CHAPTER 12 INTERLAYERS

12.1 OVERVIEW

Pavement interlayers are materials or combinations of materials that can be placed within a pavement system during new construction, rehabilitation or preservation in conjunction with an overlay or surface treatment to extend pavement service life. Most interlayers will mitigate reflective cracking and reduce the amount of surface water that will penetrate into the pavement structure. Some interlayers will also allow for a reduction in thickness of the proposed overlay because interlayers can also provide stress and/or strain relief for the subsequent surface treatment.

By accomplishing these goals interlayers can help the new pavement surface last longer, provide a smoother ride throughout the life of the pavement by reducing cracking, and require less maintenance in the future. This will provide an overall more cost effective life cycle for pavement preservation, CApital Preventive Maintenance (CAP-M) or rehabilitation.

This chapter provides general guidelines on the use of interlayers. This informational guide on interlayers is not designed to be a standalone document in the decision making process. It should be noted that factors such as traffic volume, structural section and user delays should be taken into account when considering interlayers. There are many types of interlayers. The manufacturers of these materials have conducted research and have documentation on the various interlayers. It is recommended that manufacturer representatives be consulted if there are questions in using their products. See references at end of Chapter,

12.2 TYPES OF INTERLAYERS

Several types of interlayers have been used in California including chip seals and other manufactured products. Many of the types of manufactured products discussed in this chapter require a minimum 1.5- inch hot mix overlay to complete the application which places them outside the preservation category and within the CAP-M category for Caltrans. However, most City and County agencies in California allow up to 2-inch overlays for standard maintenance and can include these types of interlayers. All of the types of interlayers can also be used with deeper lift rehabilitation strategies. Some of the types of interlayers include:

Paving Fabric (Figure 12-1) **(**Formerly called Stress Absorbing Membrane Interlayer – Fabric (SAMI-F) - A non-woven geotextile fabric that is saturated with asphalt cement and placed with an asphalt concrete overlay (overlay) or chip seal. The paving fabric followed by a chip seal system has also been used as an interlayer application prior to an overlay, slurry seal, microsurfacing or second chip seal.

Paving Mat (Figure 12-2) - A non-woven fiberglass/polyester hybrid material that is saturated with asphalt cement and placed prior to an overlay.

Figure 12-1 Polypropylene Paving Fabric

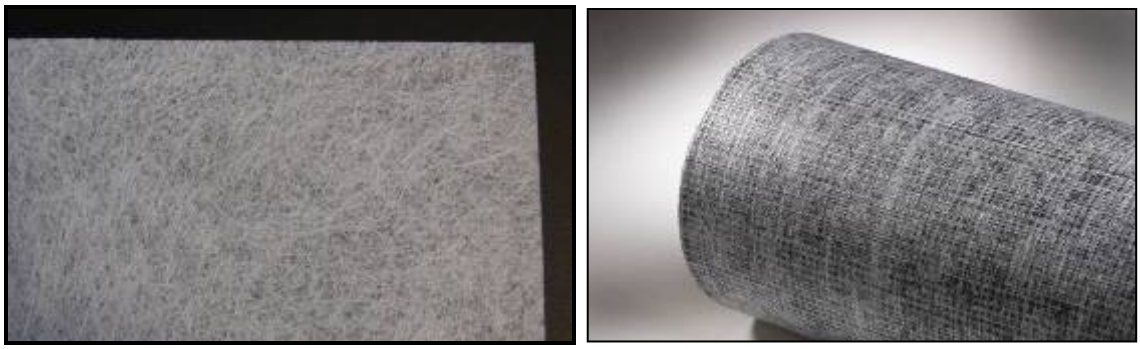
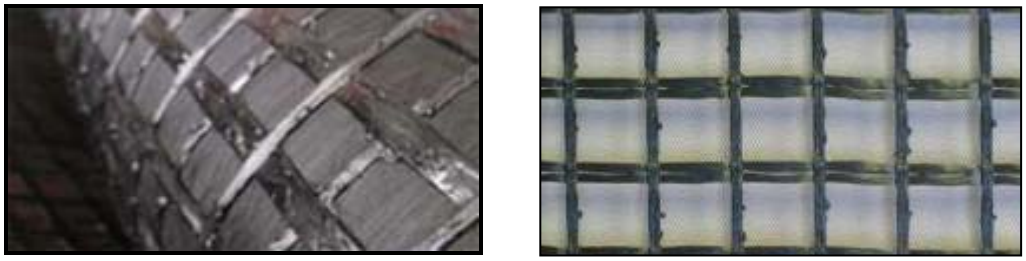


Figure 12-2 Fiberglass/Polyester Paving Mats

Paving Grids (Figure 12-3) – A material formed into a grid by a regular network of integrally connected elements with openings greater than or equal to 1/2 - inch to allow interlocking with the surrounding asphalt concrete materials. This material is applied either with a self-adhesive or with a lightweight scrim (a non-woven material <1.2 oz/yd2 attached to the grid) and/or tack application and is placed with an overlay.



Paving Grid with Scrim Backing Self Adhesive Paving Grid

Figure 12-3 Paving Grids

Paving Composite Grids (Figure 12-4) – A Paving Grid, as defined above, laminated, bonded or integrated with a paving fabric which is saturated with asphalt cement and placed with an overlay.

Composite Membranes (Figure 12-5). – Strips of various widths (12-inch, 18-inch, 24-inch, and 36-inch) comprised of rubberized and/or polymerized asphalt and geosynthetic materials that are applied either with a self-adhesive or asphalt tack application and placed prior to an overlay

Figure 12-4 Paving Composite Grids with Polypropylene Backing

Figure 12-5 Application of Composite Membranes

Asphalt Rubber Chip Seal (AR Chip Seal) (Formerly called Stress Absorbing Membrane Interlayer – Rubber (SAMI-R)): Is an application of site blended, hot applied asphalt rubber covered with a pre-coated, pre-heated aggregate (Figure 12-6) placed prior to an overlay, slurry seal or microsurfacing. ARCS's are discussed in detail in Chapter 7 (Chip Seals).

Figure 12-6 Asphalt Rubber Chip Seals

Polymer Modified Asphalt Chip Seal (PMA Chip Seal) – A PMA Chip Seal (Figure 12-7) is an application of hot applied polymer modified asphalt (that may also contain crumb rubber) followed by an application of pre-coated, pre-heated aggregate. This application is placed prior to an overlay, slurry seal or microsurfacing. Details on construction and materials are discussed in Chapter 7 (Chip Seals).

Figure 12-7 Polymer Modified Asphalt (PMA) Chip Seal

Polymer Modified Rejuvenating Emulsion (PMRE Scrub Seal) – An application of a rejuvenating emulsion that is then "scrubbed" into the existing surface by use of a mechanized broom (Figure 12-8). A layer of crushed stone or sand is then applied prior to an overlay, slurry seal or microsurfacing. For more details, please refer to Chapter 6 (Fog and Rejuvenating Seals) and Chapter 7 (Chip Seals).

Figure 12-8 Scrub Seals

Microsurfacing, although not considered a traditional interlayer, has been effective as a pre-treatment or interlayer to fill ruts or act as a leveling course. This has been particularly effective on jointed concrete pavements. Microsurfacing has also been used to "lock down" brick and/or cobblestone surface movement prior to overlays. If rutting (not caused by structural or mix design issues) exists, microsurfacing can fill and level the ruts prior to an overlay thereby acting as an interlayer. Microsurfacing is designed to chemically set and stack the aggregate within the mix preventing or severely limiting post application compaction or continued rutting. Typical applications of microsurfacing are discussed in more detail in Chapter 9.

