PAVING FABRICS FOR ROAD REHABILITATION, ASIA EXPERIENCE

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ABSTRACT

The use of paving fabric for road rehabilitation works shall extend the life of the overlay asphalt concrete pavement. The paving fabric when saturated with bitumen shall acts as a stress absorption membrane, sealing and bonding between the new overlay and old pavement. The paving fabric shall consists of a continuous filament nonwoven needle punched geotextile which is commonly used for road rehabilitation. Another type of paving fabric which is also made of the same product but reinforced with glass fibre for reinforcement. This reinforced glass paving fabric is used for airport runway, taxiway, expressway rehabilitation works which are subjected to high traffic intensity. Laboratory trial has shown that the use of paving fabric delays cracks propagation from the old pavement reflecting up to the new overlay. It can extend the life of the new overlay by more than 2 times compared to overlays method without paving fabrics. A few Asia case histories, the installation procedure, bitumen selection, spray rate for the successful application of the paving fabric are highlighted in this paper.

Keywords: Paving fabric, bitumen, road rehabilitation

INTRODUCTION

The use of paving fabrics for road rehabilitation works is becoming increasingly more common as engineers become familiar with their concept and the benefits of these materials become more apparent. Paving fabrics prevent cracks from old pavements reflecting up into new asphalt overlays, by acting as a stress absorption, bonding and sealing interlayer between the old and new pavement layers.

Experience has shown in order for these functions to be fully exploited, the geotextile paving fabric must have optimum physical and mechanical properties. The paving fabric geotextiles must also be properly installed with a good combination of tack coat, spray quantity and curing time for it to work effectively as a stress absorbing membrane interface. Correctly installed, paving fabrics extend the life of new overlays by a minimum factor of 2, resulting in a significant reduction in pavement maintenance costs.

THE PAVING FABRIC CONCEPT

The paving fabric system comprises three components; the paving fabric, a bitumen binder, and the installation process. The usual process is for a bitumen binder to be sprayed over the old cracked road surface. The paving fabric is then laid over and adheres to the bitumen binder. Asphalt is then laid over the paving fabric and rolled in the normal way. The asphalting process draws the bitumen binder up into, and saturates the paving fabric creating bitumen rich stress absorption and waterproofing layer between the old pavement and new overlay. Traffic stress and temperature differentials in the pavement are uniformly absorbed and transmitted down through the pavement and base, delaying the onset of reflective cracking and extending the life of the asphalt pavement.

Fig. 1 Spraying of bitumen.

Fig. 2 Laying paving fabrics.

Fig. 3 Overlaying with asphalt.

The performance of the system varies according to the road condition, climatic conditions and traffic stress and is influenced by the compatibility of the paving fabric and bitumen, and the quality of their installation. For example, a high quality paving fabric with poor quality bitumen, badly installed, will not perform as well as a high quality paving fabric and good quality bitumen, correctly installed.

REQUIRED PAVING FABRIC PROPERTIES AND FUNCTION

Paving Fabric Properties

The fundamental purpose of the paving fabric as an individual component in the system is to contain a defined amount of bitumen. Over thirty years of experience shows that the optimum amount of bitumen required within the fabric is 1.0 kg/m^2 -1.1 kg/m^2. Less than this quantity reduces adhesion between the old pavement and new overlay and increases the risk of delamination of layers. More than this amount results in "bleeding" and increased risk of rutting of the overlay under heavy traffic.

Therefore the most important property of a paving fabric is its capability to absorb and hold between 1.0 kg/m^2 and 1.1 kg/m^2 of residual bitumen. Spunbonded nonwoven type paving fabrics achieve this property without complication. Additionally because they are manufactured from continuous or endless filaments, they exhibit good tensile strength, which is necessary to resist tensile tearing during the asphalting process when the tracks of the paving machine exert great stress directly onto the fabric (Fig. 4). Staple (short) fibre geotextile type fabrics are not as suitable for paving applications as they have poor tensile strength and are generally thicker and require substantially more bitumen to saturate. Their use is therefore in total more costly and they are easily torn by the tracks of the paver machines.

