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Use of Waste Tyre Rubber as Aggregate in Double Layer Concrete Paving Blocks

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Abstract – *This study provided the test results on the mechanical properties of double layer concrete paving blocks (DL-CPBs) obtained by replacing portions of the natural aggregate with waste tyre rubber. The mechanical and physical properties discussed in this paper were compressive and flexural strength, and also the density of blocks. Due to the low strength and stiffness of waste tyre rubber particles, the compressive and flexural strength of DL-CPBs containing rubber appeared to be lower than that of conventional concrete paving blocks (CPBs). The reduction was found to be proportional with the waste tyre rubber content. The incorporation of 10% rubber in the CPB produced the highest level of strength compared to 20%, 30%, and 40% rubber. The reduction of strength was due to the lack of proper bonding between waste tyre rubber particles and the cement paste, as well as the reduction of solid load carrying materials. The results indicated that the density of DL-CPBs containing rubber was lower than that of conventional CPBs.*

Keywords: Double Layer, Concrete, Paving Blocks, Waste Tyre

1.0 INTRODUCTION

Over the decades, the disposal of waste rubber tyre has been a critical environmental concern. Tyres are designed to have a very good resistance to weather and waste tyres do not degrade in landfill [1]. Owing to the hardness and elasticity properties of waste tyre rubber, several studies have indicated the potential of using waste tyre rubber in concrete production as sound/crash barriers, retaining structures and pavement structures [2-5].

This study investigated the effects of using waste rubber tyre as an aggregate in the production of concrete paving block (CPB), and the properties of these paving blocks with different percentage of waste tyre rubber content. The properties of a double layer CPB incorporating waste tyre rubber have not been evaluated. Therefore, the results presented in this study would be beneficial for understanding the properties of this type of CPBs, as well as for future applications.

2.0 METHODOLOGY

2.1 Materials

Ordinary Portland cement, coarse and fine aggregate, waste tyre rubber, water and super plasticiser were used in this study. Locally available ordinary Portland cement Type I complying with ASTM C150 [6] was used throughout this investigation. The natural aggregates used include natural river sand as the fine aggregate and crushed granite with nominal size less than 10 mm as the coarse aggregate. Waste tyre rubber (Fig. 1) was obtained from the process of mechanical shredding. Two particle sizes of waste tyre rubber of size 1 – 4 mm and 5 – 8 mm were used as a partial substitute for fine and coarse aggregate in the production of concrete paving blocks. The values of specific gravity of coarse and fine aggregate were 2.50 and 1.65 respectively.

