Recycle Concrete Waste from Laboratory as Aggregates for Concrete

by

Dalila Sarah binti Darasahudin
21217

Dissertation submitted in partial fulfillment of
the requirements for the
Bachelor of Engineering (Hons)
(Civil Engineering)

SEPTEMBER 2017

Universiti Teknologi PETRONAS
32610, Bandar Seri Iskandar,
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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Approved by,

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(ASSOC. PROF. DR. MOHAMED HASNAIN ISA)

UNIVERSITI TEKNOLOGI PETRONAS
BANDAR SERI ISKANDAR, PERAK
SEPTEMBER 2017

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgments, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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DALILA SARAH BINTI DARASAHUDIN

ABSTRACT

Concrete block from laboratory can be recycled to lessen the cost of transportation to transport the waste to the landfill and also diminish the absolute of concrete wastes. Improving and recycle the crushed concrete block as coarse aggregate would lead to economic profits. This experiment study aimed to use crushed concrete block from the concrete laboratory as recycled coarse aggregate in concrete mixture. The controlled concrete mixture will be correlated with concrete mixture added with some amount of recycled aggregates as replacement with normal coarse aggregates.

The experimental was conducted to compare the strength of normal coarse aggregates and recycled coarse aggregates that have been added in concrete mixture to study the hypothetical use of recycled coarse aggregates in constructions. Before conducting the experiment, the concrete block waste will be crushed to coarse aggregate size and sieving process will be carried out to get the desired size to produce new concrete block. Finally, compressive strength and tensile strength tests will be evaluated. The result of the tests will be altered based on the different ratio of recycled coarse aggregate replacement in the concrete mixture.

Various studies have determined on improving the quality of recycled aggregate with purpose to diminish cost and to implement friendly environment. The uses of recycled aggregates for concrete can lower fuel consumption for transport and cost to source the aggregates. It is estimated that using recycled aggregates as a replacement of natural aggregates in concrete can save up to 60% (Verian et al., 2013). To conduct this experiment, natural coarse aggregate will be replaced with different ratio of recycled coarse aggregate. Three series of blocks will be equipped using cube mould with dimension 100mm x 100mm x 100mm and cylinder mould with dimension 100mm diameter x 200mm height.

ACKNOWLEDGEMENT

Firstly, I feel grateful to Allah S.W.T, the Most Merciful and the Most Compassionate for granting me strength and ability in completing my final year project. Peace is upon him, Muhammad S.A.W., the messenger of God.

I wish to express my sincere appreciation to my supervisor, Assoc. Prof. Dr. Mohamed Hasnain Isa for his advice, critics, continual guidance, and support. He always gives the idea and comment in my work in order to help me do the research in a better way.

My thanks are also extended to all my friends for sharing their ideas and discussions. Not to forget the other lecturer which helping me to complete the research. Most importantly, I would like to dedicate this dissertation to my parent's family for their continuing to support me with love, which allows me to achieve the target needed.

I other words, may Allah the Almighty return all the good deeds because, without all the above support and guidance, the project progress and writing of this report are impossible to be complete as targeted.

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CHAPTER 1
INTRODUCTION

1.1 Background of Study

Concrete are the main uses for all Civil Engineering students such as for their final year project and learning process practices. Aggregates are one of the main essential materials for concrete mix making. However, the tremendous use of aggregates every semester is became the problem. The reduction of coarse aggregates may be affected for the future works. Aggregates comprise of two types, which is known as coarse aggregate and fine aggregate. From this project, the author concern more to coarse aggregate production.

The concrete laboratory of university is equipped to conduct numerous materials testing. Engineering student especially in final year project work produces huge quantities of concrete block waste. The abandoning of these wastes is a severe social and environmental problem. Disposal of these waste become a major problem. The unavailability of space to accommodate the waste landfills, have enforced the university to search the solution. In previous study, many research produce the recycled aggregates to reduce the concrete waste and sustain the original properties of the concrete to get the good quality of the aggregates (Andal et al., 2016).

Recycled aggregate is made by concrete waste that has been crushed to the required size to use in new concrete mixture. Use concrete waste to form the recycled aggregate is an alternative to reduce the waste of concrete produced by student in concrete laboratory. Using concrete waste as recycled aggregates can decreases the use of landfill space and saving the uses of raw materials. With the rapid growth of construction materials demand especially main sources to produce the concrete, there are needed some substitute for main sources, such as aggregates replacement to avoid the depletion of those sources.

An invention of recycled aggregate with proper process can give consistent quality same as normal aggregate. The properties of natural aggregates and recycled

Aggregates need to be considered to know the difference between them and improve the recycled aggregated. In the previous research, it stated that the replacement of recycled aggregates in concrete just limit up to 30% in order to ensure the compressive strength of the concrete (Oikonomou, 2005).

In a report by Agrela et al. (2012), recycled aggregates were used in non-structural purposes, such as in road sections, landscaping, sealing of garbage dumps. This is because the quality of these aggregate is poorer than natural aggregates. For the physical properties, the coarse recycled aggregates are marginally different with natural aggregates. It has a rougher texture and more angular shape (Andal et al., 2016). These recycled aggregates are normally low in density and abrasion resistance and high in absorption and porosity due to the attachment of cement paste and mortar on the aggregate surface. Due to its low compressive strength, recycled aggregate is optional for non-structural concrete.

Using the waste concrete block as aggregates to create recycled concrete is an important enlargement direction of construction materials of environmental protection. By crushing old concrete to make recycled coarse aggregate for new concrete mixture, the environmental hazards of concrete are reduced. (McGinnis et al., 2017).

