicides, heavy metals, hazardous wastes, excess organic matter, sediment, infectious organisms and thermal pollution. Each of these pollutants has its own set of hazards.

Oil spills and dumping play a serious role in water pollution. Grease spills, oil and the other hazardous substances that result from leaking cars engine, overturned trucks and oil tankers have a serious impact on the rivers and sewers because they will eventually end up as runoff and flow back into the water. When used engine oil or grease is disposed off improperly, it will affect the water by running into storm sewers that will overflow back into the rivers, or it is deposited directly into the rivers.

Therefore, it can be seen that there are two advantages of using engine oil in concrete. Firstly, it will have to solve the problem of disposing engine oil and reduce the rate of water pollution caused by the dumping of engine oil into the river. Secondly, the engine oil is believed to be able to improve the properties of concrete. Therefore, it might be able to act as admixture in concrete which will reduce the cost of concrete production.

1.4 Scope of Research

The scope of this research is divided into several parts such as the study of the characteristic of the engine oil, the production of engine oil and the usage of engine oil in the concrete. Besides that, tests will be conducted to the concrete added with engine oil to determine the effectiveness of engine oil as concrete admixture.

The types of test conducted are divided into three main parts which are the workability test, compressive strength test and the durability test. The workability of concrete is determined using slump test and compacting factor test. Meanwhile, compressive strength test is done to determine the strength of concrete. The durability test is done by exposing the concrete to seawater.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Concrete is a composite material consisting of a binding medium within which are embedded particles or fragments of aggregate. Concrete is mainly composed of three materials i.e. cement, water and aggregates. The basic ingredients for manufacturing concrete are: cement as binding material, aggregate as inert material and water for chemical reaction i.e. hydration process. Sometimes to modify or improve certain properties of concrete, a small amount of admixtures may also be used.

2.2 Cement

In the broadest sense, the term cement can be described as a material with adhesive and cohesive properties which make it capable of bonding mineral fragments into a solid form. For construction purposes, the term 'cement' is restricted to the bonding materials used as a binding agent for sand, stone and other aggregates within the manufacture of mortar and concrete.

There are two types of cement; hydraulic cements and non- hydraulic cements. Hydraulic cements consists mainly of silicates and aluminates of lime, and can be classified broadly as natural cements, Portland cements, and high alumina cements. Hydraulic cements set and harden by internal chemical reactions when mixed with water. Meanwhile, non-hydraulic cements will only harden slowly by absorptions of carbon dioxide from the air [1].

2.2.1 Types of Cement

For practical purposes for the selection of an appropriate Portland cement or blended cement, it is useful to consider a classification based on the relevant physical or chemical property, such as a rapid gain of strength, low rate of evolution of the heat of hydration, or resistance to sulfate attack. There are four main types of cement. They are the Ordinary Portland cement, Rapid Hardening Cement, Low Heat Portland cement and Sulphate-Resisting Portland cement.

2.2.1.1 Ordinary Portland cement

Ordinary Portland cement (Type 1) is admirably suitable for use in general concrete construction when there is no exposure to sulfates in the soil or groundwater. In keeping with the modern trend towards performance – oriented specifications, little is laid down about the chemical compositions of the cement, either in terms of compounds or of oxides. Indeed, the standard requires only that it is made from 95 to 100 per cent of Portland cement clinker and 0 to 5 per cent of minor additional constituents, all by mass, the percentages being those of the total mass except calcium sulfate and manufacturing additives such as grinding aids.

The limitations on the clinker compositions is that not less than two-thirds of its mass consists of C_3S and C_2S taken together, and that the ratio of CaO to SiO_2, also by mass, be not less than 2.0. The content of MgO is limited to a maximum of 5.0 per cent [3].

The minor additional constituents, referred to above, are one or more of the other cementitious materials or filler. Filler is defined as any natural or inorganic mineral material other than cementitious material. An example of filler is calcareous material which, due to its particle distribution, improves the physical properties of the cement, for example, workability or water retention.

Table 2.1 shows the classification of Portland cement according to their compressive strength. The 28-day minimum strength in MPa gives the name of the class: 32.5, 42.5, 52.5 and 62.5. The 28-day strengths of the two lower classes are prescribed by a range, that is, each class of cement has a maximum value strength as well as minimum. Moreover, cements of class 32.5 and 42.5 are each subdivided into two subclasses, one with an ordinary early strength, and the other with a high early strength. The two subclasses with a high early strength, denoted by the letter R, are rapid-hardening cement.

Table 2.1 : Compressive Strength Requirements of Cement [3]

Class	**Minimum Strength (MPa)**			**Maximum Strength at the age of 28 days (MPa)**
	2 days	**7 days**	**28 days**	**0**
32.5 N	-	16	32.5	52.5
32.5 R	10	-	32.5	52.5
42.5 N	10	-	42.5	62.5
42.5 R	20	-	32.5	62.5
52.5 N	20	-	52.5	-
62.5 N	20	-	62.5	-

The advantage of prescribing the class 32.5 and 42.5 cements by a range of strength of 20 MPa is that, during construction, wide variations in strength, especially downwards, are avoided. Furthermore, and perhaps more importantly, an excessively high strength at the age of 28 days would allow, as was the case in the 1970s and 1980s, a specified strength of concrete to be achieved at the unduly low cement content [3].