The paving fabric properties used for road and airport rehabilitation works in Asia are given in Table 1.

Table 1 Properties of paving fabric geotextile

Properties	Test method	Unit	PGM14	PGM-G 50/50
1. Tensile strength	ISO 10319/ ISO3341	kN/m	9	50/50
2. Grab tensile strength	ASTM D 4632	kN	520	-
3. Grab elongation	ASTM D 4632	%	>50%	-
4. Elongation at break	ISO3341	%	-	3%
5. Strength at 2% strain		kN/m		34/34
6. Mesh width of the glass filament	-	mm	-	40x40
7. Mass per unit area	EN965	g/m^2	140	300
8. Variation of coefficient		%	<10	-
9. Asphalt retention	ASTM D 6140	l/m^2	1.1	1.1
10. Melting point	ASTM D 276	°C	165	165
11. Recycling	100 % Recyclable with conventional methods			

Fig. 4 Polyfelt PGM-G50/50 – nonwoven polypropylene geotextile reinforced with glass fibre.

Paving Fabric Functions

Sealing function

The main function of the bitumen – impregnated paving fabric is as a barrier to prevent the penetration of surface water and oxygen into the road pavement structure. If the sealing effect is not permanent, the penetration of oxygen will results in ageing of the surface course and subsequent cracking due to brittleness. The infiltration of moisture will weaken the shear strength of the base layer and in time, under traffic loading will lead to rutting and loss of bonding (Fig. 5).

Comprehensive laboratory tests carried out by Resource International Laboratories, Ohio USA, have quantified the sealing properties of bitumen impregnated paving fabrics. In the tests, the highest possible maximum hydrostatic pressure corresponding to that of both passenger cars and trucks over cracked road filled with water was applied. In the test the effects of moisture penetration corresponding to a pressure of 276 kPa, equivalent to a car and 517 kPa equivalent to a truck was measured. The results showed a significant reduction in forced moisture and oxygen penetration of the asphalt is achieved when bitumen impregnated paving fabric are used (Fig. 6).

Bonding

Additionally, tests to measure the effects of paving fabrics on the adhesive qualities of bitumen saturated paving fabrics between new and old asphalt layers have been undertaken. This property is critically important when the road to be treated is heavily trafficked and the old road surface is badly cracked, and in instances where paving fabrics are laid in airport taxiways and runways. To effectively transmit load stress down through the road surface layers into the base course the shear resistance at the interface between the old and new overlay must be high enough to prevent shear yielding through stress caused by braking or turning manoeuvres. To measure this adhesion tests cored samples were carried out on a Polyfelt paving fabric extracted from an airport runway project in the Philippines (Fig. 7). The results showed that paving fabrics induced high and more uniform bond strength than is achieved with conventional (no fabric interfaced) overlays (Table 2). Correspondingly it is this superior, uniform bonding of layers which improves the effective transfer of traffic stress down through the whole road structure, contributing to extended pavement life.

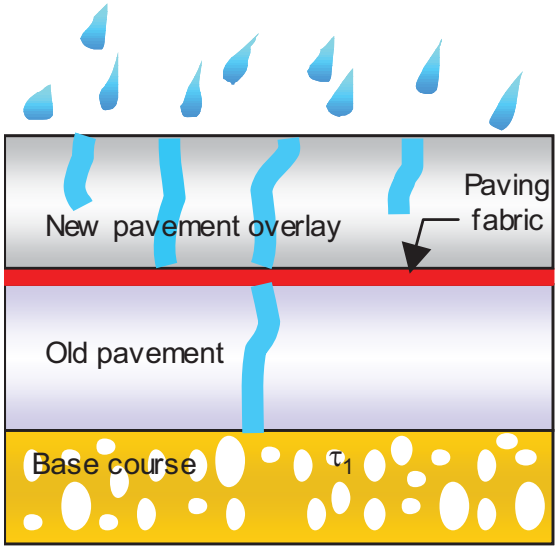

Fig. 5 Waterproof barrier between old pavement and new overlay.