1.2 Problem Statement

The growing of concrete waste in concrete laboratory created by student have become foremost problem in most university. The cost for disposal and transportation to the landfill may cause environmental hazards. To decrease the effects of such wastes, use of concrete block waste as recycled aggregate may give an benefit of the university alternative to saving the cost to get the new aggregates source and disposal process of the waste. Andal et al. (2016) specified that depletion of aggregates has become a huge problem, so with this course of action it may mitigate the problem.

With concrete invention from concrete laboratory on the rise, the waste can be used to generate new concrete mixture can reduce this problem and also save the landfill space because the waste cannot be recycled. Without appropriate organizing and treatment of concrete waste, it can cause many environmental problems such as air pollution. This harmful affect can be prevented with the alteration of concrete waste to form recycled aggregates that also can help the aggregates supply from depleted.

With the massive amount of waste produced annually which is risk to our environment along with a large amount of energy and cost consumption to manage the waste, these problems can be undertake with incorporating the wastes. (Parthiban & Mohan, 2017). In order to limit the environmental effect of concrete, recycling the concrete block waste in concrete laboratory is one of an efficient way for healthy environment in university and it also can be a new innovation way for the student to use recycled aggregate instead of natural aggregate into the concrete mixture.

1.3 Objectives and Scope of Study

The aim of this study was determined on the production of recycled aggregates from laboratory waste, which were efficient of demonstrating an adequate durability against certain extreme conditions. The purpose of this study is to examine the probability of using recycled coarse aggregates from waste concrete block in new production of concrete mixture.

In order to achieve the aim of the study, the objectives of construction waste management include:

i. To investigate the properties of recycled concrete block from laboratory as recycled coarse aggregates.
ii. To compare the strength of concrete mix with recycled aggregate and natural aggregate.
iii. To study the effect of recycled coarse aggregate content in concrete mix with different substitution percentages.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction of Concrete

In the upcoming beings, concrete waste will be increase and it is needed the substitutions to reduce the concrete waste formed from the concrete laboratory. Concrete is a compound material usually formed by lime-based such as Portland cement concrete. It was estimated 12.6 billion tons of concrete was manufactured annually (Selavakumar & Venkatakrishnaiah, 2015). Concrete usually used in construction such as for building structures, road surfaces and also in non-structures product. Concrete manufacture is the activity of mixing cement, aggregate and water. Sometimes, the concrete also be added some additives to increase the strength properties of the concrete.

To get the robust and stable concrete, the suitable ratio in mixing the ingredients has to be precise. The ratio of mixture will govern the strength and surface state of the concrete. Improper production of concrete can resulting concrete easily crack. The concrete mixture theoretical to be designed to meet the necessary strength, durability and sufficient workability for construction uses to resist the desired load.

Concrete is considered as a quai-brittle material, in which the tensile stress gradually declines after it reaches the tensile strength while the tensile strain constant to increase (Yang et al., 2017). The concrete need to have the capability to resist stress, which is will defines the characteristic of the concrete. Workability of the concrete can be measured by slump test following the ASTM C 143 test standards (ASTM, 2015).

2.2 Introduction of Aggregate

Aggregates are inert granular materials such as sand, gravel or crushed stone that along with water and Portland cement are a basic ingredient in concrete. For a good concrete mix, aggregates need to be dirt-free, hard, strong particles free of immersed chemicals or coatings of clay and other fine materials that could trigger the depreciation of concrete.

Aggregates are divided into two different categories, which is fine aggregate and coarse aggregate. Fine aggregate generally contain of natural sand or crushed stone with most particles passing through a 9.5 mm sieve. Coarse aggregate are any particles greater than 4.75 mm, but generally range between 9.5 mm to 37.5 mm in diameter.

Natural gravel and sand are usually quarried or dredged from a pit, river, lake or seabed. Crushed aggregate is produced by crushing quarry rock, boulders, cobbles or large- size gravel. Aggregate processing consists of crushing, screening and washing the aggregate to acquire virtuous cleanliness and gradation. Once processed, the aggregate are treated and stored in a way that minimize segregation and degradation and prevent contamination.

2.3 Recycled Aggregate Concrete

All generated concrete block in the laboratory will be disposed sooner or later, making a large amount of waste and there will be a to transport waste to landfills. One of the resolutions to diminish the problem is recycling the concrete waste from the laboratory to create the recycled aggregates for new concrete. The produce of the recycled aggregate need to moderately same with natural aggregates properties so that it can be used in concrete.

However, Wang et al. (2017) identified that recycled concrete aggregate have lower-grade than natural aggregate because the remaining cement mortar is coated with recycled concrete aggregate. The remaining cement mortar will disturb the properties of recycled aggregate, including higher water absorption, lower strength and higher crusher value. Some study included the high water absorption in recycled aggregate will affect their compressive strength (Lotfi et al., 2017). The proclamation were verified by some researcher that various amount of adhered cement mortar can give undesirable impact to its mechanical properties and workability (Ulsen et al., 2013).

To reduce the cement paste from the recycled aggregate, microwave-heating technology was used to generate clean aggregate from the crushed concrete waste (Menard et al., 2013). Other research adjusts the surface properties of recycled aggregates to improve the performance of the aggregates in new concrete mixture using geopolymer material based on fly ash. Properties of both natural aggregates and recycled aggregates were compared based on the workability, real density, total water absorption and compressive strength (Junak & Sicakova, 2017).

