COMPRESSIVE AND FLEXURAL STRENGTHS OF CONCRETE WITH IRON ORE AS SAND REPLACEMENT

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ABSTRACT

This project is conducted to observe the potential concrete made with replacement of 10 %, 20 % and 40 % iron ore to sand. The DOE method was used in designing the concrete mix for the concrete and then modified to replace 10 %, 20 % and 40 % of the sand by iron ore. The study was conducted in laboratory to investigate the behavior of the concrete in term of mechanical strength as well as the physical properties. In terms of mechanical strength, the harden concrete was tested for its compressive, and flexural strengths. The physical properties of fresh concrete were indicated by slump test. Several concrete samples were cast and cured using normal curing and tested at 7, 14 and 28 days. The concrete density up to 2459 kg/m^3 was obtained in this study. The result indicated that compressive strength increase with the age of sample. The flexural strength and compressive strength of concrete, with iron ore decreased as a percentage increase in the replacement of iron ore. This can be concluded 40 % was not capable to be used but there may be some condition that need for this percentage. Nevertheless, the result had proven that concrete with iron ore is denser and heavy than conventional concrete.

ABSTRAK

Projek ini dijalankan untuk mengenalpasti potensi konkrit yang dibuat melibatkan gantian pasir kepada bijih besi sebanyak 10 %, 20 % dan 40 %. Kaedah DOE telah digunakan dalam merekabentuk campuran konkrit dan kemudian diubahsuai dengan menggantikan 10 %, 20 % dan 40 % daripada pasir kepada bijih besi. Kajian ini dijalankan di makmal untuk mengkaji sifat konkrit dari segi kekuatan mekanikal serta sifat fizikal. Sifat fizikal konkrit baru telah ditunjukkan oleh ujian kemerosotan. Dari segi kekuatan mekanikal, konkrit keras dijalankan ujian mampatan dan ujian kekuatan lenturan. Beberapa sampel konkrit telah dibuat dan disembuhkan menggunakan penguringan dan diuji pada hari ke 7, 14 dan 28. Ketumpatan konkrit yang diperolehi sehingga mencapai 2459 kg/m^3 dalam kajian ini. Keputusan juga menunjukkan bahawa peningkatan kekuatan mampatan dengan usia sampel. Kekuatan lenturan dan kekuatan mampatan konkrit yang mengandungi bijih besi menurun dengan kenaikan peratusan penggantian bijih besi. Kesimpulan boleh dibuat bahawa 40 % penggantian tidak sesuai digunakan, tetapi mungkin terdapat beberapa keadaan yang memerlukan peratusan ini dan konkrit bijih besi ini boleh diperbaiki dengan bantuan bahan atau larutan tambahan. Walau bagaimanapun, keputusan telah membuktikan bahawa konkrit dengan bijih besi adalah lebih padat dan berat daripada konkrit biasa.

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R	=	Modulus of rupture (psi or MPa)
P	=	Maximum applied load indicated by the testing machine (N)
L	=	Span length in inches (mm)
b	=	Average width of specimen (inches or mm)
d	=	Average depth of specimen (inches or m)
F	=	Maximum load recorded at failure expressed N
A	=	Cross-sectional area of the specimen
f_{cc}	=	Compressive strength

LIST OF ABBREVIATIONS

ASTM	=	American Standard Testing for Material
FKASA	=	Fakulti Kejuruteraan Awam dan Sumber Alam
BS	=	British Standard
ACI	=	American Concrete Institution
DOE	=	Design of Engineering
UMP	=	Universiti Malaysia Pahang

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Construction industry increased over time and building materials is the most important components in implementing a project. There is some improvement in the construction sector such as construction of submarine gas pipeline. The advantages of submarine pipeline construction are that liquid and gas can be supplied directly without involving the transshipment and delivery work. Therefore, submarine pipe design should be done as appropriate and safe in use, such as oil and gas transportation. There are some considerations to be ensured for the pipe stress function properly during the installation, the stability of pipeline on the seabed that is influenced by the weight factor.

This research is to find solutions to overcome the problems that arise in the construction of submarine pipelines. The improvements in the components will be conducted by replacing partial of the sand with iron ore.

