FEAP-UG-96/01

March 1996

MP GL-96-7

FEAP

FACILITIES ENGINEERING APPLICATIONS PROGRAM

USER'S GUIDE

User's Guide: Resin Modified Pavement

by

Gary L. Anderton
U.S. Army Engineer Waterways Experiment Station
Vicksburg, MS 39180-6199

Approved For Public Release; Distribution Is Unlimited

EHSC WES DEH CRREL CERL PARTNERS IN PROGRESS

U.S. Army Center for Public Works
Alexandria, VA 22310-3860

Innovative Ideas for the Operation, Maintenance, & Repair of Army Facilities

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1.AGENCY USE ONLY *(Leave blank)*	2.REPORT DATE	3.REPORT TYPE AND DATES COVERED
	March 1996	Final report

4.TITLE AND SUBTITLE
User's Guide: Resin Modified Pavement

5.FUNDING NUMBERS

6.AUTHOR(S)
Gary L. Anderton

7.PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Engineer Waterways Experiment Station,
3909 Halls Ferry Road,
Vicksburg, MS 39180-6199

8.PERFORMING ORGANIZATION REPORT NUMBER
Miscellaneous Paper
GL-96-7

9.SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Center for Public Works
7701 Telegraph Road
Alexandria, VA 22310-3860

10.SPONSORING/MONITORING AGENCY REPORT NUMBER
FEAP-UG-96/01

11.SUPPLEMENTARY NOTES

12a.DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b.DISTRIBUTION CODE

13.ABSTRACT *(Maximum 200 words)*

Resin modified pavement (RMP) is a composite pavement surfacing that uses a unique combination of asphalt concrete (AC) and portland cement concrete (PCC) materials in the same layer. The RMP material is generally described as an open-graded asphalt concrete mixture containing 25- to 35-percent voids which are filled with a resin modified portland cement grout. The RMP layer is typically 50 mm (2 in.) thick and has a surface appearance similar to a rough-textured PCC.

This report includes discussions of the description, applications, benefits, limitations, costs, and recommended uses for RMP. A fact sheet and guide specification are included in the appendices of this report.

14.SUBJECT TERMS

Asphalt concrete	Open-graded asphalt concrete	Salviacim
Cement grout	Portland cement concrete	
Composite pavement	Resin modified pavement	
Flexible pavement	Rigid pavement	

15.NUMBER OF PAGES
58

16.PRICE CODE

17.SECURITY CLASSIFICATION OF REPORT	18.SECURITY CLASSIFICATION OF THIS PAGE	19.SECURITY CLASSIFICATION OF ABSTRACT	20.LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED		

Contents

List of Figures

List of Tables

1 Executive Summary

Description

Resin modified pavement (RMP) is a composite pavement surfacing that uses a unique combination of asphalt concrete (AC) and portland cement concrete (PCC) materials in the same layer. The RMP material is generally described as an open-graded asphalt concrete mixture containing 25- to 35-percent voids which are filled with a resin modified portland cement grout. The open-graded asphalt mixture and resin modified cement grout are produced and placed separately. The open-graded mixture is produced in a typical asphalt concrete plant and placed with standard asphalt paving equipment. After the open-graded layer has cooled, the slurry grout is poured onto the porous surfacing and vibrated into the internal voids. The RMP layer is typically 50 mm (2 in.) thick and has a surface appearance similar to a rough-textured PCC.

Applications

The RMP process is applicable to new pavement construction as well as rehabilitation of existing pavement structures. A new RMP layer may be placed as an overlay over existing flexible or rigid pavements. The RMP is suitable to carry heavy and abrasive traffic loads and it is resistant to damage from fuel and chemical spills. Successful RMP applications are documented for various low-speed traffic areas, such as airport aprons and taxiways, low-speed roadways, industrial and warehouse floorings, fuel depots, railways stations, and port facilities.

Benefits

RMP provides a tough and durable pavement surface that resists rutting caused by heavy channelized traffic loads, surface abrasion caused by tracked vehicle traffic, and deterioration due to fuel spillage. The jointless surface is simple to construct and requires little to no maintenance effort. Performance records in the United States indicate that RMP is suitable for practically any environmental condition.

Limitations

RMP should only be used for relatively low-speed traffic applications. The surface texture can be irregular, resulting in areas of variable skid resistance. The irregular surface texture can also be unsightly when compared to a typical PCC surfacing with a relatively uniform surface texture. Construction experience is somewhat limited, which causes paving production rates to start off slowly at the beginning of most projects.

Costs

The cost of a 50-mm-thick RMP layer is currently about $9.60 to 19.20 per square meter ($8 to 16 per square yard) as compared to a typical cost of $3.60 to 6.00 per square meter ($3 to 5 per square yard) for a 50-mm-thick layer of dense-graded AC. The initial cost of a full-depth RMP design is generally 50 to 80 percent higher than a comparable AC design when considering a heavy-duty pavement. A more important cost comparison is between the RMP design and the rigid pavement design, since the RMP is usually used as a cost-saving alternative to the standard PCC pavement. In the case of a standard military heavy-duty pavement application, the RMP design is generally 30 to 60 percent less in initial cost than a comparable PCC pavement design. In many circumstances, the RMP also provides cost savings from reduced or eliminated maintenance efforts when compared to other pavement surfacing alternatives.

Recommendations for Use

RMP is recommended for any newly constructed or rehabilitated pavement carrying low-speed traffic (less than 65 kilometer/hr or 40 mile/hr). RMP can be an ideal cost-saving alternative to PCC pavements where resistance to heavy loads, tracked vehicle traffic, or fuel spillage is required. The available guide specification should be followed closely and the recommended quality control practices should be followed at all times during construction.

Points of Contact

Points of contact regarding this technology are:

Technical:

Director
U.S. Army Engineer Waterways Experiment Station
ATTN: CEWES-GP-Q (Mr. Gary L. Anderton)
3909 Halls Ferry Road
Vicksburg, MS 39180-6199
Telephone: 601-634-2955
Facsimile: 601-634-3020

or

Director
U.S. Army Engineer Waterways Experiment Station
ATTN: CEWES-GP-Q (Dr. Randy C. Ahlrich)
3909 Halls Ferry Road
Vicksburg, MS 39180-6199
Telephone: 601-634-3367
Facsimile: 601-634-3020

U.S. Army Center for Public Works:

Commander
U.S. Army Center for Public Works
ATTN: CECPW-ER (Mr. A. Michael Dean)
7701 Telegraph road
Alexandria, VA 22310-3860
Telephone: 703-806-5995
Facsimile: 703-806-5219

2 Preacquisition

Description of Resin Modified Pavement

RMP is a relatively new type of pavement process in the United States that uses a unique combination of AC and PCC materials in the surface layer. The RMP layer is generally described as an open-graded AC mixture containing 25- to 35-percent voids which are filled with a resin modified cement grout. The open-graded asphalt mixture and resin modified cement grout are produced and placed separately. The RMP is typically a 50-mm-thick layer placed on top of a flexible pavement substructure when newly constructed. This same thickness may be placed on existing flexible or rigid pavement structures as well. RMP provides performance benefits attributable to both its AC and PCC material properties at a cost somewhere between the typical AC and PCC ranges.

The open-graded asphalt mixture is designed to be the initial "skeleton" of the RMP. A coarse aggregate gradation with very few fines is used along with a low asphalt cement content (typically 3.5 to 4.5 percent by total weight) to produce 25- to 35-percent voids in the mix after construction. The open-graded asphalt mixture can be produced in either a conventional batch plant or drum-mix plant and is placed with typical AC paving equipment. After placing, the open-graded asphalt material is smoothed over with a minimal number of passes from a small (3-tonne maximum) steel-wheel roller.

The resin modified cement grout is composed of fly ash, silica sand, cement, water, and a cross polymer resin additive. The resin additive is generally composed of five parts water, two parts cross polymer resin of styrene and butadiene, and one part water-reducing agent. The slurry grout water/cement ratio (w/c) is between 0.65 and 0.70, giving the grout a very fluid consistency. The cement grout material can be produced in a conventional concrete batch plant or a small portable mixer. After the asphalt mixture has cooled, the slurry grout is poured onto the open-graded asphalt material and squeegeed over the surface. The slurry grout is then vibrated into the voids with the 3-tonne vibratory steel-wheel roller to ensure full penetration of the grout. This process of grout application and vibration continues until all voids are filled with grout.

Depending upon the specific traffic needs, the freshly grouted surface may be hand broomed or mechanically textured to improve skid resistance. Spray-on curing compounds, typical to the PCC industry, are generally used for short-term curing. The new RMP surfacing usually achieves full strength in 28 days, but it may be opened to pedestrian traffic in 24 hours and light automobile traffic in 3 days.

Background

The RMP process was developed in France in the 1960's as a fuel and abrasion resistant surfacing material. The RMP process, or Salviacim process as it is known in Europe, was developed by the French construction company Jean Lefebvre Enterprises as a cost-effective alternative to PCC (Roffe 1989a). RMP has been successfully marketed throughout France as a pavement and flooring material in numerous applications. By 1990, Jean Lefebvre Enterprises had successfully placed over 8.3 million square meters (10 million square yards) of Salviacim pavement in France (Jean Lefebvre Enterprise 1990). Today, RMP is an accepted standard paving material throughout France.

Soon after the RMP process became successful in France, its use in other countries began to grow. In the 1970's and 1980's, RMP usage spread throughout Europe and into several countries in Africa, the South Pacific, the Far East, and North America (Ahlrich and Anderton 1991a). Twenty-five countries around the world had documented experience with RMP by 1990 (Jean Lefebvre Enterprise 1990).

The earliest documented experience with RMP in the United States occurred in the mid-1970's when the U.S. Army Engineer Waterways Experiment Station (WES) conducted limited evaluations of an RMP test section constructed in Vicksburg, MS (Rone 1976). The study was conducted to evaluate the effectiveness of the new surfacing material to resist damage caused by fuel and oil spillage and abrasion from tracked vehicles. The evaluation results indicated that the effectiveness of the RMP was very construction sensitive, and if all phases of design and construction were not performed correctly, the RMP process would not work.

In 1987, the U.S. Army Corps of Engineers tasked WES to reevaluate the RMP process for potential military pavement applications, since the field experiences in Europe continued to be positive and improved materials and construction procedures had been reported. WES engineers conducted literature reviews, made site evaluations in France, Great Britain, and Australia, and constructed and evaluated a new test section at WES (Ahlrich and Anderton 1991b). The results of this evaluation were favorable, prompting pilot projects at several military installations in the following years. The Federal Aviation Administration (FAA), also eager to develop an alternative paving material technology, used the positive WES experiences and preliminary guidance to construct several pilot projects at commercial airports (Ahlrich and Anderton 1993). Today, the RMP process is recommended as an alternative pavement surfacing material by the U.S. Army, the U.S. Air Force, and the FAA.

Applications

RMP may be used in new pavement construction or in the rehabilitation of existing pavement structures. A new RMP surfacing may be placed as an overlay over existing flexible or rigid pavements. RMP is typically used as a low-cost alternative to a PCC rigid pavement or as a means of improving the pavement performance over an AC surfaced flexible pavement. Field experience indicates that RMP may be used in practically any environmental conditions.

In general, the RMP is best suited for pavements that are subjected to low-speed traffic that is channelized or abrasive by nature. Pavement areas with heavy static point loads and heavy fuel spillage are also ideal RMP application candidates. The RMP process has been used in a variety of applications on the international market, including airport and vehicular pavements, industrial and warehouse floorings, fuel depots and commercial gasoline stations, city plazas and malls, railway stations, and port facilities. Since its first commercial application in the Unites States in 1987, RMP has been used mostly on airport and airfield pavement projects. A listing of the known RMP projects in the United States is given in Table 1.

Design Methods

The current practice for designing the RMP layer thicknesses involves a simple adaptation of the standard Corps of Engineers (CE) flexible pavement design method (Headquarters, Departments of the Army and Air Force 1989 and 1992). The pavement is designed as if it were a typical dense-graded AC surfaced pavement, and then the top 50 mm of AC is substituted with an equal thickness of RMP. Equating the RMP material with AC undoubtedly renders an over-designed pavement in terms of the strength and durability provided by the surfacing. A recent study conducted under the Strategic Highway Research Program (SHRP) on potential new bridge deck materials showed that the RMP material had approximately a two-fold increase in Marshall stability, indirect tensile strength, and resilient modulus when compared to a typical high-quality AC material (Al-Qadi, Gouru, and Weyers 1994). Even with the new SHRP results, there are not enough data on the engineering properties of the RMP to develop a suitable mechanistic design methodology. Until such a mechanistic design method is developed, the current method of adapting the results of the standard CE flexible pavement design will continue to be used.