The clearance of concrete block waste enhances serious problem in university because there is inadequate space for disposing the concrete block waste. The use of recycled aggregate in concrete can be beneficial for environmental protection. The students can use the recycled aggregates in their concrete work to reduce the consumption of natural resources. According to Belen et al. (2011), the stress-strain curves recycled concrete mixture is similar to those of control natural concrete mixture. However, with 100% replacement of recycled aggregate in concrete mixture, the highest and ultimate strain are increased for 20.5% and 22%, respectively

Based on the research, the compressive strength and tensile strength of recycled aggregate somewhat inferior than natural aggregate (Morohashi et al., 2013). This is because when the concrete is crushed, a certain amount of mortar and cement paste from the original concrete residues attached to the crushed concrete. However, with accurate ratio of recycled aggregate substitution in concrete, it will be not affect the properties of the concrete. In the previous experimental test, the maximum replacement of recycled coarse aggregate that can be used in concrete is 25-27% (Mufti & Fried, 2017).

CHAPTER 3
METHODOLOGY

3.1 Research Methodology

The experiment will be conducted by using cylinder concrete block to go through the strength testing including compressive strength and tensile strength. The samples of concrete will be filled with recycled aggregate concrete, which is will be replace the natural coarse aggregate. There are different ratio of recycled coarse aggregate in concrete block specimen, 0%, 15% and 35% of recycled coarse aggregates replaced in cement: coarse aggregate: fine aggregate ratio. The well-mixed materials were filled into steel cube moulds and cylindrical moulds with size of 100 mm x 100 mm x 100 mm and 100 mm dia x 200 mm height, respectively.

3.2 Materials

3.2.1 Ordinary Portland Cement (OPC)

Portland cement will be used as cement in concrete specimen. Cement is a binding material made by grinding of limestone and clay to a fine powder. Three samples of concrete block with cube size of 100 mm x 100 mm x 100 mm and cylinder size 100 mm (dia) x 200mm (h) will elaborated with each recycled coarse aggregate replacement ratio. Each mixture has three samples to take the average for the testing.

Figure 1 *Ordinary Portland Cement (OPC)*

3.2.2 Water

Water is one of important ingredient that responsible to binding the concrete mixture together. The ratio of water/cement also important because it is affects the strength and durability of the concrete. For this experiment, the ratio of w/c taken is 0.5.

3.2.3 Natural Coarse Aggregate

Natural aggregates are from crushed rock has rougher surface. For this experiment the ranging size used are retained sieving pan at 10.0 mm to passing sieving pan at 9.5 mm. Quantity and properties of coarse aggregate will affect the characteristic and properties of the concrete (Kanojia & Jain, 2017).

Figure 2 *Natural Coarse Aggregate*

3.2.4 Crushed Recycled Coarse Aggregate

The crushed coarse aggregates were produced from concrete block in laboratory that must be crushed by crusher machine and will be sieved with ranging size retained sieving pan at 10.0 mm to passsing sieving pan at 9.5 mm. The total weight of recycled aggregates collected is 7.33 kg, which is enough to make total 9 samples of cube mold size 100 mm x 100 mm x 100 mm consists of 15% and 35% natural aggregates replacement, respectively. Also 3 samples of cylinder mold size 100 mm dia x 200 mm height consists of 15% and 35% natural aggregates replacement, respectively.

Figure 3 *Crushed Recycled Aggregates (CRA)*

3.2.5 Fine Aggregate

Fine aggregate shall consist of natural sand or river sand. The size of the fine aggregate is less than 4.75mm. The uses of fine aggregate are necessary to obtain homogeneous, workable and durable concrete of adequate strength. (Donza et al., 2002). For this experiment the ranging size used for fine aggregates are retained at 4.0 mm and passing at 2.0 mm sieving pan.

Figure 4 *Fine aggregates*

3.3 Preparation of Samples

3.3.1 Crusher Machine

Crusher machine was used to crush the bigger stone into the smaller size to form the gravel or aggregates. Jaw crusher, gyratory crushers and smooth-roll crushers are the main types of crushers. In order to get the aggregates sizes for this project, concrete block waste will be crushed using jaw crusher from UITM Shah Alam.

Figure 5 *Crusher Machine*

3.3.2 Sieve Analysis

Following AASHTO T 27 and ASTM C 136: Sieve analysis of fine and coarse aggregates, the sieve analysis procedure is as follow:

1. Weigh the sample to the nearest 0.1g by total weight of sample. This weight will be used to check for any loss of material after the sample has been graded.
2. Select suitable sieve sizes in accordance with the specifications. Nest the sieves in order of decreasing size from top to bottom.
3. Place the aggregate on top sieve and start agitating and shaking the sample for a sufficient amount of time.

Figure 6 *Pan and shaker used for sieving*

Table 1 *Sieve Analysis of Crushed Concrete*

Sieve Size (mm)	Mass Retained (g)	Cumulative		
		Mass Passing (g)	% Passing	% Retained
14.00	6,040	60,430	90.01	9.09
13.20	8,300	52,130	78.43	12.49
10.00	10,110	42,020	63.22	15.21
9.50	10,950	31,070	46.74	16.47
6.30	14,980	16,090	24.21	22.54
Pan	16,090			
Total	66,470			

3.3.3 Preparation of Cube Samples

Concrete cube will be tested on 3^{rd}, 7^{th} and 28^{th} days. The specimens will be used for conpressive strength test. All 0%, 15% and 35% replacement of recycled coarse aggregates in concrete mixture consists three samples each, respectively to take an average of compressive strength result. The procedure to make a sample is as follow:

a) Mixture

1. 27 cube moulds size 100 mm x 100 mm x 100 mm were prepared.
2. All the materials used for concrete mix were prepared. For this project, the concrete mixture used is M25
3. Cement, aggregates and water we mixed together evenly. The ratio for w/c used is 0.5.

b) Sampling

1. The moulds were cleaned before the mixture being poured into it.
2. The mixture was filled in layers approximately 5 cm thick with total of 3 layers.
3. Each layer has been compacted with not less than 35 strokes per layer using tamping rod.
4. The trowel has been used for smoothing the top of the moulds after compacting.

c) Curing

1. The test specimens are stored in moist air for 24 hours.
2. After that, the specimens are marked and remove from the moulds and kept submerged in clean fresh water until taken out for test.

