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Cockle Shell as an Additive in Pavement Mixture

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Abstract: This study explores the use of cockle shell (CS) as an additive in premix combinations because cockle shell (CS) is rich in calcium oxide (CaO), which can affect the behaviour and characteristics of pavement. Waste cockle shells (WCS) from seafood dishes collected by restaurants have the potential to harm the environment and the neighbourhood. The major goal of this study is to develop a pavement mix employing additions of 10 g, 20 g, and 30 g of CS in a mix design that satisfies predetermined criteria. Tests on specific gravity, voids, stability, and stiffness were conducted. Various mix designs were used to compare the results. It's interesting to learn that specific gravity, voids, stability, and stiffness of pavement mixtures are all influenced by the chemical makeup of CS. In terms of density, stability, and stiffness compared to control samples, 10 g of CS is the ideal quantity to add to a pavement mixture. Future research on CS as a premix mixture component is strongly advised. This research will undoubtedly help us create a pavement combination of the greatest calibre.

Keywords: Cockle shell, calcium oxide, premix mixture, density, stability, stiffness, voids, specific gravity

1. Introduction

In civil engineering, pavement refers to the long-lasting paving of a road, airport, or other equivalent area. The main function of a pavement is to transmit loads to the soil beneath and the sub-base. In modern flexible pavements, sand, gravel, or crushed stone is compacted with a bituminous binder like asphalt, tar, or asphaltic oil. This kind of pavement can withstand impact since it is flexible. Concrete with coarse and fine aggregates, Portland cement, and other ingredients are used to create rigid pavements. Steel rod or mesh is frequently used as reinforcement.

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The earliest paved roads were constructed by the Carthaginians in 600 BC. It's probable that the idea of paved paths was borrowed from Carthage, even though ancient Rome destroyed it. They constructed about 54,000 miles (87,000 kilometres) of roads across their kingdom. He is renowned for building flat roads so that fewer horses would be needed to carry carts. His roads were adequately constructed and equipped to support heavy loads. Scottish engineer and road function object John Loudon McAdam lived from 1756 until 1836. He invented the Macadamisation technique, a fresh way to build roads with a fast-draining, smooth, hard surface.

The development of roads in Malaysia dates to the late 18th century, when the British occupied the country, and they were built in commerce, industrial, plantation, and port regions. All the country's roadways were constructed by British colonialists before to independence, and they serve as the foundation for the current network of contemporary road networks. 4 million cars were on 24000 km of roads in 1986, and this number will quickly rise each year [1].

Waste seashells created by marine products have the potential to impact the ecosystem and the nearby populations, according to the problem statement for this study. By clogging drainage drains and polluting the ecosystem, removing discarded seashells can harm the environment. On the surface of the road, several sorts of damage frequently happen. Cracks, potholes, dents, edge pieces, erosion, dislocation, and others are some of them.

2. Materials and Methods

The materials and methods section, otherwise known as methodology, describes all the necessary information that is required to obtain the results of the study.

2.1 Materials

Raw materials are utilised in a wide range of goods and come in a variety of shapes and sizes. The input commodities or inventories that a firm need to make its products are known as raw materials. The materials required in this study which will be discussed are bitumen, aggregates and crushed cockle shells.

2.1.1 Bitumen

Bitumen is a thermoplastic containing bituminous materials that is obtained from petroleum refinery bottoms and is widely used in sealants, binders, waterproof coatings, and paving materials. It is preferred for its low cost, inherent cohesive nature, rheological properties, and thermal resistance [2]. Penetration Bitumen Grade 60/70 is a semi-hard penetration grade bitumen used as a paving grade bitumen for road construction and maintenance, as well as the creation of asphalt pavements. This bitumen is primarily utilised in the production of hot mix asphalt for bases and wearing coarse.