12.3 PROJECT SELECTION, INTERLAYER SELECTION AND BENEFITS

Once the decision is made to use an overlay or chip seal as a wearing surface, consideration should be given to whether using an interlayer is a cost-effective addition to the chosen strategy. Use of an interlayer is based on several factors including:

- Final surface treatment material and thickness (if overlay)
- Existing distresses - including types and severity levels.
- Climate and traffic conditions
- Moisture or water damage - which will accelerate the distresses, weakens the subgrade, and can cause premature failure of the new treatment.

- Costs of interlayer - which will vary greatly depending on the type of interlayer. Project design life or life extension benefits.

Interlayers may reduce the overall initial cost of a project by addressing the existing pavement distresses in lieu of digouts and repairs or thicker overlays. Interlayers may also decrease the life-cycle cost of a rehabilitation or maintenance treatment by significantly extending the life of the pavement. It is important to understand that most interlayers are not used to add structural strength to a pavement. However, some interlayers have established structural coefficients. Manufacturers' documentation should be consulted when considering an interlayer to add structural strength to a pavement section.

12.3.1 Project Selection Consideration

To make an informed choice on whether or not to use an interlayer the reader must be familiar with pavement distress types and should have a good understanding of Chapter 1 of this Guide. Tables 12-1 and 12-2 offer some guidance on the type of interlayers that have proven to be effective with different types and levels of distress in addition to cost considerations.

Interlayers were originally designed specifically to deal with cracking that is not load associated and caused by a lack of structureIf alligator cracking is associated with wheel loading and is combined with a lack of structure, then interlayers are not the optimum choice to satisfy this type of cracking. However, if alligator cracking exists across the entire surface of the roadway and is not specific to the wheel path/loading area, it is most likely caused by age oxidation of the pavement. Interlayers are an excellent choice to prevent this type of distress from reflecting through the new wearing surface.

Other types of distresses (rutting, bleeding, raveling, etc) are not normally addressed with the use of interlayers. In general, if active pumping is present, it usually indicates a poor base/subgrade condition which will require treatment prior to the use of an interlayer. If these distresses are addressed with a leveling course, or microsurfacing, then an interlayer could still be applied in conjunction with a surface treatment in order to gain life extension benefits.

12.3.2 Cover Requirements for Interlayer Materials

Table 12-1 summarizes the types of final wearing surface, with required depths for HMA, necessary to be used with each interlayer material. It should be noted that an overlay thickness greater than 1.2" is generally used for CAP-M or pavement rehabilitation rather than for pavement preservation. In order to be more inclusive all depths of paving and the most common interlayers are included here.[1]

[1] A CAP-M by Caltrans definition is Capitol Preventive Maintenance. A CAP-M treatment may still be a pavement preservation technique, but does not meet the "Maintenance" funding definition.

Table 12-1 Cover requirement minimums for various interlayer materials

		HMA Overlay Thickness			
Type of Interlayers	Chip Seal	Less than 1.2-inch	Min 1.5-inch	Min 2.0-inch	**Slurry or Microsurfacing**
Paving Fabric w/ Overlay			X		
Paving Fabric w/ Chip Seal	X	X			X
Paving Mat			X		
Paving Grid			X		
Paving Composite Grid				X	
Composite Strip Membranes			X		
AR Chip Seal		X			X
PMA Chip Seal		X			X
PMRE Scrub Seal		X			X
X = Acceptable Surface Treatment for Interlayer					

Fatigue/ Alligator Cracking

Alligator cracking is either load related or caused by age oxidation of the existing pavement. If alligator cracking is caused by associated wheel loading and is combined with a lack of structure, then either movement will exist in the pavement or it will be in the wheel path area only. Interlayers are not the optimum choice to satisfy this type of cracking. However, if alligator cracking exists across the entire surface of the roadway and is not specific to the wheel path/loading area, it is most likely caused by age oxidation of the pavement. Interlayers are an excellent choice to prevent age oxidation types of distress from reflecting through the new wearing surface.

Other types of cracking (thermal cracking, block, etc) are discussed in Chapter 1 and should be referred to and understood prior to moving on to Tables 12-2 and 12-3. Other types of distresses (rutting, bleeding, raveling, etc) are not normally addressed with the use of interlayers. If these distresses are addressed with a leveling course, or microsurfacing, then an interlayer could still be applied in conjunction with a surface treatment in order to gain life extension benefits.

Table 12-2 Anticipated Effectiveness vs. Types of Cracking and Moisture Intrusion

Interlayer	Alligator Cracking			Block, Longitudinal, and Non-Thermal Transverse Cracking		Thermal Cracking			Moisture Intrusion
	Load Related	Age Oxidation (Low to Medium)	Age Oxidation (Medium to High)	Low to Medium (CW <1/2 in)	High (12/ < CW < 1 inc)	Low (CW < ¼ in)	Medium (1/4 < CW < ½ in)	High (1/2 in or grater CW)	
Paving Fabric w/ Overlay	N	E	G(1)	F	F(2)	G	F	N	E(3)
Paving Fabric with Chip Seal	N	E	G(1)	G	G(2)	F	N	N	E(3)
Paving Mat	N	E	E(1)	G	G(2)	E	G	N	E(3)
Paving Grid	N	E(1)	E(1)	E(1)	E(1)	E	E(1)	E(1)	N
Paving Composite Grid	N	E	E(1)	E	E(2)	E	E	E(2)	E(3)
Composite (Strip) Membranes	N	N	N	E	E	E	E	G	E
AR Chip Seal	N	E	E	E	G(2)	F	N	N	E
PMA Chip Seal	N	E	E	E	G(2)	F	N	N	E
PMRE Scrub Seal	N	E	E	E	E	G	F	N	E

(1) Interlayer with leveling course first
(2) Interlayer with crack filling first
(3) Interlayer dependent on binder application rate

E = Excellent
G = Good
F = Fair
N = Not Recommended

L = Low Severity
M = Medium Severity
H = High Severity
CW = Crack Width

The values in this table are informational based on available information.
This table will be updated as more data becomes available.

Table 12-3 Use vs. Climate and Traffic

Interlayer	Desert			Mountain			Coastal			Valley		
	< 5 M AADT	5 to 30M AADT	> 30M AADT	< 5 M AADT	5 to 30M AADT	> 30M AADT	< 5 M AADT	5 to 30M AADT	> 30M AADT	< 5 M AADT	5 to 30M AADT	> 30M AADT
Paving Fabric w/ Overlay	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Paving Fabric with Chip Seal	Y	N	N	Y	N	N	N	N	N	Y	N	N
Paving Mat	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Paving Grid	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Paving Composite Grid	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Composite (Strip) Membranes	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
AR Chip Seal	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y	N
PMA Chip Seal	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y	N
PMRE Scrub Seal	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y	N

Y = Recommended N= Not Recommended

12.3.3 Moisture Intrusion

Damage caused by water intrusion into a pavement structural section is a major cause of many types of distresses including, but not limited to, loss of subgrade support, stripping (separation of the asphalt and aggregate in a hot mix material), potholes, localized failures, crack propagation, and pavement deterioration caused by freeze-thaw.