Table 2 Quantity of Constituents of Cube Samples

Perentage (%)	Cement (kg)	Fine Aggregate (kg)	Natural Coarse Aggregate (kg)	Recycled Coarse Aggregate(kg)	Water (kg)	Total (kg)
0	1.99	3.40	6.81	0	1.00	13.20
15	1.99	3.40	5.79	1.01	1.00	13.20
35	1.99	3.40	4.43	2.37	1.00	13.20

Figure 7 *Concrete moulds cube size*

3.3.4 Preparation of Cylindrical Samples

Concrete cylinder will be tested on 28th days. The specimens will be used for split tensile test. All 0%, 15% and 35% replacement of recycled coarse aggregates in concrete mixture consists three samples each, respectively to take an average of tensile strength result. . The procedure to make a sample is as follow:

a) Mixture

1. 7 cylindrical moulds size 200 mm height with 100 mm diameter were prepared.
2. All the materials used for concrete mix were prepared. For this project, the concrete mixture used is M25
3. Cement, aggregates and water we mixed together evenly. The ratio for w/c used is 0.5.

b) Sampling

1. Clean all the moulds and apply oil.
2. The mixture was filled in layers approximately 5 cm thick with total of 5 layers.
3. Each layer has been compacted with not less than 35 strokes per layer using tamping rod.
4. The trowel has been used for smoothing the top of the moulds after compacting.

c) Curing

1. The test specimens are stored in moist air for 24 hours.
2. After that, the specimens are marked and remove from the moulds and kept submerged in clean fresh water until taken out for test.

Table 3 Quantity of Constituents of Cylindrical Samples

Perentage (%)	Cement (kg)	Fine Aggregate (kg)	Natural Coarse Aggregate (kg)	Recycled Coarse Aggregate(kg)	Water (kg)	Total (kg)
0	1.06	1.82	3.63	0	0.53	7.04
15	1.06	1.82	3.09	0.54	0.53	7.04
35	1.06	1.82	2.36	1.27	0.53	7.04

Figure 8 *Concrete moulds cylindrical size*

3.4 Experimental Test

3.4.1 Compressive Strength Test

To ensure the strength of concrete with the partial replacement of recycled coarse aggregate, compressive strength test will be conducted. Table 1 show the compressive strength of different grades of concrete at 7 and 28 days.

Table 4 Required *Compressive Strength in Different Days*

Grade of Concrete	**Minimum Compressive Strength at 7 days (N/mm^2)**	**Minimum Compressive Strength at 28 days (N/mm^2)**
M15	10	15
M20	13.5	20
M25	17	25
M30	20	30
M35	23.5	35
M40	27	40
M45	30	45

The apparatus used in this test is crushing machine in UTP concrete laboratory. The procedure for the test is as follow:

1. After remove the specimen from water, the specimen should be wiped before placing in the testing machine.
2. Clean the bearing surface of the testing machine
3. Adjust the plate of the machine to ensure it touch the top surface of specimen and make sure the specimen centrally on the base plate.
4. Apply the load gradually at the rate of $140kg/cm^2$/min till it reach the failure stage.
5. Step 1 to 4 were repeated for other specimens.
6. Record the ultimate compressive strength of the specimen.

Figure 9 *Compressive Strength Machine*

3.4.2 Split Tensile Strength Test

Tensile testing also known as pull testing is a standards test where a sample is placed in grips and subjected to controlled tension until it fails. Properties that are directly measured via a this test is ultimate tensile strength, maximum elongation and reduction in area. The procedure of tensile test is as follows:

1. Wipe the excessive water from the wet surface of specimen.
2. Set the compression testing machine for the required range and place the specimen and align the specimen centrally over the bottom plate.
3. Before place the specimen, keep the plywood strip on the lower plate.
4. Place the other plywood strip above the specimen and bring down the upper plate to touch the plywood surface.
5. Apply the load continuously at a rate of approximately 14-21kg/cm^2/min till the specimen reaches the failure stage.
6. Record the breaking load (P) for the specimens.