Table 1
RMP Project Locations in the United States

Location	Area (m^2)	Date of Construction
Newark Airport, NJ (Aircraft Apron)	420	May 1987
Springfield, VA (GSA Parking Lot)	1,670	Oct 1988
Vicksburg, MS (WES Test Section)	835	Aug 1989
Orange County, CA (Aircraft Taxiway)	8,350	Oct 1990
Tampa International Airport, FL (Aircraft Apron)	3,350	Jan 1991
Miami International Airport, FL (Aircraft Apron)	3,350	Jan 1991
Concord, CA (Port Facilities)	4,170 4,170 70,000	Jun 1991 Oct 1993 1995
McChord AFB, WA (Loading Facilities)	8,350	Aug 1991
Fort Campbell AAF, KY (Aircraft Apron)	6,250	Aug 1992
Malmstrom AFB, MT (Fuel Storage Areas)	10,835	Jun 1993
Fort Belvoir, VA (Loading Facilities)	8,350	Jun 1994
Pope AFB, NC (Aircraft Aprons)	29,170	Jun 1994
Altus AFB, OK (Aircraft Taxiway)	10,500	Jun 1995

RMP has been successfully constructed as an overlay material over rigid and flexible pavements as well as in original construction. No transverse or longitudinal joints are required for original, full-depth RMP designs, although joints have been cut in RMP when overlaying jointed concrete pavement. Pavement joints are required between RMP and adjacent PCC pavements but are not required between RMP and adjacent AC pavements. These joints are constructed by saw cutting to the bottom of the RMP layer, once the RMP material has sufficiently cured, and then filling the joint with a sealant material suitable for the particular site conditions.

Materials

Open-graded AC

Aggregates. The aggregates used in the open-graded AC must consist of sound, tough, durable particles crushed and sized to provide a relatively uniform gradation. The aggregates are tested against standard Los Angeles abrasion, sodium sulfate soundness, percent fractured faces, and percent flat and elongated requirements (Headquarters, Department of the Army 1993). These requirements help to ensure a stable, open-graded asphalt layer with a high internal void structure. The general requirement is 25- to 35-percent voids in the compacted mixture. Any amount less than this might not allow the slurry grout to fully penetrate the open-graded mixture, resulting in a structurally unsound surface course which would likely deteriorate under traffic rather quickly. Void contents greater than this amount would increase the cost of the pavement without providing significant structural improvements and could also reduce the pavement strength by eliminating some of the aggregate to aggregate interlock.

Asphalt cement. The type or grade of asphalt cement used in the open-graded AC is not very critical, since the asphalt cement has a limited role in the pavement's performance once the slurry grout has filled all of the void spaces. The asphalt cement is required to be a paving grade material, however, with an original penetration of 40 to 100. Asphalt cements within this penetration range are typically categorized by American Society for Testing and Materials (ASTM) D 3381 as an AC-10, AC-20, or AC-30 viscosity grade (ASTM 1995a). These asphalt cement grades are generally considered to be of medium viscosity. Lower viscosity asphalt cements could drain off of the large aggregates during mixing and transporting, which would reduce the permeability of the open-graded layer and hinder grout penetration. Asphalt cements stiffer (or higher viscosity grade) than the specified range might not allow for sufficient coating of the aggregates with the typical low asphalt contents used.

Mix design. The object of the open-graded AC mix design is to determine an aggregate gradation and asphalt content which will provide a compacted layer containing 25- to 35-percent voids. Sieve analyses of proposed aggregate stockpiles provide the necessary information for an aggregate gradation design. The gradation requirements of the final blended aggregates to be used in the open-graded mixture are given in Table 2.

An estimate of the optimum asphalt content is made to determine a suitable range of asphalt cement contents for a subsequent laboratory analysis. The asphalt content estimate is made using a design equation based on aggregate properties (Roffe 1989b). The design equation is as follows:

Table 2
Open-Graded Mixture Aggregate Gradation

Sieve Size	Percent Passing by Weight
19 mm (3/4 in.)	100
12.5 mm (1/2 in.)	54-76
9.5 mm (3/8 in.)	38-60
4.75 mm (No. 4)	10-26
2.36 mm (No. 8)	8-16
600 μm (No. 30)	4-10
75 μm (No. 200)	1-3

$$\text{Optimum asphalt content} = 3.25\ \alpha\ \Sigma^{0.2}$$

where

α = 2.65/SG

SG = apparent specific gravity of the combined aggregates

Σ = conventional specific surface area
= 0.21G + 5.4S + 7.2s + 135f

G = percentage of material retained on 4.75 mm sieve

S = percentage of material passing 4.75 mm sieve and retained on 600 μm sieve

s = percentage of material passing 600 μm sieve and retained on 75 μm sieve

f = percentage of material passing 75 μm sieve

Once the optimum asphalt content is estimated using this equation, two asphalt contents below this amount and two asphalt contents above this amount are used, along with the estimated optimum, in the laboratory production and evaluation of 75-mm (6-in.) diameter Marshall specimens. The open-graded AC specimens are compacted with 25 blows from a 4.5-kg (10-lb) Marshall hand hammer on one side of each specimen. The temperature of the laboratory produced asphalt mixture during compaction is usually around 121°C (250°F). After the laboratory specimens have been compacted and cooled, they are weighed in air and water to determine bulk density and void contents. The optimum asphalt content is typically selected where the resulting void content is nearest to 30 percent.

Resin modified grout

Standard ingredients. The standard ingredients in the resin modified grout include four materials common to PCC production: portland cement, sand, fly ash, and water. No special requirements on portland cement are necessary for a quality grout. A Type I cement should be used unless special conditions require another cement type. A clean, sound, durable, and angular silica sand with a gradation between the 1.18 mm (No. 16) sieve and 75 μm (No. 200) sieve is specified to provide a high quality sand that will stay in suspension in the grout during mixing and application. An ASTM C 618 Type F or "nonhydraulic" fly ash (ASTM 1995b) is used to help provide a consistent grout viscosity without speeding up the grout's rate of setting. Water is added to the grout in an amount that renders a w/c ratio from 0.65 to 0.70. The allowable tolerances for the resin modified grout mix proportions are given in Table 3.

Table 3
Resin Modified Cement Grout Mixture Proportions

Material	Percent by Weight
Type I Cement	34-40
Silica Sand	16-20
Fly Ash	16-20
Water	22-26
Resin Additive	2.5-3.5

Resin additive. The resin additive used in the slurry grout is a proprietary material produced in the United States by the Alyan Corporation under the international trade name Prosalvia-7 or PL7. The additive is generally composed of five parts water, two parts of a cross polymer resin of styrene and butadiene, and one part water reducing agent. The additive significantly aids the construction process by acting as a super-plasticizer in reducing the grout viscosity. The reduced grout viscosity allows the grout to fully penetrate the open-graded asphalt concrete layer more easily. The additive also increases the flexural and compressive strength of the hardened grout, improves the grout's chemical and abrasion resistance, and reduces the grout's permeability after curing.

Mix design. The goal of the slurry grout mix design is to determine the proportions of mix ingredients that will produce a slurry grout of the proper viscosity. Grout viscosity is measured by the Marsh flow cone (schematically shown in Figure 1). The Marsh flow cone is used to measure the time of flux of 1 L (0.264 gal) of grout through the cone. A high flow-time (too thick or viscous) grout does not penetrate the open-graded asphalt layer completely, while a low flow-time grout may not gain sufficient strength and may promote excessive shrinkage cracking and segregation. Grouts with an acceptable initial viscosity will have a flow time between 7.0 and 9.0 sec.

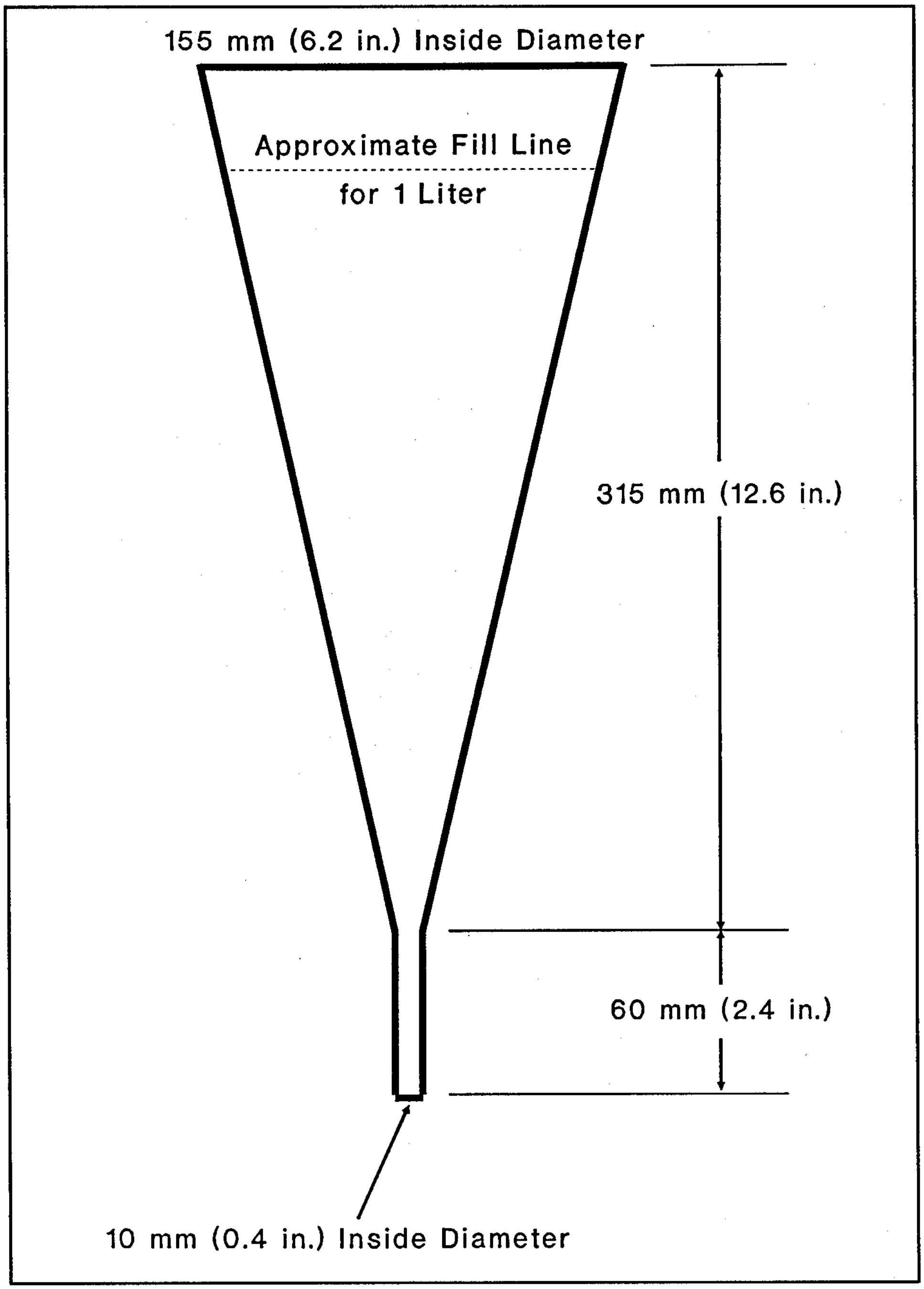

Figure 1. Schematic of Marsh flow cone

The slurry grout mix design is conducted by preparing individual batch samples in the laboratory and testing them with the Marsh flow cone. The batch samples are prepared by first dry mixing the cement, sand, and fly ash in a blender until thoroughly mixed. The appropriate amount of water is then added, and the grout mixture is blended for 5 min. After the 5-min mixing period, the resin additive is added and mixed with the grout for an additional 3 min. Immediately after the 3-min mixing period, the grout is poured into the Marsh flow cone and tested for viscosity. The individual components of the grout may be adjusted within the prescribed tolerances to obtain a desired flow time.

