EFFECT OF RECYCLED AGGREGATE FROM CONCRETE WASTE ON CONCRETE COMPRESSIVE STRENGTH

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ABSTRACT

Aggregate is one of the main ingredients in producing concrete. It covers 75% of the total for any one concrete mix. The strength of the concrete produced is dependent on the properties of aggregates used. However, the construction industry is increasingly making higher demands of this material and is feared to accommodate the many requests at one time. With this need other alternatives to prevent this from happening. The study was conducted on recycled aggregate from destroyed concrete. This study aims to investigate the characteristics of recycled aggregate concrete, which consists of various grades of hardened concrete is broken (recycle aggregate). Four different mixtures were produced. Control mixture, used as a reference while other samples containing the ratio of total aggregate content varied between normal aggregate and also "recycle aggregate." Decision analysis found that the characteristics of aggregates used are different than normal aggregate. Control mixture showed better results compared with the mixture of using recycled aggregate. Research shows that more recycled aggregate is used, the compressive strength of concrete decreases. However, recycled aggregate can be used for structures that do not require a high specification.

ABSTRAK

Agregat merupakan salah satu bahan yang utama di dalam menghasilkan konkrit. Ia meliputi 75% dari jumlah keseluruhan bagi bancuhan satu-satu konkrit. Kekuatan konkrit yang dihasilkan adalah bergantung pada sifat-sifat agregat yang digunakan. Namun begitu, keadaan industri pembinaan yang semakin meningkat membuatkan permintaan bahan ini semakin tinggi dan dikhuatiri tidak mampu menampung permintaan yang banyak dalam satu -satu masa. Dengan ini perlu adanya alternatif lain untuk menghindar keadaan ini dari berlaku. Kajian yang telah dijalankan terhadap agregat kitar semula daripada konkrit musnah. Kajian ini bertujuan mengkaji ciri-ciri agregat kitar semula yang terdiri daripada konkrit-konkrit keras pelbagai gred yang dipecahkan (agregat terpakai). Empat campuran berlainan telah dihasilkan. Campuran kawalan, digunakan sebagai rujukan manakala sampel berikutnya mengandungi nisbah jumlah kandungan agregat yang berbeza di antara agregat biasa dan juga "agregat terpakai". Keputusan analisis mendapati bahawa ciri -ciri bagi agregat terpakai adalah berbeza berbanding dengan agregat biasa. Campuran kawalan menunjukkan keputusan yang lebih baik berbanding dengan campuran kajian dengan menggunakan agregat kitar semula. Kajian menunjukkan semakin banyak agregat kitar semula digunakan, kekuatan mampatan konkrit semakin berkurang. Walaubagaimanapun agregat kitar semula boleh digunakan bagi struktur-struktur yang tidak memerlukan spesifikasi yang tinggi.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Construction and Demolition Waste (C&D) is produced during new construction, refurbishment or renovation of buildings. Demolition waste includes materials from complete building removal as well as partial removals when aspects of the buildings are retained. C&D waste includes bricks, concrete, masonry, soil, rocks, lumber, paving materials, glass, plastics, aluminum, steel, drywall (gypsum), plywood (formwork), plumbing fixtures, electrical, and roofing materials. C&D waste will increased from time to time proportionate with the development of the town and country. Thus, the necessity of finding appropriate solution to C&D waste destination must be clear. Reducing, reusing and recycling appear to be profitable alternatives that will increase the lifetime of landfills and reduce exploration of natural resources *(Woolley, 2000).*

Aggregate is a mixture of materials in the concrete mix. It is a mixture of basic material in which the content consists of three fourths of the concrete mix. In addition to the concrete mix materials are composed of water, cement and additives, if necessary. Because the total quantity of aggregate in a

concrete mixture is large, the strength and durability of a concrete depends on the characteristics aggregate itself. Among the key features of an aggregate is the strength of compressive and bond strength, size, shape and surface, the permeability and reactions to chemicals. Besides the physical properties of an aggregate such as relative density, density loam, porosity and absorption of moisture, soundness and resistance to acid and alkali attack also affect the strength. Although however, it is known that concrete strength decreases with increasing water ratio and the ratio of the design in terms of a ratio of cement to aggregate.

