
USACE / NAVFAC / AFCEA / NASA UFGS-32 01 17 (April 2006)

Preparing Activity: USACE Replacing without change
UFGS-02965 (April 2005)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2008

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SECTION 32 01 17

COLD-MIX RECYCLING 04/06

NOTE: This guide specification covers the requirements for recycled cold-mix asphalt concrete.

Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

PART 1 GENERAL

1.1 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically
be deleted from this section of the project
specification when you choose to reconcile
references in the publish print process.

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

ASTM INTERNATIONAL (ASTM)

ASTM C 117	(2004) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 131	(2006) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C 29/C 29M	(2007) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C 88	(2005) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM D 140	(2001; R 2007) Sampling Bituminous Materials
ASTM D 1556	(2000) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 2041	(2003a) Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D 2172	(2005) Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D 2216	(2005) Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D 2397	(2005) Standard Specification for Cationic Emulsified Asphalt
ASTM D 242	(2004) Mineral Filler for Bituminous Paving Mixtures
ASTM D 422	(1963; R 2002e1) Particle-Size Analysis of Soils
ASTM D 4643	(2000) Determination of Water (Moisture)

	Content of Soil by the Microwave Oven Method
ASTM D 4791	(2005e1) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D 4944	(2004) Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester Method
ASTM D 4959	(2007) Determination of Water (Moisture) Content of Soil by Direct Heating
ASTM D 6938	(2007a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D 75	(2003) Standard Practice for Sampling Aggregates
ASTM D 977	(2005) Emulsified Asphalt

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 649	(1995) Standard Test Method for Unit Weight, Marshall Stability, and Flow of Bituminous Mixtures
COE CRD-C 650	(1995) Standard Test Method for Density and Percent Voids of Compacted Bituminous Paving Mixtures

1.2 UNIT PRICE

NOTE: This paragraph will be deleted if the work is included in one lump-sum contract price for the entire work covered by the invitation for bids. This paragraph may be revised to combine the payment for cold-mix recycled mixture, rejuvenator (if needed), and emulsified asphalt cement, when separate payment for emulsified asphalt cement material is not considered warranted based on local experience and job conditions. Lump-sum contracts can be used when the total job does not exceed 16,800 square meters (20,000 square yards) or 1000 metric tons (tons).

1.2.1 Measurement

NOTE: Where inplace mixing is used, measurement will be in square meters (yards) of accepted work.

Cold-mix recycling paid for will be the number of [metric tons tons] [square

meters yards] used in the accepted work. Aggregates will be paid for by the number of [metric tons tons] [square meters yards] used in the accepted work. The recycling agent will be paid for by the number of [liters gallons] [metric 2000-pound tons] of material used in accepted work. The emulsified asphalt cement will be paid for by the number of [liters gallons] [metric 2000-pound tons] of material used in accepted work. The number of liters gallons of emulsified asphalt cement used shall be determined either by measuring the material at a temperature of 15.6 degrees C 60 degrees F or by correcting the amount measured at another temperature to liters gallons at 15.6 degrees C 60 degrees F, using a coefficient of expansion of 0.00045 per degree C 0.00025 per degree F for the emulsified asphalt.

1.2.2 Payment

The quantities of recycled paving mixture, aggregates, recycling agent, and emulsified asphalt cement, determined as provided above, will be paid for at respective contract unit prices per [metric ton ton] [square meter yard] for paving mixture and aggregates and per [liter gallon] [metric ton ton] for recycling agent and emulsified asphalt cement. If deficiencies in the finished product exceed specified tolerances, no payment will be made for such areas of pavement until the defective areas are corrected and accepted by the Contracting Officer.

1.3 SUBMITTALS

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Aggregates
Asphalt Cement
Recycling Agent

Notification on sources from which aggregates, emulsified asphalt cement (bituminous materials), and recycling agent are to be obtained within 15 days after contract award.

Job-Mix Formula (JMF) [; G] [; G, [____]]

The Job-Mix Formula (JMF) after the award of the contract and at least [30] [____] days prior to placement of recycled mixture.

SD-04 Samples

Samples

Samples from the existing pavement obtained from at least two locations to provide representative samples of the pavement.

Cold Recycled Mixture

A 50 kg 100 lb sample of each aggregate, a 100 kg 200 lb representative sample of the recyclable asphalt pavement, a 20 L 5 gallon sample of recycling agent, and a 20 L 5 gallon sample of emulsified asphalt cement for mix design, not less than [30] [____] days before material is required in the work.

