TRI-SERVICE PAVEMENTS WORKING GROUP (TSPWG) MANUAL

RESIN MODIFIED PAVEMENT (RMP) DESIGN AND APPLICATION CRITERIA

TRI-SERVICE PAVEMENTS WORKING GROUP MANUAL (TSPWG M)

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Change No.	Date	Location

This TSPWG Manual supersedes Air Force ETL 01-8, dated 25 September 2001.

FOREWORD

This Tri-Service Pavements Working Group (TSPWG) Manual supplements guidance found in other Unified Facilities Criteria, Unified Facility Guide Specifications, Defense Logistics Agency Specifications, and Service-specific publications. All construction outside of the United States is also governed by Status of Forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and, in some instances, Bilateral Infrastructure Agreements (BIA). Therefore, the acquisition team must ensure compliance with the most stringent of the TSPWG Manual, the SOFA, the HNFA, and the BIA, as applicable. This TSPWG Manual provides guidance on resin modified pavement (RMP) design and application. The information in this TSPWG Manual is referenced in technical publications found on the Whole Building Design Guide (WBDG). It is not intended to take the place of Service-specific doctrine, technical orders (T.O.), field manuals, technical manuals, handbooks, Tactics, Techniques, and Procedures (TTPs), or contract specifications but should be used along with these to help ensure pavements meet mission requirements.

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**TRI-SERVICE PAVEMENTS WORKING GROUP MANUAL (TSPWG M)
NEW SUMMARY SHEET**

Document: TSPWG Manual 3-26-02.01-8, *Resin Modified Pavement (RMP) Design and Application Criteria*

Superseding: This TSPWG Manual supersedes Air Force ETL 01-8, *Resin Modified Pavement (RMP) Design and Application Criteria*, dated 25 September 2001.

Description: This TSPWG Manual provides information and guidance on the use of resin modified pavement (RMP). 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 asphalt cement (AC) or rigid portland cement concrete (PCC) pavements. The RMP is suitable to carry heavy and abrasive traffic loads and 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.

Reasons for Document:

This TSPWG Manual provides information for the use of RMP. This surfacing material is best suited for pavements subjected to abrasive traffic, heavy static point loads, heavy fuel spillage, and channelized traffic.

Typical AC pavements are very susceptible to damage when subjected to fuel or oil spillage or severe abrasion from tracked vehicles. PCC pavements are susceptible to deterioration (cracking and spalling) of the transverse control joints, mid-slab cracking, and longitudinal cracking. RMP provides a cost-effective alternative that is a tough and durable surfacing material that combines the flexible characteristics of an AC material with the fuel, abrasion, and wear resistance of PCC.

Impact: There will be minimal cost impacts that are offset by the overall lifecycle cost. The following benefits are realized:

- RMP is used in new pavement construction or in the rehabilitation of existing pavement structures. 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 condition

- The cost of a typical 2-inch (in.) (50-millimeter [mm]) -thick RMP layer is currently about three to four times higher as compared to a typical cost of a 2-in. (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.

- RMP is recommended for any newly constructed or rehabilitated pavement carrying low-speed traffic (less than 40 miles per hour [65 kilometers per hour]). RMP is a cost-saving alternative to PCC pavements where resistance to heavy loads, tracked vehicle traffic, or fuel spillage is required.

- Only use RMP 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.

- Supplemental information on the operation, maintenance, and repair of pavements as well as airfield damage repair will be available to all Services. Maintenance or upgrading of this supplemental information will include inputs from all Services.

Unification Issues: None

Note: The use of the name or mark of any specific manufacturer, commercial product, commodity, or service in this publication does not imply endorsement by the Department of Defense (DOD).

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CHAPTER 1 INTRODUCTION

1-1   BACKGROUND.

The resin modified pavement (RMP) process was developed in France in the 1960s 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 portland cement concrete (PCC). RMP has been successfully marketed throughout France as a pavement and flooring material in numerous applications. 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. The earliest documented experience with RMP in the United States occurred in the mid-1970s when the U.S. Army Corps of Engineers (USACE) Waterways Experiment Station (WES) conducted limited evaluations of an RMP test section constructed in Vicksburg, Mississippi, 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, USACE 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. The results of this evaluation were favorable, prompting pilot projects at several military installations in the following years. Today, the RMP process is recommended as an alternative pavement surfacing material by the U.S. Army, U.S. Air Force, U.S. Navy, and the Federal Aviation Administration (FAA).

1-2   PURPOSE AND SCOPE.

This TSPWG Manual provides guidance to help in the design and maintenance of RMP. The design approach uses the elastic layered method for flexible pavements, modified to the specific material properties of RMP (paragraph 2-1). Maintenance may include joint and crack sealing, spot repairs, and surface grooving (paragraph 2-2).

1-3   APPLICABILITY.

The RMP process is applicable to any pavement or environment, excluding airfield runways, on DOD installations.

1-4   GLOSSARY.

Appendix A contains acronyms, abbreviations, and terms.
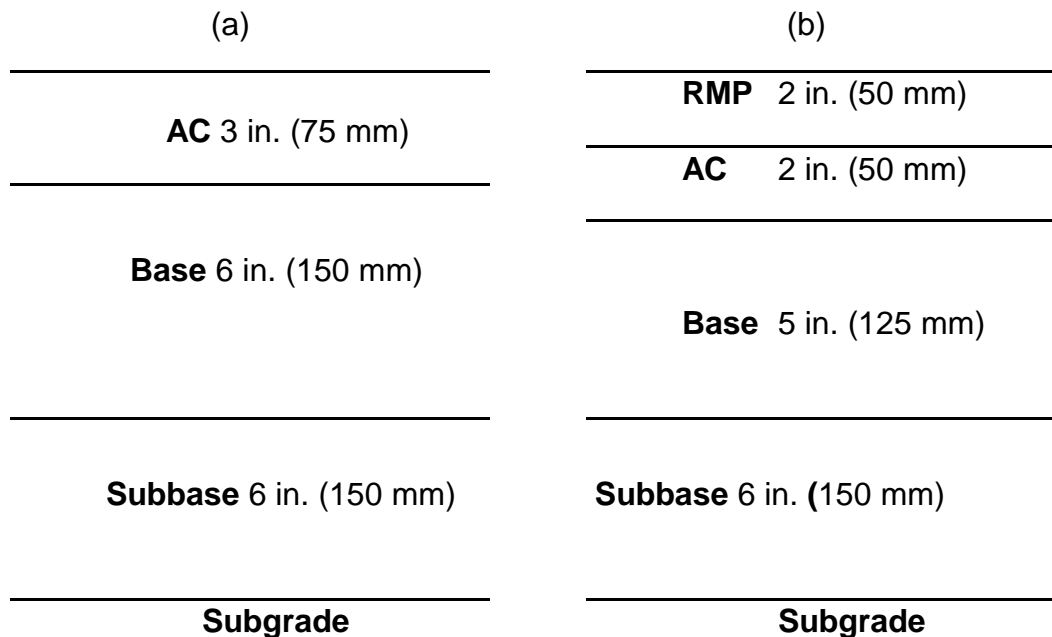
1-5 REFERENCES.

