REFLECTIVE PAVERS AND KERBS

Lazar, M. and Emery, J.

Acme Paving Consultants Pte. Ltd.
APC/John Emery JV Ltd., 9 Rowallan Drive, Putnoe
MK41 8AW, United Kingdom.Tel/Fax: 44 (0)1234 350310.
E-mail: john@johnemery.co.uk

ABSTRACT

Concrete block paving is now frequently used for surfacing roads, footpaths and other applications having directional and informational markings made using specialist paints or thermoplastic materials.

Kerb units, forming the delineation between footpaths and roadways are highlighted using a similar process. Materials used for this purpose tend not to be durable, are expensive to maintain and lack luminosity.

This paper reports on the development of reflective pavers and kerb units that offer an alternative cost-effective and durable form of marking. The coloured reflective surface, which is an integral part of the manufactured units, is, apart from occasional cleaning, maintenance-free.

The aim of these products is to promote safety of motorists and pedestrians by providing clearly visible markings at all times and in all weather conditions. Independent testing and performance surveys confirm the effectiveness these products.

Appropriate areas where reflective pavers and kerbs would be effective are identified.

Because of the versatility and aesthetic appeal of concrete block paving, Highway Authorities are increasingly using this form of surfacing for roads, footpaths and many other applications. Where directional and informational markings are needed, it is usual to make these with specialist paints or thermoplastic materials. Similarly, kerb units that form the delineation between footpaths and roadways also need to be painted to highlight the interface between them. The paints used for this purpose tend not to be durable, are expensive to maintain and lack luminosity at night and in severe weather conditions.

The development of reflective pavers and kerbs now provides a cost effective solution to these problems. The coloured reflective surface, which is an integral part of the manufactured units, is long lasting and, apart from occasional cleaning, maintenance-free. The primary function of these products is to promote safety for motorists and pedestrians alike by providing clearly visible markings at all times and in all weather conditions. Appropriate areas for use of reflective pavers and kerbs are at accident 'black spots' on roads, footpaths, pedestrian crossings, car parks, roundabouts, traffic humps and other devices incorporated into traffic calming schemes.

The modular nature of concrete block paving lends itself to the provision of directional and informational markings when needed.

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A comprehensive range of markings has been developed using reflective pavers, which may be integrated into standard block paved surfaces for use at airports, ports, highways and car parks.

A comprehensive programme of independent testing of the reflective units and performance surveys conducted by Government bodies are reported in this paper. Appropriate areas where reflective pavers and kerbs would be effective are identified.

1. INTRODUCTION

Because of the versatility and popular appeal of concrete block paving, many Authorities are increasingly using this form of surfacing for roads and footpaths and other applications. Where directional and informational markings are necessary, it is usual to make these either by using pigmented pavers or applying specialist paints or thermoplastic materials. Kerb units that form the delineation between footpaths and roadways are similarly treated to highlight the interface between them. Pigmented pavers tend to fade with time and lack reflectivity. Materials normally used for markings tend not to be durable, are expensive to maintain and lack luminosity at night and in severe weather conditions.

The recent development of an innovative process using a cement-based formulation enables pavers and kerbs to be provided with a durable and cost effective reflective surface. As this surfacing is an integral part of the units, its visual impact will effectively remain for the lifetime of the units produced in this way. The aim of these products is to promote the safety of motorists and pedestrians alike by providing clearly visible markings at all times and in all weather conditions and to avoid the expense of frequent repainting of markings.

The National Science and Technology Board of Singapore and the Economic Development Board of Singapore, having identified problems with existing road markings and kerbing systems, have supported the research and development of the process. Comprehensive programmes of independent testing as well as performance surveys conducted by Government bodies have been made and are reported in section 4 of this paper.

Appropriate areas for use of reflective pavers and kerbs are on roads, footpaths, pedestrian crossings, car parks, traffic humps and other devices incorporated into traffic-calming schemes and at identified accident ‘black spots’.

2. REFLECTIVE PAVERS

Standard pigmented pavers are often used to provide contrast for markings on block-paved surfaces. However, they tend to lack visual impact and soon fade.



Figure 1. Deterioration of markings

Alternatively, pavers may be painted using specialist paints or thermoplastic materials. These deteriorate rapidly and become visually inefficient due to their poor luminosity (see Figure 1).