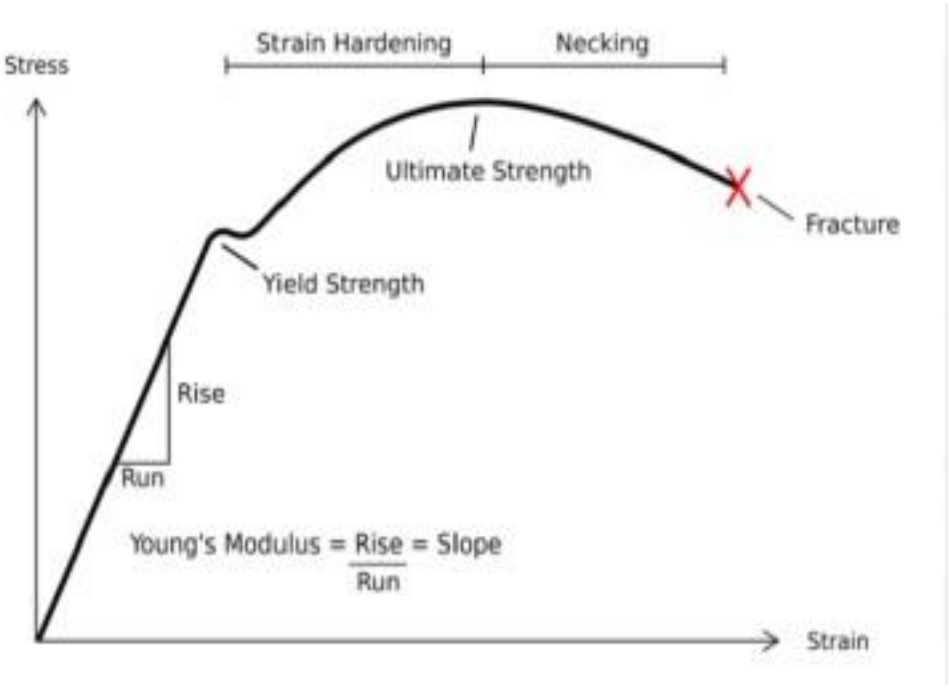


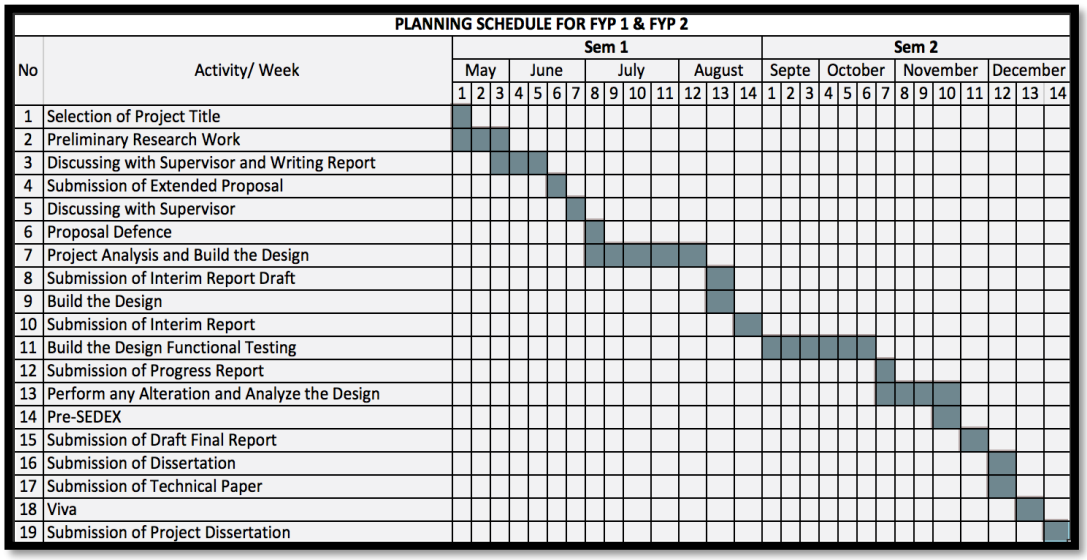
Figure 10 *Stress-strain diagram*

In the splitting test, a concrete cylindrical specimen is compressed along two diametrically opposed generators as shown in figure 11. A theoretical basis for the test has been postulate by Davies and Bose. The split tensile strength is calculated on the assumption of hypothetical load bearing strip of zero width.

Figure 11 *Equipment used for tensile test*

3.5 Gantt Chart

Table 5 *Gantt Chart*



3.5.1 Key Milestone

A key milestone of the UTP Final Year Project was shown in Table 6 below displays the plan and submission week over this semesters.

Table 6 *Key Milestone of FYP 1 and FYP 2*

No.	Activity	FYP	Week No.
1	Topic Selected	FYP 1	1
2	Preliminary Research Work		1
3	Discussion and Writing Report		3
4	Submission of Extended Proposal		6
5	Project Discussion with Supervisor		7
6	Proposal Defense Presentation		8
7	Project Analysis and Build the Design		8

8	Draft on Interim Report Submission		13
9	Build the Design		13
10	Interim Report Submission		14
11	Build and Design Functional Test	FYP 2	1
12	Progress Report Submission		7
13	Result Analysis Collection		7
14	Pre-SEDEX		10
15	Draft on Final Report Submission		11
16	Submission of Dissertation		12
17	Submission of Technical Paper		12
18	Viva		13
19	Submission of Project Dissertation		14