Appendix B contains a list of references used in this document. The publication date of the code or standard is not included in this document. Unless otherwise specified, the most recent edition of the referenced publication applies.

CHAPTER 2 SPECIFIC REQUIREMENTS

2-1 PREFACE.

2-1.1 For pavement designs other than airfields, use an RMP thickness of 2.0 in. ± 0.5 in. (51 mm ± 13 mm). In this case, RMP is considered equal to the same thickness of AC. The pavement is designed like a traditional AC-surfaced flexible pavement then the RMP thickness is used to replace an equal thickness of the top layer of AC. A minimum thickness of 2 in. (50 mm) of AC is required beneath the RMP surfacing. When the combined RMP and AC thicknesses exceed the design thickness of AC surfacing in the traditional flexible pavement design then standard AC equivalency factors are used to reduce base or subbase thickness. An example of such a design conversion is shown in Figure 2-1.

Figure 2-1   Conversion of Traditional AC-surfaced Road Design (a) to an Equal RMP-surfaced Road Design (b)

(a)	(b)
AC 3 in. (75 mm)	**RMP** 2 in. (50 mm)
	AC 2 in. (50 mm)
Base 6 in. (150 mm)	**Base** 5 in. (125 mm)
Subbase 6 in. (150 mm)	**Subbase** 6 in. **(**150 mm)
Subgrade	**Subgrade**

2-1.2 RMP on airfields is designed using the existing elastic layered method for flexible pavements under UFC 3-260-02, *Pavement Design for Airfields*. The RMP layer is added to the top of a traditional flexible pavement design with at least 2 in. (50 mm) of AC underneath and fully bonded to the RMP layer. The modulus of the RMP is temperature-dependent and is estimated from the graphical relationship given in Figure 2-2. Poisson's ratio of RMP is considered to be uniform at all normal pavement temperatures, with a value of 0.27 recommended for design.

Figure 2-2 RMP Resilient Modulus Versus Temperature Design Curve

Modulus kpsi	Modulus (GPa)									
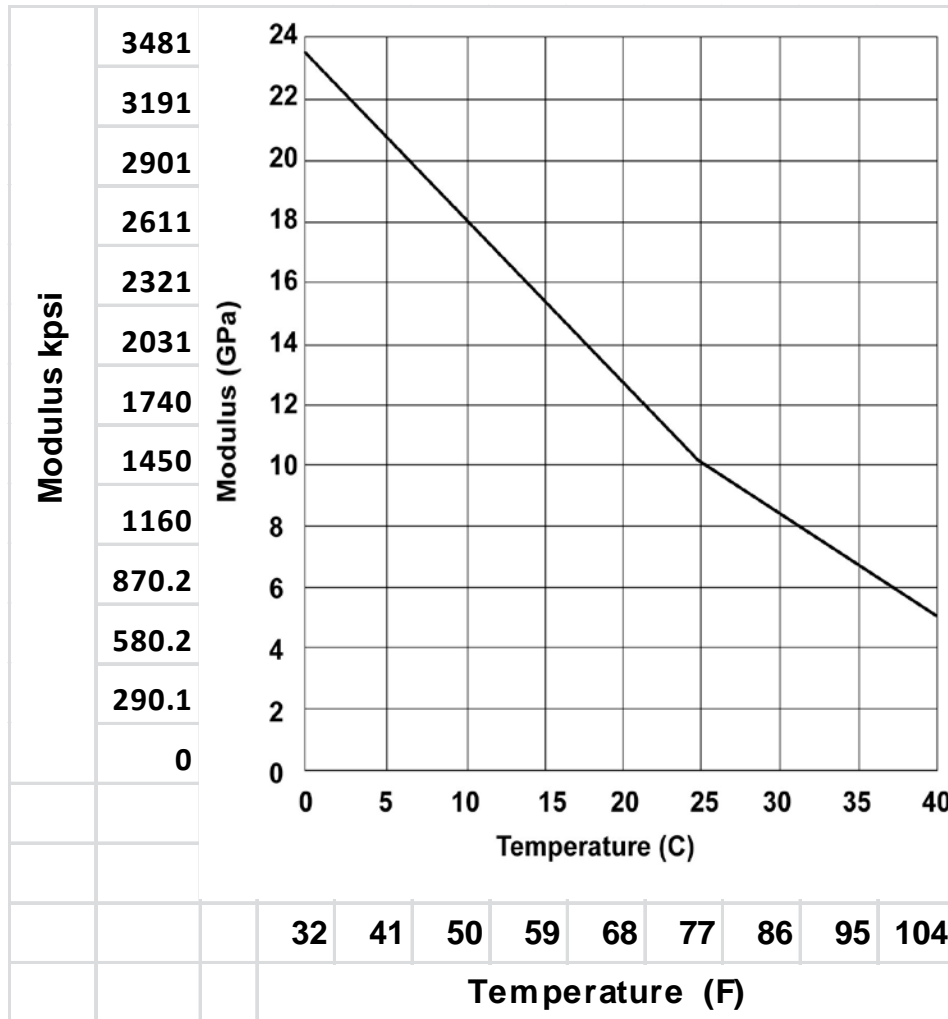
2-1.3   The critical failure points for an RMP design are the same as those that control a traditional AC-surfaced flexible pavement: excess vertical (compressive) strain on top of the subgrade and excess horizontal (tensile) strain at the bottom of the AC layer. Research has shown that pavement failure typically occurs at these points before excessive tensile strains at the bottom of the RMP layer cause cracking to occur in the surface layer; however, fatigue curves have been generated for RMP materials in the strain range and cycles-to-failure range common for typical airfield pavements. These fatigue curves cover a full range of pavement temperatures and are shown in Figure 2-3. Using the calculated strains at the bottom of the RMP layer for a given design scenario with the appropriate fatigue curve (interpolated between temperatures if necessary) gives the estimated number of allowable aircraft passes. Noting the strain range of the RMP fatigue curves, it can be said that strains in the RMP layer at or above the 10^{-3} level are likely to cause very quick failures and strains at or below the 10^{-5} level are negligible in terms of fatigue damage to the RMP layer.

