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# EXPERIMENTAL INVESTIGATION ON THE CONVENTION OF WASTE PRODUCTION

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## ABSTRACT

Recycled aggregates are comprised of crushed, graded inorganic particles processed from the materials that have been used in the constructions and demolition debris. The aim for this on – going project is to determine the strength characteristic of recycled aggregates for application in high strength structural concrete, which will give a better understanding on the properties of concrete with recycled aggregates, as an alternative material to coarse aggregate in structural concrete. The capacity of this project is to decide and balance the high strength concrete by using special percentage of recycled aggregates.The study was carried out using workability test, compressive test, not direct tensile test and modulus of flexibility test. There were total of eight batches of concrete mixes, consists of each 20% increase of cast-off aggregate substitute from 0% to 100%. in addition, 100% of recycled aggregate mix batches included fly ash, water/cement ratio of 0.36 and 0.43. The workability of concrete significantly reduced as the amount of recycled aggregate increased. This was evaluated during normal slump test and compacting factor test. For power individuality, the results showed that a regularly falling in compressive strength, tensile might and modulus of stretch as the percentage of recycled aggregate used in the specimens increased.

## 1. INTRODUCTION

### 1.1 Introduction of Recycled Aggregate

Recycling is the act of dispensation the used material for use in creating fresh product. The habit of natural aggregate is getting more and more intense with the advanced maturity in infrastructure area. In order to reduce the usage of natural aggregate, recycled aggregate can be used as the substitute materials. Recycled aggregate are comprised of crushed, graded inorganic particles processed from the materials that have been used in the constructions and devastation debris. These resources are usually from buildings, road and rail network, bridges, and sometimes even from catastrophes, such as wars and earthquakes.

### 1.2 Historical Background

The applications of recycled aggregate in the construction areas are wide and they had been used long time ago. Wilmot and Vorobieff (1997) confirmed that cast-off aggregate have been old in the road business for the last 100 years in Australia. They also stated that the use of recycled aggregate for

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the construction and treatment of local government roads has a great improve in the last five years

Figure1.1: Recycled Aggregate.

C & D Recycling Industry (n.d.), the fact file confirmed that from the time of the Romans, the stones from the earlier roads were reused when rebuilding their vaunted set of roads. It also confirmed that since the end of planet war two, the recycling business had been well recognized in Europe.According to Seecharan (2004), the Detroid News confirmed that in 1980s, the old concrete compressed into a fine particles was a popular road builder at Michigan, USA.

### 1.3 Applications of Recycled Aggregate

Traditionally, the application of recycled aggregate is used as landfill. Nowadays, the applications of cast-off aggregate in structure areas are wide. The applications are unlike from country to country.

- **Concrete Kerb and Gutter Mix**

Recycled aggregate have been used as concrete kerb and gutter mix in Australia. According to Building Innovation & Construction Technology (1999), Stone says that the 10mm recycled aggregate and blended recycled sand are used for concrete kerb and gutter mix in the Lenthall Street project in Sdyney.

Figure 1.2: Application of Recycled Aggregate as Road Kerb (Source: Building Innovation & Construction Technology, 1999)

**Advantages**

There are many advantages through using the recycled aggregate. The advantages that occur through usage of cast-off aggregate are listed below.

- **Environmental Gain**

The main advantage is based on the environmental expand. According to CSIRO (n.d.), creation and devastation waste makes up to around 40% of the total waste each year (estimate around 14 million tones) going to land fill. Through recycled these material, it can keep diminishing the resources of urban aggregated. Therefore, natural aggregate can be used in higher – grade applications.

- **Save Energy**

The recycling process can be done on site. According to Kajima Technical Research Institute (2002), Kajima is developing a method of recycling crushed concrete that used in the construction, known as the Within-Site Recycling System. Everything can be done on the construction site through this system, from the process of recycled aggregate, manufacture and use them. This can save energy to transport the recycled

materials to the recycling plants.

