PLANT TRIAL PRODUCTION PROCESS AND MONITORING OF CRUMB RUBBER CONCRETE PAVER

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ABSTRACT

In Malaysia, the amount of waste tyres is increasing due to increased number of vehicles. The waste tyres are produced every day, therefore the demand for more effective applications for recycling waste them is intense. This research studies the applicability of recycled waste tyres (crumb rubber) as a substitute for fine aggregate in concrete paver. Before the plant trial production, preliminary laboratory trials were conducted. The results in laboratory trials indicated that it is possible to cast paver containing crumb rubber up to 30 % of total sand volume. To promote a practical use and the acceptance of new material in concrete paver by potential end users, it is necessary to investigate manufacturing processes and feasibility of producing the crumb rubber concrete paver in a commercial plant setting. The produced pavers are assessed so that the performance of the pavers containing crumb rubber can be monitored and compared with those pavers made without crumb rubber.

Keywords: Crumb rubber; Concrete paver; Plant trials

1 INTRODUCTION

The use of concrete paver in Malaysia and developing countries is spreading (Ling *et al*., 2006). This has been reflected in the substantial research into the structural bahaviour of concrete block pavements undertaken within Universiti Teknologi Malaysia during last ten years. However, until recently, this research largely ignored the properties of the pavers themselves. This paper summarized research into properties of crumb rubber concrete paver particular in fresh concrete and finished products from commercial plant.

Laboratory tests have shown that the introduction of waste rubber tyre considerably increase toughness, impact resistance, and plastic deformation of concrete, offering a great potential for it to be used in sound/crash barriers, retaining structures and pavement structures (Ling and Hasanan, 2005; Eldin *et al*., 1993; Khatib and Bayomy, 1999; Goulias and Ali, 1998). No published data were found in the searched literature on the crumb rubber concrete paver produced at commercial plant setting, and therefore, it will be a significant study for future investigation in this area of studies. The studies included detailed critical evaluations during the manufacturing process and the effects of mix formulations.

2 QUALITY ASSURANCE

The quality assurance is defined as “the implementation of a suitable set of pre-establishes and systematic dispositions indented for giving confidence in the obtainment of the required quality”. The implementation comprises measures:

i. for raw materials
ii. during the manufacturing process
iii. for finished products

All the information which is gathered at different stages of the manufacturing processes and noted in registers are compared with the manufacturing instructions in order to detect and correct possible anomalies. With this, new products introduce in this study can be checked and observed during the manufacturing process.

3 PRODUCTION PROCESS

Figure 1 shows the crumb rubber concrete paver making process control flowchart. Approximately 5,000 pieces of concrete pavers using crumb rubber were produced in this study.

3.1 Raw Materials in Concrete Paving Block

The crumb rubber concrete pavers comprised of cement, aggregate, coarse sand, fine sand, crumb rubber, water and additive. The major portion of the mixture was the natural river sand having a maximum particle size of 4 mm. Nominal size of the coarse aggregate was less than 10 mm as received. Crumb rubber is a fine material with the gradation close to that of the coarse sand produced by mechanical shredding. In this study, two particle sizes of crumb rubber were used: 1 – 3 mm and 1 – 5 mm as a partial substitute for sand in the production of face and body layer of concrete paver, respectively.

3.2 Mixing Ratio

Four mixes were prepared using coarse and fine aggregate, cement, water and additive. The difference between the mixes was the percentages replacement of crumb rubber (1 – 5 mm) by sand volume. Cement: aggregate: sand (15 %: 28.3 %: 56.6 %) were used as the control mix. Crumb rubber (1 – 3 mm) was used to replace fine sand in amounts of 0 %, 10 %, 20 % and 30 % by volume for the face mix. Total mixed materials used were approximately 1,500 kg for each batch of 500 paving blocks samples.