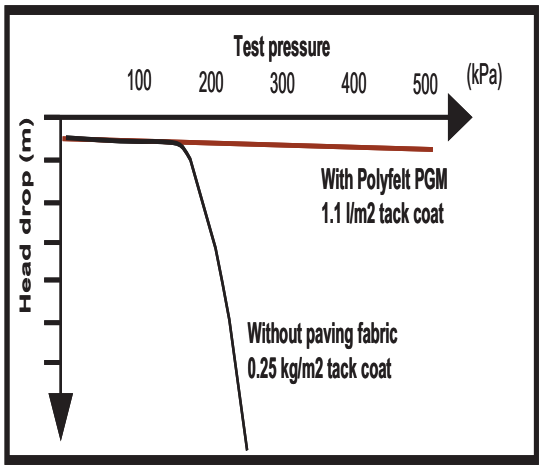

Fig. 6 Sealing benefits of paving fabric.

Table 2 Adhesion test of road section with and without paving fabric.

Properties	Unit	Without paving fabric	With paving fabric
1. Mean value of adhesive strength	kPa	109.2	117.95
2. Standard deviation of adhesive strength	kPa	29.31	12.71
3. Variation of adhesive strength	%	26.84	10.78

Fig. 7 Adhesion tests show paving fabrics improve bonding between layers.

Reflective cracking

Reflective cracking in a new overlay constructed on an old pavement can be reduced and decelerated by the application of a paving fabric. The bitumen – impregnated and compressible paving fabric act as a stress absorbing membrane interlayer (SAMI) at the bottom of the new overlay. The purpose of this SAMI is to reduce the tensile stress in the new pavement in the vicinity of the tip of the crack in the old pavement and hence to absorb "stress" and prevent reflective cracking.

Published results of tests conducted at Alun Regional Road Laboratory, France to evaluate the stress absorbing effect of paving fabric showed that bitumen impregnated paving fabric has an essential effect on the crack propagation and retard reflective cracking to a substantial extend. The series of tests evaluated and compared the results of various systems. From the test results, not only is the start of the crack delayed in the system using paving fabric, the life span is increased by 100% with a bitumen impregnated paving fabric compared with 60 mm asphalt concrete without any paving fabric (Fig. 9).

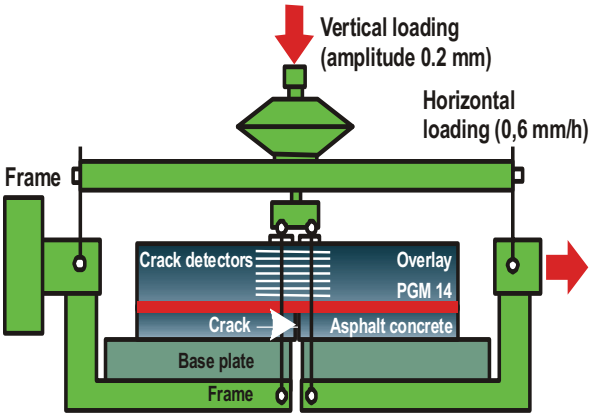

Fig. 8 Schematic drawing of the test device.

