DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

SEP 25 2001

FROM: AFCESA/CES
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SUBJECT: **Engineering Technical Letter (ETL) 01-8: Resin Modified Pavement (RMP) Design and Application Criteria**

1. Purpose. This ETL provides guidance to help the base civil engineer (BCE) and other users 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 5.1). Maintenance may include joint and crack sealing, spot repairs, and surface grooving (paragraph 5.2).

2. Application: Any pavement or environment, excluding airfield runways, on Air Force installations.

2.1. Authority: Air Force Manual (AFM) 88-7, Chapter 1, *Pavement Design for Roads, Streets, Walks, and Open Storage Areas* (Unified Facilities Criteria [UFC] 3-250-01); UFC 3-260-02, *Pavement Design for Airfields*.

2.2. Effective Date: Immediately.

2.3. Ultimate Recipients: BCEs; Rapid Engineers Deployable – Heavy Operations Squadron Engineers (RED HORSE) squadrons; other Air Force units responsible for pavement design, construction, and maintenance; U.S. Army Corps of Engineers (USACE) and Navy offices responsible for Air Force design and construction.

2.4. Coordination: Major command (MAJCOM) pavement engineers.

3. Referenced Publications. A general description of RMP technology is given in the U.S. Army Center for Public Works 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 Unified Facilities Guide Specification (UFGS) 02746, *Resin Modified Pavement*, for a model specification on RMP materials, construction, and testing requirements.

3.1. Air Force:

- Air Force Manual (AFM) 88-7, Chapter 1, *Pavement Design for Roads, Streets, Walks, and Open Storage Areas*.

3.2. Unified Facilities Publications:

- Unified Facilities Criteria (UFC) 3-250-01, *Pavement Design for Roads, Streets, Walks, and Open Storage Areas.*
- UFC 3-260-02, *Pavement Design for Airfields.*
- Unified Facilities Guide Specification (UFGS) 02760A, *Field Molded Sealants for Sealing Joints in Rigid Pavements***.**
- UFGS 02975A, *Sealing of Cracks in Bituminous Pavements.*
- UFGS 02981A, *Grooving for Airfield Pavements.*

3.3. American Society for Testing and Materials (ASTM):

- ASTM D 1190, *Standard Specification for Concrete Joint Sealer, Hot-Applied Elastic Type*.
- ASTM D 3405, *Standard Specification for Joint Sealants, Hot-Applied, for Concrete and Asphalt Pavements*.
- ASTM D 3569, *Standard Specification for Joint Sealant, Hot-Applied, Elastomeric, Jet-Fuel-Resistant-Type for Portland Cement Concrete Pavements*.
- ASTM D 3581, *Standard Specification for Joint Sealant, Hot-Poured, Jet-Fuel-Resistant Type, for Portland Cement Concrete and Tar-Concrete Pavements*.

4. Acronyms and Terms:

AC	- asphalt concrete
AFM	- Air Force Manual
ASTM	- American Society for Testing and Materials
BCE	- base civil engineer
C	- Celsius
CBR	- California bearing ratio
CDF	- cumulative damage factor
ETL	- Engineering Technical Letter
F	- Fahrenheit
GPa	- gigapascal
JPCC	- jointed Portland cement concrete
JULEA	- Jacob Uzan Layered Elastic Analysis
MAJCOM	- major command
MP	- Miscellaneous Paper
Nf	- passes to failure
PCC	- Portland cement concrete
psi	- pound per square inch
RED HORSE	- Rapid Engineers Deployable – Heavy Operations Squadron Engineers
RMP	- resin modified pavement
SI	- Système International D’unités
USACE	- U.S. Army Corps of Engineers
UFC	- Unified Facilities Criteria
UFGS	- Unified Facilities Guide Specification

5. Specific Requirements.

5.1. Structural Design Criteria.

5.1.1. For pavement designs other than airfields, RMP is to be designed using guidance provided in AFM 88-7, Chapter 1. In these cases, the RMP thickness (40 to 60 millimeters [1.5 to 2.5 inches]) is considered equal to the same thickness of asphalt concrete (AC) surfacing. The pavement is designed like a traditional AC surfaced flexible pavement, and then the RMP thickness is used to replace an equal thickness of the top layer of AC. A minimum thickness of 50 millimeters (2 inches) of AC is required beneath the RMP surfacing. When the combined RMP and AC thickness exceeds the design thickness of AC surfacing in the traditional flexible pavement design, then standard AC equivalency factors may be used to reduce base or subbase thickness. An example of such a design conversion is shown in Figure 1.