- **Cost**

Secondly is based on the cost. The cost of recycled aggregate is cheaper than virgin aggregate. According to PATH Technology Inventory (n.d.), the costs of recycled concrete aggregateare sold around $3.50 to $7.00 per cubic yard. It depends on the aggregate size limitation and local availability. This is just around one and half of the cost for natural aggregate that used in the construction works. The transportation cost for the recycled aggregate is reduced due to the weight of recycled aggregate is lighter than virgin aggregate.

- **Job Opportunities**

There will be many people involved in this new technology, such as specialized and skilled persons, general workers, drivers and etc. According to Scottish Executive (2004), a Scottish Market Development Program is developed. The purpose of this program is to recycle the materials that arising in Scotland. This program will provide 150 new jobs in the Scottish industry.

- **Sustainability**

The amount of waste materials used for landfill will be reducing through usage of recycled aggregate. This will reduce the amount of quarrying. Therefore this will extend the lives of natural resources and also extend the lives of sites that using for landfill.

- **Market is Wide**

The markets for recycled concrete aggregate are wide. According to Environmental Council of Concrete Organization (n.d), recycled concrete aggregate can be used for sidewalk, curbs, bridge substructures and superstructures, concrete shoulders, residential driveways, general and structural fills. It also mentioned that recycled concrete aggregate can be used in sub bases and support layers such as unstabilized base and permeable bases.

## 2. REVIEW OF RECYCLED AGGREGATE

### 2.1 Literature Review of Recycled Aggregate

The applications of recycled aggregate in the construction area are very wide. There are many testing based on the recycled aggregate have been carried out all around the world. Hanson and Torben (1986) stated that since 1945, the research on recycled aggregate had been carried out in many countries. Some of the literature reviews on recycled aggregate are shown as below.The main aim that testing the recycled aggregate is to find out the result of the strength characteristic on it and analysis whether recycled aggregate is suitable to apply in the construction area. According to Rammamurthy and Gumaster (1998), the compressive strength of recycled aggregate concrete was relatively lower and variation was depended on the strength of parent concrete from the obtained aggregate.

Limbachiya and Leelawat (2000) found that recycled concrete aggregate had 7 to 9% lower relative density and 2 times higher water absorption than natural aggregate. According to their test results, it shown that there was no effect with the replacement of 30% coarse recycled concrete aggregate used on the ceiling strength of concrete. It also mentioned that recycled concrete aggregate could be used in high strength concrete mixes with the recycled concrete aggregate content in the concrete.

Sagoe, Brown and Taylor (2002) stated that the difference between the characteristic of fresh and hardened recycled aggregate concrete and natural aggregate concrete is relatively narrower than reported for laboratory crush recycled aggregate concrete mixes. There was no difference at the 5% significance level in concrete compressive and tensile strength of recycled concrete and control normal concrete made from natural aggregate.

In the same year, poon (2002) reported that there were not much effect of the compressive strength of brick specimens with the replacement of 25% and 50% of recycled aggregate. But when the percentage of recycled aggregate replacement increased, the compressive strength of the specimens was reducing. Mandal, Chakarborty and Gupta (2002) also found that there will no effects on the concrete strength with the replacement of 30% of recycled aggregate. But the compressive strength was gradually decreasing when the amount replacement of recycled increased. They concluded that the properties and the strength characteristic of recycled aggregate concrete were deficiency when compared to the specimens that made by the natural aggregate.

Limbachiya (2003) found that there is no effect by using up to 30% of coarse recycled concrete aggregate on the standard 100mm concrete cube compressive strength. But when the percentage of recycled concrete aggregate used increased, the compressive strength was reducing.

From the literature review shown, the results of the compressive strength are all reducing when the replacement of recycled aggregate used in the concrete increased. There must be some influences that cause the reducing of compressive strength of recycled aggregate. According to Tavakoli (1996), the strength characteristics of recycled aggregate concrete were influenced by the strength of the original concrete, the ratio of coarse aggregate to fine aggregate in the original concrete, and the ratio of top size of the aggregate in the original concrete in the recycled aggregate. He also mentioned that water absorption and Los Angeles abrasion loss will influence the water cement ratio and top size ratio for the strength characteristic of recycled aggregate.

Bodin and Zaharieva (2002) stated that decreasing of the strength of recycled concrete specimen was due to the increase of water/cement ratio that required by the preservation of workability.