3.6 Flowchart of Methodology

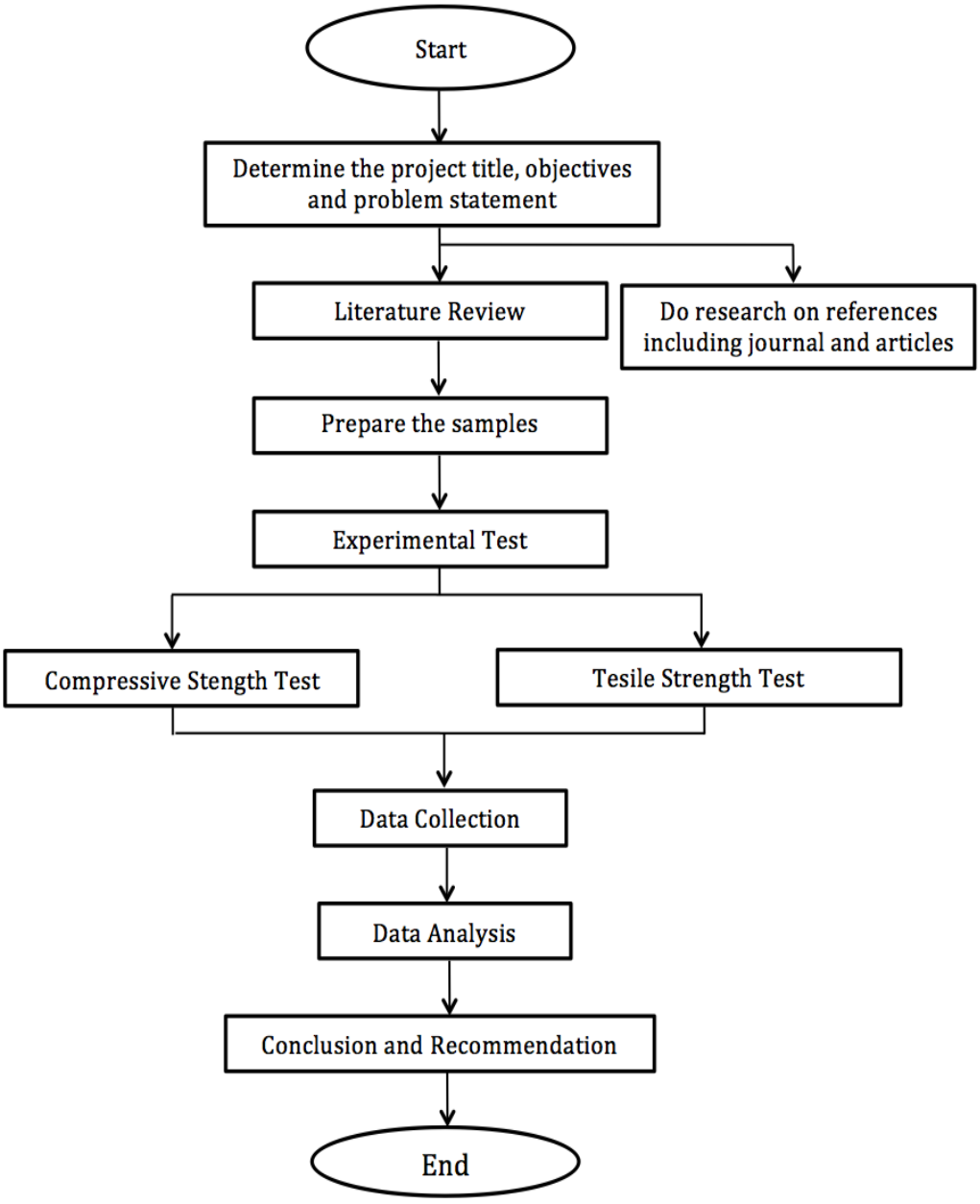


Figure 12 *Flowchart of Research Methodology*

CHAPTER 4
RESULT & DISCUSSION

4.1 Introduction

The main objective of this experimentation is to find out the differences and effect of strength of concrete mix with the replacement of recycled coarse aggregates in the mixture. In this experiment, three different percentages of recycled coarse aggregate replaced in the concrete mix, which is 0%, 15% and 35% are presented concerning each curing condition.

.

4.2 Compressive Strength Test

The samples of concrete that contain 0% of recycled aggregates and 15% and 35% of recycled coarse aggregates from total of natural aggregates weight were prepared in order to compare their properties. The cube concrete with size of 100 mm x 100 mm x 100 mm was tested to get the strength of the concrete.

Tables below shows the result of the compressive strength of cube samples for 0%, 15% and 35% replacement of recycled coarse aggregates in concrete mixture for 3^{rd}, 7^{th} and 28^{th} days, respectively.

Table 7 *Compressive Strength for 3^{rd} days*

RP (%)	Sample (MPa)			Average (MPa)
	1	2	3	
0%	17.98	20.92	19.22	19.37
15%	11.71	11.89	10.95	11.52
35%	14.63	12.37	14.94	13.98

Table 8 *Compressive Strength for 7th days*

RP (%)	Sample (MPa)			Average (MPa)
	1	2	3	
0%	22.15	23.79	23.55	23.16
15%	17.97	15.23	15.92	16.37
35%	18.47	18.69	19.21	18.79

Table 9 *Compressive Strength for 28th days*

RP (%)	Sample (MPa)			Average (MPa)
	1	2	3	
0%	25.92	26.09	26.29	26.10
15%	21.16	20.64	19.52	20.44
35%	24.35	23.52	24.22	24.03