To overcome these problems a comprehensive range of directional and informational designs has been developed using reflective pavers. Figures 2 and 3 show examples indicating how they may be integrated into standard block paved surfaces for roads, footpaths and car parks etc. The notable feature of the reflective pavers is the enhancement of the visibility of markings in daylight, at night and in adverse weather conditions. The coloured reflective surface, being an integral part of the manufactured units, is as permanent as the paver units are and, apart from occasional cleaning, maintenance-free.



Figure 2. Directional sign formed using reflective pavers



Figure 3. Pedestrian crossing made with reflective pavers

One particular safety application is on 'road humps' constructed as part of a wider traffic calming scheme. These are quite often barely visible, particularly where street lighting is poor or even non-existent. Figure 4 shows the visual effectiveness of using reflective pavers in this situation.



Figure 4. 'Road hump' constructed with reflective pavers

Reflective pavers are manufactured using standard block-making machines having a face-mix or composite layer facility. The reflective face-mix has a thickness range of 5 to 8 mm in compliance with BS6717:2001. A cement-based reflective-mix is fed into a mixer and thoroughly mixed for 2 minutes, then discharged into the hopper of a block making plant. The production process thereafter is similar to that for normal composite pavers.

Should an enhanced luminance factor be required for the pavers, glass beads are added to the reflective mix. This is achieved by attaching a bead dispenser to the feeder box, which dispenses the beads to 28 automatically controlled nozzles to apply them evenly. A spraying device is attached in-between the ram head to apply an additive when beads are used. If the bead dispenser is not use then the spraying device is not activated. The reflective mix has sufficient glass beads and other

additives to provide an average luminance factor of 60. Skid resistance of the reflective pavers comply with current BS requirements.

Independent testing has confirmed compliance of reflective pavers with BS 6717 standards and the results of these tests are reported in Section 4 below.

A trial made on pavements owned by the Port of Singapore Authority (PSA) compared existing thermoplastic markings with reflective pavers. Under similar trafficking conditions, the thermoplastic markings had disappeared within a month whereas the reflective pavers continue to perform satisfactorily after seven years in use.

During this trial, luminance-factor index (LFI) measurements were made on the thermoplastic markings and the reflective pavers. The thermoplastic markings exhibited an initial high LFI (above 70), but dropped to below 40 within two weeks due to rapid abrasion of glass beads within the matrix. By comparison, the reflective pavers indicated an average LFI of 45 shortly after installation but after three years, it had increased to 55. The reason for this increase is that as trafficking abrasion occurs it exposes glass beads in the face-mix of the pavers. The low initial LFI is the result of the coating of glass beads with cement paste etc. during production.

Following this long-term trial, it is now possible to give a five-year warranty for the performance of reflective pavers. The PSA have affirmed the successful performance of the reflective pavers over a period of 5 years in the form of a certificate of approval and this is reproduced in Appendix 1. They have also estimated that they have saved approximately S$ 200,000.00 over 5 years by not having to repaint the markings on 113 of their ‘chassis’ lanes. Conventional markings in the same area at the port were repainted 4 times a year. After the installation of reflective pavers, no repainting or cleaning has been necessary and these pavers have now exceeded their warranty period by 2 years and are still in good condition.

The newly developed tongue and groove pavers, reported at this conference and elsewhere, Lazar & Emery (2002), may also be manufactured using this process.

3. REFLECTIVE KERBS

The function of kerbs, including channels quadrants, angles etc. is to separate surfaces at the same or at different levels to provide a physical and visual delineation or containment. They also provide a separation between surfaces subjected to different kinds of traffic. To improve visual contrast between different surfaces, for example between footpaths and roadways, kerb units may be painted. However, these painted kerbs are not clearly visible to the motorist during wet conditions, especially at night, and require frequent maintenance.

A new development is the reflective directional kerb. These units are manufactured with an integrated surface reflective-mix similar to that described above for reflective pavers. The units provide an economic and more effective alternative to painted kerbs and, apart from occasional cleaning, are maintenance-free.