Figure 2-3 RMP Fatigue Design Curves at Various Pavement Temperatures
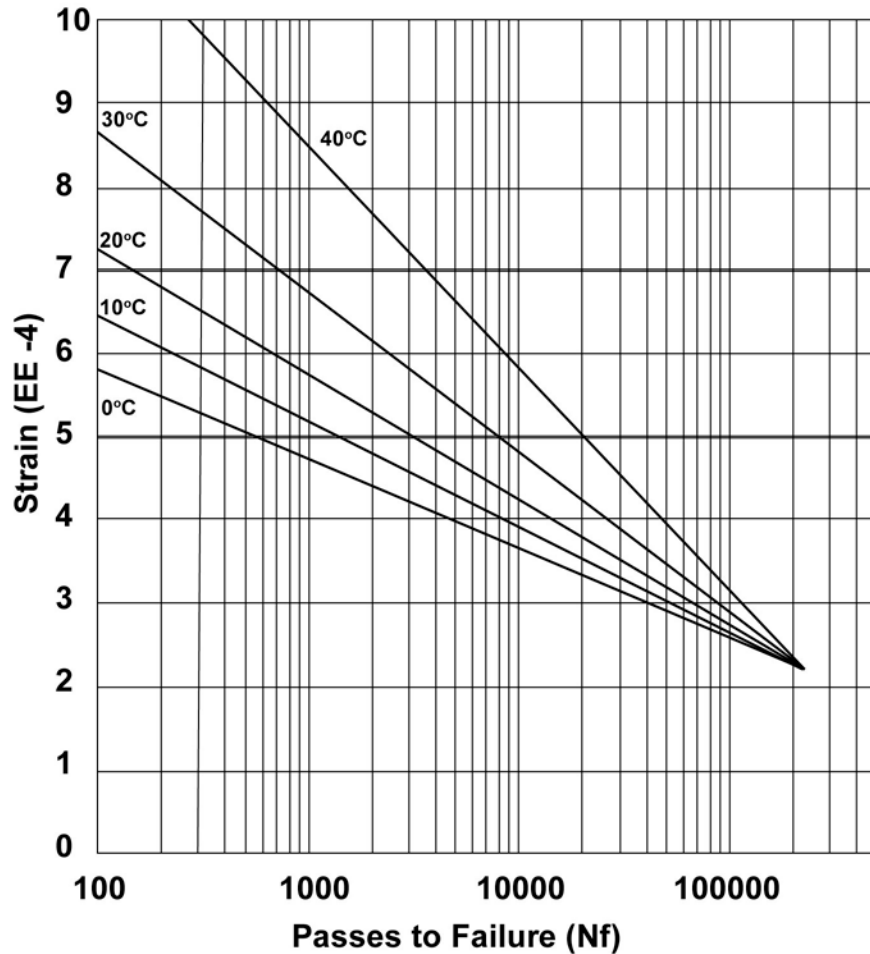
2-1.4   The typical RMP airfield pavement design includes the following, as a minimum:

- Aircraft loads and tire pressures as well as the required number of aircraft passes for the pavement's design life.

- Pavement material properties (including subgrade California bearing ratio [CBR]), AC modulus versus temperature relationship, and each pavement layer's cost and availability.

- Historical temperature data for the site to assign seasonal modulus values to the AC and possibly the subgrade layers.

- Total pavement thickness required for design aircraft and subgrade CBR from appropriate aircraft design curves found in UFC 3-260-02 and minimum surface layer and base course thicknesses from standard requirements for the given pavement design.

- An initial pavement design section based on the following:

  o   The top 1.5- to 2.5-in. (40- to 60-mm) -thick layer is RMP with a modulus based on seasonal average pavement temperature and Poisson's ratio of 0.27.

  o   The remaining amount of required pavement surfacing thickness is AC, which is fully bonded to the overlying RMP layer. The minimum thickness of this AC layer is 2 in. (50 mm). Modulus and Poisson's ratio of AC are relative to seasonal pavement temperature or other acceptable standard value used by the design agency.

  o   Begin the base course layer at the minimum thickness required for the given pavement type. Modulus and Poisson's ratio for this layer are usually standard values under UFC 3-260-02 unless test data on the base course materials suggest otherwise.

  o   Ensure the remaining pavement thickness required by the subgrade CBR criteria is a subbase material, if available. Use modulus and Poisson's ratio values under UFC 3-260-02 unless available material test data are considered to be more valid.

- A typical layered elastic design analysis (typically by computer program). Observe calculated strains and resulting number of allowed aircraft passes (N) versus the required number of aircraft passes (n) for a given season. The value of n/N is computed for each season and aircraft used in the design and then summed to get the cumulative damage factor (n/N) for each critical pavement layer (RMP, AC, subgrade).