One of the major benefits of most interlayers is to provide a moisture barrier to surface water. The effectiveness of an interlayer moisture barrier is determined by the binder application rate associated with the respective interlayer system. This prevents the intrusion of the moisture into the pavement section and thereby degradation of the pavement from rain, landscape watering, etc. Water intrusion caused by underground issues such as springs or standing water in ditches cannot be addressed with an interlayer. Drainage work will be required prior to any installation.

12.3.4 Cost of Interlayers

The next factor associated with interlayer selection is cost. The installation of an interlayer will influence the initial cost of a project. Use of interlayer materials in lieu of digouts will typically decrease the overall cost of the project and provide a longer life for the new surface. Overall the life cycle cost of the pavement will have to be influenced positively in order to use an interlayer. Life extension data is provided in many of the references at the end of the Chapter.

Table 12-4 lists approximate costs for interlayers only. The costs are based on 2006 data. Cost of the surface treatment would have to be added to these costs for inclusion in any cost analysis.

Table 12-4 Approximate Costs of Interlayers Based on 2006 Data

Strategy	Size of Job	Installed Cost $/sq. yd
Paving Fabric for Overlay	Small Medium Large	1.50- 2.50 1.30- 2.00 1.10- 1.50
Paving Fabric for Chip Seal	Small Medium Large	1.90- 3.50 1.65- 2.75 1.40- 2.25
Paving Mat	Small Medium Large	2.75-3.50 2.30- 3.25 2.00-2.75
Paving Grid	Small Medium Large	8.00- 10.00 6.00- 8.50 5.00- 7.00
Paving Composite Grid	Small Medium Large	8.50- 10.50 6.50- 9.00 5.50- 7.50
Composite Strip Membranes (18" Width) per LF (Price is for material only)	Small Medium Large	1.20- 1.40 1.00- 1.20 0.80- 1.00
AR Chip Seal	Small Medium Large	4.25-5.00 4.00-4.75 3.75-4.55
PMA Chip Seal	Small Medium Large	3.50-5.00 3.00- 4.00 2.35-3.25
PMRE Scrub Seal	Small Medium Large	2.75-3.50 2.25–2.75 1.85-2.25

- Costs for the Surface Treatment are not included. These cost numbers are for interlayer installation only and include: mobilization, material (Asphalt and Interlayer), and installation.
- Definition of Job Sizes for Fabrics, Mat, Grids, and Composite Grids:
  Small = ~5,000 SY per Day
  Medium = 5,000 – 10,000 SY per Day
  Large = 10,000 SY per Day or Greater
- Definition of Job Sizes for Composite Strip Membranes:
  Small = ~1,000 LF per Day
  Medium = ~3,000 LF per Day
  Large = ~5,000 LF per Day
- Definition of Job Sizes for Chip Seal Applications:
  Small = One of production
  Medium = Two-Three days of production
  Large = More than three days at same location

12.3.5 Life Extension of Interlayers

Interlayers can extend the life of a surface treatment when installed properly on the right pavement at the right time. The life extension benefit will depend on the following factors:

- Existing pavement condition, including any prep work done to the pavement
- Type of interlayer selected
- Proper installation/construction of the interlayer and
- Type and/or thickness of surface treatment selected

Therefore, one must consider all factors prior to selection of a specific interlayer. Other factors such as the environmental condition and traffic loading must also be considered. Manufacturer representatives may also be able to provide further guidance on proper usage of interlayers.

12.3.6 Examples for Selection of Most Appropriate Interlayers

The following examples and decision tree show how the factors and tables above should be used when considering the use of an interlayer. They are basic examples only to show how the tables and information presented in this chapter can be used to identify the most useful interlayers given the project's existing pavement distress, climate and traffic.

Example 1:
Problem: A structurally sound pavement has low to moderate alligator cracking due to age oxidation. Moisture intrusion is a concern. The traffic count is 5000 AADT. The final wearing surface will be a standard 1.2-inch maximum maintenance overlay. The climate is coastal. *Select most appropriate interlayer for use in this project.*

Solution: Based on the 1.2-inch maximum depth overlay, paving fabric, mat and composite grids would be ruled out due to a minimum 1.5-inch overlay requirement. (See Table 12-1). Due to the alligator distress, most of the remaining interlayers would do the job (Table 12-2). Composite Strip Membranes would be ruled out since they are typically only used on localized repairs in lieu of full width paving. This leaves Paving Fabric w Chip Seal, AR Chip Seal, PMA Chip Seal, and PMRE Scrub Seal. Due to the coastal climate, Paving Fabric w Chip Seal using a standard PME Emulsion, would probably be a concern during construction (See Chapter 7, *Chip Seals* for more information.) This leads to one of three options. AR Chip Seal, PMA Chip Seal or PMRE Scrub Seal. Strictly based on cost data, it would appear that the PMRE Scrub Seal would be the solution. However, other factors like life expectancy and climate may suggest a hot applied system instead.

Example 2:
Problem: An existing pavement with high severity block and transverse cracks (non-Thermal) is being considered for a 2.0- inch Capital Maintenance Overlay (CAP-M). Moisture intrusion is not an issue in this desert climate. The agency is concerned with reflective cracking occurring soon after the overlay is installed. The AADT is 40,000. *Select most appropriate interlayer for use in this project.*

Solution: Upon reviewing Table 12-2, the engineer can determine that Paving Fabric, Paving Fabric w Chip Seal, Paving Mat, AR Chip Seal and PMA Chip Seal are not the optimum materials for this project since they would not perform at the same level as the other products on this type of cracking. In addition, Composite Grid would not be a consideration because it would add cost for the moisture component which is not needed. This leaves Paving Grid, Composite Strip Membranes, or PMRE Scrub Seal. Upon considering the AADT in Table 12-3, the only two remaining options are Paving Grid and Strip Membranes. If the percentage of cracking is very high, then the Strip Membrane would be too cumbersome. This leaves the Paving Grid option as the best alternative.

Example 3:
Problem: A two-lane highway with isolated areas of moderate to high alligator cracking which is not load related, and low severity thermal cracking is being considered for an overlay of 1.5-inches. This is a mountainous climate that has high annual rainfall amounts. There are also 1/2-inch – 3/4- inch ruts in the wheel paths due to chain wear. The AADT is 20,000. *Select most appropriate interlayer for use in this project.*

Solution: The isolated alligatored areas should be repaired prior to any treatment application. The roadway would require either a Hot Mix leveling course or a microsurfacing placed as an interlayer prior to any final wearing course to address the ruts. Now the process of interlayer selection and evaluation can begin. The two concerns remaining are low severity thermal cracking and moisture. The AADT from Table 12-3 rules out Paving Fabric with Chip Seal. The moisture component rules out Paving Grids. The overlay thickness rules out Composite Grids. At this point all other interlayers are still a possibility. However according to Table 12-2 the AR Chip Seal and PMA Chip Seal are only listed as "F" instead of "G or E" for the thermal cracking. The better remaining choices are PMRE Scrub Seal, Paving Fabric, Paving Mat or Composite Strip Membranes. Upon reviewing the tables it is evident that with the exception of Composite Strip Membranes, all the products are "E" in one category and "G" in the other. This would lead to Composite Strip Membranes as the final choice. However, if the thermal cracking is too closely spaced one of the other materials might be a better compromise for the construction process. At this point the 3 remaining choices will have to be evaluated based on cost, material availability and construction limitations.

