1/ INTRODUCTION

The County of San Diego's Department of Public Works has found chip sealing over pavement reinforcing fabric as the most cost effective method for preventative maintenance for roads in the desert area of the County. This process is done to eliminate the need to crack seal the oxidized asphalt concrete surface, prevent premature aging of the roadways, and to extend the life of the roadways.

Chip sealing, which consists of the application of asphaltic emulsion and aggregate, is used to seal the roadway surface. The asphaltic emulsion prevents the penetration of water beneath the asphalt concrete surface which is known to cause potholes and further deterioration of the roadway. The aggregate used in a chip seal improves the surface friction course, also known as skid resistance, and provides an all-weather wearing surface.

The County of San Diego is responsible for maintaining 3,046 roadway kilometers (1,892 roadway miles). To maintain the roadways with the limited funds available, the County of San Diego has taken an active role in developing a Preventative Maintenance Program instead of allowing roads to deteriorate which would result in roads requiring resurfacing on a more frequent basis, and at a higher cost.

This Paper will be addressing the use of chip sealing over pavement reinforcing fabric in the desert region known as Borrego Springs. The County of San Diego's annual Borrego Springs chip seal over fabric contract ranges in value from $0.5 million to $1.5 million dollars.

2/ PROJECT INFORMATION

2/1 Where is the County of San Diego?

The County of San Diego is located in the southwest corner of the State of California and of the continental United States of America. Its geographical terrain consists of coastal lands, inland valleys, mountain ranges and desert regions. Elevations throughout the County, including the desert region, range from sea level to approximately 1,830 meters (6,000 feet).

2/2 Where is Borrego Springs?

Borrego Springs is located in the southeast quadrant of the San Diego County. It is bordered by the Cuyamaca Mountains to the west, the Santa Rosa Mountains to the north, Imperial County to the east and Interstate 8 to the south.

The County of San Diego maintains 3,046 roadway kilometers (1,892 roadway miles) in the desert region known as "Borrego Springs" which consist of circulation element roads (major roads) and non-circulation (minor) element roads. Circulation element roads account for 2,423 roadway kilometers (151 roadway miles) and non-circulation element roads (minor roads) account for 97 roadway kilometers (60 roadway miles).

This remote area of Borrego Springs is approximately 1.5 hours of driving time from the metropolitan area of San Diego.

2/3 The Need for Preventative Maintenance

County roadways are designated as either circulation or non-circulation element roads. Circulation element roads serve as arterial or major roads that carry traffic between major trip generators in unincorporated communities. Non-circulation element roads consist of residential collectors, cul-de-sacs or loop roads. Traffic volume in this remote desert region may reach 1,500 vehicles per day; however, roadway speed limits range from 40 to 90 KPM (25 to 55 MPH).

The County's Preventative Maintenance Program requires roadways be evaluated approximately every three years with the County Materials Laboratory's "Road Rating Deflection Survey" method. This method evaluates the structural integrity of the roadway and determines the type and thickness of the maintenance work needed. A visual inspection is also done to determine if any surface work is necessary. To qualify for preventative maintenance (chip sealing), the roadway must have a structural section in no need of repair.

The roadways that qualify for preventative maintenance are included in the County's annual chip seal over pavement reinforcing fabric contract. The County limits the size of its annual contract from 24 to 48 roadway kilometers (15 to 30 roadway miles). This is done to insure the work can be accomplished after Summer and before Winter, when optimum weather is present.

The County of San Diego advertises its annual contract in the Spring for public bidding by private contractors. The contract is awarded to the lowest responsive and responsible bidder.

2/5 Experimenting with Various Methods of Preventative Maintenance

Borrego Springs experiences scalding temperatures in the Summer and freezing temperatures in the Winter. Summer temperatures can reach 57°C (135°F), which results in pavement temperatures of 85°C (185°F). Because the asphalt surfaces are exposed to these extreme temperatures, it is not a surprise that cracking of the road surface is a constant maintenance problem.