- Assumed pavement layer thicknesses are adjusted until cumulative damage factors (CDF) are equal to or slightly below 1.0. Only one of the three critical pavement layer CDFs will control the design, with CDFs for the other two pavement layers well below the 1.0 design threshold. When pavement profile constraints and pavement material costs are considered in obtaining a design section with one or more CDFs at or very close to 1.0 then the optimum RMP structural design is determined.

2-1.5   A hypothetical RMP airfield apron design example is presented here to show the RMP layered elastic design method. The Jacob Uzan Layered Elastic Analysis (JULEA) computer program developed for layered elastic design of flexible pavements is used to compute strains at the bottom of the RMP and AC layers as well as at the top of the subgrade. Inch-pound units (rather than Système International [SI] units of Newton-meter) are used with the data for this example since the current JULEA computer program is designed for these units.

2-1.5.1   Step 1: Traffic Data

The airfield site is assumed to be in Shreveport, Louisiana, where an airfield apron is to be designed for 50,000 passes of a C-17 aircraft with a design load of 580,000 pounds (263 metric tons).

2-1.5.2   Step 2: Material Properties.

Modulus values for the subgrade, subbase, and base materials are assumed to be 10,000, 25,000, and 50,000 pounds per square inch (psi), respectively. Subgrade CBR is assumed to be 6 and base CBR is assumed to be 80. The AC to be used at this site was tested and has a modulus versus temperature relationship as shown in Figure 2-4. Standard Poisson's ratios for the AC, granular base, subbase, and cohesive subgrade are 0.35, 0.35, 0.35, and 0.40, respectively. AC materials are assumed to cost more than base materials, which are in turn assumed to cost more than subbase materials.

Figure 2-4 AC Temperature-Modulus Relationship for Design Example
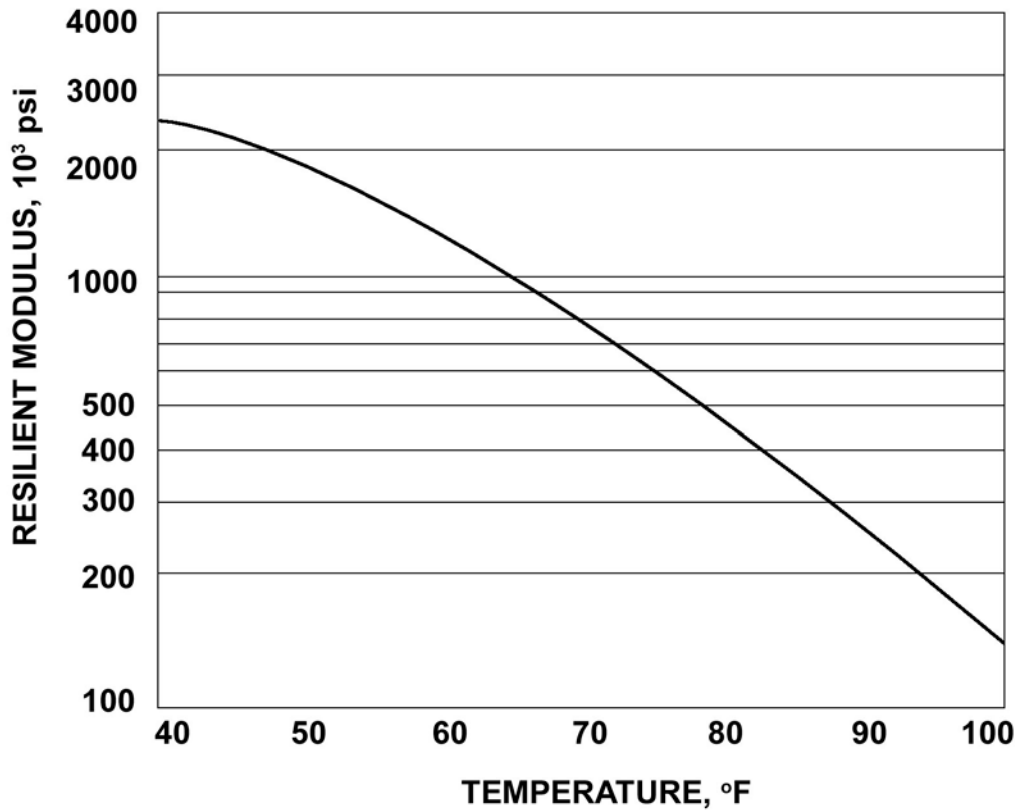
2-1.5.3   Step 3: Historical Temperature Data.

The design pavement temperature is obtained from the climatic data for this site and the design AC modulus values are found as shown in Table 2-1. To reduce the number of computations, the 12-month groups are reduced to four seasonal groups as shown in Table 2-2.

Table 2-1   Monthly Design Pavement Temperatures and AC Moduli

Month	Pavement Design Temperature	Resilient Modulus 10^3 psi (kPa)
January	56 °F (13 °C)	1500 (10,342)
February	60 °F (16 °C)	1270 (8,756)
March	67 °F (19 °C)	920 (6,343)
April	76 °F (24 °C)	570 (3,930)
May	84 °F (29 °C)	360 (2,482)
June	92 °F (33 °C)	220 (1,517)
July	95 °F (35 °C)	180 (1,241)
August	95 °F (35 °C)	180 (1,241)
September	89 °F (32 °C)	260 (1,793)
October	77 °F (25 °C)	540 (3,723)
November	65 °F (18 °C)	1000 (6,895)
December	57 °F (14 °C)	1400 (9.653)

Table 2-2   Grouping Traffic into Seasonal Traffic Groups

Group	Month	Resilient Modulus 10^3 psi (kPa)		Percent of Total Traffic	Group Required Passes (n_{reqd})
		Monthly Value	Group Average		
1	Jan	1500 (10,342)	1,390 (9,584)	25.0	12,500
	Dec	1400 (9.653)			
	Feb	1270 (8,756)			
2	Nov	1000 (6,895)	960 (6,619)	16.7	8,350
	Mar	920 (6,343)			
3	Apr	570 (3,930)	490 (3,378)	25.0	12,500
	Oct	540 (3,723)			
	May	360 (2,482)			
4	Sep	260 (1,793)	210 (1,448)	33.3	16,650
	Jun	220 (1,517)			
	Jul	180 (1,241)			
	Aug	180 (1,241)			

2-1.5.4   Step 4: Estimate Total Pavement Thickness.