Construction Techniques

Open-graded AC

The open-graded AC layer is generally produced and constructed in the same manner as conventional AC pavements. The mixture may be produced in either a batch plant or drum-mix plant and is usually mixed at about 121 to 135°C (250 to 275°F). It is hauled to the construction site in large haul trucks where it is dumped into a standard asphalt paver. The temperature of the open-graded material when being placed is less critical than for standard AC mixtures, since densification is not required. In fact, once the open-graded mixture is placed by the asphalt paver (Figure 2), the surface is simply smoothed over with a small 3-tonne steel wheel roller (Figure 3). Usually, one roller pass when the open-graded material has cooled to about 71°C (160°F) and one roller pass at about 55°C (130°F) is all that is needed to complete the open-graded asphalt construction phase.

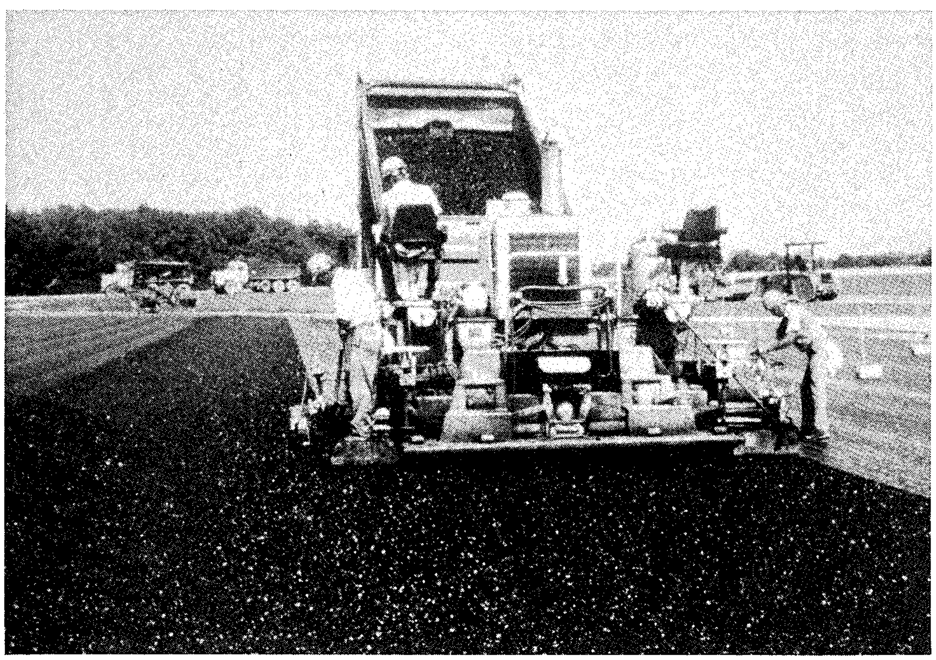

Figure 2. Asphalt paver placing open-graded asphalt mixture

Figure 3. Rolling open-graded asphalt mixture with small roller

Resin modified grout

The resin modified slurry grout material may be produced at a concrete batch plant for larger projects or with portable concrete mixers for smaller projects. For the typical batch plant-produced grout, the proper proportions of cement, sand, fly ash, and water are dumped into transit mix trucks and mixed for 5 min. When the haul distance from the concrete batch plant to the job site is less than 20 min, the cross polymer resin is poured into the mixing drum at the plant site. The slurry grout is continuously mixed in transit and until actual application to prevent the sand material from settling out of the slurry grout mixture. Once the transit mix truck reaches the job site, the mixing drum is rotated at maximum speed for an additional 10 min to ensure complete mixing of the slurry grout. If the haul distance from the concrete batch plant to the job site is greater than 20 min, then the cross polymer resin is added at the job site, followed by an additional 10 min of mixing before application.

Before placement, a sample of grout from each truck is taken and tested against the appropriate Marsh flow cone viscosity requirement (Figures 4, 5, and 6). The appropriate grout viscosity range depends upon the amount of time passed after addition of the resin additive. The slurry grout viscosity requirements are listed in Table 4.

Once the slurry grout has passed the viscosity test, it is poured onto the surface of the open-graded asphalt material from the pivoting delivery chute of the transit mix truck (Figure 7). The slurry grout is applied until the area is

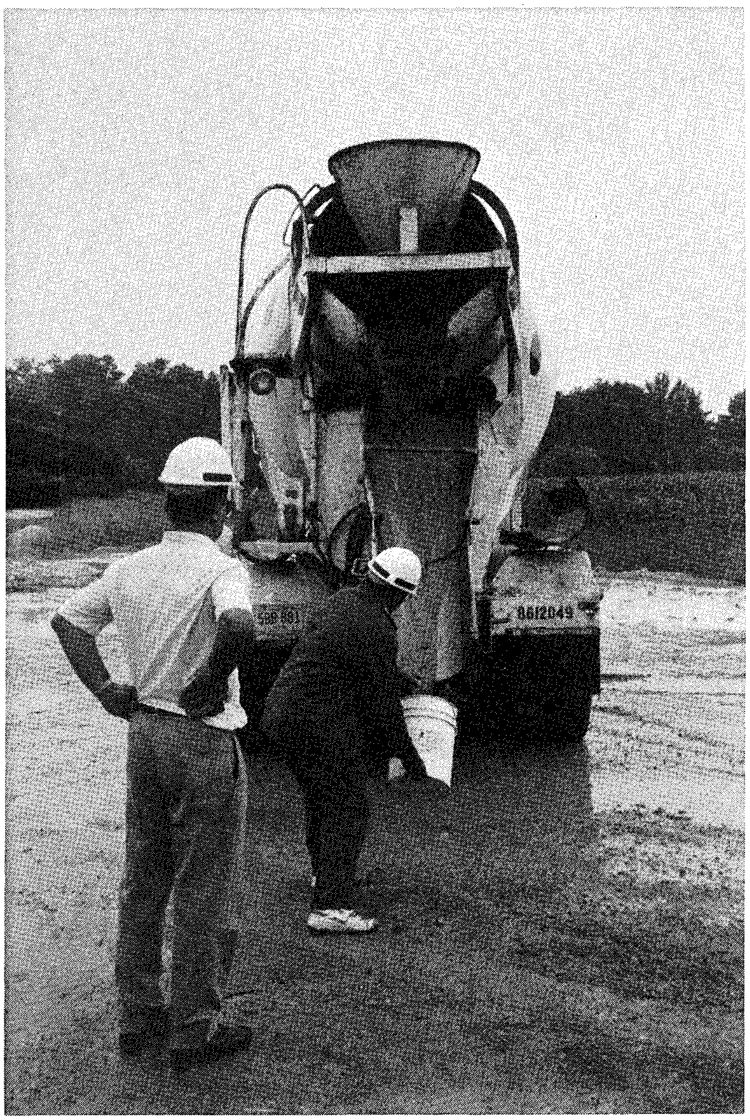

Figure 4. Catching sample of grout from truck

fully saturated. When an area becomes saturated, the transit mix truck moves forward, continuing the grout application. Grout placement is usually conducted in wide lanes (3 to 6 m or 15 to 20 ft) separated by strips of lumber (Figure 8). Grout application in this manner provides an orderly approach and keeps the grout from spilling over onto previously grouted areas. For small projects when the grout is mixed on site in portable mixers, a quick wheelbarrow delivery is suitable.

Hand-operated squeegees are used to push and pull the excess slurry grout material to the under-saturated areas (Figure 9). When the open-graded asphalt material is designed and constructed properly, the majority of the internal voids are quickly filled by gravity upon initial grout application. Immediately after placing the grout, the small 3-tonne steel wheel roller

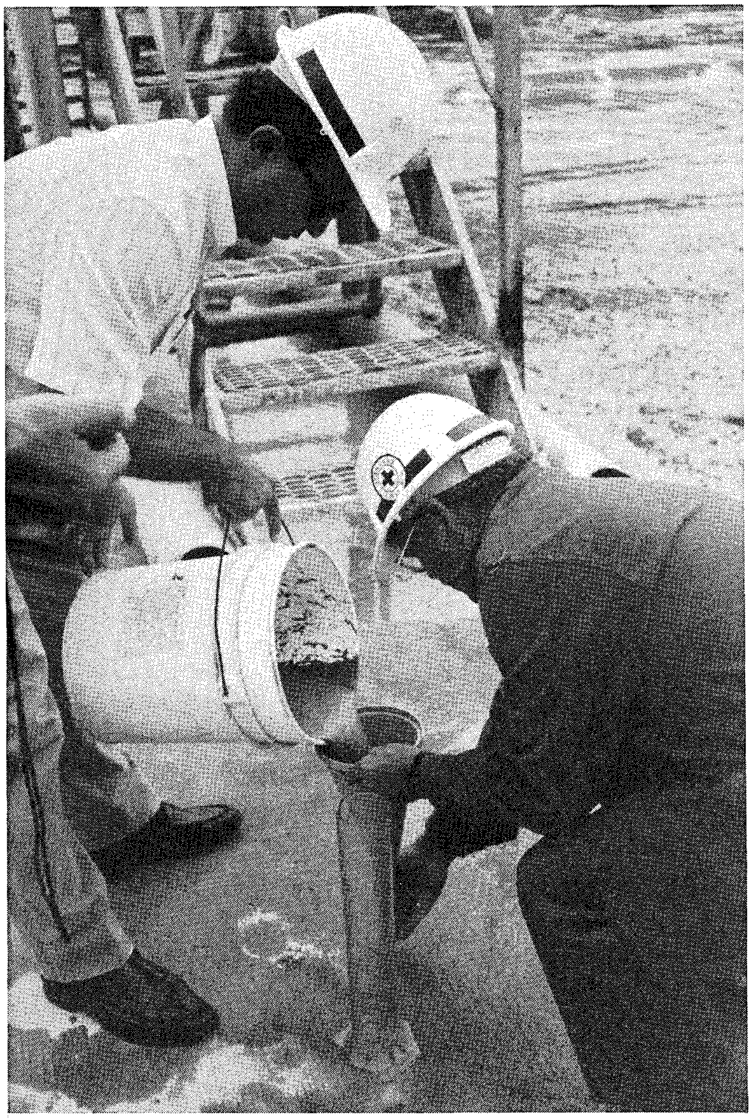

Figure 5. Filling Marsh flow cone with grout sample

Table 4
Slurry Grout Viscosity Requirements

Time Elapsed after Addition of PL7, min	Marsh Flow Cone Viscosity, sec
0-14	7-9
15-30	8-10
>30	9-11

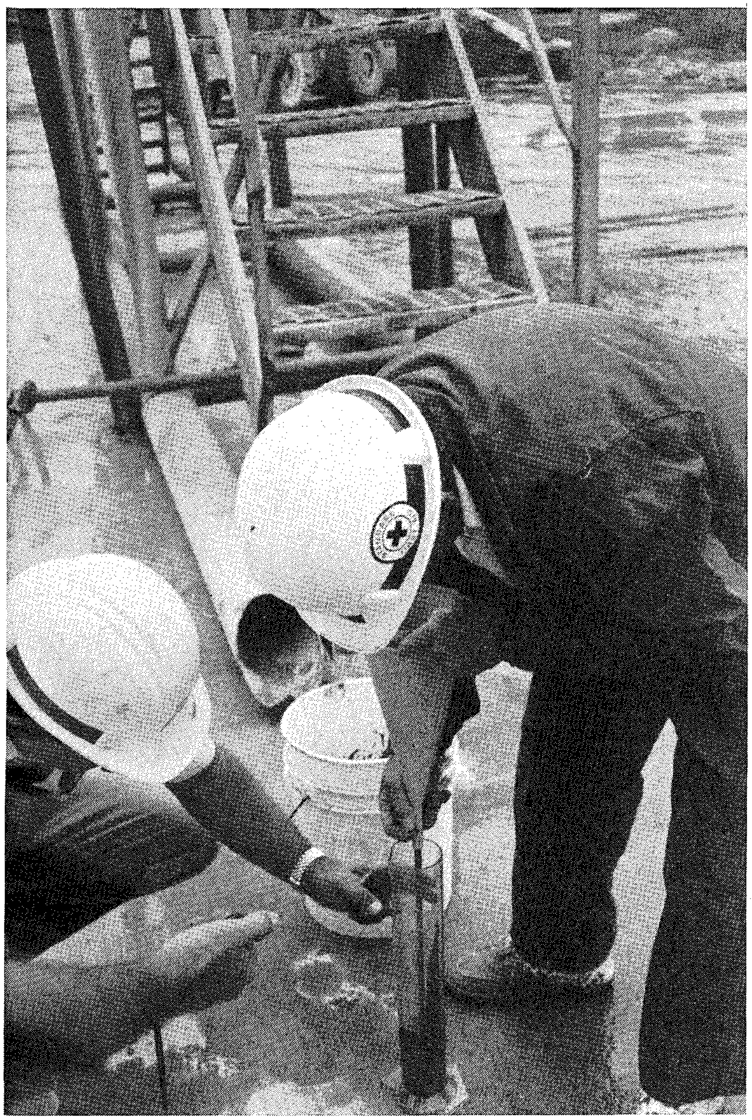

Figure 6. Measuring grout viscosity with Marsh flow cone

makes several vibratory passes over the grout filled pavement (Figure 10). The vibratory action of the roller ensures that the grout is filling all of the accessible internal voids. After an area is saturated with grout and the voids are completely filled, the excess grout is squeegeed off to produce the desired final surface texture (Figures 11 and 12).

