EGGSHELL

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ABSTRACT

An investigation on the performance of eggshell in concrete has been tested and carried out. Four proportions of concrete specimens were used in this research which is 0%, 5%, 10%, and 15%. In this concrete the material was used are Portland cement, chicken eggshell, coarse aggregate, fine aggregate, and optimum of water. The maximum size of the coarse aggregate is 20 mm and sizes of eggshell are between 2 mm – 5 mm. The test that has been conducted is slump test, compressive strength test, flexural test and water penetration test. From the investigation, eggshell concrete in compressive strength has achieved the objectives of this project where the value of 28 days compressive strength more than control. In this research also shows the measurement of slump test in medium workability which is suitable and affordable for concrete grade 20. Besides that, concrete with 5% eggshell additive achieve the highest compressive strength which is 28 N/mm^2. The eggshell concrete also improves in flexural strength which is the highest strength is 7.93 N/mm^2 and water penetration test produce a best of performance with lower depth at 14 mm only. The optimum eggshells concrete are suitable in typical reinforced concrete application in building which intended working life is at least 50 years.

ABSTRAK

Kajian mengenai prestasi kulit telur di dalam konkrit telah dijalankan serta diuji. Empat pembahagian konkrit specimen telah digunakan dalam ujikaji ini dimana meliputi 0%, 5%,10% dan 15%. Di dalam ujikaji ini, simen Portland, kulit telur, batu baur kasar, batu baur halus dan penggunaan air yang optimum digunakan. Saiz maksimum batu baur kasar ialah 20 mm dan saiz kulit telur adalah di antara 2mm – 5mm. Ujian yang telah dijalankan ke atas konkrit ini ialah ujian penurunan konkrit, ujian kekuatan konkrit, ujian kekuatan lenturan dan juga ujian ketelapan air. Daripada ujikaji yang telah dijalankan, kulit telur di dalam konkrit bagi ujian kekuatan konkrit telah mencapai objektif penyelidikan di mana nilai yang telah terhasil daripada 28 hari telah melebihi daripada kekuatan normal konkrit. Di dalam kajian ini juga telah menunjukkan ukuran kebolehkerjaan konkrit berada di dalam kebolehkerjaan yang sederhana di mana bersesuaian dan berpatutan pada konkrit gred 20. Selain daripada itu, konkrit pada 5% penambahan kulit telur telah mencapai kekuatan konkrit sebanyak 28 N/mm^2. Ujian kekuatan lenturan konkrit juga telah mendapat kekuatan yang tinggi iaitu sebanyak 7.93 N/mm^2 dan ujian ketelapan air menghasilkan prestasi yang terbaik di mana nilai penyerapan oleh konkrit sebanyak 14 mm sahaja. Nilai optimum yang terdapat pada kulit telur konkrit adalah bersesuaian dengan penggunaan konkrit bertetulang pada bangunan di mana jangka hayat bangunan dapat bertahan selama 50 tahun.

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LIST OF SYMBOLS

G	Grade
%	Percentage
°C	Degree Celcius
Δc	Tolerate to accommodate fixing precision

LIST OF ABBREVATIONS

d	Depth of the beam (mm)
ES	Eggshell
CI	Chlorine
G	Gram
kg	Kilogram
KN	Kilonewton
L	Litre
I	Span length (mm)
m	Meter
m^3	Cubic meter
MPa	Megapascal
N	Newton
WBA	Wasted Bottom Ash
P	Maximum load at failure
s	Seconds
CaO	Calcium Oxide
BS	British Standard
Mw	Saturated Weight
SO^3	Sulfur Trioxide
SSR	Sewage Sludge Ash

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Throughout the world, waste products are seriously polluting the environment. There are many types of disposal system. The common waste disposal systems used in Malaysia are open burning, composting, incineration and land filling which this leads to the accumulation of solid waste in the environment. The resultant effects to the accumulated solid waste include unsightly surroundings, obstruction to pedestrian and traffic flow, air pollution and ground water pollution due to lactates from the accumulated solid waste. There have been issues of serious concern about environmental problem of waste disposal problem.