Heavy concrete with iron ore can be applied in a wide range of densities and thickness to meet project requirements. This feature can improve installation, optimize negative buoyancy and mechanical protection while minimizing cost. In addition, an increase in weight makes the concrete blocks static as regards resistance to the waves. In the Present Scenario iron (Fe) is a metallic element and composes about 5% of the Earth's crust. When pure it is a dark, silvery-gray metal. It is a very reactive element and oxidizes (rusts) very easily. The reds, oranges and yellows seen in some soils and on rocks are probably iron oxides.

1.2 Problem Statement

Pipes are produced in a particular length and there is a connection between the pipes. The pipeline laying operation on the seabed involves flexure at the joint of pipelines. The flexural analysis should be done to ensure that the pipeline does not fail and cause leaks or damage.

The pipeline which is located in the seabed is influenced by environmental forces due to waves and stream flow uniformly. Drag force, inertia force and buoyancy force can lead to instability of the pipe. Therefore, concrete weight coating provides negative buoyancy for subsea lines, mechanical protection during handling, transportation and laying operations, and protects the line during its lifetime in a marine environment.

Resistance to movement depends on the weight of the submerged pipeline. Weight of the pipe can be added with a suitable coating concrete coating type required and optimized in order to submerge pipe. Thus, concrete is prepared with different specific gravities and thicknesses using quality iron ore and other key raw materials.

1.3 Objectives

The objectives of this study are as the following:

1. Determine the workability of concrete using iron ore as a substitute for sand compared with the control concrete
2. Determine the compressive strength of concrete using iron ore as a substitute for sand compared to the control concrete
3. Determine the flexural strength of concrete by using iron ore as a substitute for sand compared to the control concrete

1.4 Scope of Study

This study will focus on determining the value of concrete strength and workability as well when the iron ore used as a substitute for sand. Determination of this objective involves three types of tests; the Slump test, test compression and flexural tests. This test will be conducted at University Malaysia Pahang concrete laboratory involving a total of 36 samples including the control sample as a whole cube.

A concrete mix with proportions of cement:sand:coarse; 1:1:2 was considered. Mixture of concrete are chosen with 0 %, 10 %, 20 % and 40 % iron ore aggregate by volume, to observe the effect of iron ore aggregate on the mechanical properties of heavy concrete. The compressive test and the flexural test specimens are shown in Table 1.1 and Table 1.2 respectively. Compressive test and flexural test used the different dimension of specimen, Figure 1.1 show the dimension used in this study.

Table 1.1: Compressive Test specimen (150 mm x 150 mm x 150 mm)

Duration (day)	7	14	28
Specimen Iron ore (%)	cubes	Cubes	cubes
0	3	3	3
10	3	3	3
20	3	3	3
40	3	3	3

Table 1.2: Flexural Test specimen (100 mm x 100 mm x 500 mm)

Duration (day)	28
Specimen Iron ore (%)	cubes
0	2
10	2
20	2
40	2

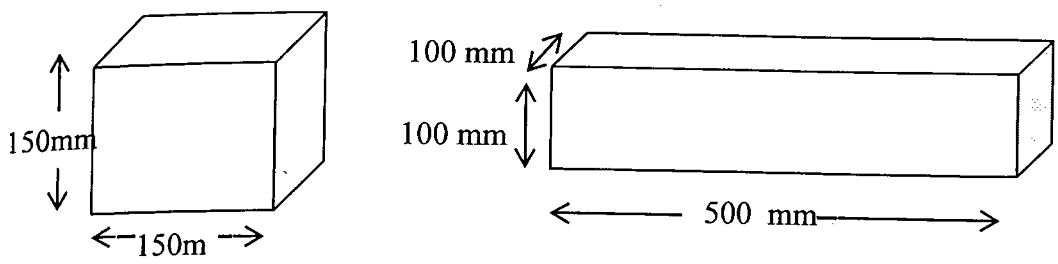

Figure 1.1: Dimension of specimens

1.5 Significant of Study

The important of this study is to determine the pattern for iron ore concrete compressive strength of partial replacement of sand with iron ore. The replacement of iron ore in concrete will produce a concrete that not only heavy concrete but also higher strength and higher density.