Curing

Experience has indicated that the short-term curing protection provided by membrane-forming curing compounds is sufficient for the typical RMP project. The curing compound is typically white-pigmented to reflect the sun's

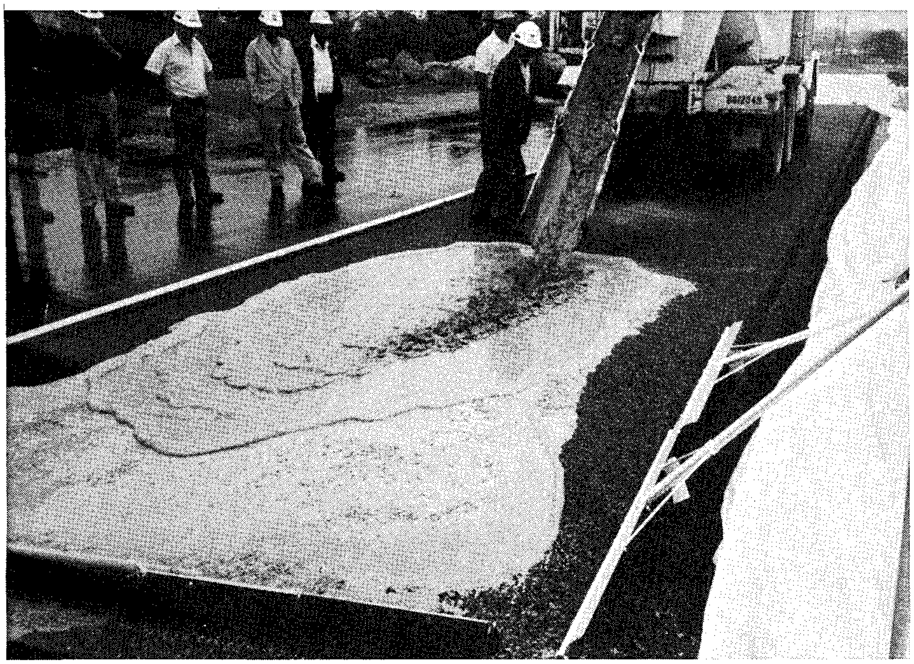

Figure 7.   Pouring grout onto open-graded material

Figure 8.   Strips of lumber used to separate grouting lanes

Figure 9. Squeegeeing excess grout over open-graded material

Figure 10. Small steel wheel roller vibrating grout into voids

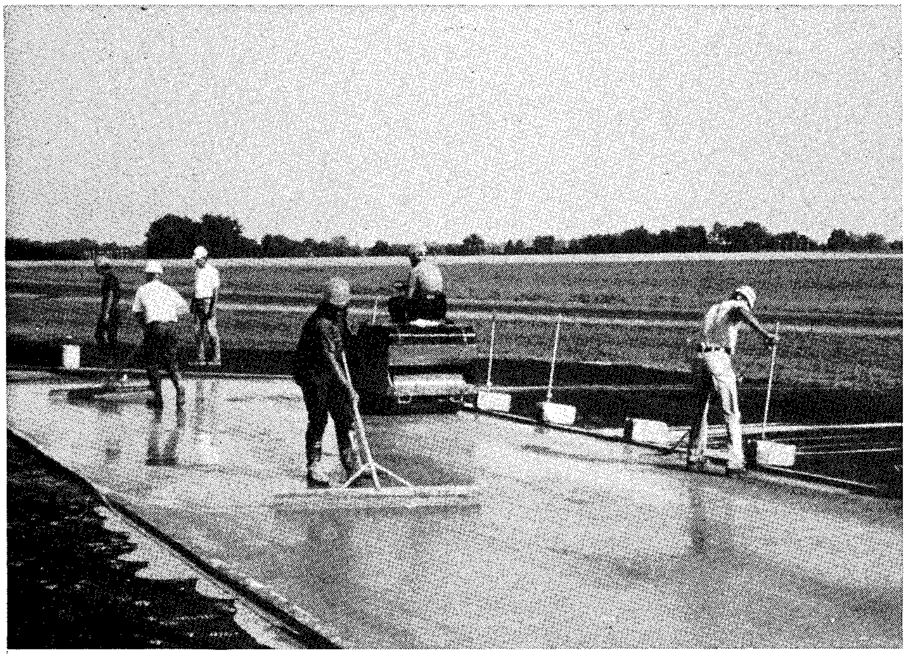

Figure 11. Removing excess grout from finished RMP surface

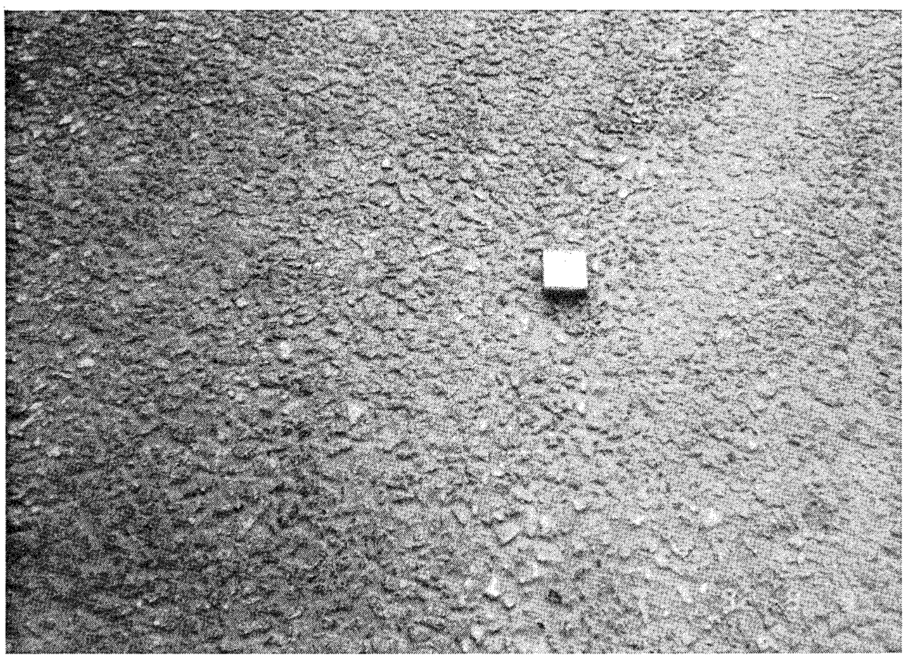

Figure 12. Typical appearance of completed RMP surface

rays. The suggested application rate is 1 L/14 m^2 (1 gal/400 ft^2), which is about one-half of the typical rate used for PCC pavements. Portable hand application of curing compound is allowable immediately after grout placement (when foot tracking is not a problem) since the open-graded asphalt layer provides enough strength to immediately support light loads.

Benefits

RMP provides many of the more attractive benefits associated with both AC and PCC. It offers the ease of construction, the jointless surface, and the cost competitiveness of an AC material. It has the fuel, abrasion, and wear resistance of a PCC. RMP has successfully demonstrated resistance to permanent deformation damage from heavy, high-pressure tire loads. It has also proven its capability in carrying tracked vehicle traffic by resisting the abrasive action of the turning tracks (Ahlrich and Anderton 1991b). The RMP material is well-suited for practically any environment, as evidenced by its international history in regions ranging from the Scandinavian countries to the deserts of Saudi Arabia (Jean Lefebvre Enterprise 1990).

Limitations

RMP should only be used for relatively low-speed (less than 65 km/hr or 40 mile/hr) traffic applications. Initial construction experience indicates that the surface texture of RMP can be irregular, with some areas containing excess grout on the surface. These areas may have a reduced skid resistance, especially at the beginning of the pavement's life. Skid resistance improves during the life of an RMP as surface grout is worn away, exposing the surface of the large-stone open-graded material. When skid resistance is a critical factor, surface texturing (brooming) immediately after grout application has been used successfully.

Because of the fluidity of the slurry grout, it is very difficult to construct an RMP surfacing on steep pavement slopes. The practical limit for the surface slope of an RMP section is 2 percent. Pavement slopes slightly higher than 2 percent can be constructed, but excess hand work and grout overruns are to be expected.

Since the RMP is a relatively new paving process in the United States, the design and construction experience is somewhat limited. As previously discussed, the current thickness design approach is highly empirical with little known about the engineering properties of the RMP material. The lack of construction experience in the United States usually increases the construction time on most projects. Construction and evaluation of test sections are important to ensure that the production of paving materials meets the specified job-mix formulas. Test sections also allow the contractor's paving crews to become familiar with the unique RMP construction techniques. Even with a thorough test section evaluation, full-scale RMP production rates generally start off slowly at the beginning of most projects and increase substantially as the construction process continues.

Costs

The initial construction costs of RMP generally fall somewhere between those of an AC pavement design and a PCC pavement design. In most instances, the RMP pavement design cost will be closer to the AC pavement design cost than to the PCC pavement design cost. Bid experiences from recent RMP construction projects indicate a current cost of about $9.60 to 19.20 per square meter ($8 to 16 per square yard) of 50-mm-thick RMP surfacing.

A cost comparison of AC, PCC, and RMP designs for two hypothetical pavement systems is provided to illustrate the typical differences in first costs for these three pavement types. Pavement designs were conducted using standard CE design methodologies (Headquarters, Departments of the Army and Air Force 1989 and 1992). Flexible and rigid airfield designs were conducted using the following input data:

Design Traffic = C-141 Aircraft at 156,109 kg (345,000 lb)
Design Passes = 100,000
No frost penetration considered
Subgrade California Bearing Ratio (CBR) = 10
Modulus of Subgrade Reaction (K) = 5.5×10^6 kg/m^3 (200 lb/in.^{3})
Subbase CBR = 40
Base CBR = 100
Rigid Design Base Thickness = 200 mm (8 in.)
PCC Flexural Strength = 5.2 MPa (750 lb/in.^{2})

Flexible and rigid road designs were also conducted for the same conditions, except for the following design parameters:

Traffic Design Index = 8
Base CBR = 80
Rigid Design Base Thickness = 100 mm (4 in.)

The thickness profiles resulting from these hypothetical pavement designs are collectively illustrated in Figure 13.