Borrego Springs also experiences inclement weather. Because of the presence of water on the roadway surface, it is important to seal the cracks to prevent the intrusion of water into the underlying base material.

Conventional chip sealing alone is not longer done in the Borrego Springs area, due to the size of the surface cracks that are present on the road surface. Conventional chip sealing is appropriate to seal the road surface but cannot bridge the road surface cracks that expand and contract with the change of temperature throughout the year.

In 1987, the County of San Diego performed a study to place various types of roadway sealing products and evaluate which product performed well with the extreme weather conditions inherit to this desert area. These test sections were placed on Yaqui Pass Road and consisted of the following test sections:

Section 1	Chip Seal With 2-1/2% Latex Modified Emulsion
Section 2	Chip Seal With 5% Latex Modified Emulsion
Section 3	51 mm (2”) of Rolled Oil Mix (ROM) With Slow Curing (SC) 250 and Seal
Section 4	Chip Seal With Ground Rubber/Paving Asphalt Binder
Section 5	Chip Seal With 2-1/2% Latex Modified Emulsion Over Pavement Fabric
Section 6	Chip Seal With 5% Latex Modified Emulsion Over Pavement Fabric
Section 7	Double Fog Seal with 5% Latex Modified Emulsion

Each section was approximately 0.89 to 1.05 roadway kilometers (0.55 to 0.65 roadway miles) in length, and was placed the full width of the roadway to evaluate the impacts of traffic in both directions. The road itself consisted of flat to steep grade, and straight to winding sections of pavement.

There were two methods that performed well in addressing reflective surface cracks and sealing asphalt pavements located in the desert:

- Chip sealing over pavement fabric
- Chip sealing with ground rubber/paving asphalt binder

The width of the surface cracks determines which of the two methods performs best.

Chip sealing with ground rubber/paving asphalt binder, also known as a SAMI (stress absorbing membrane interlayer) performs very well on roads that do not have large cracks on the road surface. Should the road have large cracks, you will also need to crack seal the cracks if this method is to be placed successfully. If crack sealing is not done prior to its placement, the County has found crack sealing will be required approximately five years after placement due to reflective cracking from the underlying surface.

Should the road surface have large cracks present, then chip sealing over fabric was found a more cost effective method. No crack sealing is necessary for this method to be successful. Both of these methods are discussed in the Life Cycle Cost Analysis section of this Paper.

3/ PRODUCT PLACEMENT

3/1 Optimum Weather for Chip Sealing over Fabric

Borrego Springs ambient temperatures vary not only in a single day, but also year round. It is not uncommon for daytime and evening temperatures to have a variation of –7 to +10 degrees (Celsius) or 20 to 50 degrees (Fahrenheit).

Due to the natural characteristic of asphalt to “soften” as temperatures get warmer, it is critical to perform this work when ambient temperatures will be 43°C (110°F), or less.

Winter temperatures are too cool to place the chip seal successfully. Chip seals need ambient temperatures of 18°C (65°F) and pavement temperatures of 27°C (80°F), and rising. Summer temperatures are too high because of the 110°F ambient temperature limit. This leaves only the Fall and Spring available to do this work.

The County of San Diego plans this annual work after the peak of summer and before the onset of winter. Work is not performed in the Spring because it is best to have the asphalt materials (fabric binder, chip seal emulsion, fog seal emulsion) to age as long as possible before they are exposed to the extreme Summer temperatures. This leaves Fall as the only season when this work can be done with optimum success.

Work is advertised in late Spring - early Summer for private industry to place their bids. During the Summer, bids are evaluated and the contract is the awarded to the lowest responsive and responsible bidder to furnish and place the materials. Construction work typically occurs during the months of September – October – November when optimum temperatures are typically present. Because of the three-month window when construction work can be done, the County limits the size of its annual contract from 24 to 48 centerline kilometers (15 to 30 centerline miles).

