

THE EFFECT OF CRUS'
BEHAVIOUR.



E PAVEMENT BLOCK
AGGREGATE

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ABSTRACT

In s modern world now, many countries are going to develop due to the population growth. Malaysia is also one of the develop country and the construction will growth in the future. Chicken's egg is one of the waste material that contribute to the to the environmental problem. In order to reduce the problem, reuse the eggshell as a replacement material in concrete is a good solution to overcome all the problem. Eggshell fine grains obtained by crushing the shells have been established to be good accelerators for cement-bound material and this would be useful for road construction work at the peak of rainy seasons for reducing setting time of stabilized road pavement. However this should be achieved not at the expense of other vital properties of the stabilized matrix. This is part of the effort in adding value to agricultural materials which probably cause disposal problem. This study is therefore aimed at determining the suitability of using egg shell as partial replacement for fine aggregates in highway concrete structures. A cubes of size 65 mm x 100 mm x 210 mm with different percentages by volume were made. Crushed egg shell are added in 2.5, 5, 7.5, 10% with other concrete components in the right measurement appropriate in making concrete pavement block. Slump test, UPV test, rebound hammer test, water absorption test and compressive strength test of the concrete are determined and compared. Compressive strength test was carried out on the concrete pavement block at three levels of curing: 1, 7, 28 days.

ABSTRAK

Dalam dunia moden sekarang, banyak negara akan berkembang dengan pertumbuhan penduduk. Malaysia juga merupakan salah satu negara yang membangun dan pembinaan akan pertumbuhan pada masa hadapan. Telur ayam adalah salah satu bahan buangan yang menyumbang kepada masalah alam sekitar. Bagi mengurangkan masalah ini, penggunaan semula kulit telur sebagai bahan gantian dalam konkrit adalah penyelesaian yang baik untuk mengatasi semua masalah ini. Bijirin halus kulit telur diperolehi dengan menghancurkan cengkerang telah ditubuhkan untuk menjadi pemangkin yang baik untuk bahan simen-terikat dan ini akan berguna untuk kerja-kerja pembinaan jalan raya di puncak musim hujan untuk mengurangkan masa menetapkan turapan jalan stabil. Walau bagaimanapun ini sepatutnya dicapai tidak dengan mengorbankan sifat penting lain matriks stabil. Ini adalah sebahagian daripada usaha dalam menambah nilai kepada bahan pertanian yang mungkin menyebabkan masalah pelupusan. Oleh itu, kajian ini bertujuan untuk menentukan kesesuaian menggunakan kulit telur penggantian separa untuk agregat halus dalam struktur konkrit lebuhraya. Kiub saiz 65 mm x 100 mm x 210 mm dengan peratusan yang berbeza dengan jumlah telah dibuat. Kulit telur hancur ditambah dalam 2.5, 5, 7.5, 10% dengan komponen konkrit lain dalam pengukuran yang sesuai yang betul dalam membuat blok turapan konkrit. Ujian kemerosotan, ujian UPV, pemulihan ujian tukul, ujian penyerapan air dan ujian kekuatan mampatan konkrit yang ditentukan dan dibandingkan. Ujian kekuatan mampatan dijalankan di blok turapan konkrit di tiga peringkat pengawetan: 1, 7, 28 hari.

Table of Contents

	Pages
SUPERVISOR'S DECLARATION	i
STUDENT'S DECLARATION	ii
DEDICATION	iii
ACKNOWLEDGEMENTS	iv
ABSTRACT	v
ABSTRAK	vi
TABLE OF CONTENT	vii
LIST OF TABLES	xi
LIST OF FIGURES	xii
LIST OF SYMBOLS	xiii
LIST OF ABBREVIATIONS	xiv
CHAPTER 1 INTRODUCTION	
1.1 Introduction	1
1.2 Background Of Study	2
1.3 Problem Statement	3
1.4 Objective Of Study	4
1.5 Scope Of Study	4
1.6 Expected Outcome	5
1.1 Significant Of Purpose Study	5

