White Paper on

Comparison of Slurry Seal Products Used in Southern California

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Background:

Emulsion slurry seals are stable mixtures of emulsified asphalt, mineral aggregate, water, set control agents and latex. There are various types of these slurry seals that vary by type of asphalt emulsions used and the mixture design (proportions of emulsions to aggregates). This report is written compare four slurry seal products commonly used in southern California:

(1) Rubberized Emulsion Aggregate Seal (REAS),
(2) Tire Rubber Modified Slurry Seal (TRMSS),
(3) Conventional Emulsion Slurry Seal, and
(4) Rubber Polymer Modified Slurry Seal (RPMS)

The report objective is to challenge the claim that new products such as the (TRMSS) and the (RPMS) are equivalent to the well established and commonly used product called (REAS). REAS has been used in the field for many years and has performed much superior to conventional slurries. The challenge is based on comparing three important characteristics: (1) composition of emulsion, (2) amount of emulsion used, and (3) cost and rate of setting.

1. Comparing Composition of Emulsions Used

It is well recognized that the performance of slurry seals depends on the type of emulsion used. Table 1 compares the minimum emulsion residue (asphalt binder amount after water evaporated) and the minimum rubber required in the production of the emulsion. These values are taken from the draft specifications of the products as listed in the green book or as supplied by the producers. Three important observations can be made:

1.1 The REAS specifications require a minimum of 15.0 % to 26% residue content. This is more than <u>double</u> the amount of residue required for the TRMSS and the RPMS. It is logical to expect that this difference in residue will provide a much thicker film of binder to protect the aggregates and give more service life. It is also known that oxidative aging of asphalt binders is highly related to the film thickness. With almost double the film thickness of binders in the REAS, deterioration of the slurry caused by aging of binders in REAS will be much slower and less damaging.

1.2 The minimum residue required for the TRMSS and the RPMS is the same as the conventional slurry seal. It is thus believed that TRMSS and RPMS should be compared to the conventional seal rather than the REAS. It is known that REAS is much more superior product than the conventional

seal and thus comparing TRMSS/RPMS and REAS is not very logical form a durability and performance expectation.

1.3 Amount of recycled rubber incorporated in the asphalt binder is known to have significant effect on rheological and failure properties of binders. It is known that more rubber increases viscosity and elasticity, allowing seals to perform much better by resisting flow under high pavement temperatures and increased traffic loading. It is also known that more rubber increases toughness and strain tolerance at low pavement temperatures making seals more resistance to shrinkage cracking and to fatigue cracking. As shown in Table 1, The REAS contains more than double the amount of recycled rubber compared to the TRMSS and the RPMS. Although the relationship between amount of rubber and resistance to damage could be not linear, there is a wealth of literature that indicates increased rubber concentration results in significantly better performance.

1.4 It is thus difficult to accept the claims that TRMSS or RPMS can deliver the same performance as the REAS. The significant margin (more than double) of the residue and the amount of recycled rubber make these two products very different and cannot be expected to perform the same.

Table 1. Comparison of Emulsions used in REAS / TRMSS / RPMS/ Conventional Slurry Seal *

Minimum Emulsion Residue Content by Dry Aggregate Weight

	REAS	TRMSS	Conventional Slurry Seal	RPMS
Type I	26.00%	10.00%	10.00%	10.00%
Type II	17.00%	7.50%	7.50%	7.50%
Type III	15.00%	6.50%	6.50%	--

Minimum Recycled Tire Rubber Content By Dry Aggregate Weight

	REAS	TRMSS	Conventional Slurry Seal	RPMS
Type I	1.69%	0.65%	0.00%	0.575%+.20%*
Type II	1.11%	0.49%	0.00%	Same
Type III	0.98%	0.42%	0.00%	--

*: Addendum A specifies tire rubber content as 5% by volume of binder. Also, it requires 2% of binder SBR latex

2. Mixture Design of Slurry Seals

The proportioning of the emulsion to aggregates is an important design aspect of slurry seals. Higher emulsion content ensures better coating of the aggregates and thicker binder films that can provide better protection to the aggregates. This increased protection results in more resistance to moisture damage in wet climates, resistance to raveling under traffic action, and resistance to oxidative aging in warm climates. It is also believed that thicker films will reduce stress/strain in binder films allowing more resistance to fatigue cracking under traffic. Table 2 shows the minimum required emulsion content for the different seals. The following observations can be made:

2.1 The first observation is that the REAS require almost 2.9 times (~ 200% more) emulsion for type I than the TRMSS and RPMS, 2.4 times (~ 140% more) emulsion for type II, and 2.5 times (~150% more) emulsion than the TRMSS/RPMS. It is thus not realistic to compare these two products as equal due to such significant variation in the composition.