3/2 Methods of Placement

The construction operation consists of placing three products: pavement reinforcing fabric, chip seal and fog seal. The method of how and when these products are placed depends on the traveling speed of the motoring public, not the volume of traffic.

Method 1 is used for high-speed roads and requires pilot car assisted traffic control to keep the motoring public at speeds of 40 KPH (25 MPH) during the placement of the fabric and chip seal. Method 1 consists of two phases:

Phase 1 – Apply paving asphalt, pavement reinforcing fabric and sand cover, followed by rolling to seat the fabric into the paving asphalt. Remove excess sand and follow with the application of a polymer modified asphaltic emulsion and screenings (chips), followed by rolling to seat the screenings into the emulsion. Remove excess screenings.

Phase 2 – Apply fog seal (50/50 mixture of asphaltic emulsion and added water with no polymer or rubber additives). Phase 2 is performed 7 to 14 days after Phase 1.

Method 2 is used on low-speed roads that do not require pilot car assisted traffic control.

Phase 1 – Apply paving asphalt, pavement reinforcing fabric and sand cover, followed by rolling to seat the fabric into the paving asphalt.

Phase 2 – Remove excess sand and follow with the application of a polymer modified asphalt emulsion and screenings (chips), followed by rolling to seat the screenings into the emulsion. Phase 2 is performed 5 to 10 days after Phase 1.

Phase 3 – Remove excess screenings. Apply fog seal (50/50 mixture of asphaltic emulsion and added water with no polymer or rubber additives). Phase 3 is performed 7 to 14 days after Phase 2.

4/ PRODUCT PERFORMANCE

As mentioned earlier in this paper, two methods of preventative maintenance performed well in the desert area - depending on the size of cracks on the road surface. Desert roads typically have cracks that are very wide in the cold months, as a result chip sealing with ground rubber/paving asphalt binder should be done when crack sealing is also done. Otherwise, to avoid spending funds on crack sealing, chip sealing over fabric should be done.

4/1 LIFE CYCLE COST ANALYSIS

Due to extreme desert temperature variations, cracking of road surfaces is a constant maintenance problem. The County's experience with testing various preventative maintenance methods shows crack sealing or placement of a fabric underlayment is necessary prior to the placement of a chip seal. Both methods eliminate the potential for the existing roadway surface cracks to travel through the new surface treatment. If the surface cracks are not dealt with prior to the surface treatment, the cracks will allow for moisture penetration into the paving causing more rapid deterioration of the pavement and the underlying sub-base.

Due to the size of surface cracks on roadway surfaces in Borrego Springs, the County of San Diego found chip sealing over pavement reinforcing fabric would be more cost effective. This study was done utilizing the following:

$2.25/square yard	Conventional Chip Seal
$1.00/square yard	Pavement Reinforcing Fabric (including binder)
$1.40/square yard	Crack Sealing
$3.50/square yard	Chip seal with ground rubber/paving asphalt binder
475,460 square yards	Size of project for comparison purposes
30-years	Life cycle

Assuming the 30-year life cycle for the following two methods:

Chip Seal with Ground Rubber/Paving Asphalt Binder

Year 1 –	Apply chip seal with ground rubber/paving asphalt binder	
	475,460 square yards @ $3.50/square yard	= $1,664,000
Year 5 -	Apply crack seal	
	475,460 square yards @ $1.40/square yard	= 665,644
Year 16 -	Apply chip seal with ground rubber/paving asphalt binder	
	475,460 square yards @ $3.50/square yard	= 1,664,000
	TOTAL =	$ 3,993,644
	Annual Cost =	$ 133,121

Convention Chip Seal Over Pavement Reinforcing Fabric

Year 1 -	Place fabric and apply conventional chip seal	
	475,460 square yards @ $2.25 + $1.00/square yard	= $1,545,000
Year 16 -	Apply conventional chip seal	
	475,460 square yards @ $2.25/square yard	= 1,070,000
	TOTAL =	$2,615,000
	Annual Cost =	$ 87,000