Job Report Cold Recycling

WR 2500: Foam recycling project, Canyon de Chelly / Arizona

Wirtgen Cold Recycling:

WR 2500: Canyon de Chelly FHWA foam recycling project

Mike Marshall, March 2003

1. Project outline

1.1 General

FHWA Central Federal Lands Denver invited Wirtgen to assist with the development of a mix design and work plan for the rehabilitation of sections of the Canyon de Chelly National Park road system using foam bitumen as the stabilization agent.

The sections to be rehabilitated by recycling with foamed bitumen were:

- Lodge Access Road
- Antelope House Overlook
- Sliding House Overlook
- Massacre Cave Overlook
- Mummy Cave Overlook
- Ledge Ruin Overlook

In total, approx 17.6 lane miles:

29,550 sqyds (24,710 sqm) x 5” (125 mm) deep
79,350 sqyds (66,350 sqm) x 8” (200 mm) deep

1.2 Traffic

The traffic analysis showed the Equivalent Standard Axle (ESAL) over the structural design period of 20 years to range from:

- South Rim Drive (Sliding House Overlook) 0,122 million ESAL’s
- North Rim Drive (Antelope House Overlook) 0.056 million ESAL’s

2. Pavement investigation

2.1 Subgrade support

The subgrade consisted of mainly clayey sands and silts and R-value tests conducted on the subgrade materials indicated a 75th percentile R-value of 30.

2.1 Pavement assessment

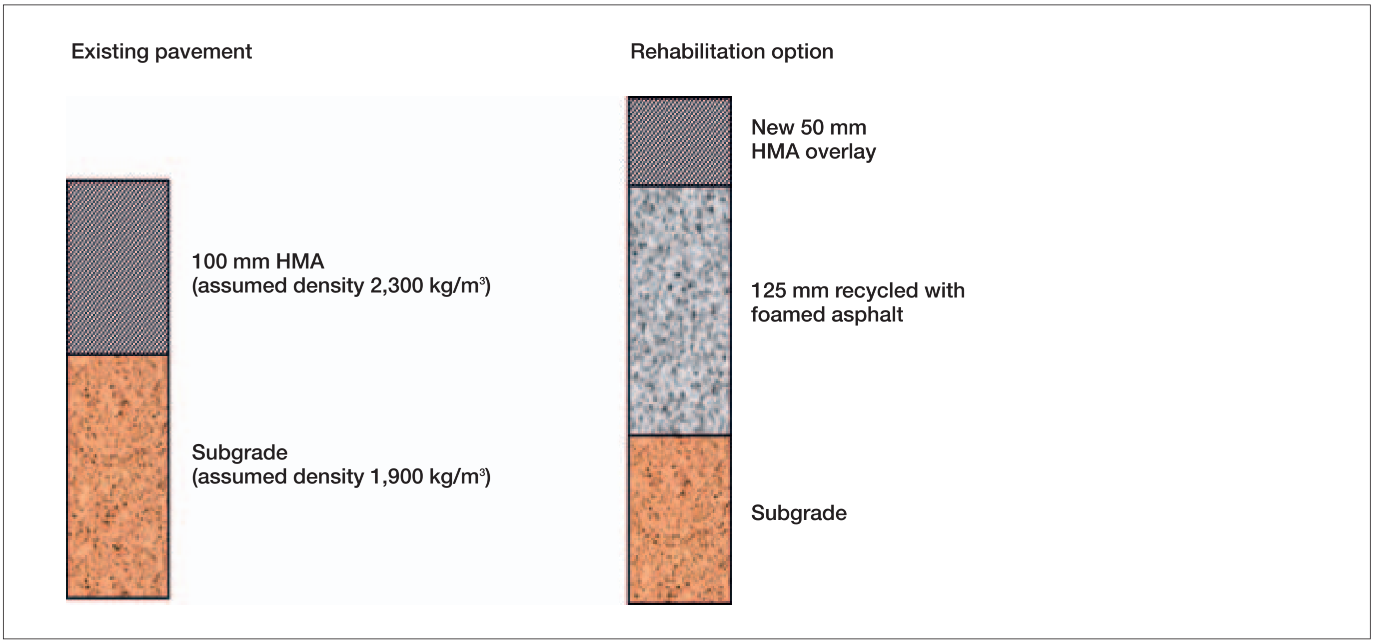
Investigation of the two sections of road shows the following pavements:

- South Rim – 100 mm chip seal and bituminous base on silty sand subgrade
- North Rim – 160 mm chip seal and bituminous base on sandy clay subgrade.

3. Determination of recycling thickness

The proposed structural number for a 20-year design for both sections of road is 1.88. The foamed asphalt mix designs were carried out with the intention to utilize as much of the existing pavement material as possible thereby reducing or eliminating the hot-mixed asphalt overlay requirement. The following strategies were adopted;

3.1 South Rim



The intention with this option was to make maximum use of the existing pavement materials but the poor quality subgrade material restricts the thickness of recycling and requires the hot-mixed asphalt overlay to obtain the required structural number.

3.1.1 Sample preparation

Samples of the HMA, granular base and subgrade were received. Since the base layer was not uniform along the section the granular base sample was discarded and only blends of the HMA and subgrade were used to simulate average pavement conditions. The HMA was softened by heating and broken down to its different fractions. No gradation was attempted on this sample.

The subgrade material was fairly sandy and therefore 50 mm of this material was incorporated into the blend. The gradation of the subgrade material is shown in Fig. 1 below.

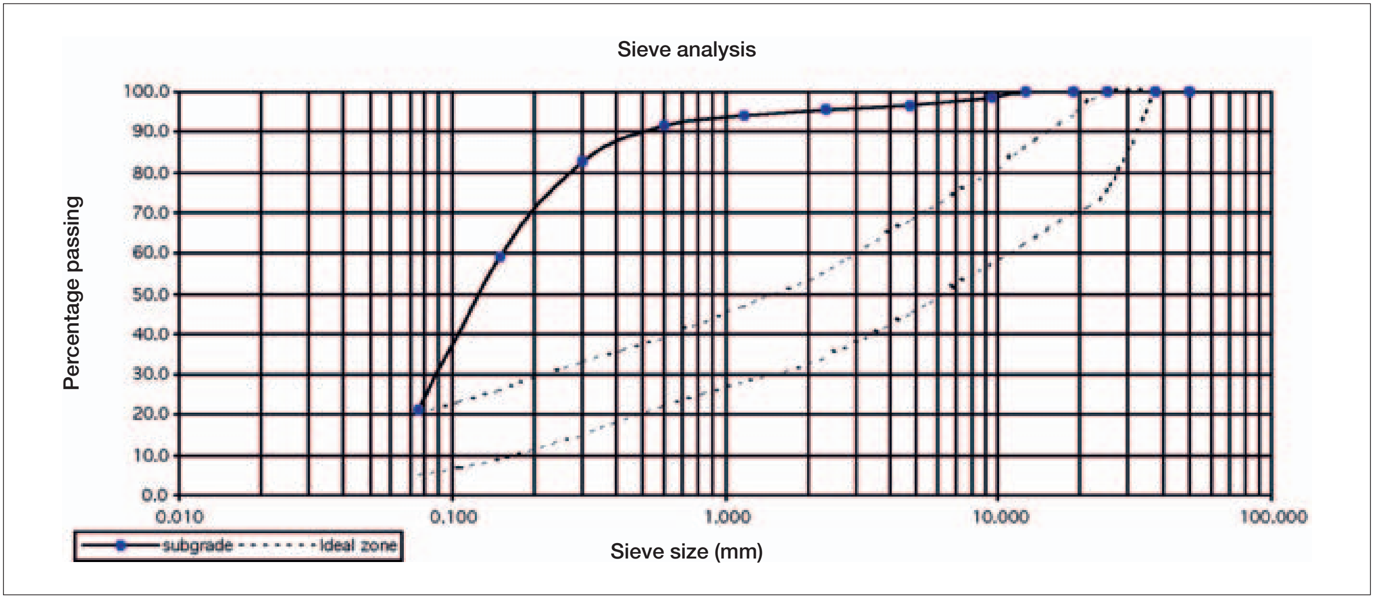


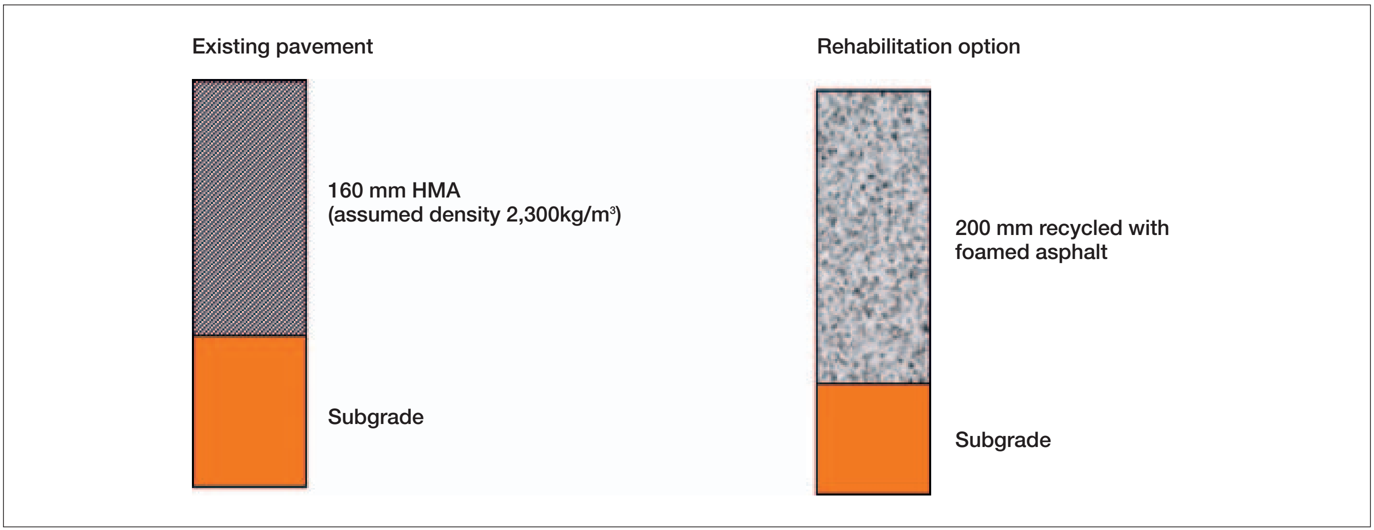
Figure 1: Gradation of subgrade material from South Rim Road

The materials were blended in proportion to layer thickness and assumed in situ density as follows;

Material	Per cubic metre (kg)	Per 10 kg sample (g)
HMA (100 mm @ 2,300 kg/m³)	230	7,100
Subgrade (50 mm @ 1,900 kg/m³)	95	2,900
Total mass	325	10,000

The samples were batched into 4 x 10 kg lots, 1 % cement and 3.5 % compaction moisture was added to each lot just prior to the addition of the foamed bitumen.

3.2 North Rim



The intention with this option was to utilise the full depth of existing asphalt pavement and include portion of the underlying subgrade in order to eliminate the hot mixed asphalt overlay.

The subgrade material is fairly fine graded; therefore the quantity was restricted to 40 mm.

3.2.1 Sample preparation

Samples of the HMA and subgrade were received. The gradation of the subgrade material showed the sample to be fairly fine and therefore the portion of subgrade material was restricted to 40 mm, which limited the percent passing the #200 sieve to approximately 10 % of the total blend of material. The gradation of the subgrade material is shown in Fig. 2.