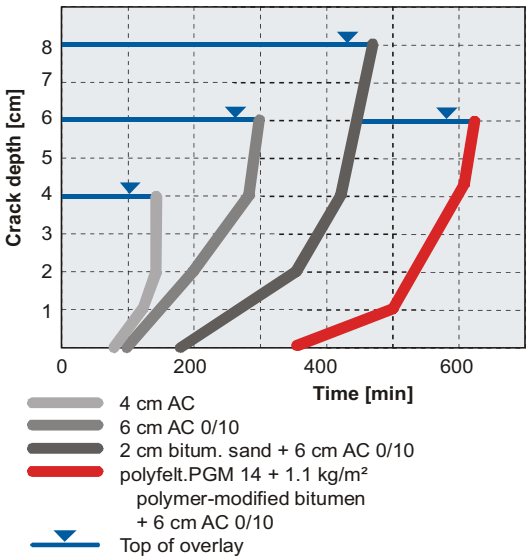

Fig. 9 Crack propagation in asphalt concrete.

CHOICE OF BITUMEN

The choice of bitumen and its rate of spraying directly affect the performance of the paving fabric system. Two types of bitumen are commonly used; pure bitumen, and emulsions. Both are suitable, provided they are correctly sprayed, and their properties checked.

Pure bitumen binders sprayed hot, have been proven to work well over a wide range of road substrate and variable climatic conditions. However, it is common practice in Asia to spray hot bitumen using small hand spray units. The weakness of this method, compared to spraying using calibrated tanker truck spray units is that the rate of spraying is dependent on the skills of the person doing the spraying and it is not possible to obtain a uniform 1.0 kg/m2 – 1.1 kg/m2 spread of bitumen over the whole road surface. Tanker spray units, which provide a more reliable and uniform spray, should be the preferred means of dispensing bitumen for paving fabrics.

Bitumen emulsions are also commonly used. The main weakness of this type of binder is that to ensure a 1.0 kg/m2 – 1.1 kg/m2 residual bitumen is applied evenly across the road and a spray rate of 1.6 kg/m2 -1.7 kg/m2 of emulsion is required depending on the proportion of water to bitumen in the emulsion. Given that most roads and airport runway have a cross-fall and an alignment gradient, in practice large volumes of emulsion runs off to the side of the road or collects in low spots. The other weakness of this type of bitumen binder is that the emulsion is required to be completely broken, and all water evaporated before the paving fabric can be laid. Depending on the weather conditions this process can take time and delays in the laying and asphalting process is often affected. Emulsions therefore should only be used on flat road surfaces in hot dry weather conditions.

Practical experience, supported by extensive laboratory research shows that modified bitumen incorporating elastomer additives perform substantially better than standard pure bitumen's. Polymer modified bitumen's are better able to absorb the extremes of heat and cold, and improve the adhesion between the old and new overlays.

The effects of Polyfelt paving fabrics saturated by different types of bitumen on crack reflection time were researched by the Alun Regional Road Laboratory, France. The results shown in Figure (8) show that the crack propagated time of paving fabrics saturated by polymer modified bitumen is approximately double that of overlays without paving fabrics.

POLYPROPYLENE vs. POLYESTER PAVING FABRICS

Suppliers of paving fabrics using polyester fibres commonly misleadingly claim that polypropylene paving fabrics are damaged by heat. The fact is that the vast majority of paving fabrics installed worldwide are polypropylene based and quite easily withstand the heat effects of hot asphalt laid directly over the fabric. The reality is that the temperature of asphalt in contact with the paving fabric as delivered to site has a temperature substantially less than the melting point of polypropylene. To clarify this issue the University of Liege, France which is world renowned for asphalt research and testing conducted extensive tests and trials. Their finding was that the temperature at the asphalt/paving fabric interface consistently never exceeds 100 ^{o} C even when the asphalt concrete overlay was laid at 160^{o}C. This range of temperature is not critical for paving fabric made of polypropylene polymer as the melting of polypropylene is about 165^{o}C (Fig. 10).

What is not explained is that polyester as a polymer cannot be recycled. Recycling of old milled asphalt surfacing into new asphalt will increasingly become common. Milled asphalt with polyester fabric residue will need to be discarded, neutralising the benefit of recycling. Polypropylene on the other hand is a performance-enhancing additive to bitumen when recycled back as new pavement.