By using the appropriate aircraft design curve found in UFC 3-260-02, the total thickness of pavement required for the design aircraft and the 6 CBR subgrade is estimated to be about 36 in. (0.9 meters [m]). UFC 3-260-02, Table 8-7, requires a minimum AC thickness of 5 in. (127 mm) and a minimum base course thickness of 6 in. (152 mm) for a medium-load design, Type B traffic area, and 80 CBR base material.

2-1.5.5   Step 5: Initial Pavement Design Section.

The initial design section is as follows: 2 in. (50 mm) of RMP; 3 in. (76 mm) of AC; 6 in. (150 mm) of base; 25 in. (0.635 m) of subbase. This would likely represent the most economical design section. If added strength were required then replacing subbase material with base material would be the first logical choice. If the design analysis showed this pavement thickness was overly conservative due to the added structural capacity of the RMP layer then subbase thickness could be reduced to make the final design more economical.

2-1.5.6   Step 6: Layered Elastic Design Analysis of Initial Design Section.

The flexible pavement elastic layer design computer program (JULEA) is used to calculate strains at the critical locations, allowable passes, and damage factors for the initial RMP design section. Traffic is assumed to be evenly distributed throughout the year and is therefore weighted for each season based on the number of months in the particular season. Modulus values of the RMP and AC layers are assigned based on each season's average pavement temperature and the relationships given in Figures 2-2 and 2-4. One computer analysis is made for each of the four climatic seasons to determine allowable aircraft passes. The computer code calculates allowable passes for subgrade and AC failure criteria but the number of passes allowed by the calculated strains at the bottom of the RMP layer must be determined from the fatigue curves provided in Figure 2-3. For accurate interpretation at specific pavement temperatures, interpolate between these curves. A summary of the design inputs, calculated strains, seasonal damage factors, and cumulative damage factors is given in Table 2-3.

The results of this design analysis show that the initial design section would prematurely fail under the given conditions because of tensile cracking beginning at the bottom of the AC layer. These cracks would likely propagate upwards into the RMP layer rather quickly since the RMP and AC layers are assumed to be fully bonded. This type of pavement failure is considered to be the most common type resulting from an inadequate pavement structure when considering RMP designs.

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Table 2-3   Summary of Initial RMP Design

Pavement Layer	Thickness in. (mm)	Seasonal Modulus Values (10^3 psi [kPa])			
		Group 1	Group 2	Group 3	Group 4
RMP	2 (50)	2100 (14,479)	1775 (12,238)	1450 (9,997)	980 (6,757)
AC	3 (76)	1390 (9.584)	960 (6,619)	490 (3,378)	210 (1,448)
Base	6 (152)	50 (345)	50 (345)	50 (345)	50 (345)
Subbase	25 (635)	25 (172)	25 (172)	25 (172)	25 (172)
Subgrade	----	10 (69)	10 (69)	10 (69)	10 (69)
n_{reqd}		12,500	8,350	12,500	16,650
RMP strain		1.58×10^{-6}	0	5.43×10^{-6}	4.65×10^{-5}
RMP N_{allow}		unlimited	unlimited	unlimited	unlimited
RMP n/N		near 0	near 0	near 0	near 0
RMP CDF = 0					
AC strain		1.60×10^{-5}	2.96×10^{-4}	5.08×10^{-4}	6.05×10^{-4}
AC N_{allow}		19.4×10^9	24,032	9690	38,682
AC n/N*		near 0	0.35	1.29	0.43
AC CDF = 2.07*					
Subgrade strain		9.71×10^{-4}	9.92×10^{-4}	1.02×10^{-3}	1.06×10^{-3}
Subgrade N_{allow}		141,711	111,204	81,126	52,467
Subgrade n/N		0.09	0.07	0.15	0.32
Subgrade CDF = 0.63					

 * Indicates premature failure in AC layer for Group 3.

2-1.5.7   Step 7: Use of Calculated Strains, Allowable Passes, and Cumulative Damage Factors to Determine Optimum RMP Design Section.

The optimum RMP design section is determined by trial-and-error computer analyses of various structural profiles. The optimum design in this example represents the most economical structural profile (minimum allowable AC and base course thicknesses) that provides CDF at or below 1.0. The CDF must be equal to or less than 1.0 for each failure point (bottom of RMP, bottom of AC, top of subgrade) to satisfy this design approach. A summary of the structural layer input data, calculated strains, and damage factors for the optimum RMP design is given in Table 2-4.

For this design example, an additional 3 in. (76 mm) of AC and 8 in. (203 mm) of base course were added to the initial design section, with an equal 11-in. (279-mm) reduction

in subbase thickness to arrive at the optimum RMP design section. This optimum design provides just enough structural capacity to protect the AC layer from premature fatigue cracking.

Table 2-4   Summary of Optimal RMP Design

Pavement Layer	Thickness in (mm)	Seasonal Modulus Values (10^3 psi [kPa])			
		Group 1	Group 2	Group 3	Group 4
RMP	2 (50)	2100 (14,479)	1775 (12,238)	1450 (9,997)	980 (6,757)
AC	6 (152)	1390 (9.584)	960 (6,619)	490 (3,378)	210 (1,448)
Base	14 (356)	50 (345)	50 (345)	50 (345)	50 (345)
Subbase	14 (356)	25 (172)	25 (172)	25 (172)	25 (172)
Subgrade	----	10 (69)	10 (69)	10 (69)	10 (69)
n_{reqd}		12,500	8,350	12,500	16,650
RMP strain*		1.34×10^{-5}	9.23×10^{-5}	8.02×10^{-5}	1.34×10^{-5}
RMP N_{allow}		unlimited	unlimited	unlimited	unlimited
RMP n/N		near 0	near 0	near 0	near 0
RMP CDF = 0					
AC strain		2.34×10^{-4}	2.79×10^{-4}	3.69×10^{-4}	4.82×10^{-4}
AC N_{allow}		29,026	32,302	47,918	120,518
AC n/N		0.38	0.26	0.26	0.14
AC CDF = 1.04*					
Subgrade strain		8.09×10^{-4}	8.43×10^{-4}	9.58×10^{-4}	9.53×10^{-4}
Subgrade N_{allow}		1,120,813	703,016	165,092	175,176
Subgrade n/N		0.01	0.01	0.08	0.10
Subgrade CDF = 0.19					

 * Rounded to 1.0 provides optimum design section with AC layer controlling.