SD-06 Test Reports

Testing

Copies of test results within 24 hours of completion of tests. Copies of test reports for aggregate source, not less than [30] [____] days before the material is required in the work. Certified copies of the emulsified asphalt cement and/or recycling agent manufacturer's test reports indicating compliance with applicable specified requirements, not less than [30] [____] days before material is required in the work.

1.4 EQUIPMENT

1.4.1 General

Plant, machines, tools, and miscellaneous equipment to be used on the production and placement of the cold recycled mixture shall be approved by the Contracting Officer. Tentative approval of specific items will be made only after adequacy of the plant, machines, tools, and miscellaneous equipment has been demonstrated in full-scale production.

1.4.2 Central Plant Mixing

NOTE: This paragraph and paragraph In-Place Mixing
should be left in only when it is desired to give
the Contractor a choice between central plant mix
and in-place methods.

The mixing plant shall be designed, coordinated, and operated to produce mixture within the JMF. The plant shall be capable of producing recycled mixture at a minimum rate of [136] [_____] Mg [150] [_____] tons per hour. The plant shall be equipped with positive means to control the amount of asphalt, water, and time of mixing.

1.4.3 In-Place Mixing

Equipment used for in-place mixing construction shall be designed, coordinated, and maintained to produce mixture within the JMF. The mixing equipment used shall be equipped with positive means to control the amount of asphalt and water added and shall be capable of producing a homogeneous mixture.

1.4.4 Straightedge

The Contractor shall furnish and maintain at the site, in good condition, one 3.66 meter 12 foot straightedge for each mechanical spreader. Straightedge shall be made available for Government use. Straightedges shall be constructed of aluminum or other lightweight metal and shall have blades of box or box-girder cross section with flat bottom reinforced to insure rigidity and accuracy. Straightedges shall have handles to facilitate movement on pavement.

1.5 ACCESS TO PLANT AND EQUIPMENT

The Contracting Officer shall have access, at any time, to all equipment used to produce the cold-recycled mixture; this can involve checking the adequacy of the equipment used, inspecting the operation of the equipment, and verifying weights, mixture proportions, and the character and physical properties of the materials used for construction.

1.6 WEATHER LIMITATIONS

A recycled cold-mix course shall not be constructed in rain or on a layer which contains free water either within the layer or on its surface. Recycled cold-mix courses shall be constructed only when the atmospheric temperature is 10 degrees C 50 degrees F or above.

1.7 SAMPLING AND TESTING

1.7.1 General Requirements

Sampling and testing shall be performed by a commercial testing laboratory or by Contractor facilities upon approval by the Contracting Officer. No work requiring testing will be permitted until the testing facilities have been inspected and approved. The first inspection shall be at the expense of the Government. Cost incurred by the Government for any subsequent inspection required because of failure of the facilities to pass the first

inspection will be charged to the Contractor.

1.7.2 Samples

Recyclable asphalt pavement and aggregate samples for laboratory tests shall be taken in accordance with ASTM D 75. Samples of the emulsified asphalt cement (bituminous material) shall be taken in accordance with ASTM D 140.

1.7.3 Sampling and Testing During Construction

Quality control sampling and testing shall be performed as required in the paragraph ACCEPTABILITY OF WORK.

PART 2 PRODUCTS

2.1 RECYCLABLE ASPHALT PAVEMENT (RAP)

NOTE: Cold-mix recycling could include the use of existing RAP material stockpiles. If this condition exists, the desired material properties must be included below. The gradation of the existing stockpile will need to be determined.

The RAP shall consist of material obtained from cold milling or from removal and crushing of the existing asphalt concrete pavement. The maximum particle size of the RAP material shall never exceed half the thickness of the compacted recycled pavement. When lifts of 75 mm 3 inches or more are used, the maximum particle size of the RAP material shall not exceed a maximum of 38 mm 1-1/2 inch and a minimum of 90 percent of the RAP shall pass a 25 mm 1 inch sieve.

2.2 AGGREGATES

NOTE: Delete this paragraph when new or additional aggregates are not required as part of the recycling project. When required, new aggregates may be added to produce an aggregate gradation that meets the desired end product. Gradations for base course, stabilized base course or asphalt concrete intermediate course materials should be specified in Table I below. The choice of which gradation to specify should be based on the type, quality, and uniformity of the RAP material available for use.