This study also to determine the modulus ruptures for each concrete mixture containing different percentages of iron ore. The flexural strength of iron ore concrete is important for the pipeline laying operation where the ability to bend at pipe connection is needed to be identified.

CHAPTER 2

LITERATURE REVIEW

1.1 Introduction

Theoretically explain the definition of concrete, the materials in the production of concrete admixtures in the concrete and the standard tests conducted on concrete. Also include the previous studies related to the topic of this study. Though number of significant results has been reported on the sand replacement in concrete but there is not much literature available on the use of Iron ore ash as partial replacement of fine aggregates.

2.2 Materials

Concrete is basically a mixture of two components which are aggregates and paste (binder). The paste is included of cement, supplementary cementitious materials and water. It binds the aggregates. The chemical reaction of the cementitious materials and water is called hydration. Hydration is the process by which paste hardens and binds the aggregates.

2.2.1 Water

Water is the important elements because it is required to prepare mortar, mixing of cement concrete and for curing during the sample preparation. The quality of water is important because the impurities in it may interfere with the setting of the cement, may affect the strength of the concrete or cause staining of its surface. The water should be clean and totally free from the injurious quantities that may affect the stone concrete. Tap water were used which is the quality is accordance to BS 3148:1959 has been specified by the Public Work Department of Malaysia.

Mostly the cement requires about 3/10 of its weight of water by hydration. Water is required to lubricate the mix to makes the mixture workable. In this study, normal tap water is used for mixing and curing.

2.2.2 Cement

Cement is material which binds together solid bodies (aggregate) by hardening from a plastic state. Although cement is a common term and can be applied to many inorganic and organic materials, by far the most commonly used and most versatile cement is Portland cement. Portland cement was developed from natural cements made in Britain in the early part of the 19^{th} century, and its name is derived from its likeness to Portland stone, a type of building stone that was quarried on the Isle of Portland in Dorset, England. Portland cement is the name given to cement found by intimately mixing together calcareous and argillaceous, or other silica. Alumina and iron oxide bearing materials burning them at a clinkering temperature, and grinding the resulting clinker.

There are many types of cement. For this project, ordinary Portland cement is used. ASTM Type I was used in all mixtures accordance to BS 12:1958. It is commonly used in the construction when there are no requirement for the other special cement is needed.

Table 2.1: General features of the main types of portland cement.

	Classification	**Characteristics**	**Applications**
Type I	General purpose	Fairly high C_3S content for good early strength development	General construction (most buildings, bridges, pavements, precast units, etc)
Type II	Moderate sulfate resistance	Low C_3A content (<8%)	Structures exposed to soil or water containing sulfate ions
Type III	High early strength	Ground more finely, may have slightly more C_3S	Rapid construction, cold weather concreting
Type IV	Low heat of hydration	Low content of C_3S (<50%) and C_3A	Massive structures such as dams. Now rare.
Type V	High sulfate resistance	Very low C_3A content (<5%)	Structures exposed to high levels of sulfate ions
White	White color	No C_4AF, low MgO	Decorative (otherwise has properties similar to Type I)

Ordinary Portland (type 1) cement is made from 95-100 per cent of Portland cement clinker and 0-5 per cent of minor constituents, which can be of a cementitious nature or filler to improve workability or water retention.

2.2.3 Aggregate

Aggregates account for 60 to 75 percent of the total volume of concrete. Fine aggregates commonly consist of natural sand or crushed stone with most particles passing through a (5 mm) sieve. Fine aggregate should not contain any significant amount of the clay or harmful impurities like salts, coal and decayed. In this study, the sand that used was river sand for it is fine sand and consist rounded grains shape.

Coarse aggregates are any particles greater than 5 mm, but generally range between 9.5 mm to 50 mm in diameter. Aggregate used must not too dry and free of dirt in order to have better hardening process. In this study, the coarse aggregate used was from crushed stone and gravel with diameter in the range 20 mm.