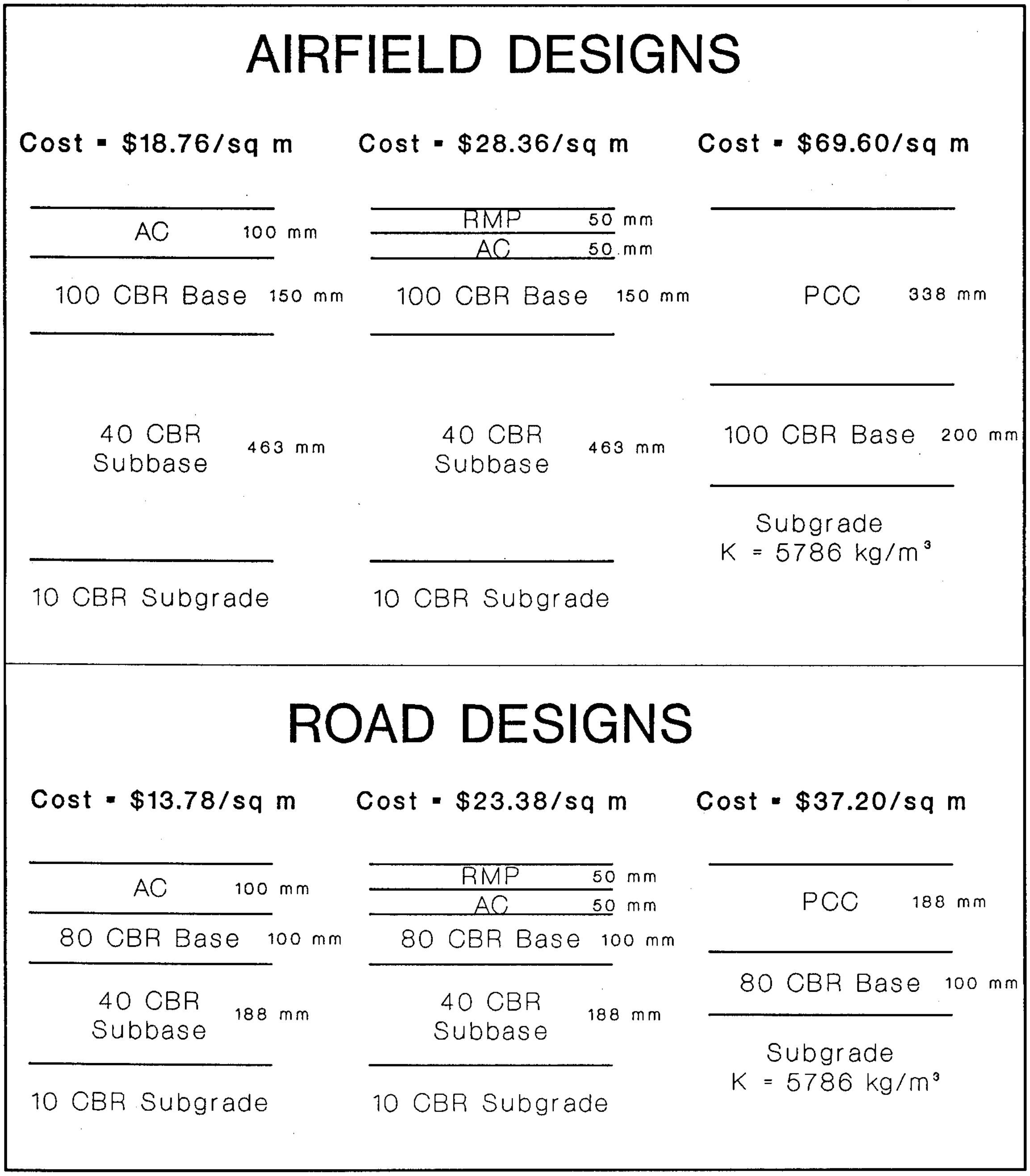

Figure 13. Comparative pavement thickness profiles and design costs

The pavement cost in terms of dollars per square meter for each 25 mm of thickness was based on the following cost assumptions:

Asphalt Concrete = $2.40/sq m
Portland Cement Concrete = $4.80/sq m
Resin Modified Pavement = $7.20/ sq m
100 CBR Base = $0.60/sq m
80 CBR Base = $0.48/sq m

40 CBR Subbase = $0.30/sq m

A quick comparison of the construction costs for these two hypothetical pavement design examples indicates the typical cost of RMP relative to the two standard pavement types: AC and PCC. Cost savings for the RMP designs versus the PCC designs are significant in each of these cases. This cost analysis clearly illustrates a critical design principal for RMP as an alternative pavement surfacing, namely:

> When an AC surfacing cannot effectively meet the pavement performance requirements where both an RMP and PCC surfacing can, then the RMP alternative will generally provide significant initial cost savings in terms of total thickness design costs.

In addition to the initial cost savings for using an RMP design instead of a PCC design, an RMP surfacing can be expected to cost much less in terms of maintenance expenditures given a proper design. The most significant maintenance cost savings will result from the lack of joints to maintain and reseal with the typical RMP surfacing. These cost savings will obviously not apply to situations where RMP is overlaid over jointed PCC pavements and joints are cut in the RMP surfacing to trace the PCC joints.

3 Acquisition/Procurement

Potential Funding Sources

Typically, installations fund the implementation of pavements and railroads technologies from their annual budgets. However, the installation's annual budget is usually underfunded and the pavements and railroads projects do not compete well with other high-visibility or high-interest type projects. As a result, it is prudent to seek out additional funding sources when the project merits the action. Listed below are some sources commonly pursued to fund projects.

a. Productivity program. See AR 5-4, Department of the Army Productivity Improvement Program (Headquarters, Department of the Army 1982) for guidance to determine if the project qualifies for this type of funding.

b. Facilities Engineering Applications Program (FEAP). In the past, a number of pavement and railroad maintenance projects located at various installations were funded with FEAP demonstration funds. At that time, emphasis was placed on demonstrating new technologies to the Directorate of Engineering and Housing (DEH) community. Now that these technologies have been demonstrated, the installations will be responsible for funding their projects through other sources. However, emphasis concerning the direction of FEAP may change in the future; therefore, one should not rule out FEAP as a source of funding.

c. Special programs. Examples of these are as follows:

(1) FORSCOM mobilization plan which may include rehabilitation or enlargement of parking areas and the reinforcement of bridges.

(2) Safety program which may include the repair of unsafe/deteriorated railroads at crossings and in ammunition storage areas.

(3) Security upgrade which may include the repair or enlargement of fencing.

d. Reimbursable customer. Examples of this source are roads to special function areas such as family housing or schools and airfield pavements required to support logistical operations.

e. Special requests from MACOM's.

f. Year end funds. This type of funding should be coordinated with the MACOM's to ensure that the funds will not be lost after a contract is advertised.

g. Operations and Maintenance Army. These are the normal funds used for funding pavement and railroad projects.

Technology Components and Sources

Components of the technology which must be procured for the use of resin modified pavement are: section design (may be in-house or contracted out) and a contractor to construct the RMP surfacing. The construction contractor must have the materials and mixing plant capable of producing the RMP open-graded asphalt mixture and, if required, a standard dense-graded asphalt mixture. In addition to the standard asphalt paving equipment, the contractor will need a small (3-tonne maximum) steel wheel roller to smooth out the open-graded material after placement.

For the modified slurry grout phase, the construction contractor will need to have access to either a nearby concrete batch plant or one or more portable concrete mixers on site. The grout batching equipment will depend upon job size and is almost always required to be the larger central batch plant. Transit mix trucks are needed to transport the grout to the job site and for placement. Hand squeegees and squeegee operators (typically three to five are sufficient) aid in the grout application. While the grout is being applied, the small 3-tonne steel wheel roller is used to vibrate the grout into the open-graded layer. Curing compounds and application equipment typical to the PCC industry are used to complete the RMP construction process.

The only unusual material required to produce an RMP surfacing is the resin additive used in the cement slurry grout. Currently, the resin additive required for grout production (Prosalvia-7 or PL7) is available only from a single source by contacting the following manufacturer's representative:

Alyan Corporation
P.O. Box 788
Vienna, VA 22183
ATTN: Mr. Ibrahim Murr
Tel: 703-573-8134
FAX: 212-486-4288

Procurement Documents

Technical reports

The Corps of Engineers has published two technical reports on the research and construction experiences of RMP:

"Construction and Evaluation of Resin Modified Pavement," Technical Report GL-91-13, USAE Waterways Experiment Station, 1991 (Ahlrich and Anderton 1991b).

"Design, Construction, and Performance of Resin Modified Pavement at Fort Campbell Army Airfield, Kentucky," Technical Report GL-94-5, USAE Waterways Experiment Station, 1994 (Anderton and Ahlrich 1994).

Applicable specifications

Several guide specifications are available to provide assistance in completing an RMP construction project. One of two applicable guide specifications is to be used for the construction of the AC layer beneath the RMP surfacing (unless the RMP is to be overlaid directly over an existing pavement surface). The choice of asphalt concrete specifications will depend upon the traffic requirements. There is also a guide specification available for the construction of the RMP layer itself. These specifications are as listed below:

CEGS-02551, "Bituminous Paving for Roads, Streets, and Open Storage Areas (Central Plant Hot Mix)," Department of the Army, Corps of Engineers Guide Specification, Washington, DC, April 1989 (Headquarters, Department of the Army 1989).

CEGS-02556, "Asphaltic Bituminous Heavy-Duty Pavement (Central-Plant Hot Mix)," Department of the Army, Corps of Engineers Guide Specification, Washington, DC, June 1991 (Headquarters, Department of the Army 1991).

CEGS-02548, "Resin Modified Pavement," Department of the Army, Corps of Engineers Guide Specification, Washington DC, October 1993 (Headquarters, Department of the Army 1993).

GSA listing

None

Vendors list and recent prices

Local contractors with experience in AC paving and PCC production should be able to successfully construct an RMP. Recent RMP construction projects indicate a price range of $9.60 to 19.20 per square meter ($8 to

16 per square yard) for a 50-mm- (2-in.-) thick RMP layer in place. Prices for any underlying AC, base course, and subbase course layers should be based upon recent local bid experiences.

Procurement Scheduling

Normal construction contract schedules should be established that allow adequate design and plan preparation time, design and review approval, contract preparation, advertising and award, and construction time. A typical pavement project is designed 1 to 2 years before it is constructed; however, plans and specifications for relatively small projects can be completed within a few months. Once construction is completed, the new RMP surfacing usually achieves full strength in 28 days, but it may be opened to pedestrian traffic in 24 hr and light automobile traffic in 3 days.

4 Post Acquisition

Initial Implementation

Equipment

Conventional AC mixing plant and paving equipment are used to construct the RMP open-graded layer. One or two small (3-tonne maximum) steel wheel rollers are used to finish the open-graded layer after paving. Polyethylene sheeting is required to protect the open-graded layer from rain when inclement weather is expected before the grout is applied.

The modified slurry grout is typically batched in standard concrete batch plants unless the pavement area is small enough to warrant portable batch mixing equipment. For the typical plant-mixed grout scenario, transit mixer trucks are used to carry the grout to the job site and place the grout onto the pavement. If the portable mixing equipment is used, wheelbarrows may be used to dump the grout onto the pavement. In either case of grout placement, hand-operated squeegees are used to spread the grout around as it is being placed. The small, 3-tonne steel wheel roller is used in the vibratory mode to promote full penetration of the grout into the open-graded layer during the grouting operation. Curing compound is applied to the finished RMP surface by means of a mechanical or hand-operated pressurized spraying apparatus.

Materials

The materials required for the production of an RMP open-graded AC layer are basically the same as those required for typical AC production. The slurry grout materials are also fairly common to the paving industry, with the exception of the resin additive. The resin additive is a specialized formulation of a styrene-butadiene polymer latex, which serves as a plasticizing and strengthening agent in the cement grout. The resin additive is currently available from only one source and is the only known additive with a proven record of successful use in such a composite pavement material.

Personnel

The personnel normally required at an AC plant and those required for AC construction are basically the same as those needed for construction of the RMP open-graded AC layer. Typical personnel required for PCC plant production and transit mix truck hauling are also virtually the same as those needed for production and transportation of the slurry grout. The following personnel are generally required for grout application: two to three transit mixer truck drivers; one mixer truck delivery chute operator; three to four squeegee operators; one vibratory roller operator; one to two personnel to move joint battens and clean grout joints.

As time allows, some of the previously mentioned personnel may be used to measure the grout viscosity of each truck batch, apply curing compound, or apply a broom finish to the freshly grouted surface if required. The quality control testing required for RMP construction is considerably less than for more traditional AC or PCC paving and can be readily handled by one or two personnel from any commercial testing laboratory qualified for both AC and PCC testing. The exact number of personnel required for an RMP construction project will depend upon project size and other site-specific conditions.

Procedure

The general procedure used to construct an RMP pavement includes the following:

a. Construct the required subgrade, subbase, base, and dense-graded AC layers in a fashion similar to that used for other flexible pavements.

b. Construct a 50-mm-thick layer of open-graded AC using typical AC paving equipment and a small (3-tonne maximum) steel wheel roller to smooth out the open-graded surface.

c. Allow the freshly placed open-graded material to cool down to at least 38°C (100°F) before applying slurry grout. Cover the open-graded layer with polyethylene sheeting if rain is imminent.

d. Secure wooden battens (50-mm by 100-mm or 2-in. by 4-in. strips of lumber) to the surface of the cooled open-graded layer to create grouting lanes. Create grouting lanes in the 3.7- to 7.3-m- (12- to 24-ft-) wide range to suit the grouting crew size.

e. Apply slurry grout to open-graded layer from transit mix trucks.

f. Vibrate the slurry grout into open-graded layer void spaces with several passes of the vibratory steel wheel roller.

g. Once a sizeable area of the grouting lane is completed, pull excess grout off of the surface by continuous squeegeeing in one longitudinal direction. Also, remove wooden battens and clean off excess grout in these areas with square-blade shovels, stiff-bristled brooms, and/or squeegees.

h. Once the surface sheen has disappeared from the freshly grouted RMP surface, apply curing compound in a manner and in amounts similar to that for standard PCC pavement.