(a)	(b)
AC 75 mm (3 in)	**RMP** 50 mm (2 in)
	AC 50 mm (2 in)
Base 150 mm (6 in)	**Base** 22 mm (5 in)
Subbase 150 mm (6 in)	**Subbase** 150 mm (6 in)
Subgrade	**Subgrade**

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

5.1.2. 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 50 millimeters 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. Poisson's ratio of RMP is considered to be uniform at all normal pavement temperatures, with a value of 0.27 recommended for design.

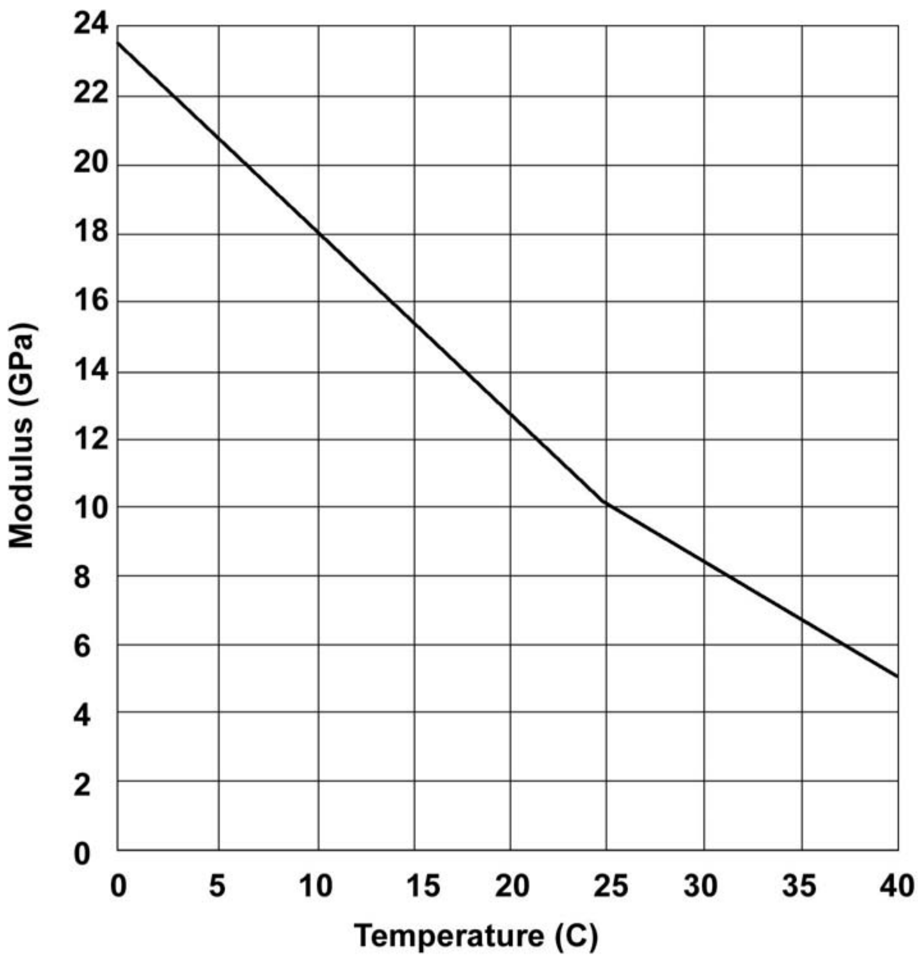

Figure 2. RMP Resilient Modulus Versus Temperature Design Curve.

5.1.3. 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 should occur 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 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.

