NEW ALTERNATIVE PRIME COAT MATERIALS

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Prime Coat in Asphalt Pavements

1. What is prime coat?

2. What function does prime coat serve?

3. An understanding of the importance and function of prime coats begins with an understanding of flexible pavements as a whole.
Prime Coat in Asphalt Pavements

Cross section of a flexible pavement (Modified from Huang, 2004)
Prime Coat in Asphalt Pavements

Schematic Showing Prime Coat Penetration into Base with Photographic Inset Showing Actual Penetration in a Laboratory-Compacted Limestone Base
Prime Coat in Asphalt Pavements

Prime coat materials mainly consist of cutback asphalt, emulsified asphalt or polymer based chemicals.

- Cutback asphalt is manufactured by blending asphalt cement with petroleum solvent
- Emulsified asphalt consists of a suspension of asphalt cement in water
- In Texas the most commonly used prime coat materials are MC-30, AEP, EC-30, CSS-1H and SS-1H
Environmental Hazard of MC-30

• The most historically utilized prime material, worldwide, has been MC-30 (Ishai and Livneh, 1984).

• However, MC-30 contains petroleum solvent which emits volatile organic compounds (VOCs) and therefore causes pollution to the environment.

• MC-30 has been banned or restricted from use by many states now.

• For this reason, emulsions and polymer based materials are becoming more and more popular due to their less harmful effects on the environment.
Different prime coat types

Spray Prime (MC-30, AE-P)  Worked-in (Cut-in) Prime
Prime Coat in Asphalt Pavements

• Proper curing of prime coat is an important construction phase because an uncured prime coat can cause more base movement than an unprimed base.

• However, how application method and type of prime coat affect curing time is yet to be known.

• Some important properties of prime coat:
  • Penetration depth
  • Curing time
  • Strength
  • Impermeability
  • Environmental impact

• Systematic investigation on prime coat properties are also crucial to make informed decisions.
A research study sponsored by TPPC is conducted at TxDOT to investigate the properties of prime coat most commonly used in Texas.

Objective of the study:

• Determine the curing times of prime coats and how the application method affect curing time; understand prime coat’s characteristics of strength growth during curing phase.

• Compare the strength, permeability and penetration of the prime coats tested and also study the effect of application method on these properties.
Experimental Design for curing testing

• Prime coat is said to be cured completely when all of its solvent has evaporated.

• Thus, the amount of solvent evaporated verses time is studied in this research.

• The researcher also tracked the strength growth of primed base sample regularly and draw curves depicting weight loss and strength growth with time.

Material used:

• Base material: crushed limestone passing through sieve #10 retained on sieve #40, and passing through sieve #40 were mixed to make the base material
Experimental Design for curing testing

• Prime coat material:

<table>
<thead>
<tr>
<th>Prime Coat</th>
<th>Type</th>
<th>Suppliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC-30 (Medium Curing)</td>
<td>Cutback</td>
<td>Valero, TX</td>
</tr>
<tr>
<td>AEP (Asphalt Emulsion Prime)</td>
<td>Emulsified Cutback</td>
<td>Ergon, Waco, TX</td>
</tr>
<tr>
<td>EC-30 (Eco Cure)</td>
<td>Emulsion-Non bituminous</td>
<td>PrimeEco, TX</td>
</tr>
<tr>
<td>CSS-1H (Cationic Slow Setting Hard Base)</td>
<td>Emulsion</td>
<td>Ergon, Waco, TX</td>
</tr>
<tr>
<td>SS-1H (Slow-Setting Hard Base)</td>
<td>Emulsion</td>
<td>Ergon, Mt. Pleasant, TX</td>
</tr>
<tr>
<td>Top Seal Black</td>
<td>Polymer based Emulsion</td>
<td>Terra Pave International, TX</td>
</tr>
</tbody>
</table>

Application method:
• Two application methods were used and compared: spray and mixed-in.
• Application rate: 0.2 gallons per square yard.
• The amount of prime coat required for this experiment was determined to be 7.3 milliliters per square millimeter.
Specimen preparation procedure:

1. Prepare Circular Can.
2. Put 300 g of base material into the can.
3. Compact the soil.
4. Spray or mixed-in prime coat.
5. Expose the specimen to weather to cure.
6. Run analysis.
Tests to Determine Curing Time

• For each prime coat, samples were prepared using two application methods: spray and mixed-in.

• Weather information was collected using weather station in TxDOT.

• The curing of prime coat is assumed to end when the reduction in weight drops below 0.1 gram, or when the strength reaches its maximum value, whatever occurs later.
Tests to Determine Curing Time

- For spray-on type of application, the curing time of tested prime coats increases in the following order: TSB<EC-30<AEP=SS-1H=CSS-1H<MC-30.
- For mixed-in type of application, the curing time of tested prime coats increases in the following order: TSB< EC-30<AEP= SS-1H< <CSS-1H =MC-30.
Tests to Determine Curing Time

Result:

• The curing time of all the prime coats was mainly affected by temperature and temperature had a negative correlation with curing time.