2-2   REPAIR AND MAINTENANCE TECHNIQUES.

Possible repair and maintenance techniques for existing RMP areas include joint and crack sealing, patching, and transverse grooving. These pavement repair and maintenance techniques involve methods similar to those used for traditional AC and PCC pavement surfacings.

2-2.1   Joint Sealing.

Joint sealing materials and methodologies follow the established guidance for AC and PCC pavement surfacing. Expansion or separation joints are required between RMP and adjacent PCC pavements. The joint is first saw-cut to a minimum depth equal to the maximum thickness of RMP. Make this initial saw-cut one to five days after grouting the RMP. A joint sealant reservoir is then cut as soon as possible using standard size and geometry relative to traditional PCC contraction or expansion joints, depending on the pavement's location. Construct the joints following the guidelines specified by UFGS 32 01 19, *Field Molded Sealants for Sealing Joints in Rigid Pavements*.

Typically, RMP joints are filled with approved, asphalt-based sealant materials meeting the requirements specified by American Society of Testing and Materials (ASTM) D6690, *Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements*. If improved joint sealant fuel-resistance is desired then Dow® DOWSIL™ 890-SL asphalt-compatible silicone sealant may be used. For even better fuel resistance, approved coal-tar-based sealants are used. Ensure coal tar joint sealants meet the requirements of D7116, *Standard Specification for Joint Sealants, Hot Applied, Jet Fuel Resistant Types, for Portland Cement Concrete Pavements*.

2-2.2   Crack Sealing.

2-2.2.1   Sealing cracks in RMP surfaces is similar to sealing cracks in AC and PCC pavements. In general, cracks in RMP have been found to ravel open at a slower rate than cracks in AC and PCC pavement surfaces. Unless fuel spills in the cracked RMP area are a particular concern, cracks less than 0.25 in. (6 mm) wide do not need to be sealed. Cracks larger than 0.25 in. (6 mm) wide are sealed, as needed, based on the pavement's use and traffic considerations.

2-2.2.2   The same sealant materials prescribed for joint sealing (paragraph 2.2.1) are used for sealing cracks in RMP. An additional choice for a crack-sealing material is a modified version of the same grout material used to construct the RMP. The use of this grout as a crack filler is limited to situations where crack movement has virtually stopped since the hardened grout filling the crack will be relatively stiff when compared to traditional asphalt-based or silicone-based joint- and crack-sealing materials. It will, however, give a more uniform appearance to the repaired RMP surfacing and likely last much longer, assuming no further crack movements. Regardless of the crack sealer material being used, clean the crack (and route if necessary) according to the guidance in UFGS 32 01 17.61, *Sealing Cracks in Asphalt Paving*.

2-2.2.3   The grout formulation for crack sealing is given in Table 2-5. Ensure the materials used in the grout for crack sealing meet all the physical requirements specified by UFGS 32 12 18, *Resin Modified Pavement Surfacing Material*. Mix the grout materials in either a rotary blender or a small, portable concrete batch mixer according to the sequence and mixing time guidelines under USACE ETL 1110-1-177, *Engineering and Design - Use of Resin Modified Pavement*. These mixing guidelines call for high-speed mixing of the portland cement, fly ash, sand, and water for five

minutes, adding the PL7 resin, and then mixing at high speed for an additional three minutes.

Table 2-5   Grout Formulation for RMP Crack Sealing

Material	Batch Weight
Portland cement	23%
Class F fly ash	39%
Silica sand	7%
Water	18%
PL7 resin	13%

2-2.2.4   Apply the modified grout into a cleaned RMP crack by carefully pouring the material into the crack by hand, as shown in Figure 2-5. Use a small container that can be capped to allow the grout to be shaken occasionally during the application process, which helps ensure a consistent grout material throughout the application of a particular batch. Fill the crack flush to the surface or to a level within 0.125 in. (3 mm) of the surface. Brush accidental over-fills flush to the surface level with a wet paintbrush.

Figure 2-5 Applying Modified Grout to Seal RMP Crack

2-2.3   Patching.

2-2.3.1   Typical reasons for required isolated patching of RMP include repair of utility cuts, concentrated failures in the pavement surfacing, or concentrated failures in the pavement's subsurface layers. Improper materials or construction techniques,

localized weakening in the pavement subsurface layers, expansive clays, or frost-heave damage can cause these isolated pavement failures.

2-2.3.2   Removing the RMP surface layers is done by one of two methods: milling or sawing and breaking. Pavement removal by a rotary-type cold milling machine is the method of choice when only the RMP layer is to be removed, as this method allows for pavement removal at precise depths. When a milling machine is not available or when the depth of desired pavement removal is deeper than practical for the milling machine, the sawing and breaking method is used. A water-cooled concrete saw is used to outline the area of pavement to be removed. The saw-cuts are typically made to the bottom of the underlying AC layer since the RMP and AC layers are expected to be fully bonded by a tack coat. The RMP and AC layers are broken up by pneumatic drills, pneumatic hammers, or other hand tools before removing the damaged material. If pavement subsurface layers are removed or disturbed then each layer is replaced or reconstructed to meet all applicable specifications used in the original construction.

2-2.3.3   It is best to repair with the same type of materials used to construct the original pavement, as this provides uniformity in and around the patch area; however, using the same original pavement material type is not always practical from an availability or economic standpoint. For this reason, two types of pavement materials are allowed when resurfacing RMP patches: RMP over AC and traditional PCC materials. The PCC material option is not recommended, however, except when the patch surface area is greater than 65 square feet (ft^2) (6 square meters [m^2]).

