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Properties of Porous Blocks Using Different Sizes of Coarse Aggregate for Pavement

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Abstract – *The objective of this research is to look at the potential of using different coarse aggregate sizes in Porous Concrete Paving Blocks (PCPB) mixes as a part of paving surface. Laboratory tests were conducted to examine the effect of particle sizes of coarse aggregate. Two coarse aggregate sizes were selected; passing 8 mm retains 5 mm and passing 10 mm retains 8 mm. Fine aggregate was eliminated from being mixed. Compressive strength, porosity and skid resistance tests were performed to evaluate the properties of PCPB. The test results indicated that there was a reduction in the strength when coarse aggregate at different size was used. Scanning electron microscopy showed that voids, poor bonding and lack of adhesion at the boundaries of the aggregate with cement paste contributing to the low PCPB strength. However, both PCPB specimens provided 30 % to 40 % increase in skid resistance compared to Concrete Paving Blocks (CPB).*

Keywords: Porous, Blocks, Concrete, Morphology

1.0 INTRODUCTION

The growth and development of cities have had an adverse effect on the quantity of surface water. During rainfall, impervious areas such as roadways, driveways and rooftops cause an adverse impact on natural percolation, raising maximum runoff rates and intensifying the effects of flooding. The solution to these problems is by applying porous surface for pavement. It has the potential to reduce the quantity of water runoff.

Porous surface has numerous structural and economic advantages compared to traditional asphalt and concrete pavement. It allows water to soak through and infiltrate, and create a drier surface during storm event, making this surface safer for road users [1,2]. Hassani et al. reported that permeable concrete block pavement is suitable for trafficking, and it also acts as a drainage system [3]. Yang and Jiang reported that porous surface in parking lots is believed to help the infiltration and cleansing of storm water, thus reducing the adverse environment impact of impervious parking area [4].

The purpose of this study is to investigate the potential of using PCPB as a part of paving surface by using different size coarse aggregate in place of Concrete Paving Blocks (CPB).

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2.0 MATERIALS

2.1 Cement

Porous concrete paving blocks (PCPB) mixtures comprised ordinary Portland Cement (OPC) Type 1 ASTM C150 [5], coarse aggregate and water were prepared accordingly. The chemical composition of OPC is in the standard range, with 70 % CaO, 17.8 % SiO2, 3.9 % Al2O3, 3.2 % Fe2O3, 1.5 % MgO and 3.6 % SO3 [6]. The OPC was analyzed chemically using an X-ray fluorescence (XRF) apparatus in accordance with the procedure given in BS EN 197-1: 2011 [7].

2.2 Aggregate

In this investigation, crusher granite was used as the coarse aggregate in the PCPB mixtures. The coarse aggregate was formed into two groups of sizes; passing 8 mm retains 5 mm, and passing 10 mm retains 8 mm sieve (as in Figure 1(a) and Figure 1(b)) to investigate its effect in this study. The specific gravities and water absorption for both coarse aggregate sizes are summarized in Table 1.

Table 1: Specific gravity and water absorption for aggregates used in this study.

Aggregate Size (mm)	Specific Gravity			Water Absorption (%)
	Oven-dried	Saturated Surface-dried	Apparent	
5 - 8	2.549	2.587	2.650	0.61
8 - 10	2.541	2.577	2.635	0.52

Figure 1: (a) 5 to 8 mm size of aggregate, and (b) 8 to 10 mm size of aggregate.

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2.3 Mix Proportions

Two different mixes of PCPB and CPB were casted with different size of coarse aggregate. The mix proportions of cement: fine aggregate: coarse aggregate were 1: 1.02: 1.53 for CPB and 1: 0: 2.54 for PCPB. However, to produce PCPB, fine aggregate such as coarse sand and fine sand was eliminated from the mixes to produce voids inside the specimens. The optimum water-cement (w/c) ratio of 0.35 was used for the concrete mix. PCPB were fabricated in a steel mould with internal dimensions of 200 mm in length, 100 mm in width and 80 mm in thickness. The mixes were poured into the steel mould and compacted using concrete vibrating table for less than 3 s. The specimens were covered with wet jute for 24 h to allow the concrete to harden and also to make sure the hydration process of the concrete was done completely.