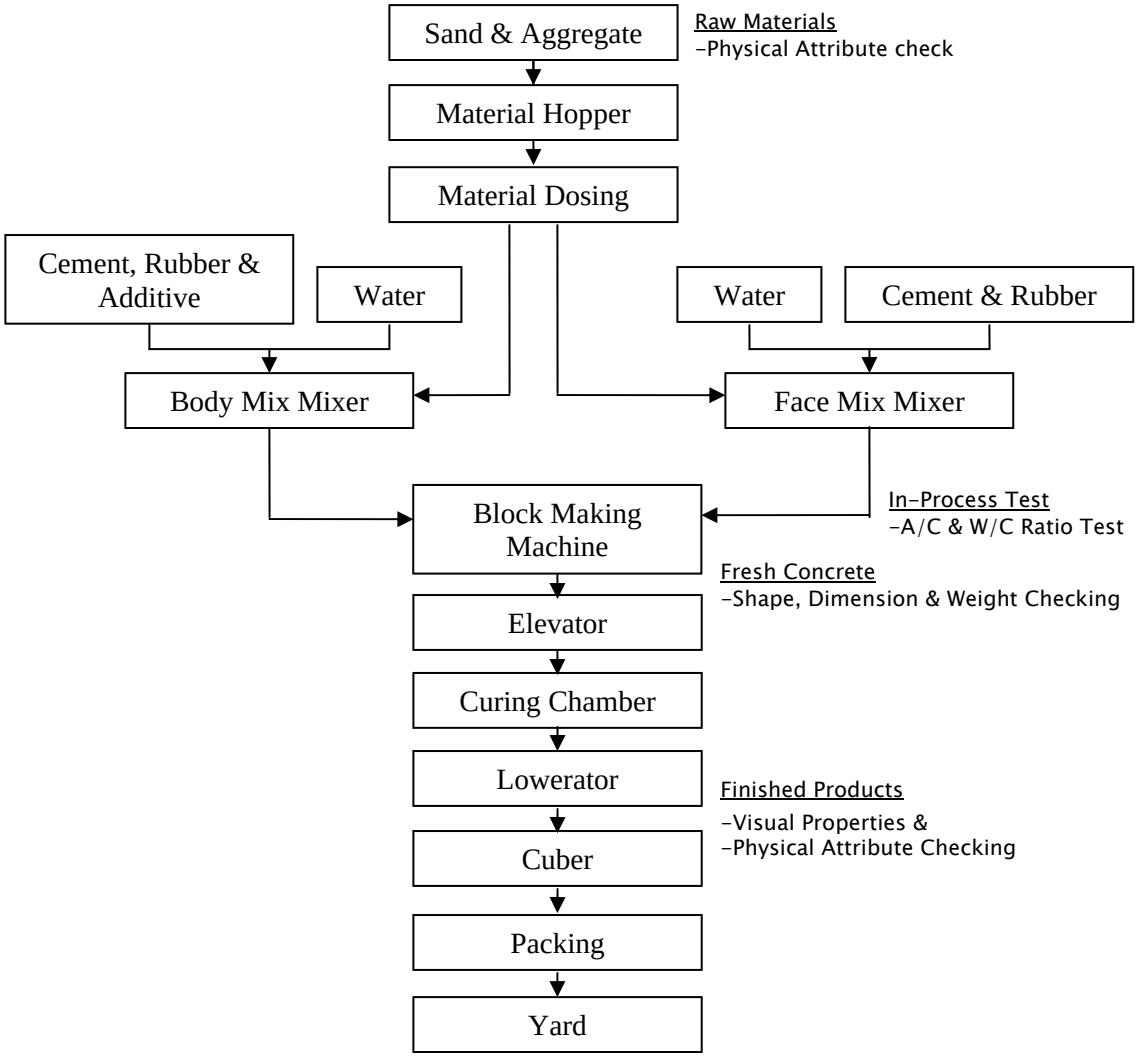

Figure 1: Crumb rubber concrete paver making process control flowchart

3.3 Block Making Process

This method of manufacturing, commonly called semi-dry pressing, was used for CRCP plant trial production. Pan mixers are used and meet the needs well as shown in Figure 2; the blades sweeping the mixer pan clean at the end of each mixing cycle. In this study, two independent mixers were used with appropriate capacity and working in parallel to ensure facing layer being added for appearance. Initially, aggregate, coarse sand, cement and crumb rubber were mixed in body mix mixer for approximately 1 min. After mixing for 1 min, water was added to the materials and mixed for another 1 min. The procedure of mixing and adding water was iterated until the desired moisture content for these dry mixtures was obtained.