2-2.3.4   When only the RMP layer is removed, RMP material is used to replace this surface since traditional PCC materials are not effective surfaces when placed at very shallow depths. Spray or brush a light coating of bituminous emulsion onto the cleaned bottom and sides of the repair area before placing the hot, open-graded bituminous mixture. Unless numerous large-scale patches are being repaired at the same time, the open-graded bituminous mixture may be hand-placed and raked to an even level at 0.2 to 0.4 in. (5 to 10 mm) above the desired finished surface. For relatively large repair areas, it is best to place the hot, open-graded bituminous materials with a standard asphalt paver to the same level slightly above the surrounding pavement surface. Compaction of the hot, open-graded bituminous mixture is done by three to five passes of a hand-operated vibratory plate compactor or two passes of a 4,409- to 6,614-pound (2- to 3-metric-ton) steel-wheel roller in the static mode. Once the open-graded bituminous material has cooled to less than 100 °F (38 °C), the resin-modified grout is poured onto the repair area, being careful not to spill the grout outside the repair area. The same vibratory equipment used to compact the open-graded bituminous material is used to vibrate the grout into the open-graded material immediately after applying the grout. Once the repair area is filled with grout, a curing compound is sprayed onto the surface in the same manner and application rate as specified for original RMP construction. The RMP patch can accept foot traffic the day after construction and light automobile traffic after three days. An RMP patch is considered full-strength 14 days after construction in relatively warm and dry environments and 21 days after construction in relatively cool and/or wet environments.

2-2.3.5 When both the RMP and AC layers are removed, the surface materials used in the patch are RMP over AC (identical thicknesses to the original pavement section) or traditional PCC materials. If the RMP over AC approach is used, ensure the AC material is of the same general quality and formulation as the AC used in the original design. The RMP layer is then placed in the same manner as previously described for a shallow RMP patch. Traditional PCC materials are used to patch RMP repair areas when placed at a depth of at least 4 in. (100 mm) and in patch surface areas no greater than 7.2 square yards (yd^2) (6 square meters (m^2)). When the patch surface area is 11 ft^2 (1 m^2) or less then PCC materials are placed in the normal manner except that no bonding agents are used. When the patch surface area is between 1.2 and 7.2 yd^2 (1 and 6 m^2) then form joints between the PCC patch and the surrounding RMP and AC pavement layers. Form the joints in-place during patching or saw-cut as soon as possible after patching. Ensure the joints have a width of at least 0.375 in. (10 mm), follow other standard PCC joint geometric provisions, and are filled with joint sealant materials previously described in this TSPWG Manual.

2-2.3.6 The four RMP patching options are shown in the pavement profiles in Figure 2-6.

Figure 2-6   General Pavement Profiles for RMP Patching Options
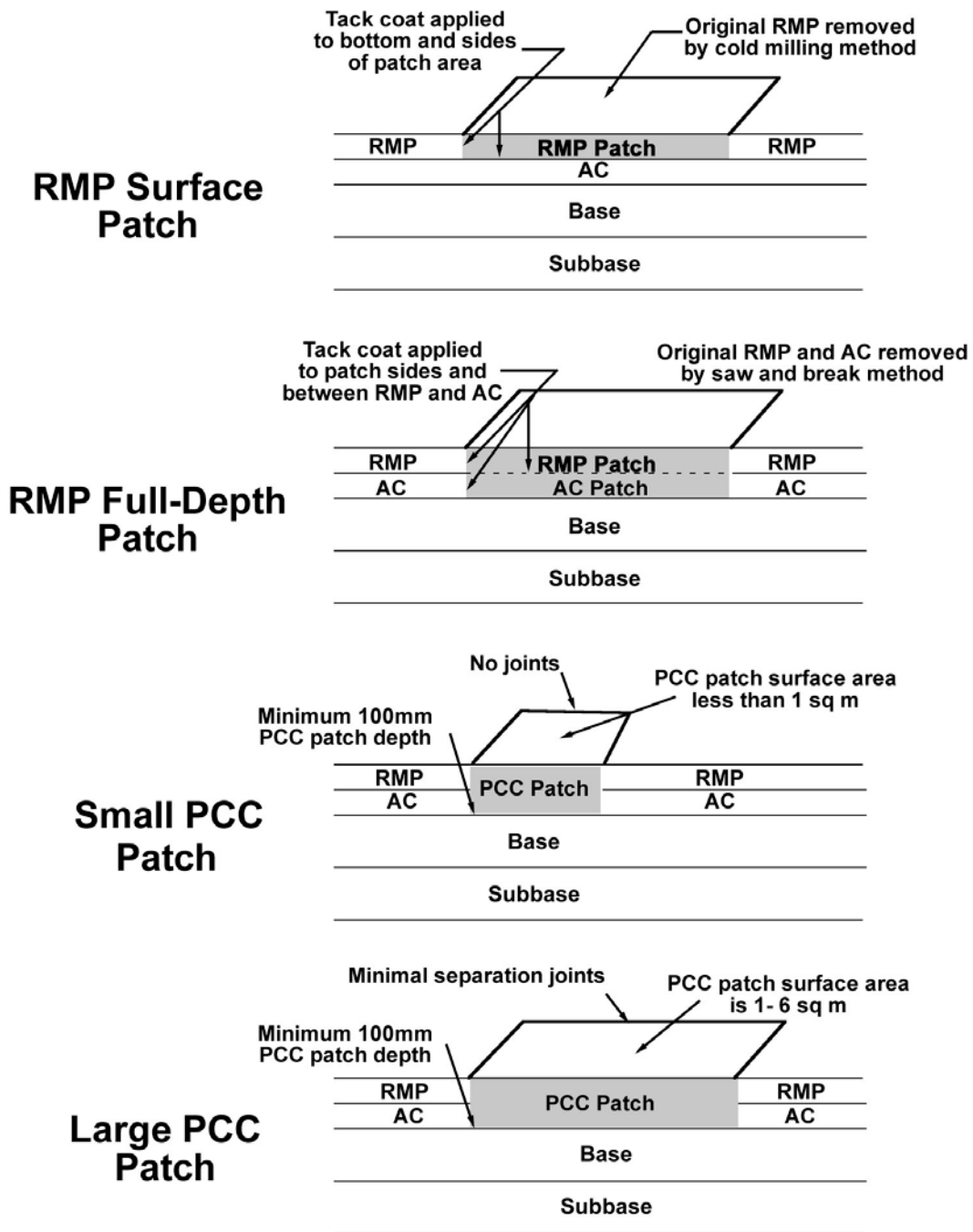
2-2.4   Grooving.

