CBP SEALING
STRUCTURAL AND ENVIRONMENTAL BENEFITS

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ABSTRACT

Whilst sealing block paving is neither new nor innovative the benefits thereof are fast becoming an integral part of the design and specification of small element paving systems. Emery, accredited with the introduction, formulation and subsequent application of urethane pre-polymers, was quick to foresee the additional benefits of sealing over and above its original use for aircraft pavements. The benefits now widely accepted are:

(1) Stabilises jointing sand thus eliminating sand erosion.
(2) Inhibits water/fuel ingress.
(3) Inhibits growth of weeds/grasses.
(4) Avoids staining of paver surface.
(5) Enhances appearance of pavers.
(6) Reduces maintenance.
(7) Prevents efflorescence.
(8) Reduces cost of paving system.
(9) Simple to apply.
(10) Reduces whole life cost.

1. INTRODUCTION

Over the past decade specialist pre-polymer urethanes (SPPU's) have been utilised in many different environments; both at civil airports (Heathrow/Sapporo) and military airfields (RAF Benson/NATO Ankara), transhipment terminals such as Mina Raysut Port,Oman, Disneyland Paris and McDonald's restaurants in the UK and Central Europe. Whilst all of these environments required the introduction of a sealer in the first instance to stabilise the jointing sand, other benefit needs have been identified.

In the case of both Heathrow and Sapporo, sand erosion by jet thrust and rotor-down wash was needed to be prevented as well as eliminating the infiltration of hydrocarbons. At Mina Raysut Port, Oman (465,000m^2), the key issues were firstly sand erosion from seasonal tidal flows and more importantly the prevention of the infiltration of rainwater during monsoon conditions. The design engineers (Han Padron of New York, U.S.A.) believed the specification of an SPPU was critical to ensure the avoidance of bedding sand liquefaction and degradation, which could potentially result in pavement failure.

McDonald's and Disneyland's requirements took a different path. In the case of Disneyland, like McDonald's, the prevention of staining from foodstuffs and general detritus was paramount. For Disney however it was equally important to prevent sand erosion from aggressive vacuum street sweepers in constant use over pavers since the moment they were installed. McDonald's major concern as well as sand erosion from high-pressure jet washing of forecourts and drive-thru's (being carried out on a daily basis), was to enhance the aesthetics of the paving system, achieved by utilising an SPPU with a higher solids content.

The partial stabilising of the joints between block paving may, be achieved by relying on the accumulation of dust and detritus. However the above mentioned environments, by their very nature prevent this from taking place. It was concluded that concrete block paving trafficked by vehicles may reverse any natural sealing action owing to the sucking/pumping action of tyres [1].

Upon polymerisation the SPPU will retain its elastomeric properties enhancing interlock [2].

1.1 Types of Sealers Available

A range of water and solvent based polymer sealers is now available for use with concrete block paving for improving the appearance and performance of pavers. As block paving is categorised as a flexible surface, it is critical that the sealer to be used should also be flexible. Four types of sealer are in general use and may be characterised as follows:

1.1.1 Water Based Emulsions

Water based polymers are emulsions having very small particles dispersed in water. These rely on penetration of solids in suspension into the surface of pavers and into the jointing sand. Additionally, they rely on the evaporation of the water to permit sand particles to bind to each other and to the concrete block sides. Whilst they will form a film on the surface of pavers, only a weak bonding is achieved within the jointing sand due to the solids being filtered out. They tend to be slow curing at low temperatures and high humidity, have poor water resistance, retain dirt and may whiten when wet.

1.1.2 Solvent Based Acrylic

These will in the short term enhance the colour of pavers, provide a degree of stain resistance and generally create a glossy finish to the surface, providing an aesthetic appeal for some individuals and an unnatural look for others. The main disadvantages of this type of sealer is that, in general, they do not have good elastomeric properties. Furthermore they will become softened when exposed to hydrocarbons.

1.1.3 Moisture Cure Urethane

The most effective sealer/stabiliser having good long term proven performance has been found to be a low viscosity urethane pre-polymer, carried in a hydrocarbon solvent, whose curing is catalysed by moisture in the substrate and in the atmosphere. This type of polymeric sealer is highly elastomeric, having an elongation at break in excess of 400%. SPPU's owe their hardness, tensile strength and elastomeric properties to their ability to bring together polyether polyols both linear and branched having medium to high molecular weights. The final polymer has an amount of cross-linkage present such that it provides excellent resistance to solvents, (inc. fuels and de-icing materials). It effectively seals and stabilises jointing sand and imparts a natural, non-glossy finish to the surface of concrete blocks with a single coat application. Some manufacturers provide such sealers with a high solids content and are thereby able to offer a written guarantee against staining from engine oil.

1.1.4 Hydrated Polymer Glues

This method of stabilising jointing sand is achieved by using a single sized jointing sand combined with a hydrated polymer glue as the binder. When wetted, following the placing of sand in the joints, the 'glue' is activated and weakly binds the sand particles together in a partially flexible state.