2.4 Compressive Strength

After demoulding, the specimens were cured in air at room temperature until the time of the tests. In this study, three specimens from each mix were tested after curing for 7 days and 28 days, and the compressive strength were measured according to the procedure outlined in the BS 6717 – 1: 1993 [8]. The specimens were tested for compressive strength using Universal Testing Machine with a maximum capacity up to 3,000 kN and a loading rate of 3.0 kN/s. The reported compressive strength was the average of the measurements of three specimens.

2.5 Skid Resistance

Skid resistance is the most important characteristic for road pavement. Skidding will happen when the pavement surface does not provide adequate friction for tire. In this study, the test method consisted of using a pendulum type tester with a standard rubber slider to determine the surface frictional properties of the specimens as specified by the BS EN 13036 – 4: 2011 [9]. The skid resistance of each specimen was expressed as the measured British Pendulum Number. Each block in the sample shall permit a test area of 136 mm x 86 mm, which is the representative of the whole specimen. Five swings of the pendulum were made for each test surface of the specimens.

2.6 Scanning Electron Microscopy (SEM)

SEM is one of the most versatile techniques for investigating the microstructure of materials. In this study, fractures were obtained by 28-day compression from fragments of the specimens to characterize the specimen morphology. A JEOL JSM – 6380 LA analytical scanning electron microscope was used to perform this test. Prior to the test, the dry specimens were coated with a thin layer of platinum in a sputter for 1 h. Then, the specimens were horizontally placed on the substrate holder (180^{o}) for surface analysis and vertically (90^{o}) for cross-sectional view. Magnifications of 5, 10, 20 and 50 kV were used to analyze the microstructure of the specimens with 3 and 5 kV operation power.

3.0 RESULTS AND DISCUSSION

3.1 Compressive Strength

The compressive strength of PCPB compared to CPB is illustrated in Fig. 2. From the results, the compressive strength of PCPB with coarse aggregate size 5 to 8 mm was higher compared to the PCPB with 8 to 10 mm size of coarse aggregate at 7 days and 28 days, 29 MPa and 33

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MPa. The difference in the strength of PCPB could be attributed to the increase of the void content inside the block. However, by comparing the compressive strength of PCPB with CPB, the strength of CPB with coarse aggregate 5 to 8 mm gave the highest results at 7 days and 28 days, which were 76 MPa and 85 MPa respectively. This is because the density of CPB is high compared to PCPB. The density of CPB was approximately 2.34 g/cm^3 to 2.40 g/cm^3, meanwhile the density of PCPB was approximately 1.94 g/cm^3 to 2.06 g/cm^3.

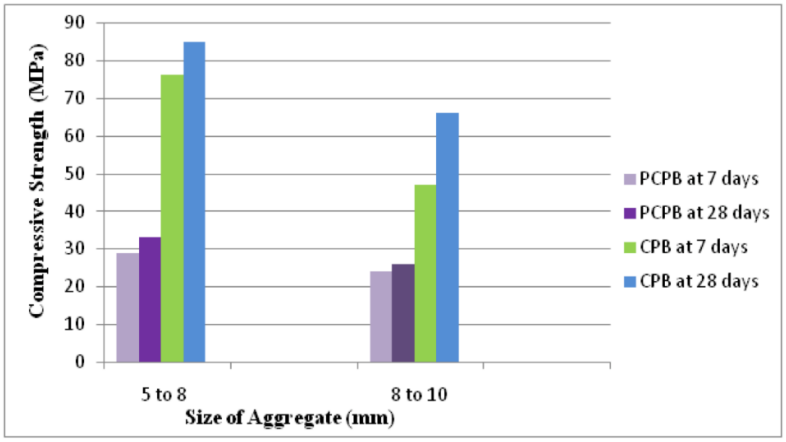

Figure 2: Results of the compressive strength of the specimens.