12.4 MATERIALS, APPLICATION AND SPECIFICATIONS

12.4.1 Paving Fabric

Paving fabric can be used with either hot mix overlays or with chip seals. If used with a hot mix overlay, the minimum depth of compacted overlay must be at least 1.5- inches which implies that it must be a CAP-M or Rehabilitation Strategy.

Table 12-5 lists specifications for paving fabric as per Caltrans Standard Specifications Section 88. Also see Section 92.104, "Applying Asphalt," of Caltrans Standard Specifications for more details.

Table 12-5 Paving Fabric Specifications

Property	Test Method	Value
Elongation, minimum in each direction, %	ASTM D4632	50
Grab breaking load, 1-ich grip, mini8mum in each direction, lbs	ASTM D4632	100
Hydraulic bursting strength, minimum, psi	ASTM D3786	200
Mass, minimum, 0z/yd^2	ASTM D5261	4.1
Asphalt retention, minimum, gal/yd^2		0.2

Binder Requirements for Installation of Fabric prior to an Overlay - The surface area to receive the fabric shall be sprayed with a PG grade asphalt binder that is determined based on the ambient temperatures on the jobsite during installation. Higher ambient temperatures will require a stiffer binder in order to reduce the chance of bleeding under construction traffic. Typical binders used are PG 64-XX and PG 70-XX.

The typical binder application shall be 0.25±0.03 Gal/yd^2. In milled areas, binder application rate shall be increased by 0.05-0.10 Gal/ yd^2 to account for the increased surface area and voids. Good practice dictates that the asphalt binder be spread in the range of 290°F to 325°F as read on the temperature gauge on the truck applying the material.

Binder Requirements for Installation of Fabric prior to a Chip Seal – Either PG 64 – XX or PG 70 – XX binder shall be applied prior to installation of the paving fabric. The difference is in the application rate and the amount of saturation of the fabric required prior to the application of the chip seal. The typical application rate of the binder shall be increased to 0.30±0.03 Gal/ yd^2. In addition, the fabric shall be rolled to ensure that the fabric is completely saturated prior to the chip seal application.

12.4.2 Paving Mat

Paving mat is used under hot mix overlays of a minimum compacted thickness of 1.5-inches. This places paving mat in the CAP-M or Rehabilitation category. Specification requirements for paving mats are shown in Table 12-6.

Table 12-6 Paving Mat Specifications

Property	Test Method	Value
Ultimate Elongation, %	ASTM D5035	≤ 5
Breaking Strength, lb/in^2	ASTM D5035	45
Mass per Unit Area, oz / yd^2	ASTM D5261	3.7
Melting Point, ^{o}F	ASTM D276	>400
Asphalt Retention, minimum, gal/yd^2	ASTM D6140	0.15

Binder Requirements for Installation of Paving Mat - The surface area to receive the mat shall be sprayed with a PG grade 64-XX or 70-XX. Higher ambient temperatures will require the stiffer PG 70 –XX binder to reduce the chances of oversaturation of the mat under construction traffic.

The typical binder application rate shall be in the range of 0.15 to 0.20±0.03 Gal/yd^2 depending on manufacturer. In milled areas, binder application rate shall be increased by .05-.10 Gal/yd^2 to account for the increased surface area and voids. Good practice dictates that the asphalt binder be spread in the range of 290°F to 325°F as read on the temperature gauge on the truck applying the material.

12.4.3 Paving Grid

Paving grid is used under hot mix overlays of a minimum compacted thickness of 1.5-inches. This places paving grid in the CAP-M or Rehabilitation category. Specifications for paving grids are shown in Table 12-7

Table 12-7 Paving Grid Specifications

Property	**Test Method**	**Value**		
		Grid Type		
		Class P1	Class P2	Class P3
Grid Aperture size, range, inches	Callipered	>0.5	>0.5	>0.5
Elongation, maximum, %	ASTM D6637	5	5	10
Mass, minimum, oz/yd^2	ASTM D5261	16	10	5.5
Tensile strength@ ultimate, minimum, lb/in		560 x 1,120	560 x 560	280 x 280

Binder Requirements for Scrim Applied Paving Grid - The surface area to receive the paving grid shall be sprayed with a PG grade 64-XX or 70-XX (depending on typical ambient temperatures on the jobsite) paving grade liquid asphalt binder. Higher ambient temperatures will require a stiffer PG 70 – XX binder in order to reduce the chances of oversaturation of the fabric under construction traffic.

The typical binder application shall be .06-.10 +/- 0.03 Gal/yd^2. Paving Grids shall not be placed directly on milled surfaces. Good practice dictates that the asphalt binder be spread in the range of 290°F to 325°F as read on the temperature gauge on the truck applying the material.

Binder Requirements for Self-Adhesive Paving Grid – Self-adhesive grids may require a tack coat for installation. Paving Grids shall not be placed directly on a milled surface. If a tack coat is specified and approved by the manufacturer or their representative, the tack coat shall be emulsified asphalt or PG grade binder as referenced above. If emulsified asphalt is used ensure a binder solids content of minimum 65% and a residual asphalt application rate of 0.02 – 0.05 gal/yd2. See the manufacturer's recommendations for details.

Cover Requirements for Paving Grid – An overlay thickness of minimum 1.5" compacted depth is required in conjunction with a paving grid application.

12.4.4 Paving Composite Grid

Paving composite grid is used under hot mix overlays of a minimum compacted thickness of 2.0-inches. This places paving composite grid in the CAP-M or Rehabilitation category. Specifications for paving composite grid are shown in Table 12-8.

Table 12-8 Paving Composite Grids Specification

Property	**Test Method**	**Value**		
		Grid Type		
		Class P1	Class P2	Class P3
Grid Aperture size, range, inches	Callipered	>0.5	>0.5	>0.5
Elongation, maximum, %	ASTM D6637	5	5	10
Mass, minimum, oz/yd^2	ASTM D5261	16	10	5.5
Tensile strength@ ultimate, minimum, lb/in		560 x 1,120	560 x 560	280 x 280
Fabric Requirements				
Grab Tensile Elongation, maximum in each direction, %	ASTM D4632	50		
Grab Breaking Load, 1-inch grip, minimum in each direction, lbs	ASTM D4632	90		
Hydraulic Bursting Strength, minimum, psi	ASTM D3786	180		
Mass, minimum, oz/yd^2	ASTM D5261	3.6		

Asphalt Retention, minimum, gal/yd^2		0.2

Binder Requirements for Paving Composite Grid Installation - The surface area to receive the composite grid shall be sprayed with a PG grade 64-XX or 70-XX (depending on typical ambient temperatures on the jobsite) paving grade liquid asphalt binder. Higher ambient temperatures will require a stiffer PG 70 – XX binder in order to reduce the chances of oversaturation of the composite under construction traffic.

The typical binder application shall be 0.25±0.03 Gal/yd^2. In milled areas, binder application rate shall be increased by .05-.10 GSY to account for the increased surface area and voids. Good practice dictates that the asphalt binder be spread in the range of 290°F to 325°F as read on the temperature gauge on the truck applying the material.

12.4.5 Composite Strip Membranes

Composite strip membranes are used under hot mix overlays of a minimum compacted thickness of 1.5-inches. This places composite strip membranes in the CAP-M or Rehabilitation category. The specifications for the materials used in composite strip membranes are shown in Table 12-9.