Curves are easily accommodated using Directional Kerbs (see Figure 5) and may be used exclusively or in combination with other directional units. Radii in excess of 2 metres are achieved using standard units and special units are available for radii less than 2 metres down to a minimum of 500 mm. Figure 6 shows a road project at night where Directional Kerbs are also used as a guide for the direction of traffic flow. This reflective concept can be used to manufacture other types of kerb units if required.



Figure 5. Curve formed using Directional Kerbs

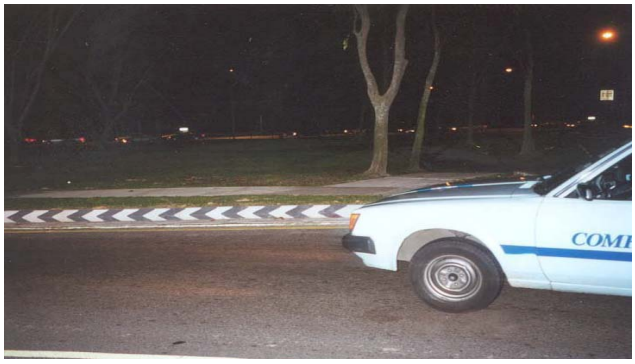

Figure 6. Night view of directional kerbs

Directional kerbs not only eliminate the need for mortar between units but also eliminate the need for splitting to construct a required radius. They may also be used in conjunction with a wide range of existing kerbs. Figure 7 shows a close-up view of reflective and black directional kerb units.



Figure 7. Close-up view of Directional Kerbs with end and starter units

Features of the reflective Directional Kerbs units may be summarised as follows:

- High strength units with long-lasting integral reflective properties
- Consistency in dimensional tolerances
- Cement mortar between kerb units unnecessary
- Consistency in colour
- Good visibility at night and in adverse weather conditions
- Re-painting unnecessary
- Practically maintenance free
- Reduces the need for directional signs
- Available in different colours

Directional reflective units will provide enhanced safety at crossroads, T- Junctions, slip roads, bus bays, road curves, road bends and other accident ‘black spots’.

4. LABORATORY TESTING AND ON SITE PERFORMANCE SURVEYS

To establish the quality and performance of reflective pavers and kerb units tests were made by an independent accredited testing laboratory, namely Setsco Services Pte Ltd of Singapore. A summary of the tests made and results appears in Section 4.1 below.

Engineers from the Port of Singapore Authority (PSA) and the Land Transport Authority (LTA) of Singapore have assessed the performance of reflective units and have made comparisons with traditional methods used for marking. The results of their findings are reported below in Section 4.2.

Various papers have been presented on the performance of reflective pavers and kerbs giving independent support for the claims made for these reflective units. See Kwang (2002), Ngee (2000), Romarao (2002), and Wei (2002).

The Government Agencies mentioned in this paper have awarded certificates of merit for innovativeness in recognition of the benefits of both the reflective pavers and reflective kerb units. Some of these listed in Appendix 1.

4.1 Laboratory testing

1. Accelerating weathering : ASTM G53 : 93
   Exposure Hours : 5000
   Grey Scale No. 4/5 (very mild discolouration)
   NB : Grey Scale 1 denotes severe discolouration
   Grey Scale 5 denotes mild or no discolouration

2. Water absorption: SS 214 : 79 (Equivalent to BS)
   Overall average of 5 samples = 2.4%

3. Luminance factor: BS 6044 : 1987 (Appendix C)
   Exposure hours : 5000
   Luminance factor before weathering = 45.0% (Average of 3 samples)
   Luminance factor after weathering =50.7% (Average of 3 samples)

4 Compressive strength : BS 6717 : Part 1 : 1993
   Average compressive strength of 16 samples : 61.4 N/mm2

4.2 On site performance surveys

A long-term assessment of reflective kerbs made by the LTA of Singapore reported that painted kerbs showed that within a two-year period, painted kerbs had to be repainted twice to maintain their clarity. Directional reflective kerbs, however, remained clearly visible after the two years construction period.

In a survey by 18 LTA Engineers to assess the visibility of reflective units during heavy rain, 17 of the Engineers reported that the reflective directional kerbs were clearly visible during rain. However, all 18 Engineers reported that headlights from cars created a dazzling effect tending to make the saturated painted kerbs less visible.

A similar survey conducted by PSA of port handling equipment drivers, port users and crane operators. 60 personnel were consulted of whom 58 responded.