CHAPTER 2 LITERATURE REVIEW

2.1	Introduction	6
2.2	Eggshell	6
2.3	Water	7
2.4	Cement	8
2.5	Aggregate	8
2.6	Slump Test	9
2.7	Compressive Strength Test	10
2.8	Rebound Hammer	11
2.9	Ultrasonic Pulse Velocity	11
2.10	Eggshell On Road Construction	12
2.11	Cement Water Ratio	13
2.12	Paving Block	13
2.13	Significant Of Purpose Study	5

CHAPTER 3 RESEARCH METHODOLOGY

3.1	Introduction	15
3.2	Research Planning	15
3.3	Preparation Of Material	17
3.4	Crushed Eggshell	17
3.5	Composite Portland Cement	18
3.6	Aggregate	19
3.7	Water	20
3.8	Moulding	20

3.9	Determination of Concrete Pavement Block Performance	21
3.9.1	Eggshell Proportion Composition	21
3.9.2	Concrete Mixing	22
3.9.3	Curing Pavement Concrete Block	23
3.9.4	Slump Test	23
3.9.5	Compressive Strength Test	24
3.9.6	Ultrasonic Pulse Velocity Test	25
3.9.7	Rebound Hammer Test	26
CHAPTER 4 RESULT AND DISCUSSION		
4.1	Introduction	27
4.2	Slump Test	27
4.3	Compressive Strength Test	29
4.4	Ultrasonic Velocity	34
4.5	Rebound Hammer	35
CHAPTER 5 CONCLUSION AND RECOMMENDATION		
5.1	Introduction	37
5.2	Conclusion	37
5.3	Recommendation and Future Study	38
REFERENCES		39
STANDARD		42

LIST OF TABLES

Table No.	Title	Pages
3.1	Material for 0.014 m ³ concrete G30	21
3.2	Proportions and type of eggshell concrete	21
4.1	Slump classification (BS 1881 : Part 102)	28
4.2	Slump test result for concrete G30	28
4.3	Compressive strength results for 1 day specimens	29
4.4	Compressive strength results for 7 day specimens	30
4.5	Compressive strength results for 28 day specimens	31
4.6	The compressive strength result	32
4.7	Ultrasonic velocity pulse result	34
4.8	Rebound Hammer result	35

LIST OF FIGURES

Figure No.	Title	Pages
1.1	Forecast of the composition of municipal waste in East Asia and Pacific region in 2025	3
3.1	Research planning	16
3.2	Crushed eggshell	17
3.3	Composite Portland Cement	18
3.4	Sand as fine aggregates	19
3.5	Rock as coarse aggregate	19
3.6	Concrete block mould	20
3.7	Concrete mixing process	22
3.8	Slump test	23
3.9	Compressive strength test	24
3.10	UPV machine	25
3.11	Rebound hammer test	26
4.1	Slump test result for eggshell replacement (ESR) fine aggregate	28
4.2	Compressive strength result for 1 day specimens	30
4.3	Compressive strength result for 7 day specimens	31
4.4	Compressive strength result for 28 day specimens	32
4.5	The compressive strength result	33
4.6	The ultrasonic velocity pulse result	34

LIST OF SYMBOL

G	Grade
%	Percentage

LIST OF ABBREVIATIONS

CEO	Chief Executive Officer
Sdn	Sendirian
Bhd	Berhad
UPV	Ultrasonic Pulse Velocity
CEMEX	Cementos Mexicanos
MS	Malaysian Standard
BS	British Standard
W/C	Water Cement Ratio
g	Gram
kg	Kilograms
L	Litres
mm	Millimeter
mm ²	Millimeter Square
m ³	Meter Cubes
Mpa	Megapascal
N	Newton
OPC	Ordinary Portland Cement
ESR	Eggshell Replacement
UMP	University Malaysia Pahang

CHAPTER 1

INTRODUCTION

1.1 Introduction

Nowadays, Malaysians are generating waste products at a rather alarming rate. It is much faster than the natural degradation process and they are using up resources at a speed exceeding the rate these materials are being replaced. As a way to disposal the waste, we need to recycle it to become useful product for the Malaysians. This method almost draws the universal acceptance but still the rate of national domestic recycling is around a mere five per cent. Despite the massive amount and complexity of waste produced, the standards of waste management in Malaysia are still poor due to outdate documentation of waste generation rates and its composition, collection system and inefficient storage, disposal of municipal wastes with toxic and hazardous waste, indiscriminate disposal or dumping of waste and inefficient utilization of disposal site space (Global Environmental Centre, n.d) .