Figure 13 Average Compression Strength of Concrete Mix

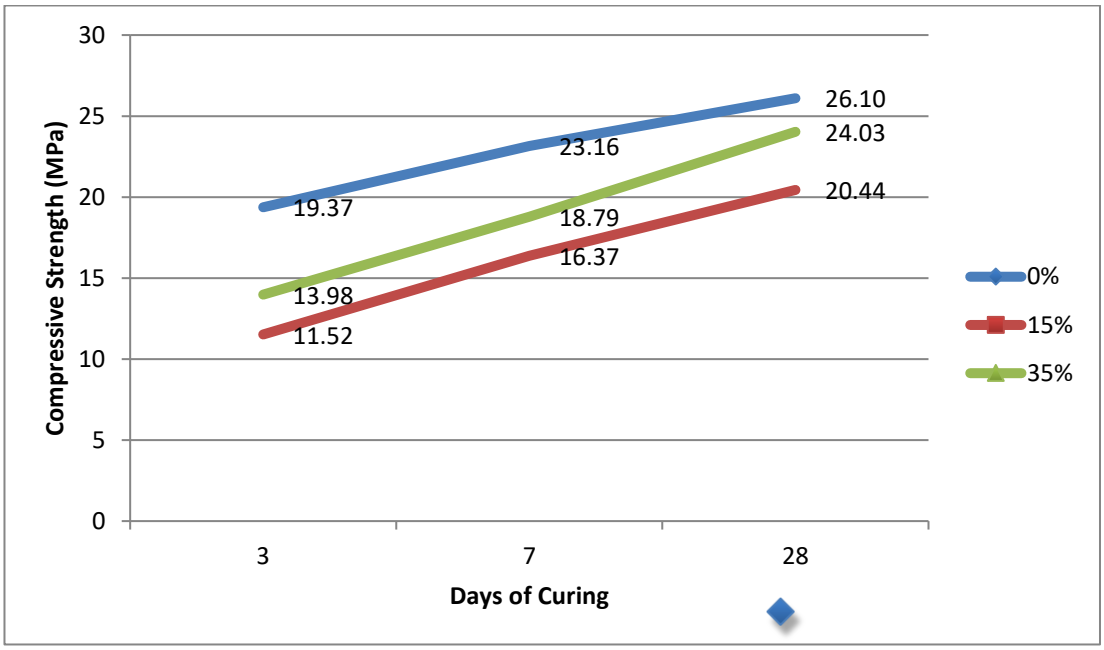


Figure 14 0% RCA samples after the test for *3rd days*

Figure 15 15% RCA samples after the test for *3rd days*

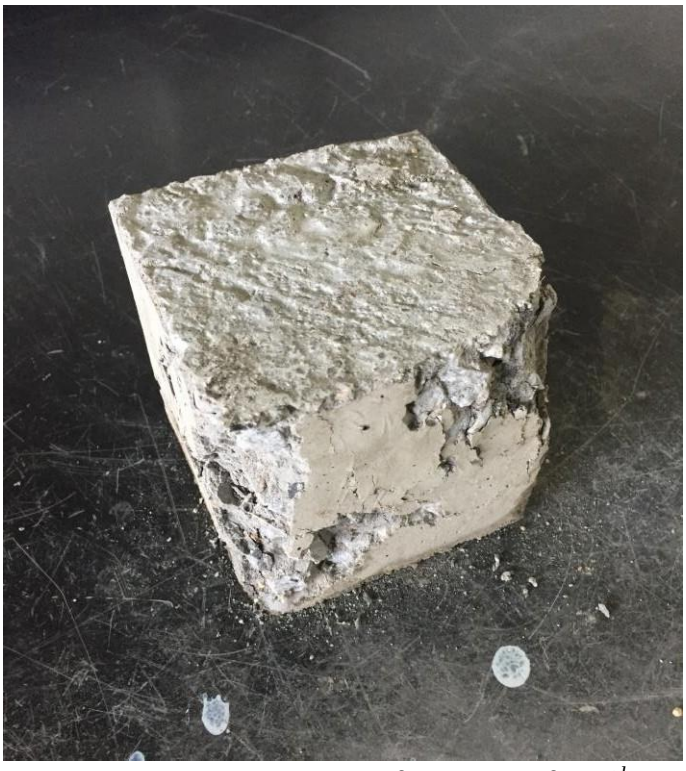


Figure 16 35% RCA samples after the test for *3rd days*

Test results to determine the effect of aggregate content on compressive strength show that the compressive strength increases with increasing of recycled coarse aggregates content. It also can be conclude that the different replacement of recycled coarse aggregates in the mixture and time of curing affect the strength of the concrete.

All mixes tested at *3rd* days, *7th* days and *28th* days. Overall, the result shows 15% recycled coarse aggregate replacement higher than 35% recycled coarse aggregates replacement. For the controlled mixture, which is 0% recycled coarse aggregates obviously has the highest compressive strength among others in *3rd*, *7th* and *28th* days with average compressive strength 19.37 MPa, 23.16 MPa and 26.10 MPa, respectively.

In the *3rd* days of curing, 15% and 35% recycled coarse aggregates shows the compressive strength 11.51 MPa and 13.98 MPa, respectively, a difference of 17.6%. At test ages *7th* of for 15% and 35% recycled coarse aggregates, there is difference 13.7% with compressive strength of concrete 16.37 MPa and 18.97 MPa, respectively. After 28 days, concrete strength increase with 20.44 MPa and 24.03 MPa with difference 14.9%.

Regardless of the result from the test, the strength of concrete depends on the different constituent of recycled aggregate. The results also show that in concrete mix, compressive strength increase with the increasing of recycled aggregates content, although the difference between 15% and 35% of recycled coarse aggregates replacement not too much.

4.3 Split Tensile Strength Test

Table 7 show the result of split tensile strength test with 0%, 15% and 35% coarse recycled aggregates replaced in concrete mix.

