

# **OPTIMUM FINE AND COARSE AGGREGATES PROPORTIONS TO PRODUCE STRENGTH OF CONCRETE**

**by:**

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## **ABSTRACT**

When a structure is built, the concrete is required to reach a certain strength before the forms are struck or additional loads are applied. For these reason frequently specified by strength, usually compressive strength.

Lately, much research on the behaviour of strength of concrete has been performed and reported. However, the influence proportions of fine and coarse aggregates contents to produce strength of concrete are still a very unexplored area of research. Generally speaking, the strength of concrete depends not only on concrete mix and chosen materials, but also depends on proportions of aggregate content.

In this project, the mixtures of concrete influenced by added quarry chip to produce strength of concrete are investigated. Furthermore, the research also includes tests on workability and compressive strength developments. The project aims to give information the design of strength of concrete made of different proportions of aggregate contents.

## **ABSTRAK**

Apabila sesebuah struktur dibina, konkrit haruslah mencapai sesuatu tahap kekuatan yang tertentu, sebelum acuan ia gagal atau penambahan beban diperlukan. Oleh itu, adalah penting menentukan kekuatan konkrit dan biasanya kekuatan mampatan ditentukan.

Kebelakangan ini, banyak kajian yang telah dijalankan mengenai ciri-ciri kekuatan konkrit. Bagaimanapun, kajian terhadap kesan nisbah kandungan agregat halus dan kasar dalam campuran konkrit untuk menghasilkan kekuatan konkrit masih kurang meluas. Sebenarnya, kekuatan konkrit tidak hanya bergantung kepada reka bentuk campuran konkrit dan pemilihan bahan sahaja, tetapi ia juga bergantung kepada nisbah kandungan agregat.

Di dalam projek ini, kesan penambahan butiran kuari di dalam campuran konkrit untuk menghasilkan kekuatan konkrit akan di kaji. Selain itu, kajian ini juga merangkumi ujian terhadap kebolehkerjaan konkrit dan kekuatan mampatan konkrit. Tujuan projek ini adalah untuk memberi pengetahuan dalam menghasilkan kekuatan konkrit dengan menggunakan perbezaan nisbah kandungan agregat.

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## NOMENCLATURE

ASTM	American Society Testing and materials
BS	British Standard
ACI	America Concrete Institute
$C_3S$	Tricalcium silicate
$C_2S$	Dicalcium Silicate
$C_3A$	Tricalcium aluminate
$C_4AF$	Tetracalcium aluminoferrite
$\mu m$	Micrometres
mm	Millimetres
s	Seconds
kN	KiloNewton
$m^2/kg$	Metres square / kilograms
$kg/m^2$	Kilograms / Metres square
kg	Kilograms
MPa/s	MegaPascal / seconds
kN/s	KiloNewton / seconds
$N/mm^2$	Newton / millimetres square
$Kg/m^3$	Kilograms /metres cube

# CHAPTER ONE:

## GENERAL INTRODUCTION

### 1.0 INTRODUCTION

In concrete design, the proportion of fine and coarse aggregates content is the most commonly important influence the properties of concrete. The different proportions of fine and coarse aggregates can produce various strength of concrete. In general, concrete can be manufactured to have a compressive strength such as in **Table 1.1**:

Type of concrete	Compressive strength
Low-Strength Concrete	Less than 20 N/mm <sup>2</sup>
Moderate –strength Concrete	20 N/mm <sup>2</sup> to 60 N/mm <sup>2</sup>
High-Strength Concrete	More than 60 N/mm <sup>2</sup>

Table 1.1: Type of concrete (*P. Kumar Metha, 1993*)

**Moderate-strength concrete** is ordinary or normal concrete, which most structural work. **High-strength concrete** is used for special application such as in the columns of tall concrete buildings, offshore oil structures, parking garages, bridge deck overlays, dam spillways, warehouses and heavy industrials slab.

Here, we can say, **aggregates** is a rocklike materials of various size and shapes used in the manufacture of Portland cement concrete, bituminous concrete (asphalt concrete), plaster, grout, filter beds, railroad ballast, base course,

foundation fill or subgrade and so on. According to the *ASTM (C125 and D8)*, aggregates as a granular materials such as sand, gravel crushed stone, or iron-blast-furnace slag used with a cementing medium to form concrete or mortar or alone as in base course or railroad ballast.

In concrete, the aggregates make up about 70 to 80 percent its volume and that can be expected to have an important influence on its properties such as strength and durability. Aggregates also provide concrete with better dimensional stability and wear resistance. The size of aggregates particle ranges between that of dust and 50.8 mm or maybe higher and based on their sizes, which aggregates can be divided into

1. Fine aggregates, and
2. Coarse aggregates.

### **1.1 FINE AGGREGATES**

Fine aggregates (also called sand) is to consist of hard siliceous sand or other approved inert materials with similar characteristics having clean, hard, uncoated grains and free from lumps, soft or flaky particles, shale, mica, crusher dust, silt alkali, loam organic matter or other deleterious substance in sufficient quantity to affect the strength or durability of concrete or reinforcement (*General Specification for Building Works by Sarawak Public Works Department*). Beside that, fine aggregates also define as natural or manufactured particles size from 150  $\mu\text{m}$  to 4.75mm. In concrete construction, the fine aggregates is defines as aggregates with predominant particles of size smaller than 4.75 mm and larger than 75  $\mu\text{m}$ .