2.1.2 Aggregate

Table 1: Size of aggregate for acw 10 mix design

BS Sieve Size (mm)	Passing (%)
14	100
10	90 – 100
5	58 – 72
3.35	48 – 64
1.18	22 – 40
0.425	12 – 26
0.15	6 – 14
0.075	4 - 8

Aggregate is utilised in flexible and stiff pavement base and sub-base courses [3]. Aggregate is important to determine the quality of a road pavement. **Table 1** shows the size of aggregate for acw 10 mix design. Portland cement concrete has an aggregate content of 70%–80%, whereas bituminous concrete has an aggregate content of 92–96%. Additionally, aggregate is used in sub-base and base courses for both flexible and rigid pavement. Aggregates used in bituminous pavements should have a lesser affinity for water as compared to bituminous materials; otherwise, the bituminous coating on the aggregate would peel off in the presence of water. According to standards, aggregates used in bituminous mixes are frequently needed to be clear, strong, and resilient, as well as free of excess flat or elongated particles, dust, clay balls, and other unwanted material.

2.1.3 Crushed Cockle Shell

Cockles (Anadra granosa) are a type of edible bivalve mollusk and one of the most important seashell species in Malaysian aquaculture. In 2011, Peninsular Malaysia gathered 57000 tonnes of cockles, often known as blood cockles [4]. The size of the crushed cockle shell that used in this research is smaller than 0.425 mm. Tabby was also utilised as a substitute for bricks, which are difficult to come by and pricey due to a lack of local clay [5].

2.2 Methods

Limestone is scarce in coastal areas; seashell by-products have been used as construction materials for hundreds of years [6]. There are several methods that used which is firstly making a preparation of the existing base course layer. The application of tuck coat and prepare it and placing the premix. It is important to checked quality control of bituminous premix construction. Each 1% increase in air spaces above 7% reduces the pavement's service life by 10% [7].

2.2.1 Preparation of Samples

Table 2: Mix Design of Four Sample

Type of Sample	Number of Sample	Raw Material		
		Bitumen (kg)	Aggregate (kg)	Cockle Shell (kg)
Control	3	0.18	1	0
A	3	0.18	1	0.03
B	3	0.18	1	0.06
C	3	0.18	1	0.09

Table 2 shows the mix design Firstly, weigh the aggregate that has been sieved. Then prepare 12 sample moulds and the other material that used to make the sample which is tray 1’ X 2’ and 2’ X 2’. Heat in the oven 12 sets of moulds which are base, mould and collar, steel rod, spatula, aggregate that had been weighed in a bowl and bitumen grade 60/70. All the material must be heated 2 hours before starting making the sample. After that, remove in the oven the heated aggregate and place it on a scale for the process of mixing bitumen. Make space in the middle of the aggregate to pour bitumen to prevent bitumen from sticking to the bowl when wanting to mix it into the automatic asphalt mixer. Then pour the bitumen slowly into a bowl that is above the scales and pour it up to 180 g for 3 samples. Pour all the material into the automatic asphalt mixer and start the mixing process until all the material is coated. Add the CS which is 10 g, 20 g and 30 g into the automatic asphalt mixer to mix with all of the materials. After completing the mixing process, pour the pavement mixture into the 3 sample moulds. After that,

compact the pavement mixture using automatic compaction for 70 times and the sample is ready to be tested.

There a four-mix design that we used which is control sample, sample A, sample B and sample C. All the sample had a same weight of bitumen and aggregate but a different quantity of cockle shell. It is because we want to investigate that the quantity of cockle shell will become affected the quality of pavement mixture.

2.2.2 Testing of Samples

Testing of sample is may provide a lot of information about the materials, prototypes, or product samples being tested and is carried out for a variety of reasons. Engineers, designers, production managers, and others may all benefit greatly from the information gathered during testing and the final test findings. Material testing is crucial for a number of reasons, including adhering to regulatory agency standards, choosing the right materials and treatments for a certain application, assessing product design or enhancement criteria, and validating a manufacturing process.

2.2.2.1 Specific Gravity Test

The parties concerned are interested in the specific gravity of both fresh and pavement for a variety of reasons, including its impact on tensile strength, durability, and permeability resistance. Simple dimensional inspections, weighing, and calculation or weight in the case of air/water buoyancy method are used to estimate the specific gravity of the pavement mixture. This test measures the specific gravity of samples of pavement mixture.