According to Bjourkland(1998) and Japan International Cooperation Agency (2006),today waste management has given rise too many pressing issues such as strict environmental regulations, expensive land expertise, improper management of waste disposal sites and health & safety issues Hence managing solid waste in Malaysia is still a big challenge where Malaysia is looking towards innovative solution to the waste disposal problem of inadequate and inefficient services.

Nowadays, waste products such as oil palm shell, glass, fly ash and bottom ash are used in construction industry to maximize the profit while reducing the amount of waste. The construction industries are searching for alternative product that would reduce the construction cost while improving the quality of building materials.

Eggshells are known to have good prospects in mixing with concrete to improve strength. Most of the eggshell waste is commonly disposed in landfill without any pretreatment because it was traditionally useless. The use of eggshell ash in concrete production reduced the cost of raw material and contributes to construction industry.

1.2 BACKGROUND OF STUDY

Earlier works on the combination concrete conducted by scholars have led us to the point that the eggshell ash can be used as an additive in concrete production. Eggshells are agricultural waste materials generated from chick hatcheries, bakeries, fast food restaurant among others which can litter the environment and consequently constituting environmental problems or pollution which would require proper handling. In the ever increasing efforts to convert waste to wealth, the efficacy of converting eggshell to beneficial use becomes an idea worth embracing. The composition of eggshells indicates that the effect of it ash on cement treated materials should be articulated. It is scientifically known that the eggshell is mainly composed of compounds of calcium which is very similar to the cement. Literature has shown that the eggshell ash primarily contains lime, calcium and protein where it can be used as an alternative raw material in the production of wall tile material, concrete, cement paste and others. Eggshell also contribute to construction industry which is it can be reduce in construction cost and landfill which it give good performance in properties in concrete and durability of the concrete. Thus, eggshells can be produced a new raw material for development in the construction industry as an additive in the conventional concrete.

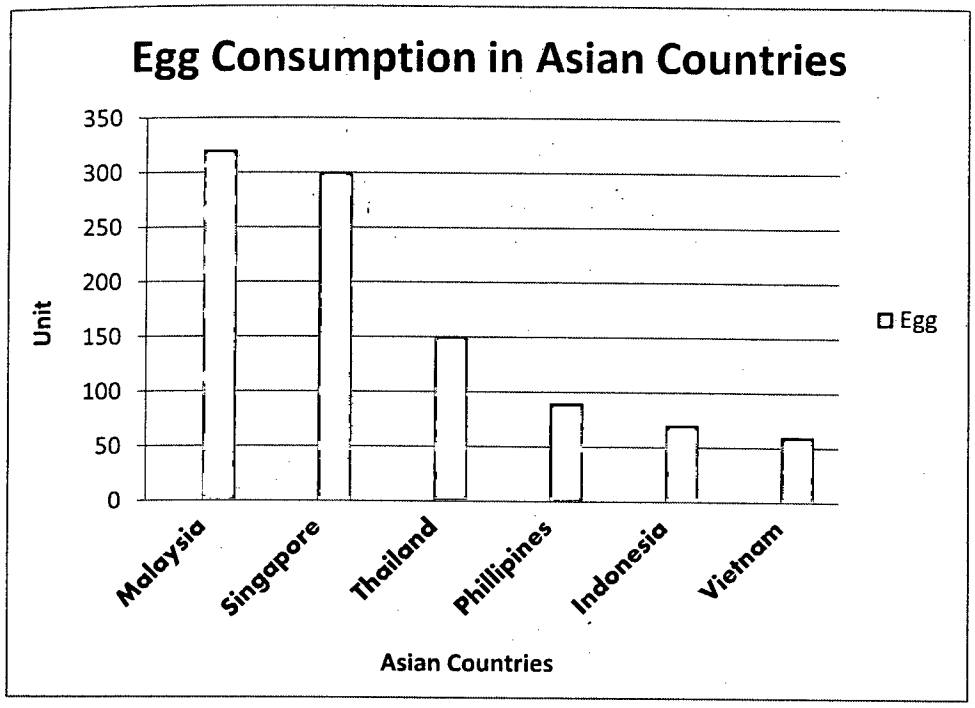

Figure 1.1: Egg consumption in Asian countries (Maybank IB, 2011)