3.2 Porosity

Figure 3 indicates that the porosity of the PCPB was high when the fine aggregate was eliminated from the mixed. It shows that PCPB with 8 to 10 mm size of coarse aggregate gives a better porosity result compared to others. This is due to the high number of the internal void content inside the blocks. On the other hand, the surface contact between the aggregates inside the blocks with 8 to 10 mm size of coarse aggregate was less compared to the other block, and this is the reason for the higher porosity of the blocks with 8 to 10 mm size of coarse aggregate.

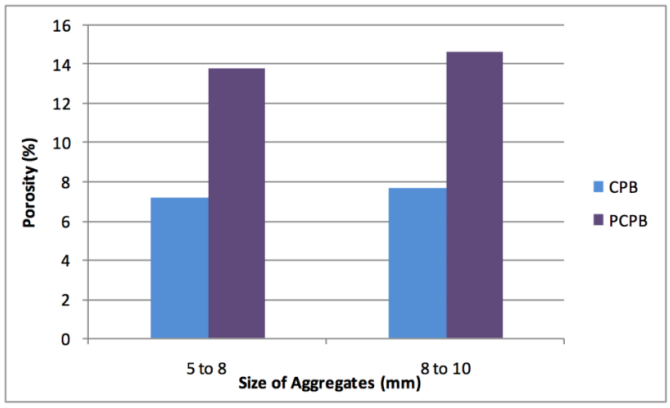

Figure 3: Results of the porosity of the specimens.

3.3 Skid Resistance

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In general, the blocks produced in this study satisfied the BS EN 1338: 2003 requirement that the BPN should be higher than 45 [10]. Figure 4 shows the higher British Pendulum Number (BPN) value of 64 and 66 of PCPB for both sizes of coarse aggregate. It was found that skid resistance was slightly higher and also had low potential for slips compared to CPB [10]. There was approximately 30 % to 40 % increase in skid resistance between PCPB and CPB. This might be contributed by the rough surface texture of the PCPB that creates more friction. Moreover, PCPB with a water permeable surface that allows water to infiltrate from the top to the bottom of block is also one of the factors that cause high skid resistance result.

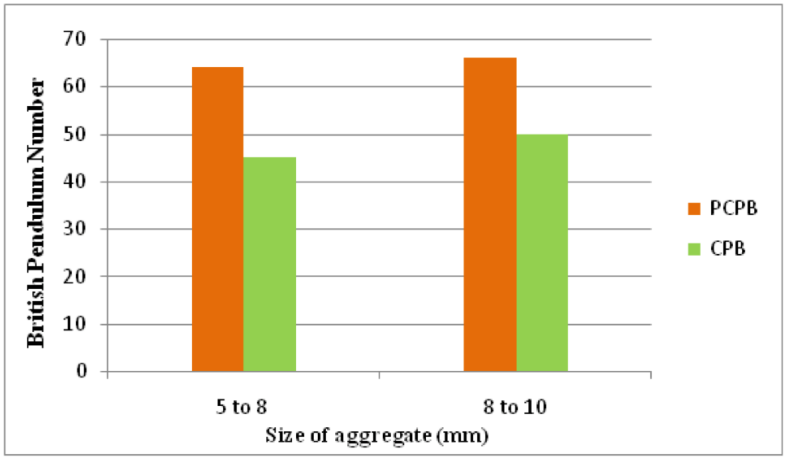

Figure 4: Skid resistance of PCPB and CPB for different aggregate sizes.

3.4 Scanning Electron Microscopy (SEM)

A microscopy study (SEM) was also performed to look for the insight and observe the interface between particles in PCPB. The microscopy analysis showed poor bonding, voids and lack of adhesion at the boundaries of the aggregate with cement paste as in Figure 5. It is an additional factor that contributes to the low PCPB strength.