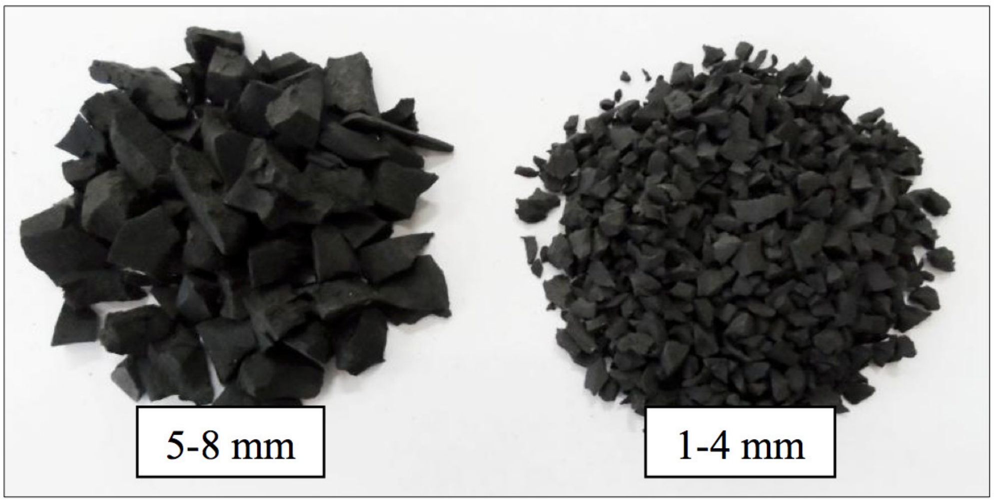

Figure 1: Waste tyre rubber

2.2 Sample Preparation

A laboratory study was conducted to investigate the effects of using waste tyre rubber as an aggregate replacement on the properties of concrete paving blocks. The control mix was prepared using natural aggregate. Waste tyre rubber was used to replace conventional aggregate at the levels of 10%, 20%, 30%, and 40%, by mass of aggregate. Water to cement ratio (w/c) of 0.47 was constantly used in this study. Two series of concrete mixes consist of ordinary Portland cement, coarse and fine aggregate, water, and admixture were prepared. The coarse aggregate replacement using waste tyre rubber of size 5 mm to 8 mm was used in the series I (Layer 1) concrete mix. Series II (Layer 2) concrete mix was mixed using waste tyre rubber of size 1 mm to 4 mm as the fine aggregate replacement. The fresh concrete mixtures were placed in 100 mm × 200 mm × 80 mm mould and cured for 24 h. To prevent evaporation, polystyrene sheets were used to cover the top of the fresh specimen. After 24 h, the sample was demoulded and cured in room temperature for a minimum of 28 days to achieve the strength of 45MPa.

2.3 Mechanical Properties

A range of tests was conducted to determine the density, compressive strength and flexural strength at 7 days and 28 days of the paving blocks specimens. The compressive strength test of all the concrete mixes was performed on 100 mm × 200 mm × 80 mm blocks. The specimens were compressed by a compression machine with the maximum capacity of 3,000 kN with a loading rate of 2.5 kN/s, according to the BS EN 1338:2003 standard [7]. The paving block was soft capped with two pieces of plywood prior to the loading (see Fig. 2(a)). Mechanical resistance of the samples was determined by measuring the ultimate three-point bending strength (flexural test) and the elongation at failure (see Fig. 2(b)), as well as by computing the dry density. Each value represents the average of five samples.

Figure 2: (a) Compression test for CPB specimen, (b) Flexural test for CPB specimen

3.0 RESULTS AND DISCUSSION

3.1 Compressive Strength

The compressive strength of the double layer CPB with the thickness of 20 mm and 60 mm for Layer 1 and Layer 2 respectively is illustrated in Fig. 3.Each value presented is the average of five sample measurements. From the results, the compressive strength of the double layer CPBs reduced significantly with the increase of rubber content. The compressive strengths of 10% and 20% rubberized concrete block on the 28th days were 45.31 MPa and 40.22 MPa respectively, whereas the compressive strengths of concrete block with 30% and 40% rubber tyre granules were 34.06 MPa and 27.75 MPa respectively. The incorporation of 10% rubber in the CPB produced the highest level of strength compared to 20%, 30%, and 40% rubber. The reduction of compression strength is due to the lack of proper bonding between waste tyre rubber particle and the cement paste. Hence, the applied stresses are not uniform and caused cracks at the boundary of cement and waste tyre rubber particles.

3.2 Flexural Strength

Based on Fig. 4, the inclusion of crumb rubber decreased the value of MOR for the CPB. At higher volume of aggregate replaced by waste rubber tyre, the flexural strength was reduced by an average of 21% and 23% for 30% and 40% tyre rubber respectively. All double-layer and control specimens exceeded the flexural strength requirement prescribed by the Concrete Segmental Pavement, T-44 [8] specification of 3 MPa from the early age. The fact that the

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existing CPB has much weaker tension than compression makes the double layer CPBs important and has the potential for use in trafficked pavement application instead of sidewalks.

