

PERMANENT REFLECTIVE MARKINGS FOR PAVEMENT SURFACES

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Note: The following is the notation used in this paper: (.) for decimals and () for thousands.

Summary

A pioneering method of forming permanent reflective markings, which had been specifically developed for concrete block paving units and kerbs, can also be used as an in-situ application on concrete and asphalt pavement surfaces. This paper reports on further developments that have been made over the last few years and examples are given of its application. The reflective mix is economical in use, has long-term luminosity and is environmentally acceptable. When applied during the manufacture of concrete block paving units it provides an integral permanent surfacing which resists heavy trafficking.

On most pavement surfaces, markings are often made using specialist plastic paints or thermoplastic materials. These products are generally not durable, deteriorate rapidly, are expensive, require frequent maintenance and become visually ineffectual due to their poor luminosity. The reflective material described in this paper requires minimal maintenance, is easily applied, will provide long-lasting clearly visible markings at night and in all weather conditions. This reflective mix has been extensively tested and found to satisfy all current specification requirements.

The reflective mix is cement-based and having binding properties that permits a tenacious adhesion to concrete and asphalt surfaces. It includes glass beads and other additives to provide an average luminance factor of 60. The durability of the reflective-mix markings has exceeded, on average, four times that of thermoplastic markings under heavy trafficking and has demonstrated superior slip/skid resistance.

1. INTRODUCTION

A pioneering method of forming permanent markings, which had originally been developed for precast concrete block products such as concrete block paving and kerb units, can also be used on other concrete and asphalt surfaces. This paper reports on further developments made since the authors' previous paper on this subject – Lazar and Emery (2002) and examples are given of applications of the reflective mix which is economical in use, has long-term luminosity and is environmentally acceptable.

For concrete block paving and kerb units the reflective surface is applied during the manufacturing process using face-mix equipment and using environmentally acceptable materials. It provides an integral, permanent surfacing with long-term luminosity and resists heavy-duty trafficking.

On many other pavement surfaces markings are often made using specialist plastic paints or thermoplastic materials. These products are generally not durable, deteriorate rapidly, are expensive, require frequent maintenance and become visually ineffectual due to their poor luminosity. The reflective material mentioned above has been empirically tested over a period of 9 years by which means it has been possible to reformulate it to enable the product to be applied to existing concrete and asphalt pavement surfaces. These markings are easily applied, require minimal maintenance and will provide long-lasting clearly visible markings at night and in all weather conditions and will also resist heavy trafficking. This reflective mix has been extensively tested and found to exceed the BS/EN requirements for adhesion and slip/skid resistance. Because of this extensive empirical approach it is now possible to provide a five year warranty for the reflective mix and examples of projects where the reflective material is in use are given.

The reflective mix is cement-based and having binding properties that permit a tenacious adhesion to concrete and asphalt surfaces. It includes glass beads and other additives to provide an average luminance factor of 60. Skid resistance of the reflective markings is superior to that of thermoplastic and paint markings.

2. PAVEMENT SURFACE MARKINGS

Pigmented standard pavers are often used to provide contrast for markings on block-paved surfaces. However, these tend to lack visual impact and eventually fade. Alternatively, pavers may be painted using specialist paints or thermoplastic materials. These deteriorate rapidly and become visually inefficient due to their poor luminosity as shown in Figure 1.

Frequently, road markings on asphalt surfaced roads are made with these paints and thermoplastic products and Figure 2 gives an example of the fading that has occurred after short-term use.



Figure 1: Faded markings on block paving



Figure 2: Faded markings on asphalt road

To overcome these problems a comprehensive range of directional and informational designs has been developed using reflective pavers. Examples of these, recently installed at Ripon City in, California, USA, are given in Figures 3 to 6 – all of which were formed with reflective units.



Figure 3: Reflective directional signs



Figure 4: Informational signs



Figure 5. Median markers



Figure 6. Road junction.

A notable feature of the reflective pavers is the enhancement of visibility of markings in daylight, at night and in adverse weather conditions (see Figure 7 and 8 which show 'Disabled Person' parking bays at night). The reflective surface, being an integral part of the manufactured units, is as permanent as the paver units themselves and apart from occasional cleaning is maintenance-free.



Figures 7 and 8. Disabled parking bays formed with reflective units.

Such reflective pavers can also be used at airports to form centreline and edge markings on taxiways and lead-in markings for apron areas where surfaced with concrete block paving units.

It is now possible to use the reflective mix to form in-situ markings for a wide range of applications including heavy duty areas such as at airports. Figure 9 shows in-situ apron stand markings at Singapore International Airport. These have now been in use for seven years.

Further heavy duty conditions prevail at Ports and Figure 10 shows application of the reflective markings at the Port of Singapore using conventional line marking equipment.



Figure 9. Apron 'Stop bars' formed using reflective material.



Figure 10. Reflective mix application.

3. PERFORMANCE TRIALS OF REFLECTIVE PRODUCTS

As part of the long-term empirical testing of these reflective materials, trials were made on pavements owned by the Port of Singapore Authority (PSA) to compare existing thermoplastic markings with reflective paver units. Under similar traffic conditions, the thermoplastic markings had disappeared within a month whereas the reflective pavers had continued 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 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 traffic 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.

The PSA have affirmed the successful performance of the reflective pavers over a period of five years in the form of a certificate of approval. They have also estimated that they have saved approximately US\$ 114,000.00 over five 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 four 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 two years and are still in good condition. Day and night views of this Chassis Lane are shown in Figures 11 and 12.

As the reflective surfacing is an integral part of the units, its visual luminosity impact will effectively remain for the lifetime of the units produced in this way. The aim of these products on roads 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. There are other reflective paver systems in use having a surface-applied epoxy material. Unfortunately, they become contaminated with traffic dust and de-icing salts and require

cleaning to maintain their reflective properties. Additionally, the coating used is unable to withstand trafficking. Conversely, the Luminance Factor (LF) of the reflective pavers described in this paper increases with age (typically having an LF of 45% at manufacture eventually increasing to and maintaining a LF of approximately 60%) and are able to withstand heavy industrial trafficking.



Figure 11. Day View.



Figure 12. Night View.

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.

Engineers from the (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.

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).

Appropriate areas for the 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'.

4. CONCLUSIONS

Following a nine year period of sustained empirical testing the authors consider that the use of reflective pavers and kerbs will contribute significantly to promoting road safety. Current research has indicated that 'speed kills' and it is for this reason that there are now many traffic calming measures throughout the world. It is essential therefore that surfacing and kerbing materials used as part of traffic calming measures should be permanently highly visual in all lighting and weather conditions.

Reflective pavers installed 5 to 9 years ago have shown no deterioration. The reflective mix, whether used as an integral surfacing on concrete block paving or applied in-situ on concrete or asphalt surfaces has a tenacious adhesion, is cost-effective and requires little or no maintenance.

A major advantage of the reflective units and reflective markings is that their Luminance Factor Index (LFI) tends to increase with age, unlike thermoplastic road markings which may have a significant drop in LFI after just three months trafficking.

5. REFERENCES

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6. ACKNOWLEDGEMENTS

Kevin Werner, City Engineer and James Pease, Engineer Tech. – City of Ripon, California, USA.