According to the CEO of Alam Flora Sdn Bhd, there are more than 30 per cent of the garbage is recyclable, and these material can be prevent from ending up in the landfills and incinerators. He believe new methods and technologies are needed to reduce waste-generation because many cities around the world are beginning to develop and implement sustainable projects. These include strategies for waste- réducing, for example by using wastes as raw materials for building home, generating energy or fertilizers.

Currently in Malaysia, the waste product such as oil palm shell, fly ash and bottom ash used in construction industries as an additional material or replacement of the material in the concrete to decrease the cost while reducing the amount of waste.

The construction industries are searching for the alternative product that can increase their profit and in the same time can be an environmentally friendly material.

Eggshells are majority by products from other processes or natural materials. The major benefit of egg shell is its ability to replace certain amount of fine aggregate and still able to display fine aggregate property, thus reducing the weight of concrete. The use of such by products in concrete construction not only prevents these products from being land-filled but also enhances the properties of concrete in the fresh and hardened states.

1.2 Background of Study

From the previous research, the eggshell had been found as a good material to be an additive material or replacement material in the concrete. Eggshell is one of the waste material that can be found easily and it also found that have good strength characteristic when mixed with the concrete. Eggshell are agriculture waste materials generated from chick hatcheries, bakeries, fast-food restaurant among other which can litter the environmental and consequently constituting environmental problem or pollution which would require proper handling. The uses of eggs are very high in the food making process and the waste of eggshell is usually disposed in landfills without any pre-treatment since it is normally useless. Scientifically, eggshells known that it is mainly composed of compound of calcium which is very similar to cement. Literature has shown that the eggshell primarily contains lime, calcium and protein where it can be used as an alternative raw material in the production of wall tile, concrete, cement paste and other. Therefore, the use of eggshell in the concrete can decrease the cost of raw material and can give a profit to the construction industries while saving the environment. Therefore, eggshell can be used to reduce the cost of construction and produced as a new material in developing the construction industries.

1.3 Problem Statement

The price of cement and aggregates gradually increase every year due to the usage in the construction. In the other hand, Malaysia's waste disposal is the main factor in contributing the environment problem and it is also increasing every year due to the increased demand in the food industries. According to the The Star Online (2011), Malaysians are the world's largest eaters, averaging 320 per person per year as compared to only 250 in the United States and a paltry 48 per person per year in India. The effect of the eggshell to the environment can be serious and it also can affect the public health. In the food industries, the eggshell is known as the waste material but it can be a highly sophisticated composite material in the construction industries. The main point is to use the eggshell in packaging to protect egg products by giving a second lease of life to the eggshell in the very role it was created for a true case of recycling. Therefore, research study is about the usage of a waste material as a replacement to the material in concrete by using the eggshell can make it into the useful product and give a benefit to the both for food manufacturers and a much larger construction industry.