Figure 1.1 shows the egg consumption for six Asian countries. It is observed that Malaysia consumed the highest egg consumption followed by Singapore, Thailand, Philippines, Indonesia and Vietnam. High consumption of eggs has generated large amount of eggshells to be disposed. Eggshell waste falls within the category of food waste, can be suitable alternative material for construction(Amu et al, 2005). Thus this research focused on making use of these waste materials and transforms it into more useful products.

1.3 PROBLEM STATEMENT

According to Galloway (2013) each year, an estimated 76 billion eggs are consumed and the prior to final consumption, about 25 billion of those eggs are first processed into egg products. The egg-processing plants must break those eggs before further processing occurs. In doing so, these plants generate an estimated 600,000 tons of eggshell waste per year. Currently 30% of all eggs produced will grow due to increased demand for ready-prepared meals, cake mixes, fast-food and other food-

preparation formats. While this is good for the egg-product processing plants, the disposal of eggshell waste is an ever-increasing problem. Eggshell waste disposal can be very costly where medium sized egg product processing plants can generate as much as 7 tons of wet eggshell waste daily. Most of the eggshell waste is commonly disposed in landfill without any pretreatment because it was traditionally useless. Therefore, turn the eggshells into useful product can contribute to construction industry where eggshell ash can be use as an additive in concrete and also known to have good material bound in strength properties. As we know also, the raw material cost nowadays is quite expensive and we can use this alternative to make replacement to reduce or cut the cost overhead.

1.4 OBJECTIVE OF STUDY

The aim of this project is to provide the compressibility characteristic of chicken eggshell and concrete mixture in order to maximize its strength reducing the disposal problem. The objectives of this study are

i. To determine physical and mechanical properties in eggshell concrete

ii. To determine the water penetration and the permeability of eggshell concrete

iii. To determine the effect of eggshell as an additive to concrete

1.5 SIGNIFICANCE OF STUDY

Waste management is one of the major issues in Malaysia where we are very poor with the management and lack of manpower in waste management system. Apart from that, researchers are find an alternative way to make this raw material into benefit product. Eggshell is one of the elements of household and industrial waste. The eggshell waste can be reduced in landfill problem and also waste management system. Hence, it resolves arising issues of waste disposal problem including support to our environmental problem that mainly caused pollution to public health. Besides that, it will improve to the properties strength and the durability of concrete characteristic with the certain concrete testing thus helps our economy industries of construction.

1.6 SCOPE OF STUDY

In order to achieve the objective, the following test and experiments are conducted. These eggshells first must be sieved into sizes. This test will be tested in1 day, 7 days and 28 days to get it strength. The test carried out is slump test where it measures the workability and the consistency of the concrete while compressive strength test is measured by breaking mould concrete specimens in a compressing testing machine where the test results are primarily used to determine that the concrete mixture as delivered meet the requirements of the specific strength. On the other hand, the flexural test is used to determine the modulus of rupture of specimens prepared and cured in accordance with ASTM Practices C293M.The results of this test method may be used to determine compliance with specifications or as a basis for proportioning, mixing and placement operations. Another last test is the water permeability test in concrete samples was tested as the penetration depth of water following the EN 12390-8 standard. According to this EN12390-8, water penetration depth is measured under pressure 150 mm x 150 mm concrete cubes were prepared and cured for 28 days. The curing temperature was around 20 – 25 degree Celsius. After the completion of 28 days curing, in order to bring the concrete specimens in air dry condition. Then the cube specimens were place in the equipment and water was introduced from bottom with a certain pressure (5 bars) in a way that water forced to penetrate through the sample. As per standard, samples were tested for 72±2 hour. For each concrete mix, total three cube specimens were prepared and tested for water penetration depth.