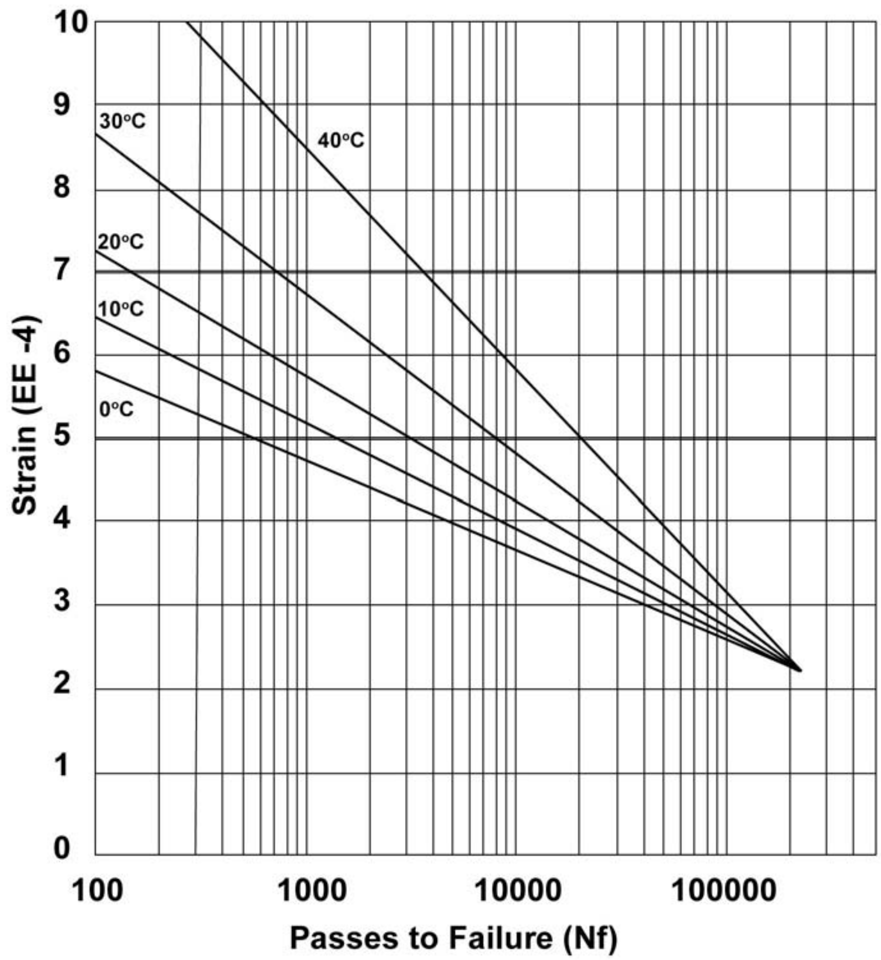

Figure 3. RMP Fatigue Design Curves at Various Pavement Temperatures.

5.1.4. The typical RMP airfield pavement design includes the following, as a minimum:

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

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

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

5.1.4.4. 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 thickness from standard requirements for the given pavement design.

5.1.4.5. An initial pavement design section based on the following:

5.1.4.5.1. The top 40- to 60-millimeter-thick layer is RMP with a modulus based on seasonal average pavement temperature and Poisson's ratio of 0.27.

5.1.4.5.2. 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 50 millimeters. Modulus and Poisson's ratio of AC are relative to seasonal pavement temperature or other acceptable standard value used by the design agency.

5.1.4.5.3. The base course layer should begin 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.

5.1.4.5.4. The remaining pavement thickness required by the subgrade CBR criteria must be 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.

5.1.4.6. 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).

5.1.4.7. 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.

5.1.5. 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) are used with the data for this example since the current JULEA computer program is designed for these units.

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.

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, 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 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.