Table 12-9 Composite Strip Membranes Specification

Property	Test Method	Value
Thickness, mills	ASTM D5147	65
Grab Tensile Strength, lbs	ASTM D4632	200
Grab Tensile Elongation, %	ASTM D4632	40
Puncture Strength, lbs	ASTM D4833	200
Permeance, perm, maximum	ASTM E96, Method B	0.1
Strip Tensile, lbs/in	ASTM 882, Modified	50
Pliability	¼ inch Mandrel, 180 @ -25^{o}F	No cracks

Primer Placement-The purpose of a primer is to improve adhesion of the strip membrane under "marginal" conditions that tend to reduce bonding. Such conditions include moisture, dust, cold temperatures and irregular surfaces. Use only primers recommended by the manufacturers of the products.

12.4.6 Asphalt Rubber Chip Seals (ARCS)

Asphalt rubber chip seals can be used under hot mix overlays of any thickness or slurry or microsurfacing. This allows ARCS to be used for maintenance, CAP-M or Rehabilitation.

Asphalt rubber chip seals (ARCS) have a long history of being used as interlayers prior to placement of an asphalt concrete overlay. They are similar in application to a conventional type chip seal, but the application rate of the binder is much higher ranging from 0.55-0.65 gal/yd^2. The thicker layer of binder provides improved resistance to reflection cracking.

The material requirements for the asphalt rubber binder component of the system are detailed in Chapter 7 of this manual. More information on the use of this product can be found in the Caltrans Asphalt Rubber Usage Guide updated in 2006.

12.4.7 PMA Chip Seals

PMA chip seals can be used under hot mix overlays of any thickness or slurry or microsurfacing. This allows PMA Chip Seals to be used for maintenance, CAP-M or Rehabilitation.

Polymer modified asphalts are currently being used in chip seal applications and also can be used as interlayers prior to the application of an HMA overlay or slurry seal or microsurfacing. Polymer Modified Asphalt materials are created at asphalt terminals. These materials are sprayed at lower temperatures than the ARCS and do not require any specialized environmental controls.

The application rates for these hot applied binders are typically 0.35-0.50 Gal/yd^2. These materials can also incorporate up to 10% ground tire rubber. The use of PMA for chip seals is discussed in more detail in Chapter 7 of this Guide.

12.4.8 PMRE Scrub Seals

PMRE scrub seals are used under hot mix overlays, slurry seals or microsurfacing. This places PMRE Scrub Seals in the maintenance, CAP-M or Rehabilitation category.

PMRE Scrub Seals are currently being used by many agencies in lieu of extensive crack sealing prior to a different application. Due to the nature of the process, cracks are filled with the emulsion during the construction of the seal. Emulsion application rates are similar to that of standard chip seal emulsions, but the "scrubbing" process places additional material in the cracks to seal them.

Scrub seals are discussed more fully in Chapters 6 and 7 of this guide.

12.5 CONSTRUCTION GUIDELINES

The following are general guidelines to ensure a successful installation of material interlayers (paving fabric, paving mat, paving grid, paving composite grid and composite strip membranes). For each specific project, the project specifications, project engineer's direction, and manufacturer's recommendations must be followed. Construction guidelines for chip seals can be found in Chapter 7.

12.5.1 Surface Preparation

- Potholes, cracks greater than 1/4- inch, and/or local distresses related to structural or subgrade failures shall be repaired.
- Pavement must be free of dirt, water, oil, and other foreign materials. Broom or air-clean the surface if necessary. This is an extremely important step. Spraying asphalt onto contaminants will prevent interlayers from adhering to the existing pavement surface. If the interlayer is not properly adhered to the existing pavement surface, the materials may delaminate during or after construction.
- Rutting must be corrected through milling or by placing a leveling course prior to placement of an interlayer.
- If a finish or profile milling is performed, a leveling course is not required prior to placement of most material interlayers. This will depend on the smoothness of the surface created during the milling operation and the specific interlayer material being placed. The following finish tolerances are required for profile or finish milling:
    - Remove asphalt concrete a minimum depth of 1/4 - inch
    - Provide a surface relief (distance between ridges) of no more than 1/4 - inch

  - Maintain 1/4 - inch grade tolerance over (transversely and longitudinally)
  - There shall be no more than 1/4 - inch vertical height variation between planed and un-planed surface at inside edge of conform and taper mills
- If cold planing is performed, a leveling course is typically required prior to placement of material interlayers other than paving fabric. This will depend on the smoothness of the surface created during the milling operation. The following finish tolerances are required for placement of paving fabric over a cold planed surface
  - Remove asphalt concrete a minimum depth of 3/8 - inch
  - Provide a surface relief (distance between ridges) of no more than 3/8 - inch
  - Maintain a 3/8 - inch grade tolerance over (transversely and longitudinally) from a 10 foot straightedge
  - There shall be no more than 3/8 - inch vertical height variation between planed and unplaned surface on inside edge of conform and taper mills
- With the exception of using composite strip membranes, a leveling course is required over all Portland cement concrete pavements. Typical Caltrans practice for rigid pavements is to crack and seat prior to a rehabilitation overlay using interlayer. However, interlayers can be used on non crack and seat rigid pavements prior to overlays also.
- All paving grid applications, except for paving composite grids, require a leveling course.
- Grade and cross-slope have been established.
- Manholes, catch basins, and utility appurtenances have been raised to a level of the new overlay.

12.5.2 Road Surface Condition (Before Installation)

- The pavement must be moisture free. Do not install material interlayers during precipitation
- The ambient air temperature must be $\geq 50^{o}$F and rising
- Pavement temperature must be $\geq 40^{o}$F and rising
- On newly placed asphalt surfaces, the surface temperature must be allowed to cool below 130ºF before placement. If necessary, the leveling course may be opened to traffic prior to placement of the interlayer to allow the tires to further knit the surface.

12.5.3 Binder Materials and Application

Binder materials must meet the following requirements.

- Delivered from an approved source.
- Delivery ticket specifies grade for use on the project.
- Temperature is within the specified range

Apply binder uniformly over the clean surface using a distributor truck with a current calibration. The truck shall have clean, uniformly angled, properly sized nozzles and a bar that is at the correct height to apply the material in a triple overlap spray pattern (Figure 12-9). Edge nozzles shall be clog free and angled perpendicular to the spray bar for a clean edge.

Figure 12-9 Interlayer Binder Application

For Paving Fabric, Mat, and Composite Grid, a binder application of PG Graded Asphalt (PG 64 – XX or PG 70 – XX) shall be used to saturate and/or bond the interlayer material to the existing pavement. PG 70 – XX or higher is recommended for job sites that are exposed to high ambient temperatures during the calendar year. For Paving Grid, refer to manufacturer's recommendations.

The distributor truck applying the asphalt binder shall be equipped with computer control and readout to ensure proper application rates. Spot application rate checks should be performed as per Section 12.6 of this chapter.