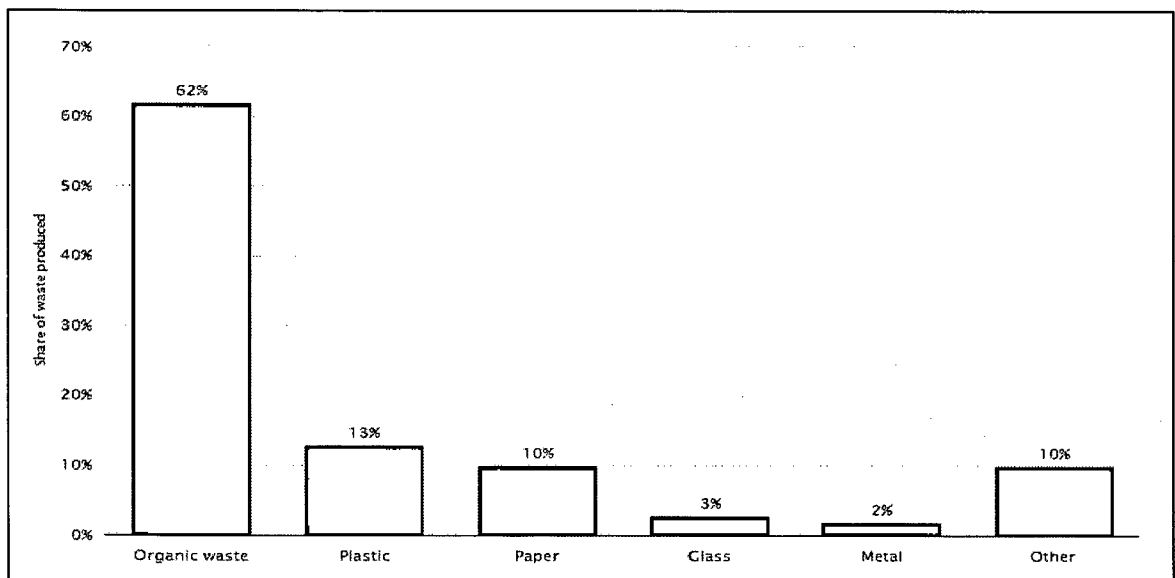


Figure 1.1: Forecast of the composition of municipal waste in East Asia and Pacific region in 2025

The chart above shows the forecast of the composition of municipal waste in East Asia and Pacific region in 2025. As we can see from the chart, the organic waste is also having the highest percentage in the others countries and it also will increase in every year referred to the forecast that had been made by The Statistic Portal. Organic waste is 62% which is the highest parentage and followed by plastic with 13%. The paper and other have the same percentage which is 10% for each of them. The least waste material is the glass and metal with 3% and 2% respectively.

1.4 Objectives of Study

- 1.4.1** To determine the effect of the eggshell powder on the concrete pavement block strength by using compressive strength test.
- 1.4.2** To determine the effect of eggshell to the workability of concrete by using slump test

1.5 Scope of Study

The scope of this research will covered the study about the effect of the eggshell to the concrete strength when the eggshell be one of the material in the concrete. In concrete production, Portland composite cement, coarse aggregate, fine aggregate, water and eggshell. There are a few experiment need to be done to know the strength of the concrete. The experiments are slump test, curing, compressive strength, ultrasonic pulse velocity test and rebound hammer test respectively. The amount of the eggshell that needs to be added is measured by percentage and the eggshell will be crushed by using hammer.

The test and experiment are done to determine the performance of the concrete pavement strength. The eggshells need to dry first without wash it so that the calcium on the egg will still remain on the shell. The slump test was done on each of the sample after mixing all the material well mixed. Compressive strength test is evaluate at 1 day, 7 day and 28 day. The other test which are UPV test and Rebound Hammer test need to be done on 28th day of the concrete. The concrete will through the curing process by submerged the concrete blocks into the water tank until the day of the test. The slump test needs to be done before pouring the concrete into the formwork, so that we can observe the workability of the concrete. The ultrasonic pulse velocity method used to assess the homogeneity and integrity of concrete. Rebound hammer test is to measure the elastic properties or strength of the concrete.

1.6 Expected Outcome

- 1.6.1 Improvement of concrete strength properties.
- 1.6.2 Contribution to our environmental problem.
- 1.6.3 Reduce landfill problem.

1.7 Significant Of Purpose Study

Malaysia is one of the develop country and the construction become bigger and the demand of the concrete is higher. Therefore this study is important and this method will help to reduce the cost of the construction and it is environmental friendly. In addition, this is the suitable method to solve the issue that arise from the waste disposal that can caused pollution to the public health.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, we will discuss about the material and the method that used in past study of the research. They will use as a references to guide this research.