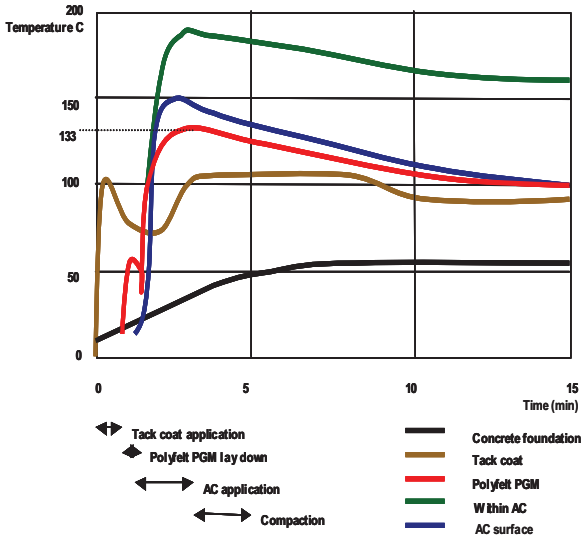

Fig. 10 Temperature gradient at different interface layers.

CONCLUSIONS

The need for road or airport rehabilitation will increase significantly in the future. Paving fabrics, properly impregnated with bitumen successfully delay the propagation of reflective cracks from the old pavement upwards through newly overlaid asphalt. Paving fabrics through a combination of performance enhancing attributes better absorb temperature and traffic stress differentials between asphalt layers than is achieved in conventional asphalting. The lifespan of the new overlay is extended significantly reducing subsequent maintenance costs.

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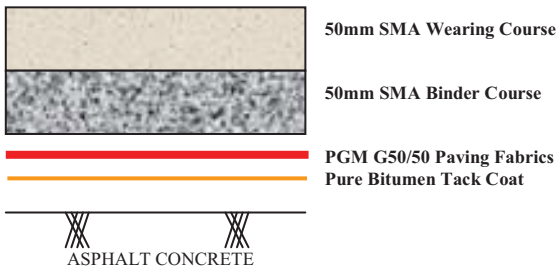
PROJECT REFERENCES

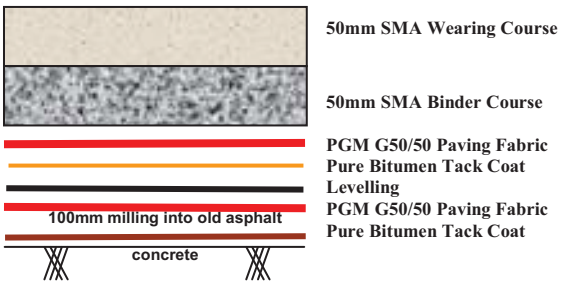
Project Reference A

Project Title:	Phuket International Airport Pavement Rehabilitation with Polyfelt Paving Fabrics
Year:	April 2002 – October 2002
Products:	Polyfelt PGM 14 Polyfelt PGM-G 50/50
Old Surface:	Asphalt Concrete (Section A and B) Concrete (Section C)
Tack Coat:	Pure Bitumen
New Overlay:	2 x 50mm SMA wearing course

Phuket is one of the most important tourist destinations in Thailand. In 2002, the runway of the International Airport with its more than 100,000 passengers per year needed urgent improvement.



SECTION A



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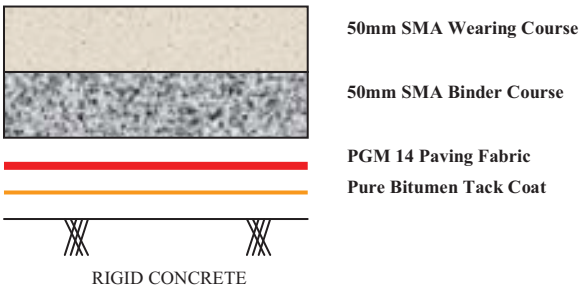


SECTION C

Fig.11 Typical Section of Pavement Rehabilitation

Since it was not possible to close the airport during rehabilitation works, the work had to be carried out at night. Each night approximately 1000m^2 of Polyfelt paving fabrics were installed within 2 to 3 hours, followed by the installation of the new wearing course.