2. SEALING OF PAVERS

The concept of interlock and the importance of jointing sand cannot be overstated. Work carried out by Knapton and Algin [3], provides a mathematical approach to understanding and interpreting the concept of interlock and demonstrates the importance of maintaining sand between the joints throughout the life of the pavement in relation to its ability to transmit shear stresses between neighbouring pavers. They confirm this may be achieved by treating the jointing sand with an SPPU.

Fast-track construction constraints dictate more often than not that it will be heavily trafficked (pedestrian or vehicular) immediately the system is opened and it is for this reason that the authors of this paper contend that the sealing of CBP will eradicate the problems discussed below:

2.1 Sand Erosion

As described above, any pavement system is dependent on interlock and in turn, jointing sand retention. Erosion of jointing sand takes many forms:

(1) The modern pedestrianised environment dictates that such an area must be maintained and cleaned on a daily basis, this being achieved by the use of aggressive vacuum/vortex sweepers commonly having a suction of air velocity of 60m/s. Areas such as Town centres and shopping malls are usually opened to traffic upon completion and therefore liable to immediate sand extraction by vacuum

sweepers. These problems may be exacerbated under canopies and internal malls. Sealing with an SPPU 24 hours prior to opening will ensure retention of the jointing sand. Some cleaning regimes are so stringent they dictate that certain public areas must be swept/cleaned as much as six times a day (Environmental Protection Act 1991, England & Wales).

(2) Turbulent high velocity water flows created in and around gullies, in drainage channels and more commonly on inclines have significantly greater sand erosion at the bottom of the gradient or water outlet. The action of this water flow can remove the jointing sand and lead to unstable conditions in the laying course. This form of erosion has been investigated [4].

(3) Flooding and tidal waters can have a destructive effect. Both Promenades at Paphos in Cyprus, and Egremont in the UK suffered extensive damage due to high tides and storms. In both cases pavers themselves were simply washed away. At Egremont following repairs the promenade was treated with an SPPU. Thereafter, despite being subjected to storm and tidal waters of approximately 1m depth, there has been no subsequent damage.

(4) Jet and pressure washing are commonplace as a quick and effective way of cleaning the paver surface, adversely the action of the washer will lead to sand removal from the joints. Trials held by the London Borough of Camden on the 7th February 2000 with the use of SPPU's in stabilising pavers involved practical test under the supervision of their Chief Engineer D. Gonsal MRI. C.Eng.,MICE whereby a concentrated jet of water at a pressure of 1500 psi was repeatedly directed at the joints over a test area of $10m^2$. It was found that the SPPU (after polymerisation) had bound the sand to the sides of the pavers to the degree whereby it remained fully intact and unaffected.

(5) Aviation facilities both military and civil suffer from extreme sand erosion via jet thrust and rotor-down wash. It has been reported by J Emery [5] that, in excess of 1cm of jointing sand can be removed by this action. Jet engine exhausts can create velocities of approximately 300m/s. In extreme cases such erosion can create a severe risk of Foreign Object Damage (FOD).

2.2 Ingress of Water

The infiltration of water through block paving is inevitable, as 5% of the paver surface is made up of joints. Investigative work carried out by the co-author [6] concluded that:

(1) Ingress of water through block paving can have a detrimental effect upon the structural performance of the pavement.

(2) Under an adverse combination of water, unsuitable bedding sand material and traffic, concrete block paving can develop significant levels of rutting after a few thousand standard axles.

(3) The application of an SPPU to fully granular concrete block pavement can result in significant improvement in pavement performance.

Laboratory research [7] whereby a simulated rainfall of approximately 45mm per hour on newly laid block paving, indicated that up to 65% of the rainfall penetrated the joints of the pavement. On block paving sealed with an acrylic-based sealer the level of infiltration, he concluded, was reduced by up to 50%.

This demonstrates that sealing will diminish ingress of water and will afford a significant degree of protection to subgrades.

Manufacturers of SPPU's will argue that acrylic based sealers are substantially inferior to a pre-polymer urethane with all of its various and multifunctional capabilities which are both technically and practically superior to acrylics.

2.3 Infiltration of Fuels

It has long been recognised that both environmental and explosion hazards can occur when hydrocarbons percolate through sand filled joints and into subgrades and may accumulate in the laying course sand. Where pavements are not sealed, this can lead to the build up of Lower Explosive Levels (LEL's) [8]. It is therefore imperative that in such environments as service stations and Bulk Fuel Storage facilities that the surface is sealed to prevent such infiltration. It is understood that in Switzerland for example, block paving has been banned from use in service station forecourts

The use of SPPU's in the United Kingdom have been independently tested by Kent County Council Highways and Transportation, Engineering Services Laboratory (NAMAS accredited) with regard to fuel infiltration, in particular:
(1) Unleaded petrol, BSEN228:1993
(2) Aviation fuel (AVGAS)
(3) Diesel oil, BSEN590:1993
In conclusion it was found that the SPPU satisfied maximum specified infiltration levels referred to in "Report No. BAE-WWT-EN-GEN 0013" British Aerospace PLC (1991)

2.4 Aesthetics

Whilst the modern concrete paver is recognised in the first instance commercially for its strength and durability its use in the domestic and prestige (Hotels/Golf Clubs) environment has become more prevalent, therefore the question of aesthetics has come to the fore.