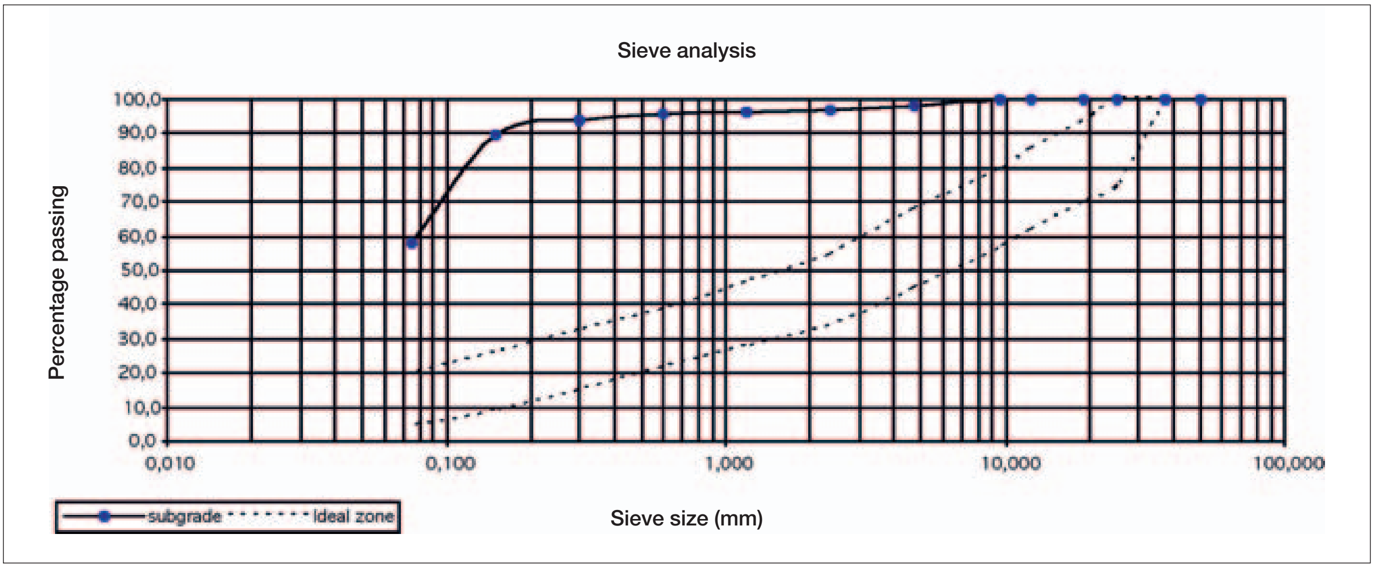


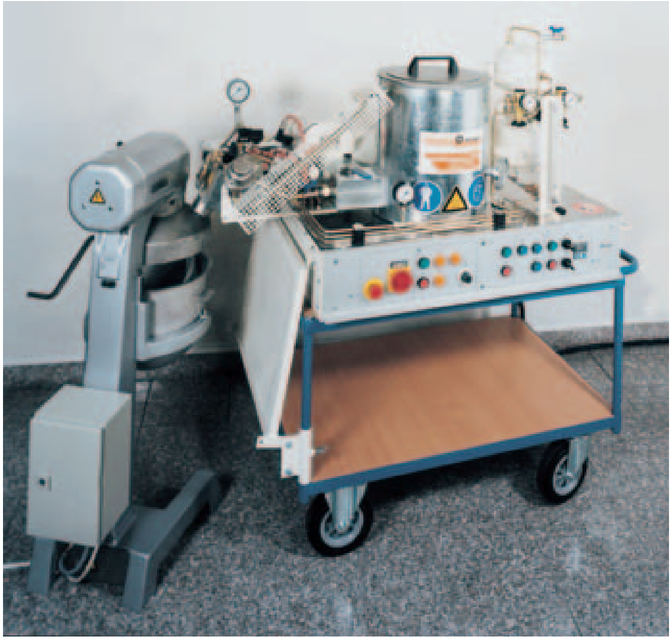
Figure 2: Gradation of subgrade material from Antelope Overlook Drive.