Figure 2: Pan mixer

Figure 3: Block making machine

The mixtures were transferred from the pan mixer to a feed hopper. The amount in feed hopper was closely controlled by an automatic weighting system. The hopper discharged the correct amount of concrete into the mould in the block making machine (Figure 3). The pavers were fabricated by block making machine in steel moulds with internal dimensions of 210 mm length, 105 mm width and 60 mm depth. The mould was filled by the body mix and first vibration and pressing were applied. The face mix was poured into the mould for second layer, and then final compaction and vibration were applied for 4 s at 60 Hz speed. The hydraulic ram was released and the head lifted to allow early stripping of concrete pavers from the steel moulds.

3.4 Fresh Concrete Pavers

As the pavers themselves are small, several could be produced at one pressing up to 54 pavers at a time is probably the most common for Quadpave-60. Figure 4 shows the first pallet of mix 1, pavers are checked and monitoring their dimensions by height control device. Any significant change indicated something awry in the parameters setting during production. Figure 5 indicates some of the pavers being rejected as the pallet pass through the height control device.

Figure 4: Paver height control

Figure 5: Some of the rejected pavers

Pavers can also be checked easily by sampling from the pallet as the pavers pass through it, looking for colour variations, both external and internal. Figure 6 shows routine sampling of concrete pavers during manufacture to comply the tests requirement of MA 20. Weight and dimensions of five sampling concrete pavers are check as can been seen in Figure 7. The raw materials are also checked to minimize the risk of unexpected variations in their properties.

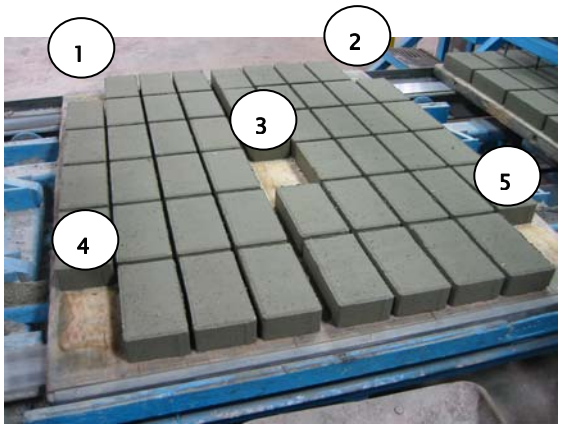

Figure 6: Pavers sampling


Figure 7: Dimensions measurement

A typical pattern of cracks is shown in Figure 8. It is possible that the cracks developed not only because of short pressing time but also because of the development of shear planes, as a result of an excess of high modulus elasticity crumb rubber. At present, because the mechanics of crumb rubber concrete paver have not been fully researched, considerable reliance has to be placed on experience to select an optimum pressing time and rubber content for each particular product.


Figure 8: Cracks on paver surface

3.5 Curing of Concrete Pavers

Rapid hydration of cement in chambers for at least 18 hours is economically desirable and to permit out door storage as soon as possible. Early strength gain also reduces the need to stockpile for long periods, prior to site delivery. Figure 9 shows pallets of

concrete pavers being removed from the roller-conveyors mounted on the outlet side of the press, and on to a lowerator.

Figure 9: A paver lowerator

3.6 Finished Products and Packaging

The pallets of concrete pavers were removed from the lowerator but the individual pavers are still separated from each other by the thickness of the mould walls. Meanwhile the visual properties and physical attribute of finished products are checked as can be seen in the Figure 10. Figure 11 shows the rejected finished products which did not meet the MA 20 requirement.