2.2 Eggshell

Eggshells are widely used in our country nowadays. Good qualities of eggshells contain 2.2 grams averagely of the calcium in the form of calcium carbonate and have typical mass of 5.5 grams. The remaining mass is composed largely of phosphorus and magnesium, and trace amounts of sodium, potassium, zinc, manganese, iron, and copper (Gary and Richard 2004). As we can see from the research that had been done, eggshells have high amount of the calcium carbonate which make it has a same properties with the cement. Another than that, the controlling rate of egg weight also contributes to a good quality of eggshell and it's not depend on the thick eggshell mean strong. The eggshell quality is depend on the colour, shape, and structure of the shell itself.(Dr Ken, 2004)

Eggshell grains can be obtained by crushing the shell have been found to be a good accelerator for cement-bound material and this would be useful for road construction work at the peak of rainy seasons for reducing setting time of stabilized road pavement. Waheed (2012) said that the eggshell content increased the strength

properties of the soil-cement eggshell mixture up to 35% in the average but fell short of the strength requirements except the durability requirement was satisfied. He also said that, snail shell also quite satisfactory other than eggshell as partial replacement for sand with less compromise in compressive strength requirement for concrete mix ratios 1:2:4. Amu et. al (2005) conclude that the eggshell also can be good replacement material in industrial lime because it has the chemical composition of both material have a similarity. Therefore, the eggshell can be stabilizing potential of lime on an expansive clay and it is aimed on a improvement of the properties of soil including the soil density, increase the cohesion, frictional resistance and reduction of plasticity index such as lime, cement, and fly ash. Amaranth (2014) also said that eggshell rich in calcium which is nearly to the limestone. Use of eggshell waste instead of natural lime to replace cement in concrete can have benefits like minimizing use of cement, conserving natural lime and utilizing waste material.

For the summary, we can conclude that eggshell is suitable to be additional or replacement material in the concrete. This is due to the chemical properties of the eggshell is almost similar to the cement and this can increase the strength properties of the concrete. The objective of the research is acceptable to prove the strength of the concrete affect by replacement of the fine aggregate by the eggshell.

2.3 WATER

Water works as a solvent to the composite material in the concrete and it the most important material in the concrete. The good quality of water can produce a good concrete and if the quality is bad, it can cause the corrosion to the steel reinforcement. Therefore it is very important to make sure that the water that had been used for the production of concrete must be deleterious substance namely oil, alkali, salt, sugar, slit and organic matter. The amount of water that poured into the concrete also needs to be measured correctly so that it not exceeds the water cement ratio. There is additional

water that becomes physically bound between the cement hydrate. In order to have enough water to possibly enable complete hydration of the cement, approximately 20 pounds of water to every 100 pounds of cement is necessary. (CEMEX USA, 2013).

2.4 Cement

Cement is known as the binder in the concrete or can be specifically, a binder that sets and hardens and can bind other materials in the concrete mixture together. The most common type of cement that had been used around the world is the Ordinary Portland cement. It used as basic ingredient in many composite material such as concrete, mortar, stucco and non-specialty grout. Cement was produced from limestone and grey in colour. The hydration reaction occurs when the water is poured into the cement and this reaction can bind all the material such as cement, fine aggregate and coarse aggregate together and lastly become a composite material that called concrete. Ordinary Portland cement is specified according to the Malaysian Standard MS 522.

2.5 Aggregate

Aggregate are inert granular material such as sand, gravel, or crushed stone, along with water and Portland cement, are an essential in concrete. There are two types of aggregates which are fine aggregate and coarse aggregate. Fine and coarse aggregate can be naturally made by crushing stone or from construction, demolition and excavation waste. The presence of aggregate can greatly increase the durability of concrete and the redistribution of aggregate after compaction often creates in homogeneity due to influence of vibration. As a result, it can lead to the strength gradient.

Aggregate is the component materials that resist compressive stress and provides bulk to the composite material. For efficient filling, aggregate should be much smaller than the finished item, but have different sizes. For example, particles of stone used to make concrete typically include both sand and rock. To make sure the concrete is in

good quality, aggregate need to be clean, hard, strong particles free of absorption chemical or coating of clay and other fine material that could cause the deterioration of concrete.