Along the centerline of the runway, the old asphalt concrete surface had to be milled to a depth of 10cm before installing the paving fabrics followed by a leveling layer (Section B). Finally another layer of paving fabrics was applied over the whole width, covered by two layers of asphalt concrete, each 50 mm thick.

Installation Methodology

Fig. A1 Milling of the center line 100mm into the existing old asphalt concrete

Fig. A2 Cleaning of dust from milled area.

Fig. A3 Spreading of pure bitumen tack coat using metered dozing system.

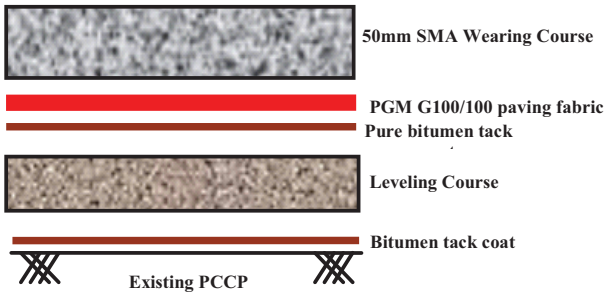
Fig. A4 Installation of PGM-G50/50 paving fabric onto tack coat.

Fig. A5 Overview of installed paving fabrics.

Fig. A6 Overview of asphalt concrete being discharge from track loader.

Project Reference B

Project Title:	Subic International Airport, Philippines Pavement Rehabilitation Work (Formerly USN Naval Airbase), Subic Bay, Olongapo City, Zambales
Year:	2004
Products:	Polyfelt PGM-G 100/100
Old Surface:	Portland Continuous Concrete Pavement (PCCP)
Tack Coat:	Pure Bitumen
New Overlay:	50mm SMA wearing course



Runway 07&25

Fig. 12 Typical Section of Pavement Rehabilitation

Installation Methodology

Fig. B1 Runway centerline milling and cleaning of existing pavement 50mm thick.

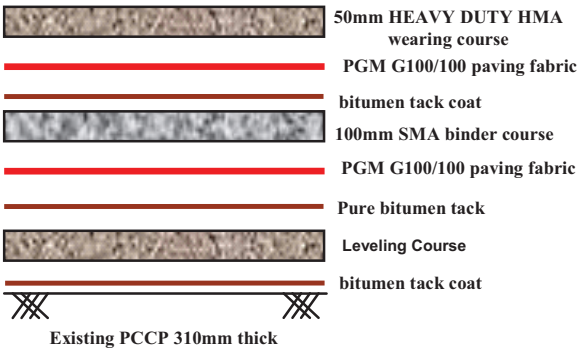
Fig. B2 Initial run of tanker controlled spray bar with 1.1kg/m^2 rate of application.

Fig. B3 Installation of PGM-G paving fabric utilizing Polyfelt custom rig.

Fig. B4 Tipping of asphalt concrete and its uniform spreading.

Project Reference C

Project Title:	Diosdado Macapagal International Airport, Philippines (Formerly USAF Clark Air Force Base), Clarkfield, Pampanga
Year:	2003
Products:	Polyfelt PGM-G 100/100
Old Surface:	Portland Continuous Concrete Pavement (PCCP)
Tack Coat:	Pure Bitumen
New Overlay:	50mm Heavy duty SMA wearing course