Operation and Maintenance

Operations and maintenance on an RMP are similar to that of a PCC pavement. Under normal circumstances, the only joints for an RMP surfacing will be those between the RMP material and any adjacent PCC pavement or building. Any cracks that may develop should remain hairline-sized, thus requiring virtually no maintenance efforts. Slight wearing off of the surface grout is normal and actually improves skid resistance. The life expectancy of an RMP surfacing should be approximately 15 to 25 years, depending heavily upon the performance of the underlying pavement layers.

Service and Support Requirements

A representative of the Airfields and Pavements Division, Geotechnical Laboratory (GL), WES, should be consulted in the planning and designing of an RMP project. It is recommended that the job-mix-formula for the open-graded bituminous mixture and the mixture proportions for the grout be produced and/or approved by the appropriate WES representative. Besides these recommendations, no other special services or support is required to implement or maintain this technology.

Performance Monitoring

Installation personnel can monitor and measure the performance of the RMP surfacing by making periodic inspections of the pavement for signs of distress (cracking, raveling, rutting, etc.). This monitoring of performance would be no more than that required for any AC pavement. The performance monitoring can be adjusted to fit into existing pavement management systems. The unique design and combination of materials do not allow for RMP to be classified as a typical flexible or rigid pavement system, however. This factor will require an independent pavement classification or category when including an RMP surfacing in a pavement management system.

References

Ahlrich, R. C., and Anderton, G. L. (1991a). "Evaluation of resin modified paving process," Transportation Research Board, Transportation Research Record No. 1317, Washington, DC.

__________. (1991b). "Construction and evaluation of resin modified pavement," Technical Report GL-91-13, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1993). "Resin modified pavement in airfield applications." *Proceedings of American Society of Civil Engineers Specialty Conference on Airport Pavement Innovations - Theory to Practice*. New York, NY.

Al-Qadi, I. L., Gouru, H., and Weyers, R. E. (1994). "Asphalt portland cement concrete composite: laboratory evaluation," *American Society of Civil Engineers Journal of Transportation Engineering* 120 (1).

American Society for Testing and Materials. (1995a). "Viscosity-graded asphalt cement for use in pavement construction," Designation: ASTM D 3381, *1995 Annual Book of ASTM Standards*, Vol 04.03, Philadelphia, PA.

__________. (1995b). "Fly ash and raw or calcined natural pozzolan for use as a mineral admixture in portland cement concrete," Designation: ASTM C 618, *1995 Annual Book of ASTM Standards*, Vol 04.02, Philadelphia, PA.

Anderton, G. L., and Ahlrich, R. C. (1994). "Design, construction, and performance of resin modified pavement at Fort Campbell Army Airfield, Kentucky," Technical Report GL-94-5, U.S. Army Engineer Waterway Experiment Station, Vicksburg, MS.

Headquarters, Department of the Army. (1982). "Department of the Army Productivity Improvement Program," Army Regulation AR 5-4, Washington, DC.

Headquarters, Department of the Army. (1987). "Bituminous paving for road, street, and open storage areas (Central-Plant hot mix)," Corps of Engineers Guide Specification CEGS-02551, Washington, DC.

Headquarters, Department of the Army. (1991). "Aspaltic bituminous heavy-duty pavement (Central-Plant hot mix)," Corps of Engineers Guide Specification CEGS-02556, Washington, DC.

__________. (1993). "Resin modified pavement surfacing material," Corps of Engineers Guide Specification CEGS-02548, Washington, DC.

Headquarters, Departments of the Army and Air Force. (1989). "Flexible pavement design for airfields," Army TM 5-825-2/Air Force AFM 88-6, Washington, DC.

__________. (1992). "Pavement design for roads, streets, walks, and open storage areas," Army TM 5-822-5/Air Force AFM 88-7, Washington, DC.

Jean Lefebvre Enterprise. (1990). *Salviacim - principal productions, french and foreign*. Paris, France.

Roffe, J. C. (1989a). *Salviacim - introducing the pavement*. Jean Lefebvre Enterprise, Paris, France.

__________. (1989b). *Salviacim (annex 1) - the paving process*. Jean Lefebvre Enterprise, Paris, France.

Rone, C. L. (1976). "Evaluation of salviacim," Miscellaneous Paper S-76-20, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Appendix A
Fact Sheet

Technique: Resin Modified Pavement (RMP) October 1995

Description

The resin modified pavement (RMP) is a tough and durable surfacing material that combines the cost effectiveness and ease of construction of an asphalt concrete (AC) material with the fuel, abrasion, and wear resistance of a portland cement concrete (PCC). The resin modified pavement process is basically an open-graded asphalt concrete mixture containing 25 to 35 percent voids which are filled with a resin modified cement grout. The RMP, or Salviacim process as it is known in Europe, was developed in France by the Jean Lefebvre Group as a cost-effective alternative to PCC.

Areas of Application

The RMP construction process can be used to build new pavements or rehabilitate existing pavements that are subject to heavy, abrasive loads and fuel spillage. The RMP can be used to surface areas used by tracked vehicles such as tank trails and crossings, hardstands, and wash facilities. This pavement may also be used in motorpools, refueling pads, aircraft parking aprons, and taxiways. RMP usage is limited to low-speed (less than 65 km/hr or 40 miles/hr) traffic applications due to its variable skid resistance immediately after construction. The RMP provides an alternative surfacing material in areas where conventional pavement materials have excessive maintenance problems. The resin modified pavement can be used in place of AC and PCC in these specialized areas.

Physiographic Factors

The RMP is a composite pavement that is composed of an open-graded AC mixture and a resin modified cement grout. The two materials are produced and placed separately. The production of the materials and the mix requirements for both the open-graded AC and the cement grout are modified and differ slightly from conventional procedures.

The open-graded AC mixture is designed to be the support layer and determine the thickness of the RMP. The open-graded mixture is placed with standard AC paving equipment but is not compacted. After placing, the open-graded asphalt is smoothed over with a small steel wheel roller, generally 3-tonne maximum. Compaction of the open-graded AC material will adversely decrease the voids and hinder grout penetration.

The open-graded AC material is designed to produce 25 to 35 percent voids. A coarse aggregate gradation with very little fines is specified. The aggregate gradation is similar to that of a porous friction course (PFC) or "popcorn mix." The asphalt content for this mixture is generally between 3.5 and 4.5 percent. The open-graded asphalt material can be produced in either a conventional batch plant or drum-mix plant.

The cement grout material can be batched in a conventional concrete batch plant or a small portable mixer. The size of the job will dictate the mixing operation. Standard concrete ready mix trucks haul the grout to the lay down site. After the asphalt mixture has cooled, the grout is poured onto the open-graded asphalt material and squeegeed over the surface. The grout is then vibrated into the voids with the small 3-tonne vibratory roller to ensure full penetration of the grout. The process continues until all voids are filled with grout.

The resin modified cement grout is composed of fly ash, silica sand, cement, water, and a resin additive. The resin modified cement grout is very fluid and has a consistency very similar to water. The grout water/cement ratio (w/c) is between 0.65 and 0.70. The resin additive, Prosalvia L7 (PL7), is a proprietary material. PL7 is a latex cross polymer resin of styrene and butadiene. The resin additive is generally composed of five parts water, two parts cross polymer resin, and one part water reducing agent. The PL7 material is utilized as a plasticizing and strengthening agent.

The type of portland cement used in the grout and the loading conditions determines the curing period. The curing period may vary between 1 and 28 days. Standard PCC curing techniques should be used with the RMP process.

Discussion and Recommendations

The U.S. Army Engineer Waterways Experiment Station (WES)[1] was tasked by the Headquarters, U.S. Army Corps of Engineers (HQUSACE), in 1987 to evaluate the resin modified pavement process. The evaluation began with a literature review and background analysis into the RMP process. This review indicated that a majority of the in-service pavements constructed with this process were in Europe and heavily concentrated in France where the process was first developed. Site inspections and evaluations were conducted at several civil and military RMP applications in both France and the United Kingdom. These visual inspections indicated that the RMP process had considerable potential for U.S. military applications.

The WES evaluation also included the construction, trafficking, and evaluation of an RMP test strip at WES. This test strip was used to evaluate the effectiveness of the RMP to resist damage due to abrasion and fuel spillage. The RMP handled the severe abrasion and high stresses from M1 tanks very well and resisted fuel spillage damage extremely well. Based on the performance in Europe and around the world and the results of the WES test strip evaluation, the RMP process has been recommended as an alternative pavement surfacing material by the U.S. Army, the U.S. Air Force, and the Federal Aviation Administration (FAA).

[1] Points of contact are: R. C. Ahlrich, Telephone: 601-34-3367, facsimile: 601-634-3020 and G. L. Anderton, telephone: 601-634-2955, facsimile: 601-634-3020, USACEWES, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199

Implementation

The RMP has been implemented at several Department of Defense installations and FAA airports. The RMP has been constructed or contracted for at four Army installations, four Air Force bases, and five FAA facilities. The RMP process has been used on various types of heavy-duty pavements including taxiways and aprons, parking lots, and storage yards for cargo and fuel. To date, the RMP process has performed satisfactorily.

Summary

The RMP provides a tough and durable surfacing material that resists severe abrasion and damage from fuel spillage. The current data and evaluations indicate that the RMP process has potential for several pavement uses. The initial cost of a 50-mm- (2-in.-) thick RMP surfacing is estimated to be between $9.60 and 19.20 per square meter ($8 and $16 per square yard). At this price, the RMP is a cost-effective method to construct or rehabilitate military pavements.

Appendix B
Guide Specification for Military Construction

****

DEPARTMENT OF THE ARMY CEGS-02548 (February 1996)
U.S. ARMY CORPS OF ENGINEERS

GUIDE SPECIFICATION FOR MILITARY CONSTRUCTION

****

SECTION 02548

RESIN MODIFIED PAVEMENT

02/96

****
NOTE: This guide specification covers the requirements for resin modified pavement surfacing material. This guide specification is to be used in the preparation of project specifications in accordance with ER 1110-345-720.
****

PART 1 GENERAL

****

NOTE: See Additional Notes A and B.

****

1.1 REFERENCES

****

NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest change (Notice) to this guide specification.

****

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

\-ASTM C 88-\ (1990) Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

\-ASTM C 131-\ (1989) Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

\-ASTM C 136-\ (1993) Sieve Analysis of Fine and Coarse Aggregates

\-ASTM C 150-\ (1994) Portland Cement

\-ASTM C 618-\ (1994) Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete

\-ASTM D 75-\ (1987; R 1992) Sampling Aggregates

\-ASTM D 140-\ (1993) Sampling Bituminous Materials

\-ASTM D 2216-\ (1992) Laboratory Determination of Water (Moisture) Content of Soil and Rock

\-ASTM D 3381-\ (1992) Viscosity-Graded Asphalt Cement for Use in Pavement Construction

\-ASTM D 4791-\ (1989) Flat or Elongated Particles in Course Aggregate

CORPS OF ENGINEERS (COE)

\-COE CRD-C 300-\ (1990) Specifications for Membrane-Forming Compounds for Curing Concrete

****

1.2 SUBMITTALS

****

NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required. Indicate submittal classification in the blank space using "GA" when the submittal requires Government approval or "FIO" when the submittal is for information only.

****

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section \=01300=\ SUBMITTAL PROCEDURES:

SD-09 Reports\

Coarse and Fine Aggregate\; *GA*\. *Open Graded Mix Aggregate Gradation*\; *GA*\. *Bituminous Material*\; *GA*\. *Slurry Grout Sand*\; *GA*\. *Fly Ash*\; *GA*\. *Slurry Grout Formula*\; *GA*\. Copies of test results. Viscosity tests shall be run after mixing and 15 minutes and 30 minutes thereafter.