The skid resistance of properly constructed RMP has been found to be suitable for high-speed airfield traffic, with friction properties comparable to traditional PCC and AC

pavement surfaces; however, it is possible that the skid resistance of RMP may fall below desirable standards due to problems such as weathering, polishing aggregates, or improper construction techniques. A pavement rehabilitation technique used to improve RMP skid resistance is grooving.

Grooving is creating a series of small grooves or cuts in the pavement surface, usually about 0.25 in. wide by 0.25 in. deep (6 mm wide by 6 mm deep) and spaced about 1.5 in. (40 mm) apart. The grooves are saw-cut across the full width of the airfield pavement and transverse or perpendicular to the normal direction of traffic. For new pavements, RMP is cured at least 21 days after grouting before grooving takes place; otherwise, RMP grooving follows the guidance set forth in UFGS 32 01 18.71, *Grooving of Airfield Paving*, and UFC 3-260-02, Chapter 21.

2-3   AREAS OF APPLICATION.

RMP is used for virtually any road or airfield pavement application except for runway pavements. RMP has been field-proven to resist damage from fuel spills and other liquid solvents due to its relatively low permeability when compared to AC and PCC. It has also been proven to resist damage from tracked vehicles and vehicles with solid rubber tires, and rutting and other deformation distresses resulting from various combinations of high tire pressures, channelized traffic, and high pavement temperatures. RMP surfacing is placed over a flexible pavement structure, with at least 2 in. (50 mm) of dense-graded AC placed underneath the RMP layer. RMP is used as overlay surfacing when rehabilitating either flexible pavements or pavements with AC over PCC.

2-4   LIFECYCLE COSTS.

The following historical cost data has been escalated to October 2019 and is provided based on limited bid documents and maintenance records from previous RMP applications in the United States:

- Unit cost for construction of a typical 2-in. (50-mm) -thick RMP layer is $19.00 to $32.00 per yd^2 ($23.00 to $38.00 per m^2).

- When RMP is placed over jointed portland cement concrete (JPCC) and matching joints are cut in RMP, add $8.00 per yd^2 ($10.00 per m^2). **Note:** This additional cost is based on a 20-year pavement life, initial and five-year cycle joint sealing and resealing, 16-foot-square (5-meter-square) JPCC slabs, and $1.83 per linear foot ($6.00 per linear meter) for joint sealing and resealing.

- When RMP is placed over JPCC (at any depth below pavement surface) and RMP surfacing is allowed to reflective-crack naturally, add $4.32 per square yard ($5.17 per square meter). **Note:** This additional cost is based on a 20-year pavement life, 16-foot-square (5-meter-square) slabs, 50 percent reflective cracking at 10 years costing $4.00 per linear foot ($13.12 per linear meter) to rout and seal, and 75 percent reflective

cracking at 15 years costing $2.4.00 per linear foot ($13.12 per linear meter) to rout and seal, plus $1.83 per linear foot ($6.00 per linear meter) to reseal existing cracks.

- No additional maintenance costs are expected for a 20-year design life when RMP is placed over structurally sound flexible pavement substructure (including rubblized or cracked and seated PCC).

APPENDIX A GLOSSARY

°C	Celsius
°F	Fahrenheit
AC	Asphalt Concrete
ASTM	American Society for Testing and Materials
CBR	California Bearing Ratio
CDF	Cumulative Damage Factor
DOD	Department of Defense
EE	Elastic Strain
ETL	Engineering Technical Letter
ft^2	Foot Square
GPa	gigapascal
in.	Inch
JULEA	Jacob Uzan Layered Elastic Analysis
kPa	Kilopascal
kpsi	Kilopound Per Square Inch
m	Meter
m^2	Square Meter
mm	Millimeter
Nf	Passes to Failure
PCC	Portland Cement Concrete
psi	Pound Per Square Inch
RMP	resin modified pavement
UFC	Unified Facilities Criteria
UFGS	Unified Facilities Guide Specification

USACE   U.S. Army Corps of Engineers

yd^2 Square Yard

APPENDIX B REFERENCES

A general description of RMP technology is given in the U.S. Army Engineer Waterways Experiment Station Miscellaneous Paper (MP) GL-96-7, *User's Guide: Resin Modified Pavement*. Mix design and quality control testing guidance for RMP is provided in USACE ETL 1110-1-177, *Engineering and Design - Use of Resin Modified Pavement*. The user is also directed to UFGS 32 12 19.16, *Resin Modified Asphalt Paving Wearing Courses*, for a model specification on RMP materials, construction, and testing requirements.

DOD

UFC 3-260-02, *Pavement Design for Airfields*, http://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc

UFGS 32 12 19.16, *Resin Modified Asphalt Paving Wearing Courses*,

UFGS 32 01 17.61, *Sealing Cracks in Asphalt Paving*, https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs

UFGS 32 12 18, *Resin Modified Pavement Surfacing Material*, https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs

UFGS 32 01 18.71, *Grooving of Airfield Paving*, https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs

UFGS 32 01 19, *Field Molded Sealants for Sealing Joints in Rigid Pavements*, https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs

ARMY

ERDC/GL TR-00-02, *Engineering Properties of Resin Modified Pavement (RMP) for Mechanistic Design*

MP GL-96-7, *User's Guide: Resin Modified Pavement*

ETL 1110-1-177, *Engineering and Design - Use of Resin Modified Pavement*

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

https://www.astm.org/

D6690, *Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements*

D7116, *Standard Specification for Joint Sealants, Hot Applied, Jet Fuel Resistant Types, for Portland Cement Concrete Pavements*