2.2 The second observation is that the requirements of the TRMSS, RPMS, and the conventional slurry seals are identical. Based on such designs, it appears more logical to compare the TRMSS and RPMS to the conventional design rather than the REAS.

Table 2. Comparison of Mixture Designs of REAS / TRMSS / RPMS/ Conventional Slurry Seal *

Minimum Emulsion Content by Dry Aggregate Weight

	REAS	TRMSS	Conventional Slurry Seal	RPMS
Type I	50.00%	17.00%	17.00%	17.00%
Type II	33.00%	14.00%	14.00%	14.00%
Type III	28.00%	11.00%	11.00%	--

2.3 Based on the mixture design (Table 2.) and the minimum residue required (See Table 1 above), it is estimated that the REAS after breaking and setting will contain residual binders almost 4 times (300% more) than the TRMSS, RPMS, and the conventional. It does not appear to be logical to compare these products as similar, or to expect same service lives. Although both products contain rubber, a difference of 300% in residual binder content, with more than double recycled rubber make these products very different.

3. Setting Rates, Cost and Life Expectancy

It is claimed that TRMSS and the RPMS, because they use a cationic emulsion, sets faster with all aggregates, more consistently, have a wider temperature application range, and costs about 25 % less than other rubberized slurry seals (Brochure from Pacific Emulsions). The following points offer challenges to these claims based on existing literature:

3.1 Based on the analysis presented in sections 1.0 and 2.0, it is clear that the cost reduction for the TRMSS and RPMS can only be achieved at the cost of inferior quality. Using less residue binder and less recycled rubber content without doubt put the quality of the slurry at risk. Considering the fact that there is more than 300% more residual binder and more than 100% more recycled rubber could imply that the TRMSS and RPMS products cost should be only a fraction of the production cost of REAS. It is also clear that the quality of TRMSS/RPMS is only a fraction of the REAS. Using simple calculation of cost of recycled rubber, asphalt binders and aggregates, one can estimate that reduction in cost for the TRMSS and RPMS, as compared to the REAS, should be more than 50 % less, not 25 % less than the REAS.

3.2 Rate of setting, consistency, and application temperature range are known to depend on many factors, not only the charge of emulsion as claimed by the producers of TRMSS and RPMS. Reviewing the TRB Circular 102 on asphalt emulsions, published in 2008, Table 3 includes some of the important factors that are considered to be important and how they are related to the REAS and TRMSS/RPMS.

Table 3. Cooments on Claims of Setting Rate and Consistency

Statements from TRB Circular 102	**Comments about REAS as Compared to TRMSS**
"Increasing or decreasing the asphalt cement content. Increasing the asphalt content will break an emulsion faster while decreasing the content will slow the set down."	It is imporant to note that REAS has much higher asphalt content than the TRMSS. Thus it is expecetd to set faster.
"Ambient and emulsion temperatures. Higher temperatures will cause an asphalt emulsion to break faster."	Selecting the appropriate temperature for application could be more important than using a different charge on the emulsion. Claiming that at all conditions a Cationic emulsion will set faster is not very scientific.
"Asphalt emulsion particle size and distribution. The finer the asphalt cement droples size and the smaller the dispersion will increase the setting time of an emulsion."	Again it is clear that charge of the emulsion is not the only factor and there are many other factors that affect setting rate.
"The use of additives can increase or decrease the breaking of an asphalt cement. In applications such as slurry seals, hydrated lime or portland cement is added to set the mixture faster."	REAS include the use of additives, such as cement to adjust the setting rate to an optimum time and conditions.

"Some aggregates, like carbonates, and fillers, like cement, may neutralize acid in cationic emulsions causing the pH to rise and the emulsion to be destabilized. Anionic emulsions may be destabilized by soluble multivalent ions. In practical situations too early coalescence of the asphalt droplets can hinder final curing by skin formation reducing the evaporation of water."	Using anionic emsulison make the risk of destabilization much less.

4. Conclusions

Based on detailed analysis of the characteristics of REAS and TRMSS/RPMS, the following conclusions can be drawn:

- These products are not equal and cannot be fairly compared due to significant differences in the composition of the emulsion and the proportions used in the mixture design.
- The claims in cost reduction are derived from significant reduction in binder content and recycled rubber content. Such reductions are known to cause reduction in quality and cause inferior performance in terms of resistance to moisture, traffic, and oxidation. Consider the performance factors one could postulate that the cost of TRMSS/RPMS should be much lower and more comparable to conventional slurry seals rather than REAS.
- The claims of faster setting and more consistency for the TRMSS are challenged by a number of important statements found in the most recently published TRB Circular 102. The claim that charge of the emulsion, by itself, is a good measure of setting and consistency is not supported by the information in this Circular written by experts in the field and endorsed by the TRB committee (AFK20) on bituminous binders.