Aggregates can be classified into two classes of coarse aggregate and the aggregate fine (sand). Classification is based on the aggregate size where the size of the aggregate Gross is more than 5.0 mm while the size of the fine aggregate shall not exceed 5.0 mm. In the concrete mixture, the quantity of both is different classes of aggregate based on the desired design strength of concrete.

Normally, the strength of a concrete can be determined through water content and the quality of cement. Besides other conditions that affect the catalyst, temperature, type of mold and more. For the aggregate size, it affects concrete strength indirectly. Up to now be used in aggregate for produce concrete is appropriate use of concrete. Here, the possibility of new aggregates exist and need to be tested to ensure use appropriate or at least have a function similar to the existing aggregate.

In Malaysia, the construction waste has course a significant impact on the environment and also increasing the concern a significant impact on the environment and also increasing the concern of the society *(Beguna, Siwar et al.2006).* Moreover, Malaysia have little reliable statistic of Construction and Demolition that shows the rate of waste generation, type of waste, method of handling the waste and the amount of waste generation, type of waste, method

of handling the waste ant the amount of waste reduced at source, reused or recycled on-site or off-site in a specific type of construction such as residential construction.

1.2 Problem statement

1.2.1 Material

Construction and Demolition materials can be recovered through reuse and recycling. The choice of what and how construction and demolition materials can be recovered depends on many factors including type of project, working area and space on the site, cost effectiveness of recovery, project timeline and experience of contractor *(USEPA, 2000)*. Many building materials from demolition projects and can be reused as part of the materials to construct a new building for a new project, which will then, involve both the construction and demolition activities. In order to ensure that certain building materials from demolition activities may be reusable, the planners or designer should design the new building with the same size and types of materials as in the old construction.

1.2.2 Environment

One of the major challenges of our present society is the protection of environment. Some of the important elements in this respect are the reduction of the consumption of energy and natural raw materials and consumption of waste materials. These topics are getting considerable attention under sustainable development nowadays. The use of recycled aggregates from construction and demolition wastes is showing prospective application in

construction as alternative to primary (natural) aggregates. It conserves natural resources and reduces the space required for the landfill disposal.

1.3 Objectives of the study

The objectives of the study are:

i. To study the effectiveness of recycled aggregate in concrete.
ii. To design optimum mix of concrete by using recycled aggregate.
iii. To study mechanical behavior of concrete by using recycled aggregate

1.4 Scope of study

In this study, the focus on the production of new aggregates residual wastes in concrete. Concrete waste was used as experiments material consisted the results of tests of hardened concrete that has been conducted in which the remains of concrete the form of a cube, cylinder and prism are composed of various grades strength.

In this study, the experiment or test conducted in will be in the lab concrete laboratory. The scopes of the study are as follows:-

a) To study the effectiveness of recycled aggregate in concrete. The recycle aggregate has been taken from concrete laboratory by using demolished concrete cube.

b) The study involved using experiment related to the compressive strength of concrete cube and water absorption by using recycled aggregate. All the experiments in this study focused on laboratory experiment. The effectiveness of the use of recycled aggregate is based on the replacement percentage by comprising it strength with concrete was used natural aggregate.

1.5 Significant of study

In recent years, concrete has diversified its production. Condition this affects the aggregate consumption indirectly. In addition, demand against increasing the concrete economic conditions are good with increase of aggregate demand.

In these situations, it is not appropriate to rely on one source of aggregate with continuing increase in demand and it will cause the shortage by natural aggregate in future. Thus, several alternatives should be established for the preparation of the possible effects on the aggregate demand in the future.

There are few studies have undertaken to produce a new aggregate. Most of the newly generated aggregate consists of waste materials such as glass, tires, broken bricks, concrete and other waste again and some of the results of this study have been practiced in the construction industry.

Therefore, this study examined the effectiveness of the use of recycled aggregate produced from concrete waste in order to test the suitability and strength. It is hoped that this study will be the beginning of efforts to use recycled aggregate in construction material in the future.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In recent years, there are various studies on of concrete in diversifying sources of the materials involved. Among the materials involved in the study of which is the aggregate. Now there are various types of aggregate which has been produced. Among the resulting aggregate consists of crushed glass, materials industrial waste, the construction waste such as concrete, crushed brick and more.