The gradation may require only that a maximum aggregate particle size not be exceeded or it may be more detailed, requiring further processing or adjustment with new aggregates to meet the desired gradation. The tolerances applied to this gradation should follow standard tolerances given for aggregates or asphalt aggregate mixtures when used in similar situations. When the recycled mixture is intended to be used as an intermediate or binder course, the gradation tolerances should follow those given in UFC 3-250-03, Table "Aggregate Gradations

for Bituminous Concrete Pavements," for low-pressure tires. When the recycled mixture is to be used as a base course, an exact JMF aggregate gradation is not normally given and therefore tolerances are not required. The only requirement is that the gradation must stay within the gradation range specified.

Aggregates shall consist of crushed stone, crushed gravel, crushed slag, screening, sand, and mineral filler, as required. 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 shall be known as fine aggregate, and the portion passing the 0.075 mm No. 200 sieve shall be known as mineral filler. The combined recycled aggregate gradation shall conform to the gradation specified in TABLE I. TABLE I is based on aggregates of uniform specific gravity; the percentage passing various sieves may be changed by the Contracting Officer when aggregates of varying specific gravities are used. Adjustments of percentage passing various sieves may be changed by the Contracting Officer when the specific gravity of the aggregates varies by more than 0.2.

TABLE I. COMBINED RECYCLED AGGREGATE GRADATION

Sieve Size	Percent Passing
-----	-----
[_____]	[_____]

2.2.1 Coarse Aggregate

NOTE: The values of percentage of loss will be based on knowledge of aggregates in the area which have been previously approved or that have a satisfactory service record in bituminous pavement construction for at least 5 years.

Coarse aggregate shall consist of clean, sound, durable particles meeting the following requirements.

- Percentage of loss shall not exceed 40 after 500 revolutions, as determined in accordance with ASTM C 131.
- Percentage of loss shall not exceed [_____] after five cycles performed in accordance with ASTM C 88, using magnesium sulfate.
- The dry weight of crushed slag shall not be less than 1200 kg/cubic m 75 pcf, as determined in accordance with ASTM C 29/C 29M.
- Crushed gravel retained on the 4.75 mm No. 4 sieve and each coarser sieve shall contain at least 75 percent by weight of crushed pieces having one or more fractured faces with the area of each face equal to at least 75 percent of the smallest midsectional area of the piece. When two fractures are contiguous, the angle between planes of fractures shall be at least 30 degrees to count as two fractured faces.

- e. Particle shape of crushed aggregates shall be essentially cubical. The quantity of flat and elongated particles in any sieve size shall not exceed 20 percent by weight, when determined in accordance with [ASTM D 4791](#).

2.2.2 Fine Aggregate

Fine aggregate shall consist of clean, sound, durable particles including natural sand or crushed stone, slag, or gravel that meets requirements for wear and soundness specified for coarse aggregate. Fine aggregate produced by crushing gravel shall have at least 90 percent by weight of crushed particles having two or more fractured faces in the portion retained on the [0.600 mm No. 30](#) sieve. This requirement shall apply to the material before blending with natural sand, when blending is necessary. Quantity of natural sand to be added to the wearing and intermediate course mixtures shall not exceed 25 percent by weight of coarse and fine aggregate and material passing the [0.075 mm No. 200](#) sieve. Natural sand shall be clean and free from clay and organic matter. Percentage of loss shall not exceed [_____] after five cycles of the soundness test performed in accordance with [ASTM C 88](#), using magnesium sulfate.

2.2.3 Mineral Filler

NOTE: The tabulated gradation requirements will be
used to eliminate undesirable one-size materials.

Mineral filler shall conform to [ASTM D 242](#). Grain size shall be determined in accordance with [ASTM D 422](#). The tabulated gradation requirements shall be used in areas where dune sand or one-size material may be used as mineral filler, unless otherwise directed.

Particle Size (mm)	Percent Finer
-----	-----
0.05	70-100
0.02	35-65
0.005	10-22

2.3 ASPHALT CEMENT

NOTE: The material being recycled may contain
sufficient asphalt binder to meet the specification
requirements. In this case, only water will be
added as a lubricant to improve compaction. Grade
SS-1 or CSS-1 should be specified in moderate or
cold climates. Grade SS-1h or CSS-1h should be
specified in hotter climates such as the southern or
southwestern areas of the United States. Medium
set, high float, or other types of emulsions may be
used with open graded mixtures or in instances where
previous experience with these types of emulsions
has provided good results.

Asphalt cement, if required, shall be an emulsified asphalt, Grade [_____] conforming to [[ASTM D 977](#)] [[ASTM D 2397](#)].