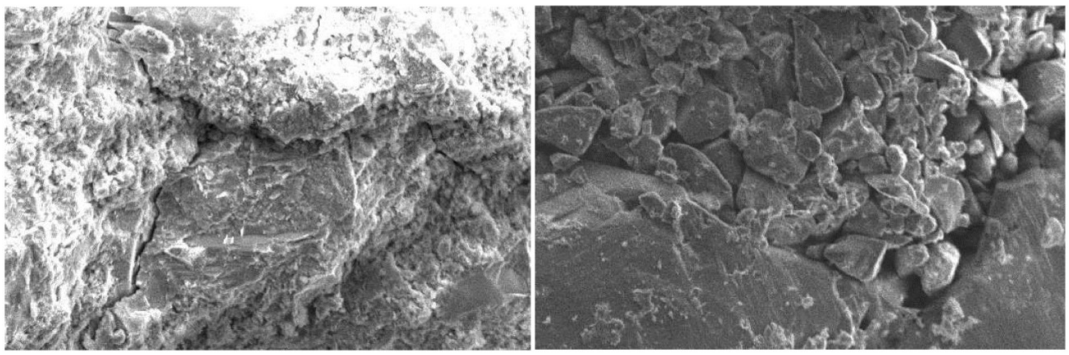

Figure 5: SEM observation of PCPB interface (Magnification= 1000x).

4.0 CONCLUSION

1. By eliminating fine aggregate in mixes, it reduces approximately 60 % of compressive strength and produces porous concrete paving blocks with low strength. It is possible that PCPB contain a high void ratio compared to CPB. However, PCPB satisfy the BS EN requirement, which makes it suitable to be used for low traffic loading pavement.

2. Porosity of the blocks is one of the factors that affect the performance of the blocks. The block with high porosity will have poor strength. However, the blocks with high porosity give more advantage during rainy season where it helps to reduce surface runoff and prevent sliding of t.

3. Poor bonding, voids and lack of adhesion at the boundaries of the aggregate with cement paste is also another factor that contributes to the low PCPB strength. It affects the density and compressive strength of the block.

4. PCPB is found to provide better skid resistance due to the rough surface texture and water permeable surface of the PCPB, which creates more friction and allows water to infiltrate.

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REFERENCES

[1] S. G. Sneha and S. V. Pataskar, Use of porous concrete as a green construction material for pavement, International Journal of Earth Sciences and Engineering (4) (2011) 764-767.

[2] B.K. Ferguson, Porous Pavements Integrative Studies in Water Management and Land Development, United States (2005).

[3] A. Hassani, S. Mohammad and P. Ghoddusi, Runoff infiltration through permeable block pavements, Proceeding of the Institution of Civil Engineering - Transport 163 (2010) 183-190.

[4] J. Yang and G. Jiang, Experimental study on properties of pervious concrete pavement materials, Cement and Concrete Research 33 (2003) 381-386.

[5] American Society for Testing and Materials: Standard Specification for Portland Cement, ASTM C150, United States (2012).

[6] P.J. Ramadhansyah, Properties of Concrete Containing Rice Husk Ash Under Aggressive Environment Subjected To Wetting and Drying, PhD Thesis, Universiti Sains Malaysia, School of Civil Engineering (2012).

[7] BS EN 197 – 1: 2011, Composition, Specifications and Conformity Criteria for Common Cements, British Standard Institution, London (2011).

Journal of Advanced Research in Applied Mechanics
ISSN (online): 2289-7895 | Vol. 1, No.1. Pages 18-24, 2014

[8] BS 6717 – 1: 1993, Specification for Paving Blocks, British Standard Institution, London (1993).

[9] BS EN 13036 – 4: 2011, Method for Measurement of Slip/Skid Resistance of a Surface: The Pendulum Test, British Standard Institution, London (2013).

[10] BS EN 1338: 2003, Concrete Paving Blocks. Requirement and Test Methods, British European Standard. London (2003).