Through the observation of several studies, see that the material used in this study consists of waste materials. The evidence can be seen with the aggregate income by disposal of construction waste such as crushed brick and concrete (aggregate applicable) that has been done in many countries like America and England. These materials are usually available from the work of collapsed buildings or structures.

Actually, the use of this material has been instituted at about more than 50 years after the end of the Second World War. Countries involved in the war have resulted in the city piled with a lot of concrete piles from the effects

of fire. With the presence of a lot of concrete piles, there is a problem of disposal of these materials. Then here comes the idea of remaining debris is used as a new aggregate alternative measures for the disposal of this material. Currently, there are several factors that lead to the use of waste materials as aggregate concrete. Among these are economic factors in the areas difficult to get the aggregate supply due to the lack of these resources. In At the same time to travel far distances to obtain these materials from seek to apply the existing aggregate. In addition, the remaining concrete is cheaper than the cost of disposal.

According to a researcher, Frandistou-Yannas, 1980, there are several factors to the successful use of this material as a new aggregate. Among these are:-

1. There remains a concrete waste materials and excess.
2. High disposal costs for waste material are concrete.
3. Major route facilitating the concrete waste is picked up large trucks.
4. There are suitable industrial lands.
5. The lack of other quality materials to be used as the cost of the aggregate is high.
6. Existing markets.

2.2 Recycled aggregate concrete

The crushing characteristics of hardened concrete are similar to those of natural rock and are not significantly affected by the grade or quality of the original concrete. Recycled aggregates produced from all but the poorest quality original concrete can be expected to pass the same test required of conventional aggregates.

Recycled aggregate can be batched, mixed, transported, placed and compacted in the same manners as convention concrete. Special care is necessary when using fine recycled aggregate. Only up to 10%-20% recycled fine aggregate is beneficial. The aggregate should be tested at several substitution rates to determine the optimal rate.

2.3 Properties of aggregate recycled

2.3.1 Size distribution

Generally, a series of successive crushers are used, with oversize particles being returned to the respective crusher to achieve desirable grading. The best particle distribution shape is usually achieved by primary crushing and then secondary crushing, but from an economic point of view, a single crushing process is usually most effective. Primary crushing usually reduces the C&D concrete rubble to about 50 mm pieces and on the way to the second crusher, electromagnets is used to remove any metal impurities in the material *(Corinaldesi et al., 2002).* The particle shape analysis of recycled aggregate indicates similar particle shape of natural aggregate obtained from crushed rock. The recycled aggregate generally meets all the standard requirements of aggregate used in concrete.

2.3.2 Strength

Though researchers have reported a reduction in strength in recycled aggregate, it should be noted that the extent of reduction is related to the parameters such as the type of concrete used for making the recycle aggregate (high, medium or low strength), replacement ratio, water/cement ratio and the

moisture condition of the recycled aggregate *(Crentsil et al., 2001; Ajdukiewicz and Kliszczewicz, 2002).* For example, Katz found that at a high w/c ratio (between 0.6 and 0.75), the strength of recycled aggregate is comparable to that of reference concrete even at a replacement level of 75% *(Katz, 2003).* Rao found the strength of recycled aggregate and reference concrete to be comparable even at 100% replacement, provided that the water–cement ratio was higher than 0.55 *(Rao, 2005).* However, as the water–cement ratio is reduced to 0.40, the strength of RAC was only about 75% of the reference mix *(Rao, 2005).*

2.3.3 Water absorption

The water absorption in recycled aggregate ranges from 3 to 12% for the coarse and the fine fractions *(Jose, 2002, Katz, 2003 and Rao, 2005)* with the actual value depending upon the type of concrete used for producing the aggregate. It may be noted that this value is much higher than that of the natural aggregates whose absorption is about 0.5–1%. The high porosity of the recycled aggregates can mainly be attributed to the residue of mortar adhering to the original aggregate.