1.7 THESIS OUTLINE

Chapter 1:

This chapter discussed the background of the eggshell as waste material in concrete composition, which also, included the properties of eggshell, the consumption of eggshell per year and environment impact on the waste disposal. This chapter also included the problem statement of eggshell, objectives, scope and limitation.

Chapter 2:

In this chapter covered the characteristics of cement, aggregate, water and eggshell. In additional, the past researchers on waste material in composition of concrete also were discussed.

Chapter 3:

This chapter covered the materials and experiment used for this research. Material used for concrete is sand, aggregate, water, cement and the only one important material is eggshell. Test has been carried out in laboratory which is slump test, compressive strength test, flexural test, and water penetration test.

Chapter 4:

This chapter is the analysis on the results after the several testing on concrete and the durability in concrete for research investigated. Besides that, the results and eggshells concrete for suitability was discussed.

Chapter 5:

The conclusion is based on the studies and recommendation for further study in concrete.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Literature review discussed the relevant materials which involves in concrete mixtures. In this chapter discussed the characteristics of cement, aggregate, water, and eggshell. Besides that, permeability and durability of concrete composition are discussed. In addition, the past researches on waste material in composition of concrete are discussed. Since the topic is related to the eggshell, several eggshell research applications in construction industry are also discussed.

2.2 CONCRETE

Concrete is a material used in building construction, consisting of a hard, chemically inert particulate substance, known as an aggregate (usually made from different types of sand and gravel), that is bonded together by cement and water. Concrete production is consist of several methods to produced a high strength concrete that is batching, mixing, consolidation, finishing and curing. The other major part of concrete besides the cement is the aggregate. Aggregates include sand, crushed stone, gravel, slag, ashes, burned shale, and burned clay. Fine aggregate (fine refers to the size of aggregate) is used in making concrete slabs and smooth surfaces. Coarse aggregate is used for massive structures or sections of cement.

Concrete can be labeled as our backbone of construction industry today because Malaysia also is the highest consumer in concrete production. All mega projects and big projects use concrete as a major material in the heavy construction such as for the

construction of the PETRONAS Twin Towers used 13200 cubic meters concrete poured in 54 hours requiring the site to be covered with tarpaulins to allow work to continue. It is obvious from pass until now, concrete is playing the important role in construction industry.

Due to the waste management problems and green building issues, concrete have to evolve in the respect of the environment within a sustainable development perspective. Beside that ,the production of cement are producing large amount of carbon dioxide which is hazardous to the environment. Therefore waste components like oil palm and sludge are mixed into concrete in order to reduce the waste material and mitigate the environment pollution.

2.3 PORTLAND CEMENT

According to Rupnow (2008),there are many different properties and applications of cements for used in concrete including Portland, blended, and hydraulic cements. Portland cement is a main element of the fundamental ingredient in concrete, is a calcium silicate cement made with a combination of calcium, silicon, aluminum, and iron. Producing a cement that meets specific chemical and physical specifications requires careful control of the manufacturing process. The first step in the Portland cement manufacturing process is obtaining raw materials. Generally, raw materials consisting of combinations of limestone, shells or chalk, and shale, clay, sand, or iron ore are mined from a quarry near the plant. Two different methods dry and wet, are used to manufacture Portland cement. In the dry process, dry raw materials are proportioned, ground to a powder, blended together and fed to the kiln in a dry state. In the wet process, slurry is formed by adding water to the properly proportioned raw materials. The low cost and widespread availability of the limestone, shale, and other naturally occurring materials make Portland cement one of the lowest-cost materials widely used over the last century throughout the world. Concrete becomes one of the most versatile construction materials available in the world. The manufacture and composition of Portland cements, hydration processes, and chemical and physical properties have been repeatedly studied and researched, with innumerable reports and papers written on all aspects of these properties.