## 1.2 COARSE AGGREGATES

A coarse aggregate is to consist of gravel, crushed stone or other approved material similar characteristics with fine aggregates. A coarse aggregate is to be uniformly graded from the nominal size stated down to 4.75 mm only. The nominal size for mass concrete less than 305 mm thickness or over is to be 40 mm; that for mass concrete less than 305 mm thickness and for all reinforced concrete is to be 20 mm.

## 1.3 OBJECTIVES OF THE PROJECT

The purpose of this project is:

1. To show and investigate the different proportions of fine aggregates and coarse aggregates to produce the strength of concrete.
2. To investigate the use more fine aggregates than coarse aggregates to produce the strength of concrete. This project **do not** used the presence of admixtures.
3. To investigate the use of dust aggregates (quarry chip) in concrete mixing to produce the strength of concrete. Quarry chip is a waste material from quarries plant.

## 1.4 PROJECT OVERVIEW

This project was divided into five chapters. **Chapter one** will elaborate the general information about the aggregate and the objectives of the project. Literature review will be in **chapter two**, which will discuss detail all the information concerning the strength of concrete. This chapter is divided into concrete materials, strength of concrete, aggregate characteristics and signification, mix proportioning of concrete and testing of concrete.

The methodology of the project is discussed in **chapter three**, which the entire stage based on the information in literature review. Requirements analysis of the result will be done in **chapter four**. Finally, **chapter five** is the conclusion of the project, findings and future research recommendations if necessary.

## **CHAPTER TWO:**

### **LITERATURE REVIEW**

#### **2.0 INTRODUCTION**

This chapter discusses the literature review of project, which to gather all the information concerning the strength of concrete. This chapter will cover

1. The properties of constituent materials such as cement, aggregate, water and admixture.
2. Strength of concrete, where the compressive strength is important property.
3. Aggregate characteristic such as shape and texture, size gradation, maximum aggregate size, density and moisture state, which is influence the strength and durability of concrete.
4. The factor influence of the proportioning of concrete mixes and the basics step in designing a concrete mix.
5. Testing of concrete to determine the fresh concrete and hardened concrete.

This hopefully can be use as guidance when comes requirements analysis and design phases.

## 2.1 CONCRETE MATERIALS

The words **concrete** comes from the Latin term's "*concretus*" which means to grow together. In the practice, the concrete is constituent material as cements (Portland cement), aggregates, water and admixtures are mixed together and molded into the desired size and shape when the mixture is still wet. Within a few hours of mixing, the cement and water undergo a chemical reaction. The products of reaction, which continues with times are hard and durable, it is called concrete.

### 2.1.1 PORTLAND CEMENT

Portland cement is the name given to cement, where it is made primarily a combination of a calcareous and argillaceous material, such as limestone and alumina found as clay or shale and burning them at a clinkering temperature and grinding the resulting clinker.

#### 2.1.1.1 CHEMICAL COMPOSITION

Basically, Portland cement consists essentially of various compounds and four compounds are regarded as the major constituents of cement are listed in **Table 2.1** together with their abbreviation symbols.

Name of compounds	Oxide Composition	Abbreviation
Tricalcium silicate	$3\text{CaO}.\text{SiO}_2$	$\text{C}_3\text{S}$
Dicalcium Silicate	$2\text{CaO}.\text{SiO}_2$	$\text{C}_2\text{S}$
Tricalcium aluminate	$3\text{CaO}.\text{Al}_2\text{O}_3$	$\text{C}_3\text{A}$
Tetracalcium luminoferferrite	$4\text{CaO}.\text{Al}_2\text{O}_3.\text{Fe}_2\text{O}_3$	$\text{C}_4\text{AF}$

Table 2.1: Major constituent of cement

The **Silicates**,  $C_3S$  and  $C_2S$  are the most important compounds, which are responsible for the strength of hydrated cement paste. The presence of **Tricalcium aluminate**,  $C_3A$  contributes little to strength of cement except at early ages. However,  $C_3A$  is beneficial in the manufacture of cement in that facilities the combination of lime and silica. **Tetracalcium aluminoferrite**,  $C_4AF$  is also present in cement in small quantities, it does not affect the behavior significantly, however it reacts with gypsum to form calcium sulphoferrite and its presence may accelerate the hydration of the silicates.

#### 2.1.1.2 TYPES OF PORTLAND OF CEMENT

Several types of Portland cement are available and additional special cements can produce for special uses. **Table 2.2** at appendix 2.1 lists the main types of Portland cement together with the appropriate **BS** and **ASTM** Standards, while **Table 2.3** at appendix 2.2 gives the average values of compounds composition.