The materials were blended in proportion to layer thickness and assumed in situ density as follows;

Material	Per cubic metre (kg)	Per 10 kg sample (g)
HMA (160 mm @ 2,300 kg/m^3)	368	8,350
Subgrade (40 mm @ 1,800 kg/m^3)	72	1,650
Total mass	440	10,000

The samples were batched into 4 x 10 kg lots, 1 % cement and 3 % compaction moisture was added to each lot prior to the addition of the foamed bitumen.

4. Foamed bitumen mix design



Using a Wirtgen WLB 10 foam lab, foamed bitumen was added to representative samples of each design at 2.0, 2.5, 3.0 and 3.5 % foamed bitumen by mass of sample.

The cement was included to increase the percentage dust (fraction passing the #200 sieve), which is critical for the proper dispersion of the foamed bitumen.

The foamed bitumen stabilised samples were then compacted into 100mm diameter briquettes using Marshall compaction. The compacted briquettes were then placed in an oven at 40 deg C for curing. The briquettes were cured for a period of 3 days prior to testing. The briquettes were then tested for indirect tensile strength under dry and soaked (in water at ambient temperature for 24 hours) conditions. A summary of the tests can be found in the tables below.

Foamed asphalt added	2.0	2.5	3.0	3.5
Additive and percentage	1% cement	1% cement	1% cement	1% cement
Bulk density (kg/m^3)	2,045	2,064	2,062	2,056
ITS dry (kPa)	573	578	550	553
ITS soaked (kPa)	227	372	392	374
Retained ITS	40	64	71	68

The influence of the higher percentage of subgrade material can be seen in the soaked ITS strengths. The optimum foamed asphalt content required for this blend is approximately 3 %. The bulk densities and dry ITS strengths remain virtually constant. Based on the soaked strengths a structural coefficient of 0.26 can be assumed.

5. Recommendations

5.1 South Rim

The rehabilitation strategy recommended utilising existing pavement materials only was;

- 50 mm (2in) HACP (as per specifications in geotechnical report)
- 125 mm (5 in) recycle existing pavement applying 3 % ± 0.3 % (by mass) foamed bitumen and 1 % cement (by mass), shape and compact to minimum 98 % modified AASHTO (T180).
- Structural number = 2.16 (1½ x 0.44 + 6 x 0.26)

5.2 North Rim

- Chip seal as per standard specifications.
- 200 mm (8 in) recycle existing pavement applying 2.5 % ± 0.3 % (by mass) foamed bitumen and 1 % cement (by mass), shape and compact to minimum 98 % modified AASHTO (T180).
- Structural number = 2.8 (8 x 0.35)

6. Quality assurance testing

A quality assurance testing programme has to be set up to monitor recycled material quality during construction. The following tests should be carried out.

Test	Test method	Quantity	No of
Tests (minimum)			
Foaming characteristics	Visual	Per tanker	1
Compaction	AASHTO T191	Lot	6
Density – Moisture Content Relationship	Modified AASHTO T180	Lot	2
ITS Test	Appendix A – Wirtgen Manual	Lot	2

- **Foaming characteristics**

The recycler shall have a test nozzle attached to one side of the spray bar from which a quantity of foamed bitumen is injected into a straight sided container while recycling. The half-life is the measure of the time taken for the foamed bitumen to reach half the height of the maximum expansion noted in the container.

The container is then set aside for at least 1 hour or until the foamed bitumen has subsided completely and the unexpanded volume of the quantity of bitumen injected into the container is noted. The expansion ratio is the ratio of the maximum expansion to the unexpanded volume where the unexpanded volume is taken as one unit.