12.5.4 Material Application General Guidelines

- Using mechanical placement equipment, or manually, embed the interlayer in the hot PG tack coat before the asphalt cools. (Figures 12-10. 12-11, 12-12 and 12-13). If using an emulsion for placement of a paving grid, allow the tack to break completely before placing the grid
- Keep the interlayer material taut and wrinkle free. Providing tension during application will help to achieve this. Providing broom pressure will also assist in reducing wrinkles
- For sharp curves, material can be cut from the roll to desired length and positioned by hand to avoid wrinkles
- For paving fabric and mat, transverse overlaps shall be 4 to 6 inches. Longitudinal overlaps shall be 2 to 4 inches
- For paving grid and composite grid, transverse overlaps shall be 3 to 6 inches. Longitudinal overlaps shall be 1 to 2 inches
- Transverse overlaps should be lapped in the direction of paving to minimize the risk of being picked up by the paving equipment and process. All overlaps shall receive an application of tack coat.
- Only construction and emergency vehicles are allowed to drive on the interlayer prior to the placement of an overlay
- Longitudinal joints shall be placed on lane delineation if possible.
- Manufacturers' MSDS's shall be reviewed and adhered to during installation

Figure 12-10 Tractor Mount Application of Fabric

Figure 12-11 Truck Mount Application of Paving Mat

Figure 12-12 Tractor Mount Paving Grid Installation

Figure 12-13 Composite Paving Grid Installation

12.5.5 Specific Guideline for Each Type of Interlayers

The following items are specific to each of the individual interlayer materials and need to be adhered to in addition to the general guidelines above. Manufacturer guidelines and recommendations should be consulted prior to installation.

Specifics for Paving Fabric Installation prior to HMA Overlay

- Large wrinkles (1- inch and larger) shall be slit and lapped in the direction of paving
- All fabric shall be broomed in order to maximize pavement contact and remove air bubbles
- The width of liquid asphalt application shall be 2 to 4 inches beyond the edges of the fabric
- No joints shall be lapped with more than two layers of fabric

Specifics for Paving Fabric Installation prior to Chip Seal Application

- The width of liquid asphalt application shall be 2 to 4 inches beyond the edges of the fabric
- All wrinkles must be cut out completely with no lapping. Wrinkles and/or laps will reflect through a chip seal immediately
- Fabric shall be butted at both longitudinal and transverse joints
- Fabric must be completely saturated during lay down procedure. Binder application rate for the chip seal can be increased to compensate for incomplete saturation of the fabric, however this is not the recommended practice.
- Fabric shall be rolled immediately after placement to maximize pavement contact and remove air bubbles.
- Sanding can be used to prevent roller tires from adhering to and picking up the fabric. The cover sand shall be uniform, clean dry and free from deleterious matter. All loose sand shall be removed prior to application of the chip seal
- Ambient temperature requirements for fabric under chip are between 60°F and 100°F. Pavement temperature shall be 55°F and rising. Fabric shall not be placed unless temperatures and weather conditions will also allow for completion of the chip seal immediately following the fabric application
- Brooms on lay down equipment shall apply uniform pressure across full width of fabric
- Grades or slopes greater than 10% require additional consideration
- Fabric for chip applications are not recommended in the following areas
    1. The bubble portion of cul-de-sacs
    2. Sharp curves
    3. Intersection radii
    4. The last 100 feet approaching an intersection that requires traffic to stop, turn or reduce speed

Specifics for Paving Mat Installation prior to HMA Overlay

- If milling of the existing asphalt pavement has been performed, a leveling course may be required prior to placement of a paving mat. This will depend on the smoothness of surface created during the milling operation
- A leveling course is required over all Portland cement concrete pavements
- The width of liquid asphalt application shall be 2 to 4 inches beyond all edges of the mat
- Large wrinkles (1-inch and larger) shall be slit and lapped in the direction of paving

Specifics for Paving Grid Installation prior to HMA Overlay

- A leveling course is required for all Paving Grid Installations
- For scrim-applied paving grids, tack coat shall be applied at a rate between 0.06 and 0.10 gal/yd^2 that will bond the scrim and the paving grid to the existing pavement
- For self-adhesive paving grids, if a tack coat is specified and approved by the manufacturer or their representative, then the tack coat shall be used on the self adhesive paving grid. See manufacturer's recommendations for details
- Prior to installation of a self adhesive grid, test for proper adhesion to the existing pavement according to manufacturer's adhesion guidelines

Specifics for Paving Composite Grid Installation prior to HMA Overlay

- If milling has been performed, a leveling course is recommended prior to placement of composite paving grid, especially if the milling is deep or rough
- A leveling course is highly recommended over all Portland cement concrete pavements

Basics for Asphalt Rubber Chip Seal Construction (Figure 12-14) *The specifics listed here are very limited. For complete documentation on Chip Seal Construction refer to Chapter 7 of this manual.*

- Asphalt rubber chip seal applications are similar to those of a conventional chip seal
- The surface must be prepared and cleaned
- The binder is applied at an application rate which is a factor of the existing distresses, traffic and size of cover aggregate but is typically between 0.55-0.65 Gal/yd^2.
- Aggregate is typically pre-heated and pre-coated to reduce the amount of dust on the aggregate and ensure a good bond to the sprayed asphalt
- The aggregate is applied as soon as possible and rolled into the mat
- Finishing consists of brooming off the excess aggregate

Figure 12-14 Asphalt Rubber Binder Being Applied

Basics for Modified Binder Chip Seal Construction (Figures 12-15 and 12-16)**.***The specifics listed here are very limited. For complete documentation on Chip Seal Construction refer to Chapter 7 of this manual.*

- PMA chip seal applications are similar to those of a conventional chip seal also
- The surface must be prepared and cleaned
- The binder is applied at an application rate which is a factor of the existing distresses, traffic and size of cover aggregate but is typically between 0.35-0.50 gal/yd^2.
- Aggregate is typically pre-heated and pre-coated to reduce the amount of dust on the aggregate and ensure a good bond to the sprayed asphalt The aggregate is applied as soon as possible and rolled into the mat
- Finishing consists of brooming off the excess aggregate
-

Figure 12-15 Installation of Binder

Figure 12-16 Chips Applied and Sweeping Edge for 2nd Pass

Basics for Scrub Seal Construction(Figures 12-17 through 12-19)**.***The specifics listed here are very limited. For complete documentation on Chip Seal Construction refer to Chapter 7 of this manual.*

- Scrub seal applications are similar to those of a conventional chip seal
- The surface must be prepared and cleaned
- The binder is applied at an application rate which is a factor of the existing distresses, traffic and size of cover aggregate but is typically between 0.25-0.40 Gal/yd^2.
- The binder is then "scrubbed" into the existing pavement.
- Aggregate is then applied and rolled. Due to the nature of rejuvenating emulsions the aggregate does not have to be as clean as conventional chip seal aggregates. It also does not require pre-heating or pre-coating.

Figure 12-17, 18, 19 Scrub Seal Construction

12.6 FIELD TESTING FOR MATERIAL INTERLAYERS

The following focuses on paving material type interlayers only. (Paving Fabric, Mat, and Composite Grid). **Field testing related to chip seals may be found in Chapter 7 of this Guide**.