2.4 WATER

Water is needed to chemically react with the cement (hydration) and too provide workability with the concrete. The amount of water in the mix in pounds compared with the amount of cement is called the water/cement ratio. The lower the w/c ratio, the stronger the concrete. Khan (2007) state that the requirements of water used in concrete role of water in cement concrete, water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials. Portable water is generally considered satisfactory for mixing concrete. Mixing and curing with sea water shall not be permitted and the pH value shall not be less than 6

2.5 DURABILITY OF CONCRETE

Nemati (2013) said the durability of concrete may be defined as the ability of concrete to resist weathering action, chemical attack, and abrasion while maintaining its desired engineering properties. Different concretes require different degrees of durability depending on the exposure environment and properties desired. For example, concrete exposed tidal seawater will have different requirements than an indoor concrete floor. Concrete ingredients, their proportioning, interactions between them, placing and curing practices, and the service environment determine the ultimate durability and life of concrete. Concrete is resistant to wind-driven rain and moist outdoor air in hot and humid climates because it is impermeable to air infiltration and wind-driven rain. Moisture that enters a building must come through joints between concrete elements. Annual inspection and repair of joints will minimize this potential. More importantly, if moisture does enter through joints, it will not damage the concrete. Concrete also will shrink slightly when it dries out. Common shrinkage is about $1/16^{th}$ of an inch in a 10 foot length of concrete. The reason contractors place joints in concrete pavements and floors is to allow the concrete to crack in a neat, straight line at the joint, where concrete cracks due to shrinkage are expected to occur. Generally, durability of concrete not purposely affected by material and the composition of the mixture also needs to take attention.

2.6 PERMEABILITY OF CONCRETE

Concrete used in water-retaining structures, exposed to severe weather, or exposed to an aggressive environment must be virtually impermeable or watertight. Water tightness refers to the ability of concrete to hold back or retain water without visible leakage. Permeability refers to the amount of water migration through concrete when the water is under pressure, and also to the ability of concrete to resist penetration of any substance, be it a liquid, gas, or chloride ion. Today there is renewed interest in the permeability of concrete. It deals mainly with permeability to deleterious substances such as chloride ions from seawater and deicing salts, sulfate ions, and other aggressive chemicals. In 1986, Construction Technology Laboratories researchers studied the effects of mix design, materials, and curing on permeability of selected concretes. The concretes were subjected to tests that included: permeability to water and air, ponding with chloride solution, rapid chloride permeability, helium porosity, and volume of permeable voids. The results of the study confirmed that water/cement ratio strongly influences the permeability of concrete

2.7 EGGSHELL

The gross majority of egg consumption takes place in the intensely populated region of Asia where this protein serves as a major food. A great variety exists in the production, processing and pricing of eggs and egg products. Over 65% of global egg consumption takes place in Asia. It is observed that Malaysia consumed the highest chicken and egg consumption followed by Singapore, Thailand, Philippines, Indonesia and Vietnam. High consumption of egg also follows increasing the eggshell waste development rate.

A good quality eggshell will contain, on average, 2.2 grams of calcium in the form of calcium carbonate ($CaCO^3$). Approximately 94% of a dry eggshell is calcium carbonate and has a typical mass of 5.5 grams, although these values can differ depending on sources. Amounts as low as 78% have been published. The remaining mass is composed largely of phosphorus and magnesium, and trace amounts of sodium, potassium, zinc, manganese, iron, and copper (Richard.,). According to Kent.(2006)

there are many factors that affect the overall quality of the egg shell, but before discussing these factors, it is important to know what makes up the structure of the egg shell. The egg shell consists of about 94 to 97% calcium carbonate. The other three percent is organic matter and egg shell pigment. Egg shell quality is determined by the color, shape, and structure of the shell. Colors can range from white to tints to brown and egg shape can also vary.

2.8 COARSE AGGREGATE

Coarse aggregate usually contain of small particle of that are bounded differences to the aggregate surfaces (Steven et.al, 2005). Previous research associates the presence that surface of these aggregate with deleterious properties of concrete. Besides that, different types of coarse aggregate will influence the strength of concrete while sizes of the coarse aggregates also playing an important roles to improve strength of concrete (Chen et al.,2005). According to (Erol et.al, 2005), research about influence of coarse aggregate shape of the strength of asphalt concrete mixtures. Therefore the effects of aggregate shape and texture on the strength of hardened concrete should not be over-generalized. Other than that, aggregate properties significantly affect the workability of concrete and also the durability, strength, thermal properties, and density of hardened concrete.