Usually superficial efflorescence or lime bloom commonly disappears in the longer term by natural weathering. For the domestic user however aesthetics are of primary concern and therefore the appearance of efflorescence is unsightly and requires an immediate remedy. There are a number of remedial treatments, Professor Bensted expressed the opinion that the transport of dissolved salts would be halted by introducing an SPPU to the surface of the pavers [9] thereby cutting off the water flow to the surface.

McDonald's restaurants' continued use of high-solids SPPU's throughout the UK and Central Europe underlines the significance they attach to the ability these products have in reducing food/oil staining.

2.5 Pavement Installation and Whole Life Costs

In a recent paper the co-author [10] demonstrates that a range of pavements could have been installed with lower quality bedding material thereby reducing the overall cost of the paving system. The application of an SPPU will it is suggested, ensure the pavements' stability.

When taking into account the whole life cost of a paving system in terms of maintenance budgets; these amounts can be significantly reduced to such a level whereby the cost of the pavement system is effectively reduced.

3. CONCLUSION

The use of SPPU's world-wide thus far has been to resolve perceived specific issues that have arisen following installation of a pavement surfaced with pavers. It is the authors' contention that sealing a paver pavement has much more far reaching benefits than has previously been considered. These are chiefly those environmental factors which are commonly associated with pavements surfaced with pavers. Because pavers are used to surface a wider range of end use pavements than are many other pavement surfacing materials, there is a commensurate increase in environmental factors which can affect paver pavement adversely. Many now consider paver joints to be the weak link in the system. Many who have investigated paver failures have concluded that jointing defects have been the underlying cause of the failure. The use of high deformation polymer based stabilisers/sealers significantly enhances the strength, durability and fluid resistance of joints and thereby enhances the performance of the entire pavement. For many categories of pavements, the use of SPPU's is the cost-effective way to significantly enhance many important properties of paver pavements.
Because these materials have now been in service for over 12 years, they should be considered to be a normal part of paver specification for many categories of pavement. Experience to date has been favourable with no examples of failure associated with stabilisers. Specifiers of the following categories of pavements should include SPPU's in their pavements:

(1) Pavements which are to be subjected to vacuum sweeping.
(2) Aircraft pavements.
(3) Heavy duty pavements.
(4) Pavements which incorporate areas subject to high velocity water flows.
(5) Heavily channelised pavements.
(6) Pavements subjected to unusual environmental effects.
(7) Pavements on severe grades.
(8) Pavements over moisture susceptible materials.
(9) Pavements used by animals.
(10) Pavements serving areas where food is consumed.

Whilst stabilisers will be beneficial in other categories, it is the above where cost savings are likely to be even greater.

REFERENCES

1. Smith, D.R. and Hade, J.D. (1988) Permeability of Concrete Block Pavements, International Conference on Concrete Block Paving Pavitalia Rome, pp.217-223.
2. Emery, J. and Lazar, M. (1996) Block Paving To Seal or Not to Seal?, Proceedings of the 5th International Conference on Concrete Block Paving, Tel Aviv, Israel, pp.605-611.
3. Knapton, J. and Align, M. (1996) Stresses in Bedding Sands Resulting from Rolling Loads, Proceedings of the 5th International Conference on Concrete Block Paving, Israel.
4. Ishai, I. et al (1988) November The Resistance of Steep Concrete Block Pavements to High Velocity Water Flow Technician Israel Institute of Technology, Haifa.
5. Emery, J. (1988) An Evaluation of the Performance of Concrete Blocks on Aircraft Pavements at Luton Airport, Proceedings of the 3rd International Conference on Concrete Block Paving, Rome.
6. Knapton, J. (1992) An Investigation into the Effects of Water Penetrating the Surface of Block Paving, Journal Institute of Highways & Transportation, August, pp.25-28.
7. Shackel, B. (1984) Laboratory Measurement of Water Infiltration Through Concrete Block Pavements, Proceedings of the 2nd International Workshop on Concrete Block Paving, Delft, pp.127-133.
8. Emery, J. (1995) Infiltration of Fuels and Water Through Paver Joints, Journal of the Institute of Highway & Transportation, October, Vol.42 No.10, pp.25-28.
9. Bensted, J. Efflorescence - Prevention is Better than Cure. Concrete 34, 2000 (in press). Visiting Professor in the Department of Crystallogy, Birbeck College, University of London.
10. Knapton, J. The use of Resiblock in Discrete Element Paving Systems, unpublished.