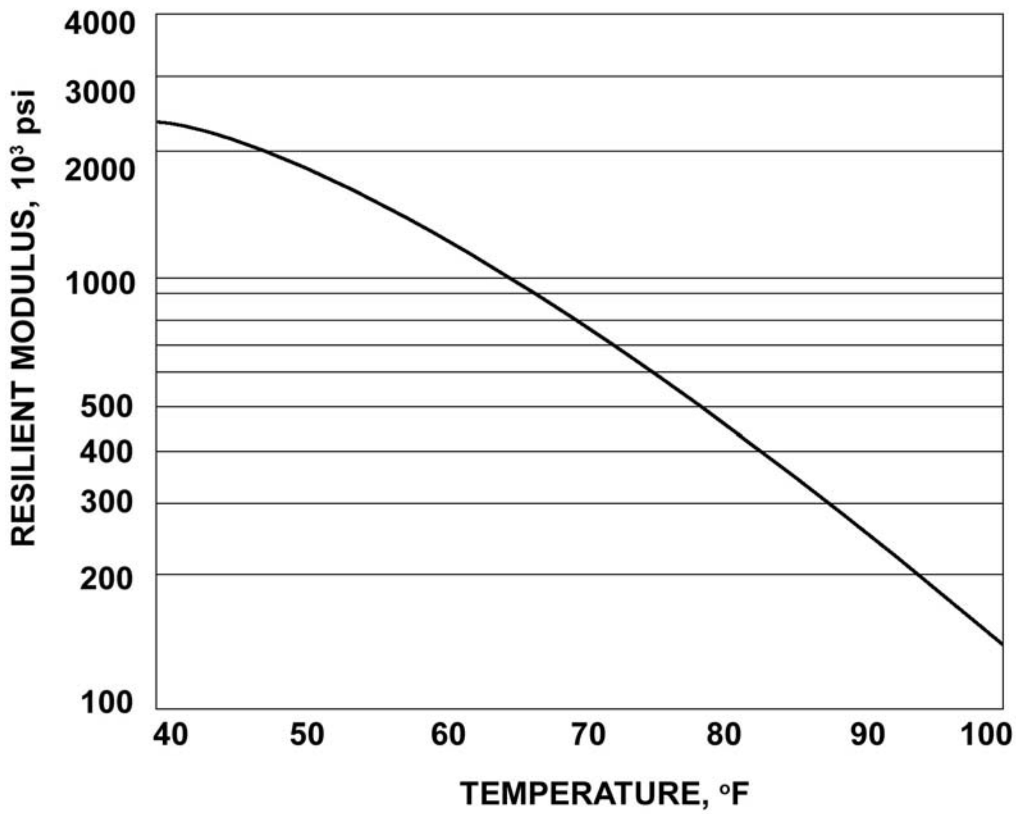

Figure 4. AC Temperature-Modulus Relationship for Design Example.

Step 3: Historical Temperature Data. The design pavement temperature is obtained from the climatic data of this site, and the design AC modulus values are found as shown in Table 1. To reduce the number of computations, the 12-month groups are reduced to four seasonal groups as shown in Table 2.

Table 1. Monthly Design Pavement Temperatures and AC Moduli.

Month	Pavement Design Temperature	Resilient Modulus (10^3 psi)
January	56 °F	1500
February	60 °F	1270
March	67 °F	920
April	76 °F	570
May	84 °F	360
June	92 °F	220
July	95 °F	180
August	95 °F	180
September	89 °F	260
October	77 °F	540
November	65 °F	1000
December	57 °F	1400

Table 2. Grouping Traffic into Seasonal Traffic Groups.

Group	Month	Resilient Modulus (10^3 psi)		Percent of Total Traffic	Group Required Passes (n_{reqd})
		Monthly Value	Group Average		
1	Jan	1500	1390	25.0	12,500
	Dec	1400			
	Feb	1270			
2	Nov	1000	960	16.7	8350
	Mar	920			
	Apr	570			
3	Oct	540	490	25.0	12,500
	May	360			
	Sep	260			
4	Jun	220	210	33.3	16,650
	Jul	180			
	Aug	180			

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 inches. Air Force standards (UFC 3-260-02, Table 8-5) require a minimum AC thickness of 5 inches and a minimum base course thickness of 6 inches for a medium-load design, Type B traffic area, and 80-CBR base material.