12.6.1 Equipment Required

- Field Inspection Form
- Weight to application rate conversion chart (Table 12-10)

Table 12-10 Weight to Application Rate Conversion Chart

g/ft^2	oz/ft^2	gal/yd^2
82	2.88	0.19
90	3.18	0.21
99	3.48	0.23
107*	**3.78**	**0.25**
116	4.09	0.27
124	4.39	0.29
133	4.69	0.31
141**	**4.99**	**0.33**
150	5.29	0.35
158	5.59	0.37
167	5.89	0.39

* Typical Overlay Application
** Typical Chip Seal Application

- Measuring Scale of 2 g accuracy (preferably portable)
- Testing units (12" X 12" rigid material, 1/8th or ¼ inch hardboard or plywood)

12.6.2 Testing Activities Required for Tack Coat Application Rate Determination

- Pre weigh test units and write weight on underside of test units.
- Have Binder Spreader unit pull to level area (both across and down the length of the truck).
- Record starting gallons of asphalt binder taken from Spreader Truck tank gauge. Truck must be parked level for 1st and all subsequent readings. Using the same location is optimal
- Instruct the spreader operator not to pump additional binder onto or off the truck without taking readings.
- Record the temperature of the asphalt binder inside the tank.

12.6.3 Calibration

- Have binder application spray unit locate at starting point of tack coat placement.
- Instruct spreader operator to set the application rate of the spreader to the desired rate (e.g. 0.25 Gal/ yd^2).
- Place test unit(s) on pavement (minimum of one, maximum of three) directly in front of truck. If one, place in center of truck, if three place in center of truck and outside of wheel paths.
- Instruct the operator to proceed forward applying asphalt binder until the test unit(s) has been crossed with sprayed asphalt binder.

- Retrieve test units (show care handling hot asphalt coating) and re weigh.
- Subtract the original weight recorded on the underside of the sample from the gross weight including the sprayed asphalt binder.
- Compare resulting weight with binder weight application chart.
- If required, have operator adjust application rate up or down to reach desired rate.
- Retest if necessary until desired application rate is confirmed. (Note: the same testing units can be used repeatedly by simply recording new tare weights prior to a second application of binder).

12.6.4 Project Monitoring

- All rolls of paving interlayer materials should arrive at the job site in a plastic wrapper. This indicates the roll is complete and has been protected from sun and water. (If partial rolls are brought to the jobsite, these should be set aside and all placed at the same time as the length will have to be calculated to determine total square yardage). On partial rolls, the inspector can request one or two wraps of the exposed fabric to be removed to assure no ultraviolet degradation has occurred. The manufacturers tag each roll both outside on that wrapper as well as inside on the cardboard core. These tags provide all necessary information regarding the manufacturer, manufacturer tracking number, the weight per square yard, the width and length of that roll.
- If the inspector is not with the interlayer laydown operations at all times the spreader operator shall retain the tags as the rolls are applied, for determination of total square yards placed.
- At any time during the project the inspector can take another reading on the tank (truck must be level) at the completion of a full fabric roll.
- Subtract the current tank reading from the beginning to determine total gallons of paving grade asphalt binder placed.
- Retrieve the roll tags from the spreader operator to determine number of rolls installed.
- Multiply the number of rolls times the square yards in the roll to get total square yardage.
- Divide the total gallons of paving grade asphalt binder placed by the total square yards placed and determine tack coat application rate to that point.

12.7 TROUBLESHOOTING GUIDE

The following guide provides a summary of possible problems, typical causes and potential solutions associated with paving material interlayers (Table 12-11). The guide was primarily based on guidelines from the FHWA Pavement Preservation Checklist Series and manufacturers' installation guidelines. The troubleshooting guide for chip seals used as interlayers may be found in Chapters 6 and 7.

Table 12-1 Troubleshooting Guide for Interlayers

Problem	Causes and solutions
Wrinkles have formed during placement of a material interlayer	Cause: • Lay down equipment out of alignment or lack of tension on roll • Lay down equipment turned without stopping and cutting the interlayer • Equipment has turned on top of the interlayer • Broken or weak core causes sagging Solutions: • Make sure fabric applicator is driving straight; veering to the left or right can cause wrinkles • Check equipment for proper tension and alignment of the fabric roll • Minimize equipment traffic on interlayer • Insert metal bar inside fabric core to prevent fabric rolls from sagging
Vehicles and/or equipment tires are picking up, sticking to or tearing material interlayer	Cause: • High ambient temperatures • Over-application of binder (if this is the cause, reduce binder rate but do not go below the specified application rate) • Excess construction or public traffic on installed material Solution: • Broadcast hot mix asphalt or sand over interlayer (sweep up all sand prior to surface treatment) • Do NOT reduce tack coat below specified application rate • If problem is persistent in an area, switch to a modified asphalt tack coat • Repair damaged areas
Blisters form under material interlayer	Causes: • Pavement is wet and/or saturated Solution: • Roll the interlayer with a rubber-tire roller until it adheres to the pavement • Dry the rest of the pavement before continuing with interlayer installation • Install drainage if subgrade is saturated and not drying out
Paving fabric shrinks (edge curls) when laid on tack coat	• Cause: • Tack coat is too hot • Solution: • Cool tack coat before applying or wait longer before installing fabric or mat on tack coat
Material interlayer is not	Cause:

Problem	Causes and solutions
sticking to pavement	• Binder too cold • Insufficient Binder • Milled surface too rough • Material placed with wrong side down • Binder absorbed by leveling course or patch Solution: • Check binder temperature and application rate • Close gap between distributor and tractor • Add leveling course or patching • Ensure proper material placement
Binder not sticking to pavement	Cause: • Pavement is wet or dirty (dust/oil/etc) • Binder too cold Solution: • Clean and or dry the pavement • Check and adjust binder temperature

12.8 REFERENCES

Formal Complete Reference/Publications

Amanda Joy Bush, Eric W. Brooks, (2007), "Geosynthetic Materials in Reflective Crack Prevention", Performance Review SR537, Oregon DOT.

Amini, Farshad (2005) "Potential Applications of Paving Fabrics to Reduce Reflective Cracking," Report No. FHWA/MS-DOT-RD-05-174.

Brown, S.F., Thom N.H., University of Nottingham, Sanders P.J., TRL UK, "A study of grid reinforced asphalt to combat reflection cracking", Journal, AAPT, 2001 Annual Meeting.

Button, Joe W., and Robert Lytton, 1987. "Evaluation of Fabrics, Fibers, and Grids in Overlays," Sixth International Conference on Structural Design of Asphalt Pavements, University of Michigan.

Coppens, M. H. M., and Wieringa, P. A. (1993), "Dynamic testing of glass fiber grid reinforced asphalt." Proceedings, 3rd International RILEM Conference - Reflective Cracking in Pavements, E & FN Spon, 200-205.

Dave Ta-Teh Chang,1 Rui-Qi Lai,2 Jung-Yang Chang,2 and Yao-Hung Wang,2."Effects of Geogridin Enhancing the Resistance of Asphalt Concrete to Reflection Cracks", Flexible Pavement Rehabilitation and Maintenance, ASTM STP 1248, P. S. Kandhal and M. Stroup-Gardiner, Eds., American Society for Testing and Materials, 1998.

de Laubenfels, L., "Effectiveness of Rubberized Asphalt in Stopping Reflection Cracking of Asphalt Concrete, " (Interim Report), California Department of Transportation, FHWA/CA/TL-85/09, January 1988.

Doliges, D., and Coppens, M. H. M. (1996), "Fatigue Improvement of Asphalt Reinforced By Glass Fiber Grid," Proceedings, 4th International RILEM Conference - Reflective Cracking in Pavements, E & FN Spon, 387-392.