2.4 Production of aggregates in economic

In general, apply to the aggregate income is one of the alternative disposal of waste concrete rubble. As we know, the war the world has left many of them are the effects and the remaining debris a lot of concrete. Alternative selection is made to address the problem of disposal concrete waste caused by the Second World War and subsequently received adopted to date for most countries in the Americas and Europe. This is because the costs of the aggregate used are lower than the cost of waste disposal concrete

rubble. Through studies carried out, potentially applicable to the aggregate used as secondary sources of natural aggregate (aggregate normal). Then use increasingly sophisticated technology now provides an opportunity to generate aggregate applies to more quickly and quality is lower operating costs.

2.5 Specifications and applications

Internationally, the RILEM specification is the most commonly accepted standard for recycled aggregates. But in Hong Kong, due to our limited experience in using recycled aggregates and Hong Kong's different nature of building construction, a prudent approach has been adopted. The specification requirements for recycled aggregate are listed in Hong Kong in table 2.1. After detailed laboratory investigations and plant trials , the government has formulated two sets of specifications governing the use of recycled aggregates for concrete production .For lower grade applications, concrete with 100% recycled coarse aggregate is allowed. Recycled fines are not allowed to be used in concrete. The target strength is specified at 20 MPa and the concrete can be used in benches, stools, planter walls, concrete mass walls and other minor concrete structures. (*Winston F.K. Fong, Jaime S.K. Yeung, and C.S. Poon, 2002)*

Table 2.1: The specification requirements for recycled aggregate are listed in Hong Kong

Requirement	Limit	Test method
Min. dry particle density (kg/m3)	2000	BS 812: Part 2
Max. water absorption	10%	BS 812: Part 2
Max. content of wood and other material less dense than water	0.5%	Manual sorting in accordance with BRE
Max. content of other foreign materials (e.g.,metals, plastics, clay lumps, asphalt, glass, tar)	1%	
Max. fines	4%	BS 812: Section 103.1
Max. content of sand (< 4 mm)	5%	BS 812: Section 103.1
Max. sulphate content	1%	BS 812: Part 118
Flakiness index	40%	BS 812: Section 105.1
10% fines value	100 kN	BS 812: Part 111
Grading	Table 3 of BS 882: 1992	
Max. chloride content	Table 7 of BS 882 0.05% by mass chloride ion of combined aggregate	

CHAPTER 3

METHODOLOGY

3.1 Introduction

Regarding the objectives, laboratory works need to be done to obtain the data and information related to the project. The data is the reference of study experiment that has to be done. After discussion of study objectives in introduction part, some experiment need to be done in order to achieve that objective given such as compressive strength and water absorption. Information and material from the experiment will help to collect the information regarding the study and also can help to achieve the study objective. Several planned before laboratory work will make sure our work more regulated nicely and systematic. The step that has to take before laboratory works such as:

i. Preparing a flow chart regarding the experiment that has to be done as a reference to laboratory keeper to facilitate a preparing regarding experiment needs.
ii. List all of the material and equipment that needs in laboratory experiment. This is important in order to make sure the work complete and arrange able.

iii. Inform the technician about the experiment works that have been planned to do.

3.2 Material preparation

3.2.1 Water

Water or tap water can be used and suitable for manufacturing brick. Water used should be of potable quality if possible, but in no case should dirty or saline water be used. Water sources from rivers or groundwater are usually suitable for making cement mixtures. Actually, water is need for two purposes that are for chemical reaction with cement and contribute the workability. The workability or consistency is affected by the water content, the amount of cement paste in the overall mix and the physical characteristics of the aggregates such as maximum size, shape and grading. Only 1/3 of the water is needed for chemical reaction while the extra water remains in pores and holes.

Water is important because water distribute every single particles of cement so every crushed rock are covered tightly and water make the mixture of concrete easy to handle. Water from standing ponds or swamps may be high in organic materials and it is not suitable to use in brick mixture. The mass ratio of water to cement is the main factor that determines the strength of brick. A lower water cement ratio will yield a concrete which is stronger, while higher water to cement ratio make a concrete with a lower strength.