Mandal (2002) stated that adjusted the water/cement ratio when using recycled concrete aggregate during the concrete mixing can improved the strength of the recycled aggregate concrete specimens. From the obtained result, recycled aggregate concrete specimens had the same engineering and durability performance when compared to the concrete specimens made by natural aggregate within 28days design strength.

Chen and Kuan (2003) found that the strength of the concrete specimens was affected by the unwashed recycled aggregate in the concrete. The effect will more strange at the low water cement ratio. These effects can be improved by using the washed recycled aggregate.

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## 3. PROPERTIES AND TESTING OF AGGREGATE

### 3.1 Particle Density and Water Absorption of Course and Fine Aggregate

Particle density is one of the important factors that used to determine the properties of aggregate. It is required when calculate the mix design for concrete. Australian Standard HB64 (2002) stated that in the concrete mix, substituting different density of aggregate would influence the yield, unit mass of concrete and quality of aggregate needed for a concrete volume. The particle density of aggregate is generally affected by the amount of moisture present and the geological properties of aggregate. In this project, particle density of aggregate was carried out to determine the volume and weight of aggregate needed for the concrete mixes. The determination of particle density was according to AS1141.5 and AS1141.6.1.

Water absorption is the amount of moisture absorbed in the aggregate. The water absorption capacity is based on saturated surface dry condition and oven dried condition. Australian Standard HB64 (2002) mentioned that the amount of water in a concrete mix has direct effect on the setting time and compressive strength of concrete. It also stated that moisture content of the aggregate had to determine first before preparing a mix design for a particular aggregate. If the moisture content of the concrete is not met the target, then more water have to add to avoid a loss of workability. If the moisture content exceeds the target, then less water should be added. The determination of water absorption of aggregate was according to AS1141.5 and AS 1141.6.1.

In this project, determination of particle density and water absorption of aggregate were based on natural aggregate with grain size of 20mm, 10mm and 7mm, recycled aggregate with gain size of 14mm and 5mm, and fine aggregate (sand). All the testing was carried out in the engineering laboratory of University of Southern Queensland.

### 3.2 Sieve Analysis

Sieve investigation is used to find the quantity of different size of aggregate used in a concrete mix. It is accepted out to let the aggregate pass during a series of sieves. The sieve analysis can be done either by hand or sieve apparatus. It is recommended that using sieve machine will give more accurate result and can use several sieves in one time. The aggregate was air – dehydrated before accepted out the sieve analysis. According to Neville (1997), this is to evade lumps of fine particles being classified as bulky particles and prevent clogging of the more sieves. A process called ‘sample reduction’ was accepted out, where the amount of aggregate was compact from bucket by riffling. The aggregate was discharged in the riffle and composed in two boxes at the foundation of the chutes. One box was discharge and the other box was riffled repeatedly until met the specification. resolve of the sieve analysis was according to AS1141.11.

In this assignment, sieve analysis was passed out base on course aggregate and fine aggregate. The sieve sizes for course aggregate was from 19mm to 1.18mm and sieve sizes for fine aggregate was from

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2.36mm to 75µm.

## 4. EXPERIMENTAL METHODOLOGY

### 4.1 Introduction

This chapter discussed on the testing procedure for the workability test and hardened concrete specimens test. Workability test included slump test and compacting factor test. Hardened concrete specimens tests included compression test, indirect tensile test and modulus of elasticity.

### 4.2 Workability Tests of Fresh Concrete

Sabaa and Ravindrarajah (1999) had mentioned that workability is a very important property of concrete which will affect the rate of placement and the degree of compaction of concrete.

Cement relationship of Canada (2003) confirmed that the workability is the ease of insertion, combining and finishing freshly concrete assorted and the degree to which it resists separation.According to Cement Manufacturer's involvement India (n.d), a high-quality concrete must has workability in the fresh condition and also extendadequate strength. It also mentioned that there are four factors that can involve the workability. They are as below:

***Consistency***: The degree of consistency is depended on the nature of works andtype of compaction.

### 4.3 Testing on Hardened Concrete Specimens

Concrete is a combination of Portland cement, water and aggregate that consists of rocks and sand. Normally, concrete is strong in compression but weak in tension.