Table 10 *Split Tensile Strength for 28th days*

RP (%)	Sample (MPa)			Average (Mpa)
	1	2	3	
0%	3.05	3.21	3.16	3.14
15%	3.14	3.13	3.13	3.13
35%	3.17	2.89	3.04	3.03

Table 17 *Average Split Tensile Strength at 28 Days*

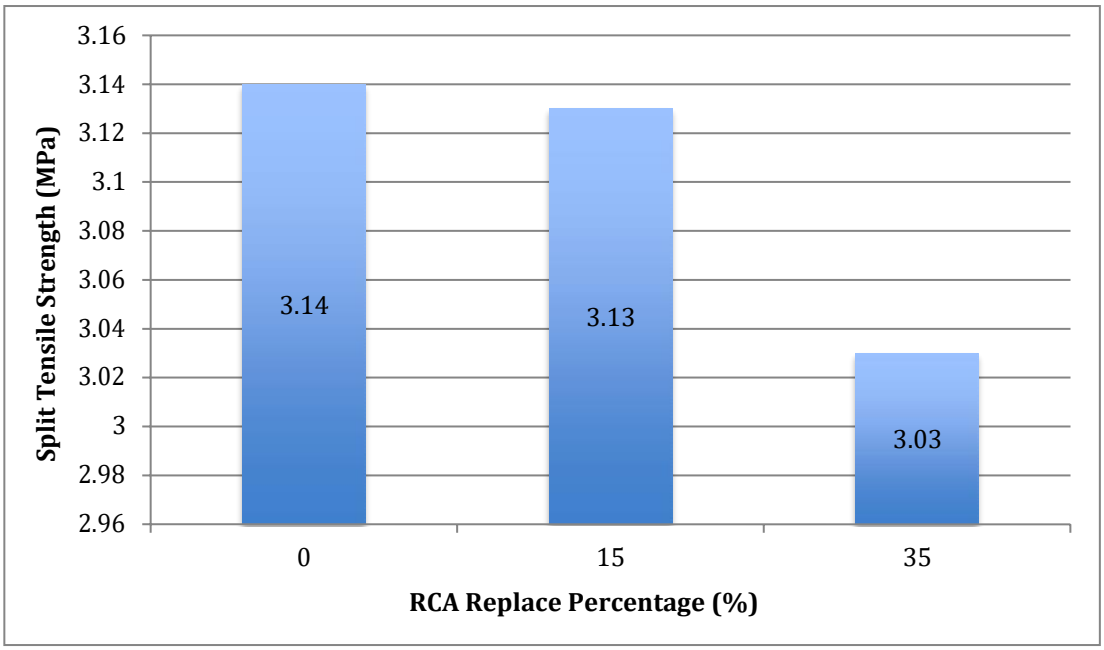


Figure 18 Split Tensile Strength Test

The splitting tensile strength of the tested samples showed that the concrete have been produced with 35% recycled coarse aggregates replacement has the lowest value with 3.03 MPa. While the value of 15% recycled coarse aggregate have only 0.3% difference with controlled concrete mix. The split tensile strength values are found to decrease with the increase of recycled coarse aggregates content.

From the observation, the samples after failure show a broken area vertically from the point of load application. The In author opinion, there is need some solution to avoid any stress concentration in the area when the load was applied to increase the strength of concrete.

Figure 19 *The Vertical Crack on Sample*

From the results, it also can be conclude the decreasing of split tensile strength affect by the increasing of recycled coarse aggregates replacement. Concrete containing high proportions of recycled coarse aggregates weaken than concrete containing natural aggregates.

CHAPTER 5
CONCLUSION

5.1 Conclusion

From result attained from both compressive strength and split tensile strength concrete test, it is observed that up to 15% of recycled coarse aggregates replacement in concrete mix most likely have same strength with M25 concrete. So the uses of recycled coarse aggregate in concrete mix can be low cost for concrete production.

Overall, both mixture of concrete with recycled coarse aggregate can be used as M25 concrete because the difference strength not too enormous. Aggregates from recycled aggregates still can be used in civil engineering works such as road pavement materials, sub base and improvement of sub ground (Oikonomou, 2005).

This study recognizes the appropriate waste management and recycling approach to reducing waste concrete that have been increasing every year in concrete laboratory. In order to make sure the recycled aggregates can be used in concrete block, their properties such as the strength should be conventional compared with natural aggregates. This result is basically will be a predictable outcome foreseen for this research.

As to achieve the target and objectives stated in chapter 1 which to ensure the environmental sustainability productivity of the natural aggregates sources, the strength and workability of the recycled aggregates is the most significant factor that need to be considered to make sure the concrete mixture with recycled aggregates can be used in laboratory testing. Laboratory activities are currently wasteful with untenable amounts of materials being sent to landfills, which in itself is a costly process and can affect the environment.

Correct waste management strategies are observed to control the number of health and environmental problem and depletion of the aggregate resources in the future. People in the laboratory and for student that use the concrete laboratory to do their project work testing should be conscious of protecting the health and environment for a better management and performance. At the end of this project, by using recycled aggregate in new concrete mixture, it may be able to reduce the using of natural aggregate yet can decrease the cost to supply the aggregate in laboratory.

5.2 Recommendations

Further test need to be conducted to determine if differences recycled coarse aggregates content will effect the strength of concrete mix. The surface moisture of aggregate are needed when selecting aggregate because the structure of recycled aggregate may or may not absorb the water and it may effect the water content in the mixture.

Also, there is need addition test to be conducted to test if the recycled aggregates surface will affect the strength of concrete mix. As we known, recycled aggregate produced from recycled concrete that have been gathered from various place and the mixture is unspecified. So the texture of recycled aggregate may be different from natural aggregate.

In the future research, the environmental impact of using recycled aggregates in construction need to be done to see how much the usage of recycled aggregate give an impact to the future. In this case, the government needs to take an action to support the research that can give advantages to the district economy and environment.

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