Epps, J.A. University of Nevada, Reno, Nevada, "Synthesis of Highway Practices 198: Uses of Recycled Rubber Tires in Highways." TRB/NCHRP, January 1994.

Fujian Ni, Yingmei yin, Xingyu Gu "Study on the Fatigue Properties Asphalt Mixtures with Fiberglass/Polyester Mat Reinforcements, Transportation Research Circular 05-5555, Transportation Research Board

Hicks, R. G., Lundy, James R., Epps, Jon A., "Life Cycle Costs For Asphalt-Rubber Paving Material." Rubber Pavements Association, Tempe, Arizona, April 1999.

Jaecklin, F. P. (1993), "Geotextile Use in Asphalt Overlays - Design and Installation Techniques for Successful Applications," Proceedings, 3rd International RILEM Conference - Reflective Cracking in Pavements, E & FN Spon, 100-117.

Joe Button, Robert Lytton, (2003), Guidelines for using Geosynthetics with HMA Overlays to Reduce Reflective Cracking, TxDOT

Kuo, C.M., (2003) "Traffic Induced Reflective Cracking on Pavements with Geogrid-Reinforced Asphalt Concrete Overlay," Transportation Research Circular 03-2370, Transportation Research Board

Marienfeld, M.L., and Baker, T.L., (1999) "Paving Fabric Interlayer as a Pavement Moisture Barrier," Transportation Research Circular E-C006, Transportation Research Board

Peggy L. Simpson; August 2006, "Asphalt Emulsion Technology" / Overview of Asphalt Emulsion Applications in North America, Circular Number E-C102, TRB.

Philip Vandermost; December 2003, "Emulsion Keeps Roadways from Crumbling" Public Works Magazine, Asphalt Maintenance

Philip Vandermost; October 2006, "Ahead of the Game" / Emulsion Scrub Seals Save County Dollars" Public Works Magazine, Asphalt Maintenance

Robert B. McCrea, P.E.; September 2004 "Cape Seals using Polymer Modified Rejuvenating Emulsions" APWA International Congress and Exposition, Atlanta, Ga.

Schnormeier, Russell Howard, "Fifteen Year Pavement Condition History of Asphalt Rubber Membranes in Phoenix, Arizona." Published by the Asphalt Rubber Producers Group, 1985.

Sebaaly, P., Gopal, V., G. and Troy K., University of Nevada, Reno, "Evaluation of Crumb Rubber Modified Paving Mixtures in Nevada", report 1197-02, 1997.

Sprague, C.J., (2006) "Study of the Cost-Effectiveness of Various Flexible Pavement Maintenance Treatments," Transportation Research Circular E-C098, Transportation Research Board

Thom, N.H., (March 2000), "A Simplified Computer Model for Grid Reinforced Asphalt Overlays". Proceedings, 4th International RILEM Conference - Reflective Cracking in Pavements in Practice.

Van Kirk, J.L., "The Effect of Fibers and Rubber on the Physical Properties of Asphalt Concrete," State of California, Department of Transportation, CA/TL-85/18, June 1986.

Van Kirk, Jack L., Holleran, Glynn, "Reduced Thickness Asphalt Rubber Concrete Leads to Cost Effective Pavement Rehabilitation." 1st International Conference World of Pavements, Sydney, Australia, February 20-24, 2000.

Informal Reference Materials & Presentations

County of Sacramento, Department of Transportation (2000), "Chip Seal Over Fabric, Excelsior Road"

Darling, JR. (1999), Performance Evaluation of GlasGrid® Pavement Reinforcement for Asphaltic Concrete Overlays (SUBJECT SITE: US 190, Hammond, LA),

Darling, JR. (1999), Performance Evaluation of GlasGrid® Pavement Reinforcement for Asphaltic Concrete Overlays (SUBJECT SITE: US 96, Lumberton, TX),

Davis, Lita, "Chip Sealing Over Fabric," (2003) GFR Magazine, June/July

Doty, Robert N., "Flexible Pavement Rehabilitation Using Asphalt-Rubber Combinations, A Progress Report," Presented at the 67th Annual Meeting of the Transportation Research Board, Washington, D.C., January 1988.

Epps, J.A., Sebaaly, P., Hand, A., University of Nevada, Reno, "Nevada Laboratory evaluation of Rubber Modified HMA Mixtures", 1998.

Guo, Z., and Zhang, Q. (1993), "Prevention of Cracking Progress of Asphalt Overlay with Glass Fabric,"

J.R. Darling1 and J.H. Woolstencroft2, (2004) "Fiberglass Pavement Reinforcements used in Dissimilar Climatic Zones for Retarding Reflective Cracking in Asphalt Overlays", RILEM Conference., Where and when

Jaecklin, F. P., and Scherer, J. (1996), "Asphalt Reinforcing Using Glass Fiber Grid, Glasphalt,"

Klesges, Robert C., "The Alternative: Asphalt-Rubber." Manhole Adjusting Inc. Document, 1990.

Lytton R.L. 1989, "Use of Geotextiles for Reinforcement and Strain Relief in Asphalt Concrete", Geotextiles and Geomembranes, Vol. 8, pp. 217-237.

Marvin, Steven R., "Pavement Investigation of Enterprise Street and Randolph Avenue within the City of Costa Mesa, California", August 2004.

Predoehl, Nelson H., "Performance of Asphalt-Rubber Stress Membranes (SAM) and Stress Absorbing Membrane Interlayers (SAMI) in California." California Department of Transportation, 1990.

Proceedings of the 3rd International RILEM Conference - Reflective Cracking in Pavements, E & FN Spon, 398-405.

Proceedings of the 4th International RILEM Conference - Reflective Cracking in Pavements, E & FN Spon, 268-277.

Reconstruction Alternatives, "The Three-Layer System Strategy." Manhole Adjusting Inc. Document, Published by the Asphalt Rubber Producers Group, 1989.

Robert B. McCrea, P.E. , Vijay Sinha P.E.; October 2007 "Cost Effective Resurfacing Treatment Using Scrub Seals as an Interlayer for Slurry Seals and Micro-Surfacing" Presentation at APWA Northern California Chapter 2007 Street Seminar, San Ramon CA.

Sebaaly, P., University of Nevada, Reno, "Evaluation of HMA Mixtures Manufactured with Terminal Blend Rubber Modified Binders", 2007.

Van Kirk, J.L., "An Overview of Caltrans Experience With Rubberized Asphalt Concrete," Presented at the 71st Annual Meeting of the Transportation Research Board, Washington, D.C., 1992.

Van Kirk, Jack. L., "Review of the Use of Crumb Rubber in Pavement Maintenance and Rehabilitation Strategies," Basic Resources Inc., Presented at a Meeting of the Rubber Division, American Chemical Society, Orlando, Florida, September 1999

Van Kirk, Jack, "Maintenance and Rehabilitation Strategies Using Asphalt Rubber Chip Seals", Proceedings, Asphalt Rubber 2003 Conference, Bresilia, Brazil, December 2-4, 2003.

Van Kirk, Jack, "Multi-Layer Pavement Strategies Using Asphalt Rubber Binder", Proceedings, Asphalt Rubber 2006, Palm Springs, California, October 25-27, 2006.

Van Kirk, Jack. L., "Caltrans Pavement Rehabilitation Using Rubberized Asphalt Concrete," California Department of Transportation, Rubber Division, American Chemical Society, Anaheim, California, May 1997.