2.9 FINE AGGREGATE

Fine aggregate is an essential component of concrete. Fine aggregates consist of natural resources and manufactured from stone gravel. The most commonly used fine aggregate is natural river sand. The finer aggregate have better positive effects on the properties of concrete and hardened high performance concrete. Fine aggregate are playing important role in the concrete mixtures. According to Steven et al, (2005), fine aggregate particle shape and texture effect concrete mainly through their influence on the workability of fresh concrete. The influence of fine aggregate shape and texture on the strength of hardened concrete is almost entirely related resulting of the concrete, provided that the fine aggregate has a grading within normally accepted limits

2.10 CONCRETE WITH FLY ASH, RICE HUSK ASH AND EGGSHELL ASH

Coal fly ash, an industrial solid waste by-product, is produced by thermal power plants. Vast quantities of fly ash (about 80 million tons per year in the United States) are produced when coal is burned or gasified. It has been already proved that they can enhance the mechanical and durability properties of concrete, reduce the risk of thermal cracking in massive concrete applications and lower the environmental impact of concrete. Ramasamy (2012) also said that the utilization of Rice Husk Ash as a pozzolanic material in cement and concrete provides several advantages, such as improved strength and durability properties, reduced materials cost due to cement savings, and environmental benefits related to the disposal of waste materials. In the present investigation, Portland cement was replaced by rice husk ash at various percentages and its effect on the compressive strength and its durability properties like water absorption, porosity, permeability, resistance to acid attack, alkaline attack and sulphate attack was studied. Eggshell is one of the waste materials and dispose used landfill although volume of eggshell less than the rice husk paddy but it also polluting the environment.

2.11 THE USE OF EGGSHELL AS FILLER IN HOT MIX ASPHALT (ROAD CONSTRUCTION)

Few years ago, many studies towards the use of other more road construction quality has shown positive results and encouraging in road repairs. This allows the use of organic and inorganic materials in asphaltic pavement as plastics, polymers, glass and much more can be developed. With this, not only can solve the problem of the lack of original material in asphaltic pavement construction present and future, but also using alternative by recycling process can be implemented. This alternative should be developed from time to time not only in Malaysia but such technology should be shared around the world. One of the filler material used in this mix is Portland cement. It serves as subtle fill cavities in paving mixtures aims to strengthen the structure of the road, according to its nature as a binder. Because the demand for cement is high in road construction and development, other alternatives should be sought to address this problem is by using other filler material. As well as to mix such as fine and coarse

aggregate, quarry dust and sand. There are various proposals for solving this problem. One of them is use egg shells as filler material. (Yuliarahmadila et.al, 2012).

Eggshell study is an alternativeto partially replace the use of Portland cement as a filler in asphalt mixture. Thus using eggshells as a filler, sustainable performance can be improved. This study was conducted to evaluate the effect of using egg shells as filler in hot mix asphaltic concrete (AC14). Performance of the mixture specified by obtaining the optimum bitumen content (OBC) and optimal eggshell content (OESC). Percentage of Eggshell content rate used was 0%, 1%, 3% and 5%. In summary, the results of conventional samples and modified samples show effective eggshell content in the range of 3% to 5%. In addition, the specific gravity was carried out by using eggshell as filler will reduced the specific gravity. In conclusion, the egg shell is one of the substances that can be used as filler.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

In this chapter, the experiments and test discussed the materials used in this research. Material used for concrete such as sand, aggregate, water, cement and one of research material which is eggshells. Tests are carried out in laboratory which is slump test, compressive strength test, flexural strength test, and water penetration test. This chapter also discussed the procedures of the concrete mixture with good performance.

3.2 MATERIALS

This research is mainly on the application of the eggshell in concrete, the materials used for this experiment is Portland Composite Cement, eggshell , fine aggregate , course aggregate and water. The eggshell was used in the concrete composition according to the designed concrete ratio.