SD-13 Certificates\

Cement\; *GA*\. *Cross Polymer Resin*\; *GA*\. *Curing Compound*\; *GA*\. Copies of certificates.

SD-14 Samples\

Open Graded Mix\; *[_____]*\. *Slurry Grout Job-Mix-Formula*\; *[_____]*\. Materials required to produce the open graded mixture and slurry grout job-mix-formulas shall be submitted in the quantities indicated below.

Aggregates representing each stockpile to be used in the production of the open-graded mixture	\^45 kg^\ \~100 pounds~\ each
Bituminous Material	\^19 liters^\ \~5 gallons~\
Slurry Grout Sand	\^23 kg^\ \~50 pounds~\
Fly Ash	\^23 kg^\ \~50 pounds~\
Cement	\^23 kg^\ \~50 pounds~\
Cross Polymer Resin	\^4 liters^\ \~1 gallon~\

Samples shall be delivered, along with the Contractor's preliminary job mix formula, 30 days before starting production to U.S. Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, Mississippi, 39180-6199, ATTN: CEWES-GP-Q.

1.3 PLANT, EQUIPMENT, MACHINES, AND TOOLS

The bituminous plant shall be of such capacity as to produce the quantities of bituminous mixtures required for the project. Hauling equipment, paving machines, rollers, miscellaneous equipment, and tools shall be provided in sufficient numbers and capacity and in proper working condition to place the bituminous paving mixtures at a rate equal to the plant output. The additional requirements for construction of the Resin Modified Pavement (RMP) are a concrete batch plant, a ready mix truck or portable mixer for grout mixing, and a small \^2.7 metric ton (3-ton)^\ \~3-ton~\ tandem steel wheeled vibratory roller for compaction.

1.4 SAMPLING AND TESTING

1.4.1 Aggregates

1.4.1.1 General

\-ASTM D 75-\ shall be used in sampling coarse and fine aggregates. Points of sampling will be designated by the Contracting Officer. All tests necessary to determine compliance with the specified requirements shall be made by the Contractor.

1.4.1.2 Sources

Sources of aggregates shall be selected well in advance of the time that the materials are required in the work. Samples shall be submitted 30 days before starting production. If a sample of material fails to meet specification requirements, the material represented by the sample shall be replaced, and the cost of testing the replaced sample shall be at the expense of the Contractor. Approval of the source of the aggregate does not relieve the Contractor of the responsibility to deliver aggregates that meet the specified requirements.

1.4.2 Bituminous Materials

Samples of bituminous materials shall be obtained in accordance with \-ASTM D 140-\. Sources shall be selected in advance of the time materials will be required for the work. In addition to the initial qualification testing of bituminous materials, samples shall be obtained and tested before and during construction when shipments of bituminous materials are received, or when necessary to assure that some condition of handling or storage has not been detrimental to the bituminous material.

1.5 DELIVERY, STORAGE, AND HANDLING OF MATERIALS

1.5.1 Mineral Aggregates

Mineral aggregates shall be delivered to the site of the bituminous mixing plant and stockpiled in such a manner as to preclude segregation or contamination with objectionable material.

1.5.2 Bituminous Materials

Bituminous materials shall be maintained below a temperature of \^150 degrees C^\ \~300 degrees F~\ during storage and shall not be heated by the application of a direct flame to the walls of storage tanks or transfer lines. Storage tanks, transfer lines and weigh buckets shall be thoroughly cleaned before a different type or grade of bitumen is introduced into the system.

1.6 ACCESS TO PLANT AND EQUIPMENT

The Contracting Officer shall have access at all times to all parts of the bituminous plant for checking adequacy of any equipment in use; inspecting operation of the plant; verifying weights, proportions, and character of materials; and checking temperatures maintained in preparation of the mixtures.

PART 2 PRODUCTS

2.1 AGGREGATE

Aggregate shall consist of crushed stone, or crushed gravel without sand or other inert finely divided mineral aggregate. The portion of materials retained on the \^4.75 mm^\ \~No. 4~\ sieve shall be known as coarse aggregate, the portion passing the \^4.75 mm^\ \~No. 4~\ sieve and retained on the \^0.075 mm^\ \~No. 200~\ sieve as fine aggregate. Sieve analysis of coarse and fine aggregates shall be conducted in accordance with \-ASTM C 136-\.

2.1.1 Coarse Aggregate

Coarse aggregate shall consist of sound, tough, durable particles, free from adherent films of matter that would prevent thorough coating with the bituminous material. The percentage of wear shall not be greater than 40 percent when tested in accordance with \-ASTM C 131-\. The sodium sulfate soundness loss shall not exceed 9 percent, after five cycles, when tested in accordance with \-ASTM C 88-\. Aggregate shall contain at least 70 percent by weight of crushed pieces having two or more fractured faces. The area of each fractured face shall be equal to at least 75 percent of the smallest mid-sectional area of the piece. When two fractured faces are contiguous, the angle between the planes of fractures shall be at least 30 degrees to count as two fractured faces. Fractured faces shall be obtained by artificial crushing.

2.1.2 Crushed Aggregates

Particle shape of crushed aggregates shall be essentially cubical. Quantity of flat and elongated particles in any sieve size shall not exceed 8 percent by weight, when determined in accordance with \-ASTM D 4791-\.

2.1.3 Open Graded Mix Aggregate

The gradations in Table I represent the limits which shall determine the suitability of open graded mix aggregate for use from the sources of supply. The aggregate, as finally selected, shall have a gradation within the limits designated in Table I and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice versa, but shall be uniformly graded from coarse to fine.

TABLE I

OPEN GRADED MIX AGGREGATE

Sieve Size	Percent by Weight Passing
3/4 in.	100
1/2 in.	54-76
3/8 in.	38-60
No. 4	10-26
No. 8	8-16
No. 30	4-10
No. 200	1-3

Table I is based on aggregates of uniform specific gravity; the percent passing various sieves may be changed by the Contracting Officer when aggregates of varying specific gravities are used. Adjustments of percentages passing various sieves may be directed by the Contracting Officer when aggregates vary more than 0.2 in specific gravity.

2.1.4 Slurry Grout Sand

Slurry grout sand shall consist of clean, sound, durable, particles of processed silica sand that meets the requirements for wear and soundness specified for coarse aggregate. The sand shall contain no clay, silt, or other objectionable matter. The gradations in Table II represent the limits which shall determine the suitability of silica sand for use from the sources of supply.

TABLE II

FINE SAND FOR SLURRY GROUT

Sieve Size	Percentage by Weight Passing
No. 16	100
No. 30	95-100
No. 200	0-2

The sand gradations shown are based on sand of uniform specific gravity, and the percentages passing the various sieves will be subject to appropriate correction by the Contracting Officer when aggregates of varying specific gravities are used.

2.1.5 Filler

If filler in addition to that naturally present in the aggregate is necessary, it shall be fly ash. Fly ash shall have at least 95 percent by weight of material passing the \^0.075 mm^\ \~No. 200~\

sieve. Fly ash shall conform to \-ASTM C 618-\ Class F requirements.

2.2 BITUMINOUS MATERIAL

Bituminous material shall conform to the requirements of \-ASTM D 3381-\ and shall be of the viscosity grade [AC-10] [AC-20] [AC-30] [AR-4000] [AR-8000] with an original penetration of 40 to 100.

2.3 CEMENT

The cement used in the slurry grout shall be portland cement conforming to \-ASTM C 150-\, Type [I] [II] [III] [V].

2.4 CROSS POLYMER RESIN

****

NOTE: See Additional Note C.

****

****

NOTE: A complete description of the Marsh flow cone and the grout viscosity test method is found in the Waterways Experiment Station Technical Report GL-91-13 "Construction and Evaluation of Resin Modified Pavement."

****

A cross polymer resin of styrene and butadiene, Prosalvia L7, shall be utilized as a plasticizing and strength producing agent. After mixing the resin into the slurry grout, the mixture shall have a viscosity which would allow it to flow from a Marsh Cone in accordance with Table III. A Marsh cone has dimensions of 155 mm base inside diameter, tapering 315 mm to a tip inside diameter of 10 mm. The 10 mm diameter neck shall have a length of 60 mm.

TABLE III

SLURRY GROUT VISCOSITY

Time Elapsed After Addition of PL7	Marsh Flow Cone Viscosity
0 to 14 minutes	7 to 9 seconds
15 to 30 minutes	8 to 10 seconds
After 30 minutes	9 to 11 seconds

2.5 CURING COMPOUND

Membrane-forming curing compound shall be white pigmented compounds conforming to \-COE CRD-C 300-\.

2.6 JOB MIX FORMULA AND COMPOSITION OF SLURRY GROUT

****

NOTE: See Additional Note D.

****

2.6.1 Job Mix Formula

The Job Mix Formula (JMF) for the open graded bituminous mixture will be furnished by the Government. No payment will be made for mixtures produced prior to the approval of the JMF by the Contracting Officer. The JMF will indicate the percentage of each stockpile, the percentage passing each sieve size, the percentage of bitumen, and the temperature of the completed mixture when discharged from the mixer. The tolerances given in Table IV for sieve analysis, bitumen content, and temperature shall be applied to quality control test results on the open graded bituminous mixture as discharged from the mixing plant.

TABLE IV

JOB-MIX-FORMULA TOLERANCES

Material	Tolerance, Plus or Minus
Aggregate passing No. 4 or larger sieves	4 percent
Aggregate passing Nos. 8 and 30 sieves	3 percent
Aggregate passing No. 200 sieve	1 percent
Bitumen	0.20 percent
Temperature of discharged mix	\^11^{o}C^\ \~20^{o}F~\

2.6.2 Composition of Slurry Grout

The Job Mix Formula (JMF) for the slurry grout will be furnished by the Government. The slurry grout job-mix-formula will be developed using the proportions given in Table V.

TABLE V

RESIN MODIFIED CEMENT SLURRY GROUT MIXTURE PROPORTIONS

Material	Percent by Weight
Silica Sand	16-20
Fly Ash	16-20
Water	22-26
Type I Cement	34-40
Cross Polymer Resin	2.5-3.5

Approximately \^12 kg to 15 kg^\ \~22 pounds to 28 pounds~\ of mixed slurry grout will fill in one square \^meter^\ \~yard~\ (\^25 mm^\ \~1 inch~\ thickness) of open graded bituminous mixture with 25 to 35 percent voids total mix.

PART 3 EXECUTION

3.1 WEATHER LIMITATIONS

The bituminous mixture shall not be placed upon a wet surface, in rain, or when the surface temperature of the underlying course is less than \^10 degrees C.^\ \~50 degrees F.~\ The temperature requirements may be waived by the Contracting Officer. Once the bituminous mixture has been placed and if rain is imminent, protective materials, consisting of rolled polyethylene sheeting at least \^0.1 mm (4 mils)^\ \~4 mils~\ thick of sufficient length and width to cover the mixture shall be placed. If the open graded bituminous mixture becomes saturated, the Contractor shall allow the pavement voids to thoroughly dry out prior to applying the slurry grout.

3.2 PREPARATION OF OPEN GRADED MIXTURES

Rates of feed of aggregates shall be regulated so that moisture content and temperature of aggregates will be within tolerances specified. Aggregates and bitumen shall be conveyed into the mixer in proportionate quantities required to meet the JMF. Mixing time shall be as required to obtain a uniform coating of the aggregate with the bituminous material. Temperature of bitumen at time of mixing shall not exceed \^135 degrees C.^\ \~275 degrees F.~\ Temperature of aggregate in the mixer shall not exceed \^150 degrees C^\ \~300 degrees F~\ when bitumen is added. Overheated and carbonized mixtures or mixtures that foam shall not be used.

3.3 WATER CONTENT OF AGGREGATES

Drying operations shall reduce the water content of mixture to less than 0.75 percent. Water content shall be determined in accordance with \-ASTM D 2216-\; weight of sample shall be at least \^500 grams.^\ \~500 grams.~\ The water content shall be reported as a percentage of the total mixture.

3.4 STORAGE OF MIXTURE

The open graded bituminous mixture shall not be stored for longer than one hour prior to hauling to the jobsite.

3.5 TRANSPORTATION OF MIXTURE

Transportation from the mixing plant to the jobsite shall be in trucks having tight, clean, smooth beds lightly coated with an approved releasing agent to prevent adhesion of mixture to truck bodies. Diesel fuel shall not be used as a releasing agent. Excessive release agent shall be drained prior to loading. Each load shall be covered with canvas or other approved material of ample size to protect mixture from the weather and to prevent loss of heat. Loads that have crusts of cold, unworkable material or have become wet will be rejected. Hauling over freshly placed material will not be permitted.