2.6 Slump test

Consistency and workability of fresh concrete are significant criteria for the proportioning of concrete mix design and important properties affecting the placing of fresh concrete on site and the later performance of the hardened state of concrete. (Khaled and Ozgur, 2011). Workability is one of the physical parameters of concrete which affects the strength and durability as well as the cost of labour and appearance of the finished product. Slump test is suitable for the site used and it needs to be done before pouring the concrete into the formwork. The slump of the concrete cannot be too high or too low. High slump which mean the concrete content too much water which can cause concrete defect and same goes to the concrete that have low slump. Low slump which means low workability can cause a difficulty to the worker to do the compaction process. The slump can be categorized in three type which are true slump, shear slump and collapse slump.

According to the Hover (2008) the amount of water in concrete will affect the height of slump and the higher the water content, the higher the slump of the concrete. Some of the concrete mix that is already been set by particular of slump and it can be predicted by adding some water that can increase the slump by inch. In relation for the other findings the slump test is use for determining of the workability of concrete grades. For the workability of fresh concrete, the capability, mobility and stability can be related to it. It can also be define as the relative plasticity of freshly mixed concrete as indicative of it workability. There concrete may have the following types of consistency which are; plastic consistency, semi-fluid consistency, and fluid consistency. So that, different occasions has a different degree of workability.

In our research, the slump test needs to be done to know the workability of the fresh concrete. It is true to said that increasing the amount of water in fresh concrete may increase the workability which is the slump of the concrete. However the

additional amount of water may affect the concrete properties and the concrete may defect after it is harden. It is because the higher workability does not mean the higher the concrete properties. The concrete properties may affect by replace the fine aggregate to eggshell and it is also will affect the workability of the fresh concrete. The method of the slump test will be done by referring to the British Standard 1881: Part 102.

2.7 Compressive Strength test

Concrete has versatile use in the construction practise for its availability, cheap rate, flexibility of handling and giving shape to any desire form. Designing the concrete structures required the concrete compressive strength to be used. According to the Hamid-Zadeh et al. (2006), the concrete strength design normally represents its 28th day strength. The properties and combinations of specific materials, as well as placement techniques and environmental conditions, will dictate the actual in-place strength. Hasan and Kabir (2011) in his research said that the characteristic like, durability, permeability, volume stability may be important in some case of designing concrete structure but the most important one is the strength of the concrete. The strength of the concrete will represent the overall of concrete quality and the process of strength will growth is called 'hardening'.

According to the Obafemi et al. (2005), used of lime as an additive in unconfined compression test and undrained triaxial shear strength raised the properties strength on the stabilizing potential on an expansive clay soil. Thus, the eggshell also can increase the optimum moisture content but reduced the maximum dry density. So that, it can be considered the eggshell in concrete can increase into the strength properties of the concrete. As a conclusion, all the additive or admixture related to eggshell in concrete improves the performance of strength properties in any material involved.

2.8 Rebound Hammer

Rebound hammer is a one of the non-destructive test. This test is to measure concrete strength and it is cheap, easy to operate and should have reproducibility for the fairly accurate result. Referring to Neville, in the book *Properties of Concrete* (fourth edition), the rebound hammer is useful in the assessment of uniformity of concrete with a structure. The measurement results are influenced by various factors such as components and composition of concrete and humidity or age which are well known for normal-weight concrete. According to the Hannachi and Nacer (2012) the combination of several techniques of non-destructive testing is often implemented empirically. In order to enhance the reliability of the compressive strength that had been estimate, the two technique need to be combined so that the error in the result can be minimized.

2.9 Ultrasonic Pulse Velocity

Ultrasonic pulse velocity is the test that measuring pulse velocity through the concrete with a generator and a receiver. This type test can be performed on samples in the laboratory or on-site. Referring to the Hannachi and Nacer (2012), in their research said that many factors affect the result such as the surface, and the maturity of concrete, the travel distance of the wave, the presence of reinforcement, mixture proportion, aggregate type and size, age of concrete, moisture content, etc. Furthermore some factors significantly affecting UPV might have little influence on concrete strength. This test method is applicable to assess the uniformity and relative quality of concrete, to indicate the presence of voids and cracks, and to evaluate the effectiveness of crack repairs. It is also applicable to indicate changes in the properties of concrete, and in the survey of structures, to estimate the severity of deterioration or cracking. When used to monitor changes in condition over time, test locations are to be marked on the structure to ensure that tests are repeated at the same positions. The need of repeating is to ensure that the result will not have any error.