The 58 personnel that responded reported that the reflective pavers were highly visible even in wet condition whereas the painted markings, especially on concrete surfaces, were not visible at all due to dazzle from headlights during wet conditions.

5. CONCLUSIONS

The authors consider that the use of reflective pavers and kerb units can contribute significantly to road safety by virtue of their high luminosity, day and night and in poor weather conditions. Current research has indicated that 'speed kills' and it is for this reason that there has been a proliferation of traffic calming measures throughout the world. It is axiomatic, therefore, that surfacing and kerbing materials used as part of traffic calming measures should have good visibility properties.

The independent surveys conducted by the PSA and the LTA corroborate the authors' contention that reflective pavers and kerbs are more effective and economical than the paints and thermoplastic material currently in use.

There may be other applications where reflective pavers may be used. Whilst not necessarily contributing to safety they can, nonetheless, enhance the aesthetic appeal of block paving in general.

Further research work is in progress to analyse accident statistics to quantify the benefits of the developments reported in this paper

6. REFERENCES

Kwang W (2002) "Feasibility Study of use of precast base with reflective directional kerbs" - Proceedings 2nd Seminar on concrete block paving – Singapore.

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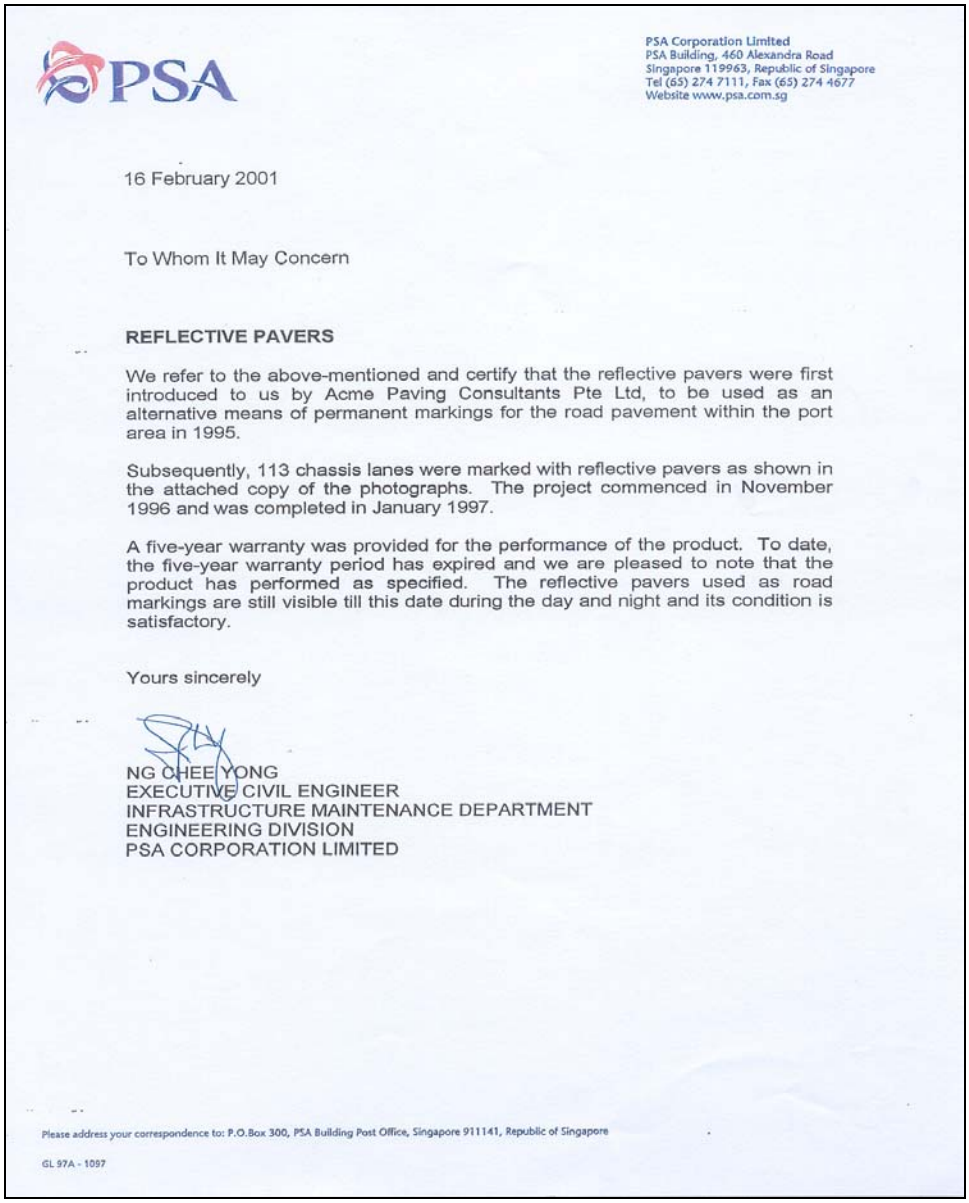
Ngee L (2000) "Concrete block paving – PSA's experience" – Proceedings 1st Seminar on Concrete block paving – Seminar.