3.2.2 Cement

The most common hydraulic cement is ordinary Portland cement, a finely pulverized material that develops its binding property using water. The term hydraulic cement is referred as any cement that turns into a solid product in the presence of water, resulting in a material that does not disintegrate in water *(Shan Somayaji, 2001)*

The raw materials used to manufacture Portland cement are lime, silica, alumina, and iron oxide. It is manufactured by heating a mixture of limestone and clay until it almost fuses and then grinding the clinker to a fine powder. The maximum size of the cement particles is 0.09 mm and the average diameter of the particles are smaller than 0.045 mm (0.0018 in.), and the average diameter is 0.01 mm (0.0004 in.*)(Shan Somayaji, 2001).*

3.2.3 Find aggregate

River sand fine aggregates are formed form weathering and decomposition of all types of rock, the most abundant material constituent being quartz. It is used in variety of products such as brick, glass, concrete and explosives. Manufactured sand is produced by crushing stones, gravel or air-cooled blast-furnace slag and is characterized by sharp and angular particles. Sand is known as very fine loose fragment of crushed rock. Fine aggregates also known as sand shown consists of natural particles ranging in size from 600μm to 3/16 (4.75 μm). The figure 3.1 shows the find aggregate used for the test.

Figure 3.1: Fine aggregate (sand)

3.2.4 Coarse aggregate

In conventional brick crushed rock was used as coarse aggregate. Coarse aggregate should be rough and clean with broken faces; rounded particles will not adhere well in the mixture and should be avoided, if possible. In this study, the crushed rock with size 10 mm will be used. The figure 3.2 shows the coarse aggregate.

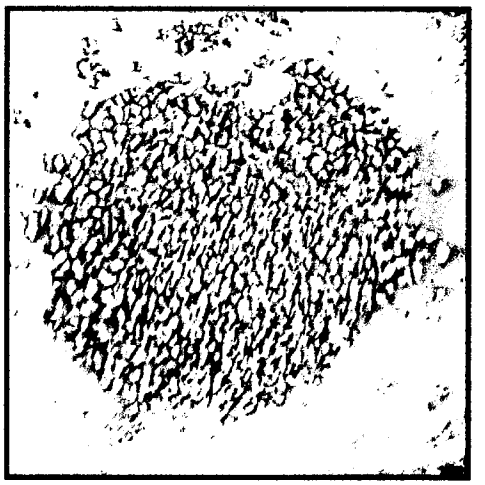

Figure 3.2: Coarse aggregate

3.2.5 Recycled aggregate

The process of preparing an initial aggregate used for the study this. As is known, the sources of aggregate used consisted of a cube-cube removed after the concrete compressive strength tests performed on the cube -cube. Cubes can be found mainly outside the lab faculty civil engineering.

Cubes are collected and compiled through the process of destruction. Crushing process begins with a cube Machine Jaw Crusher (Figure 3.1). This machine is used only to solve the cube into smaller chunks according to the desired aggregate size. This crushing process control activities to obtain the desired aggregate size. In the study, the aggregate size used for the purpose of concrete mix is 20 mm. While aggregate size for purposes of testing aggregate properties are mostly sized 20 mm and below. Figure 3.4 show the cube concrete before crushing and figure 3.5 show after the cube crushing.

To further isolate the size of each aggregate, sieve analysis process should done. Sieve analysis process is to sort and find the aggregate size required to apply for certain.

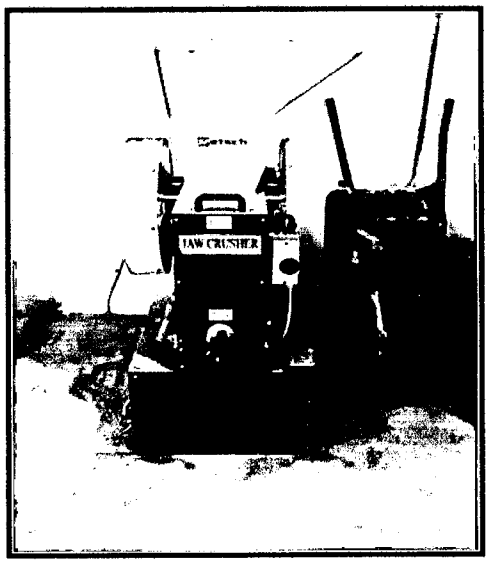

Figure 3.3: Machine Jaw Crusher