Step 5: Initial Pavement Design Section. The initial design section is as follows: 2 inches of RMP; 3 inches of AC; 6 inches of base; 25 inches 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.

Step 6: Layered Elastic Design Analysis of Initial Design Section. The flexible pavement elastic layer design computer program 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 and 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 3. Interpolation between these curves may be necessary for accurate interpretation at specific pavement temperatures. A summary of the design inputs, calculated strains, seasonal damage factors, and cumulative damage factors is given in Table 3.

The results of this design analysis show that the initial design section would fail prematurely 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.

Table 3. Summary of Initial RMP Design.

Pavement Layer	Thickness	Seasonal Modulus Values (10^3 psi)			
		Group 1	Group 2	Group 3	Group 4
RMP	2 in	2100	1775	1450	980
AC	3 in	1390	960	490	210
Base	6 in	50	50	50	50
Subbase	25 in	25	25	25	25
Subgrade	----	10	10	10	10
n_{reqd}		12,500	8350	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.

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 thickness) 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 4.

For this design example, an additional 3 inches of AC and 8 inches of base course were added to the initial design section with an equal 11-inch 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 4. Summary of Optimum RMP Design.

Pavement Layer	Thickness	Seasonal Modulus Values (10^3 psi)			
		Group 1	Group 2	Group 3	Group 4
RMP	2 in	2100	1775	1450	980
AC	6 in	1390	960	490	210
Base	14 in	50	50	50	50
Subbase	14 in	25	25	25	25
Subgrade	----	10	10	10	10
n_{reqd}		12,500	8350	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.

5.2. 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.

5.2.1. Joint Sealing.

5.2.1.1. Joint sealing materials and methodologies follow the established guidance for AC and PCC pavement surfacings. 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. This initial saw-cut should be made 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. Construction of the joints should follow the guidelines specified by USACE UFGS 02760A, *Field Molded Sealants for Sealing Joints in Rigid Pavements*.

5.2.1.2. Typically, RMP joints are filled with approved, asphalt-based sealant materials meeting the requirements specified by American Society of Testing and Materials (ASTM) D 1190, *Concrete Joint Sealer, Hot-Applied Elastic Type*, or ASTM D 3405, *Joint Sealants, Hot-Applied, for Concrete and Asphalt Pavements*. If improved joint sealant fuel-resistance is desired, then Dow Corning 890-SL asphalt-compatible silicone sealant may be used. For even better fuel resistance, approved coal-tar-based sealants are used. Coal tar joint sealants must meet the requirements of ASTM D 3569, *Joint Sealant, Hot-Applied, Elastomeric, Jet-Fuel-Resistant-Type for Portland Cement Concrete Pavements*, or ASTM D 3581, *Joint Sealant, Hot-Poured, Jet-Fuel-Resistant-Type for Portland Cement Concrete and Tar-Concrete Pavements*.

5.2.2. Crack Sealing.

5.2.2.1. Sealing cracks in RMP surfacings 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 surfacings. Unless fuel spills in the cracked RMP area are a particular concern, cracks less than 6 millimeters (0.25 inch) wide should not be sealed. Cracks larger than 6 millimeters wide should be sealed, as needed, based on the pavement's use and traffic considerations.

5.2.2.2. The same sealant materials prescribed for joint sealing (paragraph 5.2.1) should be 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 should be 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, the crack should be cleaned (and routed if necessary) according to the guidance found in UFGS 02975A, *Sealing of Cracks in Bituminous Pavements*.

5.2.2.3. The grout formulation for crack sealing is given in Table 5. The materials used in the grout for crack sealing must meet all the physical requirements specified by UFGS 02746, *Resin Modified Pavement Surfacing Material*. The grout materials should be mixed 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, then mixing at high speed for an additional three minutes.