There are many ways that we can used to indicate the strength of concrete, according to University of Florida (n.d.), the tests used to point to the strength of concrete canister be categorized as critical and non – negative tests.The trying for the strength if concrete is extremely important in the civil works. University of Florida (n.d.) also mentioned that the engineers can evaluate the value of the testing to the intended value used for the building construction. This is to formulate sure that the constitution was built well.

This chapter consists of three types of hardened concrete testing. They are compression test, indirect tensile test and modulus of elasticity. All the procedure used was according to the Australia Standard Code.

## 5. TESTS RESULTS AND ANALYSIS

### 5.1 Introduction

Series of test was carried out on the concrete cylinder to obtain the strength characteristics of recycled aggregate for potential application in high strength structural concrete. This episodetalk regarding on the results that obtained from the testing. The results are such as slump test, compacting factor test, compression test, indirect tensile test and modulus of elasticity.

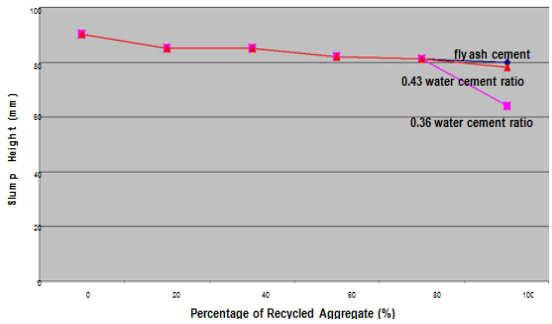


Figure 5.1: Graph showing the result of Slump Test

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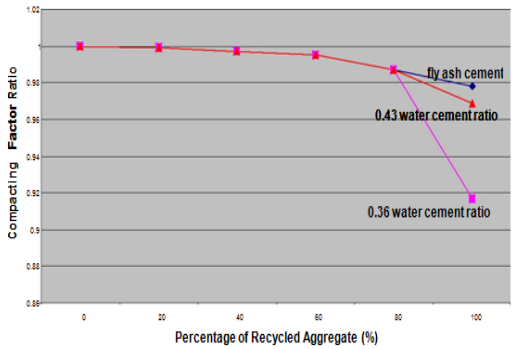


Figure 5.2: Graph showing the result of Compacting Factor Ratio

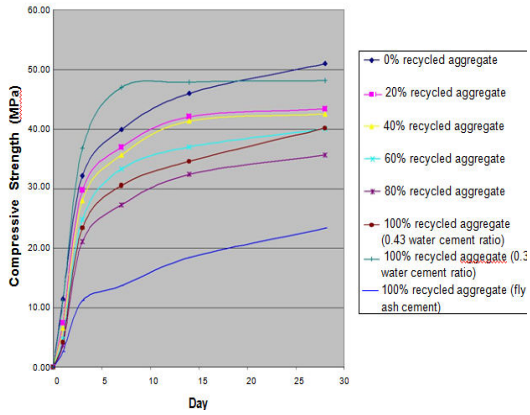


Figure 5.3: Variation of Compressive Strength with

## CONCLUSION

Investigate on the convention of waste production materials is extremely significant due to the equipment waste is steadily growing with the improved of residents and increasing of town development. The reasons that many investigations and analysis had been made on recycled aggregate are because recycled aggregate is easy to obtain and the cost is cheaper than virgin aggregate. Virgin aggregate need to mine but recycled aggregate can ignore this process.This on-going research project is to determine the strength characteristics of recycled aggregate for potential application in the high concrete structural concrete. The study shows that when the water/cement ratio was decreased, the compressive strength can reach 48MPa. This is classified as high strength concrete and they can be applied in the infrastructures, which need compressive strength up to 40MPa. Furthermore, with the cheaper price of recycled aggregate compared to natural aggregate, the builders can carry out the construction task with lesser material costs.Another result found in this research is that when reducing the water amount used in recycled aggregate mixes, tensile strength and modulus of elasticity are also improved. This will give an improvement in general strength characteristics of structural building.

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