• MC-30 cures the slowest, up to 240 hours. Curing time is the same for sprayed samples and mixed-in samples.

• Application methods (spray-on or mix in) have no significant impact on curing time for all the samples.
Strength Test

- The pocket penetrometer was used to determine the strength of cured specimens so that a comparative study of the strength of the prime coats could be performed.
Strength Test

**Unconfined Compressive Strength for different types of prime coat**

- For sprayed type of application, the unconfined compressive strength of tested prime coats increases in the following order: AEP<MC-30<EC-30<CSS-1H<SS-1H<TSB
- For mixed-in type of application, the strength of tested prime coats increases in the following order: AEP<MC-30< SS-1H<CSS-1H< EC-30<TSB.
**Strength Test**

- TSB mixed sample has the highest strength among all the tested prime coat materials – 4.5 kg/cm²
- AEP has the lowest strength among all the prime coat materials. For AEP spray samples the strength is 0.08 kg/cm² and the strength for mix-in type AEP prime coat is 0.225 kg/cm². It can barely provide any effectively support to the vehicle load.
- Application methods have significant impact on unconfined compressive strength – normally mixed-in type application has higher strength than sprayed-on type application.
- This is because by mixing prime coat with base soil, the pores inside the base are filled more effectively and a strong adhesive bond between fines and prime coat is formed and thus improving its load resistance.
Permeability Test

- One of the main purposes of prime coat is to seal the surface pores in the base and stop the moisture coming into the base.

- This study looks into how effectively each prime coat prevents water from penetrating into the base material.
The minimum permeability was measured for MC-30 for both mixed-in and sprayed specimens. The maximum permeability was shown by CSS-1H in the case of sprayed specimens and EC-30 in the case of mixed-in specimens.
Penetration Test

• Penetration is important as it determines how effectively and efficiently a prime coat can perform.

• Sand penetration tests were conducted according to the procedures that are commonly used by TxDOT.
Penetration Test

Cutting through the surface of the specimen to determine penetration depth

Cross section of the cut specimen depicting the penetration
Penetration Test

Penetration shown by asphalt emulsion

Penetration shown by cutback asphalt
Penetration Test

- The penetration obtained was the maximum for EC-30 and minimum for CSS-1H and SS-1H.
- Emulsions have very little penetration when compared to cutbacks or polymer based prime coats. It just cover the surface without penetrating into the base.
- The penetration values decrease in the following order: EC-30>MC-30=TSB>AEP>CSS-1H=SS-1H.
Summary and Ranking

• All prime coats are ranked from 1 to 5, with 1 being the best and 5 being the worst.
• The prime coat with the maximum strength, least permeability and most penetration will be ranked 1 in their respective categories.
• Curing times, strength and permeability values are averages for both mixed-in and sprayed specimens.
• TSB was not included in the comparison for curing time as the testing for TSB was done when the weather conditions were different from other prime coat specimen.
## Summary and Ranking

1 being the best for the intended purpose and 5 being the worst
* indicates a tied ranking

<table>
<thead>
<tr>
<th>Prime coat</th>
<th>Curing time</th>
<th>Dry Strength</th>
<th>Wet Strength</th>
<th>Permeability</th>
<th>Penetration</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC-30</td>
<td>5</td>
<td>5</td>
<td>2*</td>
<td>1*</td>
<td>2*</td>
</tr>
<tr>
<td>EC-30</td>
<td>2</td>
<td>2</td>
<td>3*</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>CSS-1H</td>
<td>4</td>
<td>3</td>
<td>3*</td>
<td>5</td>
<td>4*</td>
</tr>
<tr>
<td>SS-1H</td>
<td>3*</td>
<td>4</td>
<td>2*</td>
<td>3</td>
<td>4*</td>
</tr>
<tr>
<td>AEP</td>
<td>3*</td>
<td>6</td>
<td>3*</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>TSB</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1*</td>
<td>2*</td>
</tr>
</tbody>
</table>
Conclusion

Curing time of prime coats

- MC-30 cured the slowest and TSB cured the fastest.
- Curing times of the various prime coats increased in the order TSB<EC-30<SS-1H=AEP<CSS-1H<MC-30.
- The amount of solvent remained after curing was greater in the case of mixed-in application than in sprayed application.

Engineering properties of prime coats

- The maximum strength was exhibited by Top Seal Black (TSB) and the least strength was shown by AEP.
- The strength of prime coats tested ranged from 0.08 kg/cm² to 4.5 kg/cm² and increased in the following order: AEP<MC-30<SS-1H<CSS-1H<EC-30<TSB.
- All the mixed-in specimens showed higher strength than sprayed specimens.
Conclusion

Engineering properties of prime coats

• The minimum permeability was measured for MC-30 for both mixed-in and sprayed specimens.
• The maximum permeability was shown by CSS-1H in the case of sprayed specimens and EC-30 in the case of mixed-in specimens.
• All mixed-in specimens showed smaller permeability values when compared to sprayed specimens.
• For sprayed specimens, the permeability increased in the following order: MC-30<TSB<AEP<SS-1H<EC-30<CSS-1H
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