2.10 Eggshell on Road Construction

Good qualities of eggshell contain approximately 2.2 grams of calcium in the form of calcium carbonate from commercial layers. Dry Eggshell contain about 95% of calcium carbonate weighing 5.5 grams and the other are contains about 0.3% phosphorous, 0.3% magnesium, and traces of sodium, potassium, zinc, manganese, iron an copper (Amu and Salami, 2010). The organic material has calcium binding properties, and its organization during shell formation influences the strength of the shell. The organic material must be deposited so that the size and organization of the crystalline components (mostly calcium carbonate) are ideal, thus leading to a strong shell.

Most parts of the world did not use the eggshell as stabilizing material but it can be the other type of stabilization if it is use as a replacement. Olarewaju et al. (2011) found that the mixtures consist of lateritic soil and eggshell can produce the low binding properties and significant to improve the strength of the soil which had been used as a sub grade where has good performance. The requirements of the capacities of the stabilization of the base or sub base for road construction have not met the minimum needed. The increase of the eggshell content can increased the optimum moisture content but it can reduced the maximum dry density of the soil-cement eggshell ash stabilized lateritic soil and the strength properties of the cement-stabilized matrix increase up to about 35% averagely (Okonkwo et al., 2012).

For the conclusion, the eggshell is suitable to use as the stabilizing materials and it also can increase the strength of the soil. The result of the investigation shows that eggshell significantly increase the maximum dry density and optimum moisture content of the soil. As 8% eggshell stabilization lateritic soil processes close optimum moisture content and maximum dry density properties. Thus, the eggshell is also suitable in road construction and not only in the building construction field.

2.11 Cement Water Content

The rate at which concrete sets is independent of the rate at which it hardens. There are many factors which control concrete compressive strength. Concrete mix

proportioning, aggregate quality, aggregate gradation, type of cement, mixing and placing method, concrete curing and curing temperature and the most important one is the water cement ratio. Water cement (W/C) ratio has a critical impact on concrete strength characteristic. A minimum amount of water is necessary for proper chemical reaction in the concrete and extra amount of water increases the workability and reduces strength.

According to the Alawode (2011), the water cement ratio that above 0.65 was found to cause a very significant reduction in the compressive strength of the lateritic concrete mixes. The volume of water in the fresh cement paste or fresh concrete is related to the volume of empty pore space in hardened cement paste or hardened concrete. Similarly, the volume of cement in fresh concrete is related directly to the solid volume in hardened concrete. Ken Hover, popular speaker in Cornell University said that Water-cement ratio is therefore a measure of the void volume relative to the solid volume in hardened cement paste, and its strength goes up as the void volume goes down. So, the lower the W/C, the lower is the void volume/solid volume, and the stronger the hardened cement paste.

2.12 Paving Block

The concrete blocks are precast concrete units about the size of a normal brick. They are manufactured with close dimensional tolerance is a wide variety of shape. Interlocking concrete block pavement is constructed with individual block being laid in patterns with close, unmortar joints on a bedding sand layer between restrain. The block is made by combination of well-graded aggregates, cement and water which fits closely together with other paving blocks to form a pavement surface. The blocks are generally laid by hand on a sand layer. The blocks are then compacted with a manually operated vibratory plate compactor which seats the blocks in the sand layer, compacts the sand layer, and forces some sand into the joints between the blocks. Additional sand is then applied to the surface and swept into the joints between the blocks. More passes are made with the vibratory plate compactor to compact and wedge the sand into the joints. According to the Patel (2014) said that if the compressive strength can be improve, it

can also be used in the heavy traffic area. Referred to Ahirrao et al. (2014), they concluded that the paving block that had been cured has higher compressive strength than non-cure paving block. The compressive and the flexural strength increased by 37% and 50% respective. Therefore, in order to get a higher compressive strength of the paving bock, the process of the curing need to be done.