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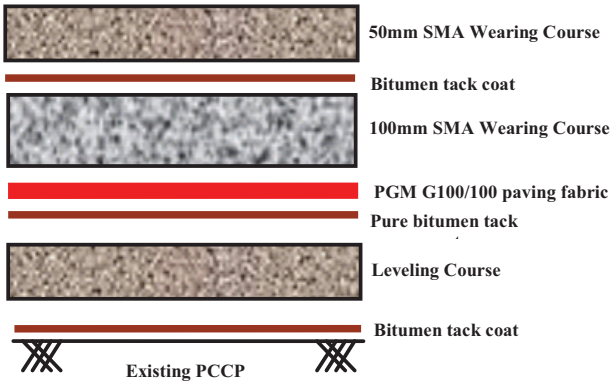

Taxiway D01- D02

Fig. 13 Typical Section of Pavement Rehabilitation

Installation Methodology

Fig. C1 Tanker with controlled spray bar for initial pure bitumen application.

Fig. C2 Installation of PGM-G 100/100 paving fabric using a customize Polyfelt paving rig.

Fig. C3 Specially fabricated brushes prevent wrinkles on the fabric.

Project Reference D

Project Title:	North South Highway Rehabilitation, Southern Region, Malaysia
Year:	2004-2005
Products:	Polyfelt PGM 14
Old Surface:	Asphalt Concrete (Flexible Pavement)
Tack Coat:	Polymer Modified Bitumen
New Overlay:	50mm Asphalt Concrete Overlay

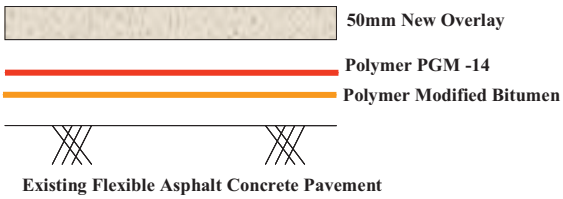

Fig. 14 Typical Section of Pavement Rehabilitation

The North South Highway in the southern region of Malaysia has reached its design life of 10 years and the distress on the pavement has caused riding discomfort to the road users. In view of this, rehabilitation that involved 20km of road has to be carried out. Polymer modified bitumen was used in this rehabilitation work. This type of bitumen incorporating elastomer additives perform substantially better than standard pure bitumen. Polymer modified bitumen are better able to absorb the extremes of heat and cold, and improve the adhesion between the old and new overlays.

Fig. D1 Milling of old pavement.

Fig. D2 Polymer modified bitumen tack coat was applied to the old pavement.paving rig.

Fig. D3 Installation of PGM 14 paving fabric.

Fig. D4 Tipping of asphalt concrete

Project Reference E

Project Title:	Saraburi-Nakhon Ratchasima Road Rehabilitation Works, Thailand
Year:	2004
Products:	Polyfelt PGM14
Old Surface:	Rigid Concrete Pavement
Tack Coat:	Emulsion Bitumen
New Overlay:	40mm SMA wearing course

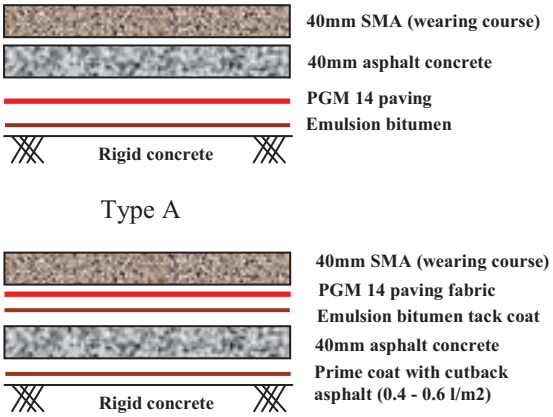

Fig. 15 Typical Section of Pavement Rehabilitation

Installation Methodology

Fig. E1 Sealing of base course with cement grout.

Fig. E2 Spraying of Cationic Rapid Setting (CRS-2) bitumen emulsion tack coat.

Fig. E3 Installation of paving fabric.

Fig. E4 Butt joint along the length of the paving fabric.