3.6 TEST SECTION

Prior to full production, and in the presence of the Contracting Officer, the Contractor shall prepare and place a quantity of open graded bituminous mixture and slurry grout according to the JMF. The test section shall be a minimum of \^30 meters^\ \~100 feet~\ long and \^6 meters^\ \~20 feet~\ wide placed in one section and shall be of the same depth specified for the construction of the course which it represents. The underlying pavement structure upon which the test section is to be constructed shall be the test section of the intermediate course. The equipment used in construction of the test section shall be the same type and weight to be used on the remainder of the course represented by the test section. The test section shall meet the requirements specified in paragraph ACCEPTABILITY OF WORK. If the test section should fail to meet these requirements, the necessary adjustments to the mix design, plant operation, and/or construction procedures shall be made. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications at the expense of the Contractor.

3.7 SURFACE PREPARATION OF UNDERLYING COURSE

Prior to placing of open graded bituminous mixture, the underlying course shall be cleaned of all foreign or objectionable matter with power brooms and hand brooms.

3.8 TACK COATING

Contact surfaces of previously constructed pavement shall be sprayed with a coat of bituminous material as specified in Section \=02558=\ BITUMINOUS TACK COAT.

3.9 PLACING OPEN GRADED BITUMINOUS MIXTURE

****

NOTE: The amount of rolling required to achieve the required voids total mix criteria is usually 1 to 3 passes of the 2.7 metric ton (3-ton) tandem steel wheel roller in the static mode. The appropriate temperature of the freshly placed bituminous mixture required to prevent undue shoving and cutting from the roller is usually in the 50 to 70 degrees C (120 to 160 degrees F) range. The actual number of required passes and temperature range for rolling should be determined during construction and subsequent evaluation of the test section.

****

The mix shall be placed at a temperature of not less than \^80 degrees C^\ \~175 degrees F~\ Upon arrival, the mixture shall be spread to the full width (minimum \^3 meters^\ \~10 feet~\) by an approved bituminous paver. It shall be struck off in a uniform layer of such depth that, when the work is completed, it shall have the required thickness indicated. The speed of the paver shall be regulated to eliminate pulling and tearing of the bituminous mat. Unless otherwise directed, placement of the mixture shall begin along the center line of a crowned pavement or along the highest side of a sloped cross-section. The mixture shall be placed in consecutive adjacent strips. On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread, raked, and luted by hand tools.

3.9.1 Rollers

Small (\^2.7 metric ton^\ \~3-ton~\ maximum) tandem steel wheel vibratory rollers shall be used to smooth over the surface of freshly placed open graded bituminous mixture. The vibratory unit shall be turned off during smoothing of the bituminous mixture. Rollers shall be in good condition, capable of operating at slow speeds to avoid displacement of the bituminous mixture. The number, type, and weight of rollers shall be sufficient to roll the mixture to the voids total mix requirement of 25 to 35 percent while it is still in a workable condition. The use of equipment which causes excessive crushing of the aggregate will not be permitted.

3.9.2 Smoothing of Open Graded Bituminous Mixture

The open graded bituminous mixture shall be smoothed with one to three passes of the prescribed roller without vibration. The temperature of the freshly placed open graded bituminous mixture shall be low enough to prevent excessive shoving or cutting of the mat under the roller.

3.9.3 Protection of Ungrouted Pavement

The Contractor shall protect the ungrouted pavement and its appurtenances against contamination from mud, dirt, wind blown debris, waterborne material, or any other contamination which could enter the void spaces of the open graded bituminous mixture before grout application. Protection against contamination shall be accomplished by keeping the construction site clean and free of such contaminants and by covering the ungrouted pavement with protective materials when directed by the Contracting Officer. Such protective materials shall consist of rolled polyethylene sheeting as described in paragraph WEATHER LIMITATIONS. The sheeting may be mounted on either the paver or a separate movable bridge from which it can be unrolled without dragging over the pavement surface.

3.10 PREPARATION OF SLURRY GROUT

****

NOTE: Generally, the cross polymer resin should be added to the grout mixture at the batch plant if the haul distance is less than 20 minutes. If the haul distance is greater than 20 minutes, the cross polymer resin should be added to the grout mixture at the jobsite.

****

The slurry grout shall be mixed using a batch plant, portable mixer and/or ready-mix truck and according to mix proportions stated in the Government's JMF. The cross polymer resin shall be added to the mixture after all other ingredients have been thoroughly mixed. When using ready-mix trucks for transporting slurry grout, the grout mixture shall be thoroughly mixed at the jobsite immediately before application for a minimum of 10 minutes. Thorough mixing shall be accomplished by rotating the mixing drum at the maximum allowable revolutions per minute.

3.11 PLACING SLURRY GROUT

Temperature of the bituminous mixture shall be less than \^38 degrees C^\ \~100 degrees F~\ before applying grout. Each batch of slurry grout shall be tested at the jobsite immediately before placement and shall be used in the finished product only if it meets the requirements specified in paragraph ACCEPTABILITY OF WORK. The slurry grout shall be spread over the bituminous mixture using a spreader or squeegees. The application of the slurry grout shall be sufficient to fill the internal voids of the open graded bituminous mixture. The grouting operation shall begin at the lowest side of the sloped cross-section and proceed from the low side to the high side. The practical limit for the surface slope of an RMP section is 2 percent. Pavement slopes up to 5 percent can be constructed, but excess hand work and grout overruns are to be expected at slopes greater than 2 percent. The slurry grout shall be placed in successive paving lanes with a maximum width of \^6 meters.^\ \~20 feet.~\ The use of \^50 by 100 mm (2-inch by 4-inch)^\ \~2-inch by 4-inch~\ strips of lumber as wooden battens separating each of the grouting lanes and the RMP from adjacent pavements is optional. The direction of the grouting operation shall be the same as used to pave the open graded bituminous mixture. The small (\^2.7 metric ton (3-ton)^\ \~3-ton~\ maximum) tandem steel wheel roller (vibratory mode) passing over the grout covered bituminous mixture shall be used to promote full penetration of the slurry grout into the void spaces.

3.12 JOINTS

3.12.1 Joints Between Successive Lanes of RMP

Joints between successive lanes of RMP shall be made in such a manner as to ensure a continuous bond between the paving lanes. All RMP joints shall have the same texture, density, and smoothness as other sections of the course.

3.12.2 Joints Between RMP and Adjacent Pavements

Joints between the RMP and any surrounding pavement surfaced with portland cement concrete shall be saw cut to the full thickness of the RMP layer and filled with a joint sealant material approved by the Contracting Officer.

3.13 CURING

The curing compound shall be applied to the finished pavement surface within 2 hours of the completed slurry grout application. The curing compound shall be applied by means of an approved pressurized spraying machine. Application of the curing compound shall be made in one or two coats with a total application rate of not more than \^10 square meters per liter.^\ \~400 square feet per gallon.~\

3.14 PROTECTION OF GROUTED PAVEMENT

The Contractor shall protect the pavement and its appurtenances against both public traffic and traffic caused by the Contractor's employees and agents for a period of 28 days. Any damage to the pavement occurring prior to final acceptance shall be repaired or the pavement replaced at the Contractor's expense. In order that the pavement be properly protected against the effects of rain before the pavement is sufficiently hardened, the Contractor will be required to have available at all times materials for the protection of the edges and surfaces of the unhardened RMP. The protective materials and method of application shall be the same as previously described in paragraph WEATHER LIMITATIONS. When rain appears imminent, all paving operations shall stop, and all available personnel shall begin covering the surface of the hardened RMP with protective covering.

3.15 ACCEPTABILITY OF WORK

3.15.1 General

Routine testing for acceptability of work shall be performed by the Contractor and approved by the Contracting Officer. Additional tests required to determine acceptability of non-conforming material shall be performed by the Contractor at the expense of the Contractor. When a section of pavement fails to meet the specification requirements, that section shall be totally removed and replaced at the Contractor's expense. The Contracting Officer reserves the right to sample and test any area which appears to deviate from the specification requirements.

3.15.2 Field Sampling of RMP Materials

3.15.2.1 Open Graded Bituminous Mixture

****

NOTE: Voids total mix of laboratory specimens and ungrouted field cores shall be calculated using the following formula:

$$VTM = (1 - WT_{air}/Volume \times 1/SG_T) \times 100$$

where

VTM = voids total mix
WT_{air} = dry weight of specimen
Volume = $\pi/4\ D^2H$
D = diameter H = height
SG_T = theoretical specific gravity

****

Samples of open graded bituminous mixture shall be taken from loaded trucks for every 1,000 square \^meters^\ \~yards~\ of pavement, but not less than two samples for each day of paving for determining asphalt content, aggregate gradation, and laboratory compacted voids total mix. Laboratory specimens of open graded bituminous material shall be compacted in \^101.6 mm (4 inch)^\ \~4 inch~\ diameter molds to a \^50.8 mm (2 inch)^\ \~2 inch~\ thickness using 25 blows on one side from a Marshall hand hammer. Test results from the sampled open graded bituminous mixture shall be compared to the approved job-mix-formula and approved by the Contracting Officer for acceptance.

3.15.2.2 Slurry Grout

Each batch of slurry grout shall be tested for viscosity at the jobsite after thorough mixing and before application. Any batch of slurry grout failing to meet the viscosity specified requirements shall be rejected and removed from the jobsite. Slurry grout with visible amounts of sand settling out of suspension during application shall be rejected and removed from the jobsite.

3.15.2.3 Core Samples

Random core samples shall be taken from the in-place open graded bituminous mixture before and after application of the slurry grout. The Contractor shall take at least two field core samples before grout application and two after grout application for every 1,000 square \^meters^\ \~yards~\ of finished RMP. Field core samples shall be \^101.6 or 152.4 mm (4 or 6 inch)^\ \~4 or 6 inch~\ diameter and extend the full depth of the RMP surface layer. The ungrouted core samples shall be tested for thickness. The grouted core samples shall be visually inspected for acceptable grout penetration. Acceptable grout penetration shall be through the full thickness of the RMP layer with a minimum of 90 percent of the visible void spaces filled with slurry grout. After testing, the Contractor shall turn over all cores to the Contracting Officer. Core holes in ungrouted RMP shall be filled with hot open graded bituminous material and leveled to match the surrounding pavement surface. Core holes in grouted RMP shall be filled within 24 hours from the time of coring with RMP material, portland cement concrete material, or other approved portland cement concrete patching material.

3.15.3 Thickness and Surface-Smoothness Requirements

Finished surface of RMP, when tested as specified below, shall conform to the thickness specified and to surface smoothness requirements specified in Table VI.

TABLE VI.

SURFACE-SMOOTHNESS TOLERANCES

Direction of Testing	Resin Modified Pavement Tolerance
Longitudinal	\^6 mm^\ \~1/4 inch~\
Transverse	\^6 mm^\ \~1/4 inch~\

3.15.3.1 Thickness

The thickness of the RMP shall meet the requirements shown on the contract drawings. The measured thickness of the RMP shall not exceed the design thickness by more than \^13 mm,^\ \~1/2 inch,~\ or be deficient in thickness by more than \^3 mm.^\ \~1/8 inch.~\

3.15.3.2 Surface Smoothness

Finished surfaces shall not deviate from testing edge of a \^3.66 meter (12 foot)^\ \~12-foot~\ straightedge more than the tolerances shown for the respective pavement category in Table VI.

****

ADDITIONAL NOTES

NOTE A: For additional information on the use of all CEGS, see CEGS-01000 CEGS GENERAL NOTES.

NOTE B: A representative of the Airfield and Pavements Division, Geotechnical Laboratory, U.S. Army Engineer Waterways Experiment Station (WES) should be consulted in the planning and designing of an RMP.

NOTE C: The cross polymer resin to be used in the slurry grout, Prosalvia-7, is available from the Alyan Corporation, P.O. Box 788, Vienna, VA 22183, (703) 573-8134.

NOTE D: It is recommended that the job-mix-formula for the open graded bituminous mixture and the mixture proportions for the slurry grout be produced and/or approved by the appropriate WES representative. This recommendation is to ensure that proper laboratory procedures are used to determine mix designs for this new paving process.

****

— End of Section —