2.4 WATER

Generally, any potable water will be acceptable. Prior to construction, a sample of the water intended for use on the job shall be mixed with a sample of the emulsion at the ratio to be used in the project. If any adverse effect is observed on the emulsion, a new source of water shall be used.

2.5 RECYCLING AGENT

NOTE: Depending on the material properties of the existing asphalt cement binder and the type and method of recycling used, an appropriate type of recycling agent (rejuvenator) will be selected. An emulsified rejuvenator which is widely used is reclamite (Golden Bear Division of WITCO Chemical Co., Los Angeles, CA). Non-emulsified recycling agents should be specified according to ASTM D 4552. The type of rejuvenator specified must match the recycling process used. The recycling agent selected should be capable of decreasing the viscosity of the recycled asphalt cement to levels that approach the viscosity values of asphalt cement in new asphalt concrete pavements for that area or region. Delete this paragraph if a recycling agent is not required.

The recycling agent shall be [_____] or an approved equal.

2.6 JOB-MIX FORMULA (JMF)

NOTE: The mix design primarily establishes the amount of asphalt binder and recycling agent (if used) to be added to the mixture, and then establishes the amount of water to insure optimum compaction conditions. The asphalt content (this includes the recycling agent, if used) is determined based on hot compacted samples because this produces the density that will ultimately be obtained in the field. Ideally, the water content should be selected based on samples compacted at the mixture temperature (ambient air temperature) which will be encountered during construction. This paragraph should be edited where a choice is given between using 50 blows for roads or 75 blows for airfields and heavy duty roads.

Prior to bidding the contract, the designer may want to sample and obtain the material properties of the asphalt and aggregates in the existing pavement. This information is required to allow the development of a JMF and to allow for estimates of emulsified asphalt cement and/or recycling agent type and quantities required. The need for new aggregates to meet JMF requirements may also be

determined. For lump sum bidding, a reasonable estimate of required quantities of materials will be needed.

The JMF for the recycled mixture shall be furnished by the Contractor to the Contracting Officer for acceptance. The Contracting Officer will verify this JMF through samples of materials submitted by the Contractor. No payment will be made for cold recycled mixtures produced prior to the completion and acceptance of the JMF. The formula will indicate the gradation of the aggregate and a definite percentage of water [,recycling agent] and asphalt to be added to the mixture.

2.6.1 Gradation Tolerances

NOTE: Eliminate the corresponding material size and tolerance values to agree with sieve sizes specified in Table 1. Eliminate these completely if no new aggregate is added and no specific JMF gradation is developed.

The tolerances allowed on the gradation are as follows:

Material	Tolerance, Plus or Minus

Aggregate passing the 4.75 mm or larger sieve	4 percent
Aggregate passing the 2.36, 1.18, 0.6, and 0.3 mm sieves	3 percent
Aggregate passing the 0.15 and 0.074 mm sieves	1 percent
Material	Tolerance, Plus or Minus

Aggregate passing the No. 4 or larger sieve	4 percent
Aggregate passing the Nos. 8, 16, 30, and 50 sieves	3 percent
Aggregate passing the Nos. 100 and 200 sieves	1 percent

2.6.2 Asphalt Content

The JMF will be allowed an asphalt content tolerance of 0.3 percent. The asphalt content may be adjusted by the Contracting Officer to improve paving mixture, without adjustment in contract unit price. The optimum asphalt content shall be selected to provide the tabulated properties when samples are compacted at 120 degrees C 250 degrees F with [50] [75] blows of standard Marshall hammer on each side of the specimen, according to COE CRD-C 649 and COE CRD-C 650.

Property	Requirement (75 blows)	Requirement (50 blows)

Stability, minimum, Newtons	8000	2200
Flow, maximum, 25/100-mm	16	20
Voids in total mix, percent	3-5	3-5

Property	Requirement (75 blows)	Requirement (50 blows)
Voids filled with bitumen, percent	70-80	75-85

Property	Requirement (75 blows)	Requirement (50 blows)
Stability, minimum, pounds	1800	500
Flow, maximum, 1/100-inch units	16	20
Voids in total mix, percent	3-5	3-5
Voids filled with bitumen, percent	70-80	5-85

2.6.3 Water Content

The water content shall be selected to provide maximum dry density when samples are prepared at the optimum asphalt content and compacted with [50] [75] blows of Marshall hammer at ambient temperature. When no asphalt binder is added to the mixture, the water content shall be selected to provide maximum dry density. Samples shall be prepared with water contents, in 0.5 percent intervals, from 0 to 2.5 percent (water content may be increased to achieve maximum density). After compaction, the samples shall be placed in an oven at 60 degrees C 140 degrees F for 96 hours. After cooling to ambient temperature the dry density shall be determined according to COE CRD-C 650.