- **ITS Test**

Samples for the ITS test shall be taken immediately behind the recycler and sealed in such a manner that no moisture is lost from this material. If necessary, additional moisture is added to the sample to bring the sample to optimum compaction moisture and the required quantity of briquettes are compacted immediately. The briquettes are then cured as specified in the test method prior to testing. The minimum ITS values recommended for these segments are;

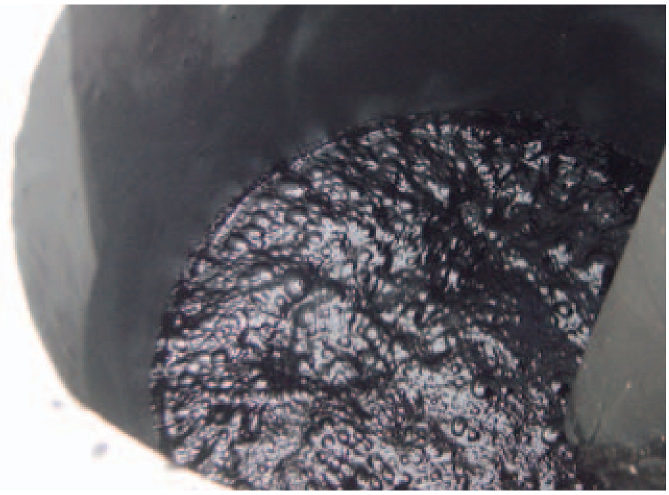
South Rim	Dry ITS	400 kPa
	Soaked ITS	300 kPa
North Rim	Dry ITS	600 kPa
	Soaked ITS	500 kPa

7. Recycling process

Prior to recycling all vegetation is cleared from the road edge using the motor grader blade.

As specified in the mix design 1 % cement is spread onto existing pavement.

A sample of foamed bitumen is taken from the side test nozzle of the WR 2500.



A foam sample injected into the container is checked for:

- Expansion ratio
- Half life

Once the foaming characteristics of the bitumen have been verified against mix design requirements, the recycling process can commence.

The recycling train consists of:

- WR 2500 recycler
- Bitumen supply tanker
- Water cart

The WR 2500 recycler pushes the oil tanker and pulls the water cart.

The WR 2500 recycler simultaneously:

- Pulverises the pavement
- Mixes in the cement
- Adds 3.0 % foamed bitumen
- Adds required amount of moisture for compaction
- Maintains the required depth

Where cracks in the pavement are full depth it is essential that the recycler be capable of cutting through the existing asphalt into the base, thereby eliminating any possible reflective cracking in the future.

A vibrating padfoot compactor follows immediately behind the WR 2500 for initial compaction of the recycled material.

Following the initial compaction, a motor grader is used to cut the recycled material to the desired levels.

A steel drum vibrating compactor follows the motor grader after the final levels have been cut.

The required densities should be achieved after the required number of passes with the steel drum compactor.

The finished compacted sections are lightly watered.

While the finished compacted recycled material is moist, a pneumatic tyred roller is used to achieve surface finish. The rolling action of the tyres creates a “slush” bringing fines to the surface which form a closely knit surface for traffic to run on. At this stage the recycled section can be immediately opened to traffic.

8. Before & after views

Full depth cracking through the asphalt pavement.

The recycler cuts through the asphalt into the base eliminating the crack.

Typical views of the pavement condition prior to recycling.

Recycled pavement finish shaped and compacted prior to overlay.

9. Comparison design results versus field results

9.1 Design results

See quality assurance section 6.
"The minimum ITS values recommended for these segments are";

South Rim	Dry ITS	400 kPa
	Soaked ITS	300 kPa
North Rim	Dry ITS	600 kPa
	Soaked ITS	500 kPa

9.2 Field results

Average 1st 6 briquette samples from field

Dry ITS	775 kPa
Soaked ITS	628 kPa

Average 2nd 6 briquette samples from field

Dry ITS	653 kPa
Soaked ITS	571 kPa

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