As we know, **Ordinary Portland Type I** is an excellent and is the cement most widely used in general concrete construction. The characteristics of ordinary Portland cements have a higher  $C_3S$  (Tricalcium silicate) and a greater fineness. **BS 12:1989** specifies a minimum of 275  $m^2/kg$  for ordinary cement and 225  $kg/m^2$  for controlled fineness Portland cement. In consequence, the cements have a higher 28-day strength but the gain in strength is smaller. **Modified, Type II** is the lower of hydration than Type I and used where moderate exposure to sulfate attack exists or where moderate heat of hydration is desirable. The **High Early strength, Type III** used when high early strength desirable has considerably higher heat of hydration than Type I cement. **Low heat, Type IV** used in mass concrete dams and other structures where heat of hydration is

dissipated slowly. **Sulfate resisting, Type V** used in footing, basement walls, sewers and so on, exposed to soils containing sulfates.

**Figure 2.1** illustrates the rate of strength gain with different cements. Concrete made with Type III, high early strength more rapidly than does concrete made with type I, normal cement, reaching about the same strength at 7 days as a corresponding mix containing Type I cement would reach at 28 days. All five tend to approach the same strength after a long period of time.

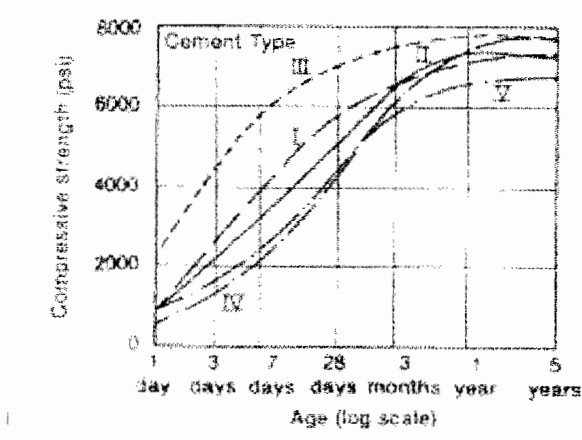


Figure 2.1: Effect of type cement on strength gains concrete

**2.1.2 AGGREGATES**

Since approximately three-quarter of the volume of concrete is occupied by aggregate, that its quality is of considerable importance. Not only may the aggregate limit the strength of concrete, but also the aggregate properties greatly affect the durability and structural performance of concrete.

Aggregate characteristics that are significant to concrete technology include porosity, grading or size distribution, moisture absorption, shape and surface

texture, crushing strength, elastic modulus and the type of deleterious shown in **Table 2.4** at appendix 2.3 and are described in more detail at **Section 2.3**.

### **2.1.3 WATER**

Water is an important ingredient of concrete because impurities in it may interfere with the setting of the cement, may adversely affect the strength of the concrete or cause staining of surface and may also lead to corrosion of the reinforcement. For that reason, the suitable water for mixing should be considered. As a rule, water unsuitable for drinking may not necessarily be unfit for mixing concrete. The satisfactory strength development is primary concern, impurities contain in the mix water may affect the strength of concrete. Water should be avoided if it contains large quantities of suspended solids, excess amount of dissolved solids or appreciable amounts of organic materials. Concentrations for various impurities are in **Table 2.5** can get at appendix 2.4.

### **2.1.4 ADMIXTURE**

The definition of an admixture set out in **ASTM C 125** is a materials other than water, aggregate and hydraulic cement that is used as an ingredient of concrete and added to the batch immediately before or during its mixing. Admixtures vary in composition surfactants and soluble salts and polymers to insoluble minerals. The purpose for used in concrete include improvement of workability, acceleration or retardation of setting time, control of strength development and enhancement to frost action, thermal cracking, alkali-aggregate expansion and acidic and sulfate solution. The majority of admixtures do affect several concrete properties will see at **Table 2.6** in appendix 2.5. In this project, the using admixtures will be ignoring.

## **2.2 COMPRESSIVE STRENGTH OF CONCRETE**

In concrete, strength is related to the stress required to cause fracture and is synonymous with the degree of failure at which the applied stress reaches its maximum value (*P.Metha Kumar, 1993*). The working theory stress for concrete design considered concrete as mostly suitable for *bearing compressive load*, this why it is compressive strength of the material that is generally specified. The general assumption is that an improvement in concrete strength will improve its other properties as well.

The response of concrete to applied stress depends not only on the stress type but also on how a combination of various factors affects porosity of different structural components of concrete. The factors include properties and proportions materials in mix design, degree compaction and condition curing. To simplify an understanding of these factors, described separately under three categories:

1. Characteristics and proportions of materials
2. Curing condition
3. Testing parameters

### **2.2.1 CHARACTERISTICS AND PROPORTIONS OF MATERIALS**

Before making a concrete mixture, the selection of proper constituents materials and determination of their proportions is the first step toward obtaining the specified strength of concrete. In practice, many mix design parameters are interdependent, therefore their influence cannot really separated.