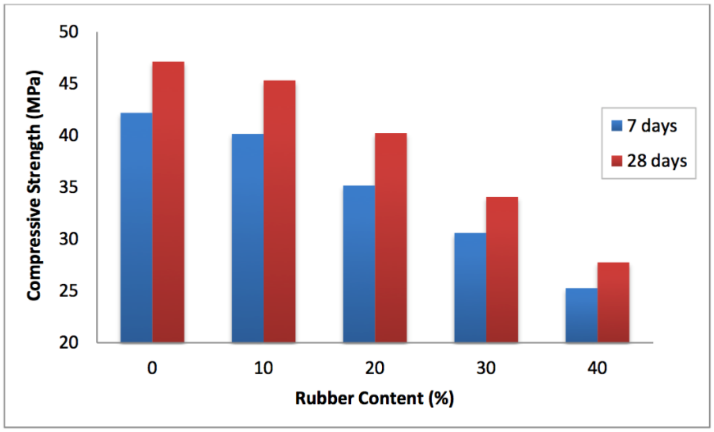

Figure 3: Compressive strength of double layer RCPB

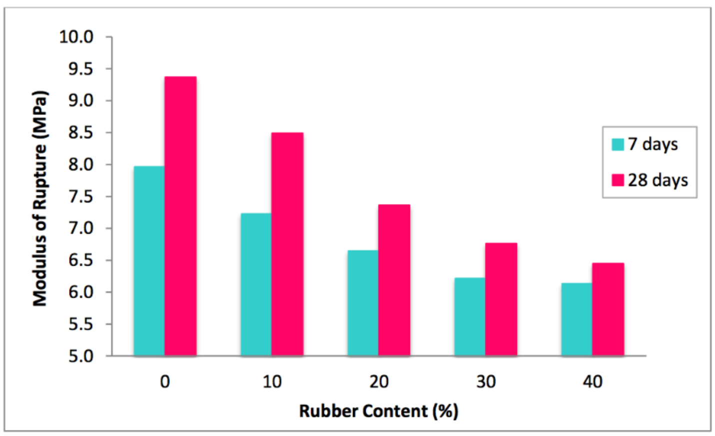

Figure 4: Modulus of rupture for double layer CPB

3.3 Density

The results in Fig. 5 indicated the density of double layer CPB ranged from 2.48 g/cm^3 to 1.88 g/cm^3 depending on the percentage of waste tyre rubbers substituted in the mixture. From the results, it showed that the density of concrete blocks decreased gradually with the increase of rubber content. Low specific gravity of waste tyre rubber contributed to the reduction of concrete blocks density. Furthermore, the density of the mixtures was reduced with the increasing rubber content due to the non-polar surface of rubber particles that tend to entrap air and increase air content.

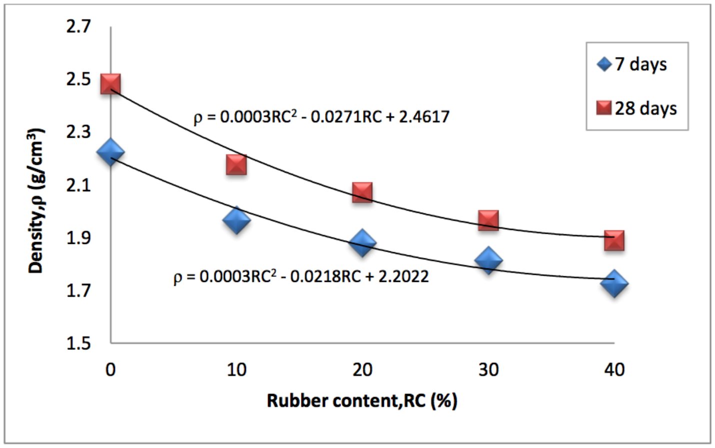

Figure 5: Density of double layer concrete paving blocks.

4.0 SUMMARY

This study presents the results for the effects of waste tyre rubber as a replacement of aggregate on the compressive strength, flexural strength and density of double layer concrete paving blocks. Based on the results obtained from this study, there is a possibility to produce a double layer concrete paving blocks by replacing aggregate with waste tyre rubber with balance between the mechanical properties (compressive and flexural strength) and other properties such as the density. However, the ratio of aggregate replacement should not exceed 20%; otherwise, the strength would become too low.

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REFERENCES

[1] J.D. Martínez, N. Puy, R. Murillo, T. García, M.V. Navarro, A.M. Mastral, Waste tyre pyrolysis – A review, Renewable and Sustainable Energy Reviews 23 (2013) 179–213.

[2] M.M.R. Taha, A.S. El-Dieb, M.A.A. El-wahab, M.E. Abdel-Hameed, Mechanical fracture and microstructural investigations of rubber concrete, Journal of Materials in Civil Engineering 20 (2008) 640–649.

[3] B. Huang, G. Li, S. Pang, J. Eggers, Investigation into waste tire rubber-filled concrete, Journal of Materials in Civil Engineering 16 (2004) 187–194.

[4] M. Sobral, A.J.B. Samagaio, J.M.F. Ferreira, J.A. Labrincha, Mechanical and acoustical characteristics of bound rubber granulate, Journal of Materials Processing Technology 142 (2003) 427–433.

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[5] T.C. Ling, H.M. Nor, S.K. Lim, Using recycled waste tyres in concrete paving blocks, Proceeding of the Institution of Civil Engineers (2010) 37–45.

[6] ASTM C150-12. Standard Specification for Portland Cement. American Society for Testing and Materials.

[7] BS EN 1338:2003. Concrete paving blocks — Requirements and test methods.BS EN British Standards.

[8] CMAA T44:1997. Concrete Segmental Pavements. Concrete Masonry Association of Australia.