Figure 10: Finished pavers checking

Figure 11: Rejected pavers

Figure 12 shows the start of the building up of a cube of concrete pavers. Clamps were lowered over a layer and the pavers pinched together, after which the layer was picked up, turned through 90° and then placed back on the pallet. Again the layer is clamped together then picked up, layers pavers being transferred to sit one on top of the next, until a cube up to 14 layers and weighing 2.0 tonnes has been formed. This was then strapped together with a plastic as shown in Figure 13. This helps continuation of the

curing process and at this stage the products were stored in an open yard and the concrete pavers continue to gain strength.

Figure 12: Making a 'cube' of pavers

Figure 13: Packed concrete pavers

4 ANALYSIS

4.1 Properties of Fresh Concrete Paver

Table 1 shows the properties of fresh concrete pavers. Because of low specific gravity of rubber particles, weight of pavers decreases with the increase in the percentage of rubber content. Moreover, increase in rubber content increases the air content, which in turn reduces the unit weight of the mixtures. The decrease in weight of rubber is negligible when rubber content is 10 % of the total aggregate volume.

As the results of the visual inspection of two-layer paver, no honeycombs, cracks or outstanding deformation were found on concrete pavers in mix 1 and 2. On the other hand, at the higher rubber content in concrete pavers, cracks may appear on the facing layer and delamination between the layers.

Table 1: Properties of fresh concrete pavers

Mix notation	Rubber Content (%)	Depth (mm)	Top Surface (mm)	Weight (kg)	Visual Observations
Mix 1	0	59.6	5.5	2.82	Very good, no cracking
Mix 2	10	59.8	5	2.82	Good
Mix 3	20	59.2	5	2.74	Some cracking
Mix 4	30	59.8	3.3	2.68	Some cracking, delamination

4.2 Surface Colour

Figure 14 shows the surface colours of the concrete pavers in the mixes with crumb rubber replacement ratios of 20 % and 30 % were slightly darker than that with the crumb rubber substitution ratios of 0 % and 10 %. This slight coloration would not cause significant problem when used as the base layer of concrete pavers.

Figure 14: Four mixes specimens

CONCLUSIONS

The test results showed that the replacement of sand by crumb rubber particles at the levels of 10 % had little effect on the dimensions and visual appearance, but higher levels of replacement at 20 % and 30 % increase the colour darkness and width and length of the pavers.

There were no complications when applying the preliminary laboratory test to plant trials production of crumb rubber concrete pavers. This application of crumb rubber to concrete pavers may show future success and cloud be used as a viable method for by-product disposal. The use of residues is also beneficial to environment, as it can greatly reduce the accumulation of discarded waste tyre which is not easily biodegradable even after a long period of landfill treatment.

REFERENCE

Eldin, N. N. and Senouci, A.B. (1993). Rubber-Tire Practices as Concrete Aggregate. *J Mater Civil Engng*. 5(4), 478–96.

Goulias, D.G. and Ali, A.H. (1998). Evaluation of Rubber-Filled Concrete and Correlation between Destructive and Nondestructive Testing Results. *Cem Concr Aggreg*. 20(1),140–4.

Khatib, Z. K. and Bayomy, F. M. (1999). Rubberized Portland Cement Concrete. *ASCE Journal of Material in Civil Engineering*. 11(3), 206-213.

Ling, T. C, Hasanan, M. N. and Mudiyono, R. (2006). The The Effect of Cement and Water Cement Ratio on Concrete Paving Block. *1st Regional Postgraduate Conference on Engineering and Science*. 26-27th July 2006

Ling, T. C and Hasanan, M. N. (2006). Granulated Waste Tyres in Concrete Paving Block. *The 6th Asia Pacific Structural Engineering and Construction Conference*. 05-06th September 2006.

MA (1996). Specification for Concrete Segmental Paving Units. *Concrete Masonry Association of Australia.*