Table 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%

5.2.2.4. Apply the modified grout into a cleaned RMP crack is by carefully pouring the material into the crack by hand, as shown in Figure 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. The crack should be filled flush to the surface or to a level within 3 millimeters (0.125 inch) of the surface. Accidental over-fills may be brushed flush to the surface level with a wet paintbrush.

Figure 5. Applying Modified Grout to Seal RMP Crack.

5.2.3. Patching.

5.2.3.1. Isolated patching of RMP may be required for some reasons, including 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.

5.2.3.2. Removing the RMP surface layers can be 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 should be used. A water-cooled concrete saw is used to outline the area of pavement to be removed. The saw-cuts will typically be 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 can be 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 must be replaced or reconstructed to meet all applicable specifications used in the original construction.

5.2.3.3. 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. It is for this reason that 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, when the patch surface area is greater than 6 square meters (65 square feet).

5.2.3.4. When only the RMP layer is removed, RMP material must be used to replace this surfacing since traditional PCC materials are not effective surfacings when placed at very shallow depths. A light coating of bituminous emulsion should be sprayed or brushed 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 5- to 10-millimeters 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 2000- to 3000-kilogram (2- to 3-metric-ton) steel-wheel roller in the static mode. Once the open-graded bituminous material has cooled to less than 38 °C (100 °F), 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.

5.2.3.5. When both the RMP and AC layers are removed, the surface materials used in the patch may be RMP over AC (identical thicknesses to the original pavement section) or traditional PCC materials. If the RMP over AC approach is used, the AC material must be 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 may be used to patch RMP repair areas when placed at a depth of at least 100 millimeters (4 inches) and in patch surface areas no greater than 6 square meters. When the patch surface area is 1 square meter (11 square feet) 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 and 6 square meters, then joints must be formed between the PCC patch and the surrounding RMP and AC pavement layers. The joints can be formed in place during patching or saw-cut as soon as possible after patching. The joints should have a width of at least 10 millimeters (0.375 inch), follow other standard PCC joint geometric provisions, and should be filled with joint sealant materials previously described in this ETL.