2.2.2.2 Voids Test

Using conventional test procedures from relevant codes as ASTM C 29/C29M-17a, IS: 2386 (Part 3) - 1963, or BS 812-2:1995, the bulk density and void percentage of aggregate may be assessed. The space between particles in an aggregate mass that is not occupied by solid minerals is referred to as voids in a unit volume of aggregate. Numerous ways of choosing proportions for concrete mixes can be applied using the bulk density values discovered because of this test. Additionally, the bulk density affects how much space there is between particles in fine, coarse, or mixed aggregates.

2.2.2.3 Stability Test

This test is widely utilised in regular testing programmes for paving projects. Maximum load borne by a compacted specimen at a standard test temperature of 60 °C is used to define the mix's stability. After that, it is inserted into the Marshall stability testing device and subjected to a steady 5 mm per minute rate of deformation till failure. Marshall Stability is the total maximum (kN) that results in specimen failure.

2.2.2.4 Stiffness Test

To ascertain the stiffness distribution in various cross-sections along the blade, stiffness tests are carried out. It is possible to conduct stiffness testing both edgewise and flap wise. The angular deflection at the various cross-sections along the blade may be calculated using the observed deflections. An estimation of the torsional stiffness distribution may be made using the calculated angular deflections and the torsional bending moment.

3. Result and Discussion

The findings report will be covered in the results and discussion in this part. the results of the tests for stiffness, stability, and voids of specific gravity. These tests were carried out to ascertain the combination's strength in terms of density, hardness, voids, and stability rate in comparison to other CS contents. These tests were conducted at the University Tun Hussein Onn Malaysia Pagoh Campus (UTHM).

3.1 Specific Gravity Test

Table 3: Result of Specific Gravity Test on Pavement Mixture

Sample	Specific Gravity (SG)
Control	13.124
A	13.306
B	13.247
C	13.365

Table 3 shows result of specific gravity test on the pavement mixture with different quantity of CS. The highest average specific gravity of pavement mixture with 30 g of CS is 13.365. The average specific gravity of pavement mixture with 20 g of CS is 13.247. The average specific gravity of pavement mixture with 10 g of CS is 2.262 which 13.306 and the lowest specific gravity value is for control sample which is 13.124.

3.2 Voids Test

Table 4: Result of Voids Test on Pavement Mixture

Sample	Voids (%)
Control	65.125
A	69.877
B	68.284
C	71.532

Table 4 shows the result of voids in mineral aggregate. For value of VFB, the highest average value is for pavement mixture with 30 g of CS which is 71.532% and the lowest average value is for pavement mixture without of CS which is 65.125%. Next for pavement mixture with 10 g of CS is 69.877% and 68.284% for pavement mixture with 20 g of CS.

3.3 Stability Test

Table 5: Result of Stability Test on Pavement Mixture

Sample	Stability (kN)
Control	9.80
A	9.49
B	9.14
C	9.10

From the **Table 5**, the result of stability test on pavement mixture were recorded and the highest value is for pavement mixture without of CS which is 9.8 kN and 9.1 kN is the lowest value is for pavement mixture with 30 g of CS. Furthermore, the value for pavement mixture with 10 g of CS is 9.49 kN and 9.14 kN for value of pavement mixture with 20 g of CS.

3.4 Stiffness Test

Table 6: Result of Stiffness Test on Pavement Mixture

Sample	Stiffness (kN/mm)
Control	2.094
A	2.174
B	2.377
C	2.179

From the **Table 6**, the value of stiffness for sample pavement mixture without of CS is 2.094 kN/mm. Next is the value stiffness for pavement mixture 10 g of CS. the average value for this sample is 2.174 kN/mm. Furthermore, for sample pavement mixture with 20 g of CS, the value for this sample is 2.377 kN/mm. Lastly, for sample pavement mixture with 30 g of CS, the value of stiffness is 2.179 kN/mm.

4. Conclusion

The subsequent common findings are based on the laboratory test reported in this paper. The specific conclusions that can be outlined from this study is the optimum density is reached when 10 g of CS is added, which is intriguing since the densification of the hydration product in the cockle shell is associated with high CaO concentration, which might reduce porosity and enhance density. Besides, by adding CS indicated better stability and stiffness records compared to control samples. From this research we can contribute that with adding cockle shell in pavement mixture we can gain an extra stability and strength of the pavement. My proposal is, the government should try innovate this findings to produce a strong and high quality of pavement mixture.

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