Particle shape and surface texture affect the properties of freshly mixed concrete more than the properties of hardened concrete. Rough-textured, angular, and elongated particles require extra water to produce workable concrete than smooth, rounded compact aggregate. The properties, such as size, grading, shape and surface texture, have marked influence on workability and strength of concrete. According to Kaplan, (1959), the mechanical bond between the aggregate surface and cement paste, by virtue of interlocking, influences the strength of concrete

Wills B.A. (1988) stated that crushed aggregates present good adherence with cement paste due to their surface and geometry properties when they are exposed to appropriate granulometry.

The choice of aggregates is important, their quality shows a great role, they can not only limit the strength of concrete but owing to their characteristic, they affect the durability and performance of concrete. (Neville, 2000)

2.2.4 Iron Ore

The density of concrete can be increased by using high-weight aggregate, such as iron ore with densities over 4000 kg/m^3. Ismail and AL-Hashami, (2007) examined the potential for using waste iron ore in concrete mixes as a partial replacement of sand. The test of those iron ore concrete mixes revealed that this performed efficiently to improve compressive and flexural strength in time, increase density but decrease the slump value.

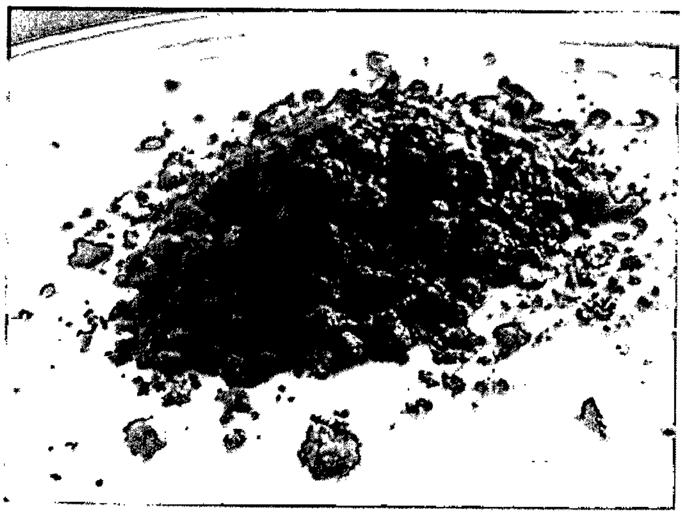

Figure 2.1: Iron ore

Iron ore used in this study is from Aras Kuasa supplier. This type of iron ore used in the production of the company Bredero Shaw pipe in Malaysia. The size of the iron ore used is less than 6.30 mm, which is located in the category of fine ore. By BS Sieve, iron ore was sieved passed 6.30 mm about 99.91 % and fall within 95 to 100 % ideal. The density of iron ore reached 4354 kg/m3 and humidity of 2.74 %.

2.3 Curing

Curing was the process where it controls the rate and extent of moisture loss from the concrete and where the concrete achieves its strength through a hydration. Esrig, (1999) stated that most strength gain occurs within the first 28 days after mixing, and strength continues to increase at a slower rate thereafter.

2.4 Workability

In general, workability cannot be defined as property of the concrete which determines it. Neville, (1981) defined the workability of the concrete as physical property of the concrete alone without reference to the circumstance of a particular type of construction due to ease of placement, resistance to segregation and the mean of compaction available. In this study, slump test are according to BS 1881: Part 102:1983.

2.5 Compression Test

Primary function of concrete is to applied loads where is expressed in terms of strength. Compressive strength can be defined as the measured maximum resistance of a concrete specimen to axial loading. Olawuyi, (2010) stated that, at the end of each curing period three specimens of each mixture were tested for compressive strength and the average was recorded.

The strength of the concrete was influenced by the specimen size and shape, the method of the pore formation, water content, characteristics of the ingredients used, direction of the loading and the method of curing (Valore, 1954).

2.6 Flexural Test

Gambhir, (2006) stated that , the result of the flexural strength were mainly affected by the size of the specimens, the casting methods, curing and moisture conditions, manner of loading and the rate of the loading.

According to Valore, (1954), the strength of the concrete was influenced by the specimen size and shape, the method of the pore formation, water content, characteristic of the ingredients used, direction of the loading and the method of curing.