2.2.1.2 Rapid Hardening Portland cement

This cement comprises Portland cement subclasses of 32.5 and 42.5 MPa. Rapid-Hardening Portland cement (Type III), as its name implies develops strength more rapidly, and should, therefore, be correctly described as high early strength cement.

The increased rate of gain of strength of the Rapid-Hardening Portland cement is achieved by a higher C_3S (higher than 55 per cent, but sometimes as high as 70 per cent) and by a finer grinding of the cement clinker. British Standard BS12:1991 provides a standard an optional controlled fineness Portland cement. The range of fineness is agreed between the manufacturer and the user. Such cement is valuable in applications where it makes it easier to remove excess water from the concrete during compaction because the fineness is more critical than the compressive strength.

In practice, Rapid-Hardening Portland cement has higher fineness than Ordinary Portland cement. Typically, Rapid-Hardening Portland cement has specific surface, measured by the Blaine method, of 450 to 600m^2/kg, compared with 300 to 400m^2/kg for OPC cement. The higher fineness significantly increases the strength at 10 to 20 hours, the increase persisting up to about 28 days. Under wet curing conditions, the strengths equalize at the age of 2 to 3 months, but later on the strength of the cements with a lower fineness surpass that of the high fineness cements.

The use of Rapid-Hardening cement is indicated where a rapid strength development is desired, e.g. when formwork is to removed early for re-use, or where sufficient strength for further construction is wanted as quickly as practicable. The rapid gain of strength means a high rate of heat development, thus rapid hardening Portland cement should not be used in mass construction or in large structural sections. On the other hand, for construction at low temperatures the use of cement with a high rate of heat evolution may prove a satisfactory safeguard against early frost damage [3].

2.2.1.3 Low-Heat Portland cement

The rise in temperature in the interior of a large concrete mass due to the heat development by the hydration of cement, coupled with a low thermal conductivity of concrete, can lead to serious cracking. For this reason, it is necessary to limit the rate of heat evolution of the cement used in this type of structure; a great proportion of the heat can then be dissipated and a lower rise in temperature results.

Cement having such a low rate of heat development was first produced for use in large gravity dams in the United States, and is known as Low Heat Portland cement (Type IV). This type of cement is appropriate for use in mass concrete, where rapid internal evolution of heat could cause cracking. It contains a higher proportion of dicalcium silicate which hardens and evolves heat more slowly.

The rather lower content of the more rapidly compounds, C_3S and C_3A, results in a slower development of strength of low heat cement as compared with Ordinary Portland cement, but the ultimate strength is unaffected. In any case, to ensure a sufficient rate of gain of strength the specific surface of the cement must be not less than 320 m^2/kg [4].

2.2.1.4 Sulphate-Resisting Portland cement

Sulphate-Resisting Portland cement is suitable for concrete and mortar in contact with soils and groundwater containing soluble Sulphate up to maximum levels of 2% in soil or 0.5% in groundwater. In normal Portland cements, the hydrated tricalcium aluminate component is vulnerable to be attacked by soluble sulfates, but in Sulphate-Resisting cement this component is restricted to a maximum of 3.5%.

Much sulphate-resisting cement is known as low alkali due to its alkali content less than 0.6%. Thus durable concrete, without the risk of subsequent alkali-silica reaction, can be manufactured with alkali-reactive aggregates, using up to 500kg/m^3 of cement, providing no other alkalis are present [1].

2.2.2 Chemical Properties of Cement

The starting materials for Portland cement are chalk or limestone and clay, which consist mainly of lime, silica, alumina and iron oxide as shown in Table 2.2. These compounds interact with one another in the klin to form a series of more complex products and, apart from a small residue of uncombined lime which has not had sufficient time to react, a state of chemical equilibrium is reached.

However, equilibrium is not maintained during cooling, and the rate of cooling will affect the degree of crystallization and the amount of amorphous material present in the cooled clinker. The properties of this amorphous material, known as glass, differ considerably from those of crystalline compounds of a nominally similar chemical composition. Another complication arises from the interaction of the liquid part of clinker with the crystalline compounds already present [1].

Table 2.2 : Typical composition of starting materials for Portland cement manufacture [1]

Component	Percentage (%)
Lime	68
Silica	22
Alumina	5
Iron Oxide	3
Other Oxide	2

Nevertheless, cement can be considered as being in frozen equilibrium, i.e. the cooled products are assumed to reproduce the equilibrium existing at the clinkering temperature. This assumption is, in fact, made in the calculation of the compound composition of commercial cements: the ‘potential’ composition is