5.2.3.6. The four RMP patching options are shown in the pavement profiles in Figure 6.

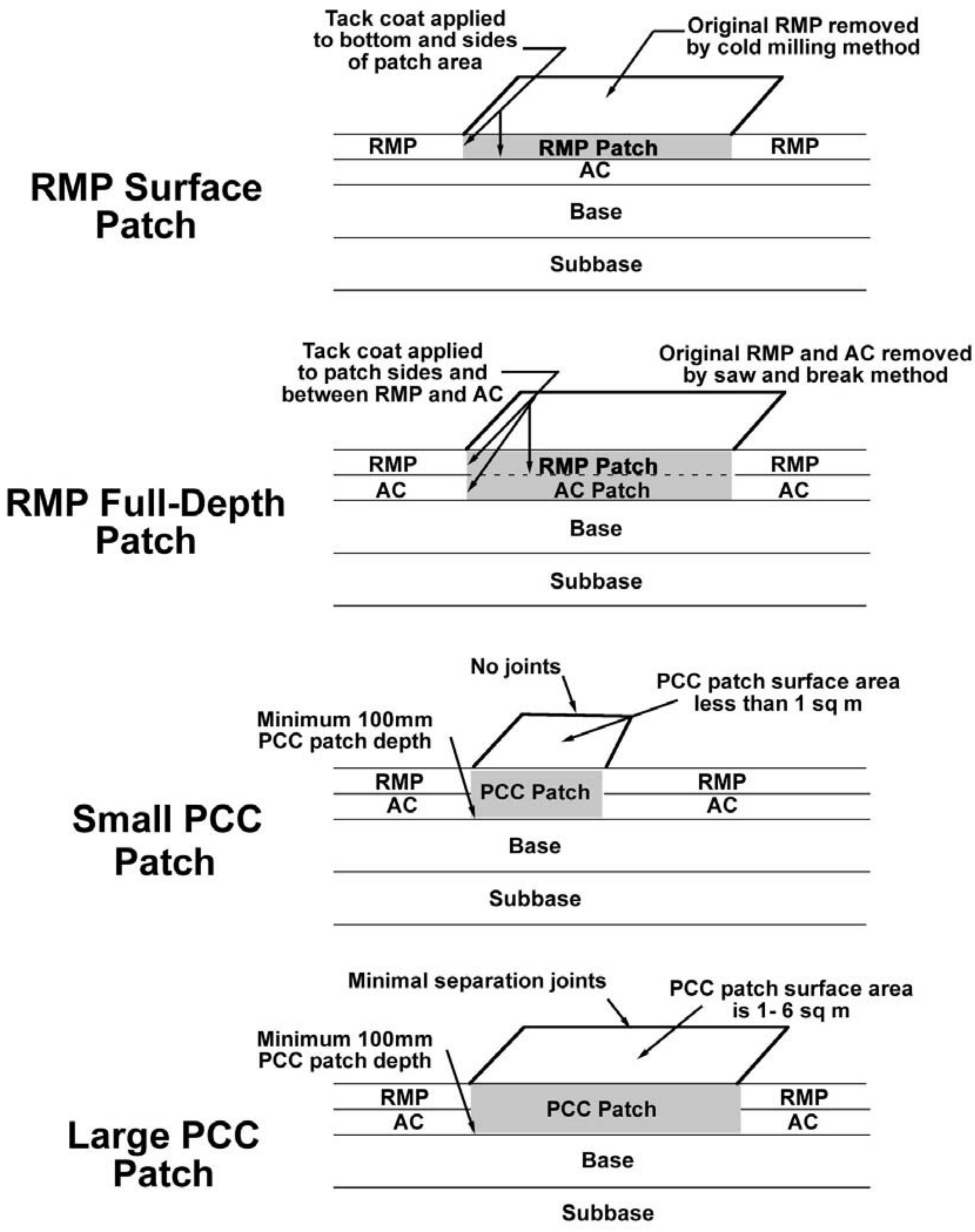

Figure 6. General Pavement Profiles for RMP Patching Options.

5.2.4. Grooving.

5.2.4.1. 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 surfacings; 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 that may be used to improve RMP skid resistance is grooving.

5.2.4.2. Grooving is creating a series of small grooves or cuts in the pavement surface, usually about 6 millimeters wide by 6 millimeters deep, and spaced about 40 millimeters 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 should be cured at least 21 days after grouting before grooving takes place. RMP grooving should otherwise follow the guidance set forth in UFGS 02981A, *Grooving for Airfield Pavements*, and UFC 3-260-02, Chapter 21.

5.3. Areas of Application. RMP may be 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 may be placed over a flexible pavement structure, with at least 50 millimeters (2 inches) of dense-graded AC placed underneath the RMP layer. RMP may be used as overlay surfacing when rehabilitating either flexible pavements or pavements with AC over PCC.

5.4. Life Cycle Costs. The following cost data are provided, based on limited bid documents and maintenance records from previous RMP applications in the United States:

5.4.1. Unit cost for construction of a typical 50-millimeter-thick RMP layer is $14.00 to $24.00 per square meter ($12.00 to $20.00 per square yard**).**

5.4.2. When RMP is placed over jointed Portland cement concrete (JPCC) and matching joints are cut in RMP, add $6.00 per square meter ($5.00 per square yard). ***Note:*** *This additional cost is based on a 20-year pavement life, initial and 5-year cycle joint sealing and resealing, 5-meter-square (16-foot-square) JPCC slabs, and $3.77 per linear meter ($1.15 per linear foot) for joint sealing and resealing.*

5.4.3. When RMP is placed over JPCC (at any depth below pavement surface), and RMP surfacing is allowed to reflective-crack naturally, add $3.25 per square meter ($2.71 per square yard). ***Note:*** *This additional cost is based on a 20-year pavement life, 5-meter-square slabs, 50% reflective cracking at 10 years costing $8.20 per linear meter ($2.50 per linear foot) to rout and seal, and 75% reflective cracking at 15 years costing $8.20 per linear meter to rout and seal, plus $3.77 per linear meter to reseal existing cracks.*

5.4.4. 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).

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