Ramarao G (2002) "Review of project – Jalan Dan Wangi Bus transit mall with reflective paver markings" – Proceedings 2nd Seminar on concrete block paving – Singapore.

Wei J, et al (2002) "Concrete Interlocking pavers, Singapore's experience – Reflective pavers for permanent road markings" Proceedings 2nd Seminar on concrete block paving – Singapore.

APPENDIX 1

Certificate of approval from the Port of Singapore Authority



PSA

PSA Corporation Limited
PSA Building, 460 Alexandra Road
Singapore 119963, Republic of Singapore
Tel (65) 274 7111, Fax (65) 274 4677
Website www.psa.com.sg

16 February 2001

To Whom It May Concern

REFLECTIVE PAVERS

We refer to the above-mentioned and certify that the reflective pavers were first introduced to us by Acme Paving Consultants Pte Ltd, to be used as an alternative means of permanent markings for the road pavement within the port area in 1995.

Subsequently, 113 chassis lanes were marked with reflective pavers as shown in the attached copy of the photographs. The project commenced in November 1996 and was completed in January 1997.

A five-year warranty was provided for the performance of the product. To date, the five-year warranty period has expired and we are pleased to note that the product has performed as specified. The reflective pavers used as road markings are still visible till this date during the day and night and its condition is satisfactory.

Yours sincerely

NG CHEE YONG
EXECUTIVE CIVIL ENGINEER
INFRASTRUCTURE MAINTENANCE DEPARTMENT
ENGINEERING DIVISION
PSA CORPORATION LIMITED

Please address your correspondence to: P.O.Box 300, PSA Building Post Office, Singapore 911141, Republic of Singapore

GL 97A - 1097

Certificates of merit awarded for reflective paver and kerbs

1. Champion Award – Land Transport Authority, Singapore – Work improvement Teams - 2002.

2. Gold Award – National Quality Circle Convention, Singapore Productivity Board - 2002.

3. NOVA (Innovation Award), Public Service Convention (21st Century) - 2002

4. Outstanding Performance Award. International Exposition of Innovation & Quality Circles, Singapore - 2002

5. Gold award – National Quality Circle, Productivity Standard Board, Singapore - 2000

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APC/John Emery JV Ltd., 9 Rowallan Drive, Putnoe
MK41 8AW, United Kingdom.Tel/Fax: 44 (0)1234 350310.
E-mail: john@johnemery.co.uk

CURRICULUM VITAE
John Emery

"John Emery is currently Managing Director of John Emery Consultants (U.K) and the external consultant for Acme Paving Consultants Pte Ltd (Singapore).

Following 6 years with consulting engineers, Scott Wilson Kirkpatrick & Partners, working on the design of roads and airports projects in Nigeria, Belize and in the Caribbean, he spent 18 years with Luton Borough Council mostly working at Luton International Airport. It was here that he introduced and developed the use of concrete block paving on aircraft pavements.

He has written and presented many papers at International Conferences and workshops in Columbia, Israel, Italy, Netherlands, New Zealand, Norway, Singapore, Turkey and USA. In 1996, he co-authored, with Prof. John Knapton, a report on the use of pavers on aircraft pavements commissioned by the UK Civil Aviation Authority.

He formally retired after giving his 'final' paper at the Conference in Colombia in 1998 but has since been recycled and rejuvenated to appear at Sun City to present another 'Final' paper."