PART 3 EXECUTION

3.1 CONDITION OF EXISTING SURFACE

Areas in the existing pavement that provide indications of underlying structural deficiencies (alligator cracking or depressions) shall be corrected prior to the completion of the recycling process.

3.2 CONSTRUCTION METHODS

NOTE: Depending on the type of recycling desired
the following paragraphs should be edited to remove
the undesired method. The following can remain in
its entirety when the type of construction used is
to be a Contractor's option.

The RAP material, prior to mixing, shall meet the requirements given in paragraph RECYCLABLE ASPHALT PAVEMENT.

3.2.1 Central Plant Mixing

The required amount of bituminous material for each batch, or calibrated amount of continuous mixing, shall be introduced into the mixer to meet the requirements of the JMF. The mixing process shall provide a uniform dispersion of the emulsified asphalt and water to achieve a thorough coating (visually) of all aggregate particles. If this process requires

excessive mixing, resulting in premature breaking of the emulsified asphalt, the mixing times shall be shortened as directed by the Contracting Officer. As a minimum, when the recycled mixture contains fine particles passing the 4.75 mm No. 4 sieve, the mixing process shall provide a thorough coating of these particles.

3.2.2 Test Section

NOTE: Use of a test section is recommended for all recycled mixtures, especially for central-plant mix recycling. The following paragraph is written for placing central-plant mix with a paver and must be edited when another type of recycling is used.

Prior to the start of the recycling project, a sufficient quantity of mixture shall be prepared to construct a test section at least 15 meters 50 feet long, two spreader widths wide and of thickness to be used in the project. Mixture shall be placed, spread, and rolled with the equipment to be used in the project and in accordance with requirements specified above. This test section will be tested and evaluated as a lot and shall conform to all specification requirements. If approved by the Contracting Officer, the test section may be located in one of the less critical areas of the project pavement construction. Otherwise, it shall be located outside the project paving. If tests results are satisfactory, the test section shall remain in place as part of the completed pavement if constructed in the project pavement area. If tests indicate that the pavement does not conform to specification requirements, the test section shall be removed and the material disposed of offsite. Necessary adjustments to the plant operations and rolling procedures shall be made immediately, and another test section constructed, all at no additional cost to the Government. Other additional test sections, as necessary and as directed, shall be constructed and will be sampled and tested for conformance with specification requirements. In no case shall the Contractor start full production with the recycled mixture without approval of the Contracting Officer.

3.2.3 In-Place-Mixing

NOTE: In-place recycling can be divided into either partial- or full-depth recycling. Partial-depth recycling involves only a portion of the asphalt bound layers and normally involves recycling to a depth of 50 to 100 mm (2 to 4 in.). Full-depth recycling involves all asphalt bound layers and often portions of the underlying base course layer.

The in-place recycling process shall provide a uniform blend of the RAP, aggregate (when required), asphalt emulsion, and water. The mixing process shall be capable of producing a mixture containing the required amounts of emulsified asphalt and water as given in the JMF.

3.3 PLACEMENT

3.3.1 Spreaders

Spreading equipment shall be capable of spreading material uniformly; the surface shall conform to the grade and smoothness requirements when compacted. Unless otherwise directed, spreading shall begin along the centerline of areas paved on a crowned section, or on the high side of areas with a one-way slope, and shall be in the direction of major traffic flow. Contact surfaces of previously constructed pavement, curbs, manholes, and other structures shall be sprayed with a thin coat of bituminous material conforming to Section 32 12 10 BITUMINOUS TACK AND PRIME COATS. The placement process shall place the recycled mixture without segregation; when segregation occurs during placement, the spreading operation shall be suspended until the cause is determined and corrected. When placing by hand, the mixture shall be dumped, distributed into place, and spread with lutes in a uniformly loose layer of such thickness to conform to the required grade and thickness when compacted. During hand spreading, each shovelful of mixture shall be carefully placed by turning the shovel over in a manner to prevent segregation. In no case shall mixture be placed by throwing or broadcasting.

3.3.2 Placement with a Paver

The recycled asphalt mixture shall be placed with a self-propelled asphalt paver or similar equipment containing a vibrating or tamping screed. The paver shall be operated so that the surface course being laid will be smooth and continuous without pulling or tearing.

3.3.3 Layer Thickness and Curing

NOTE: The minimum layer thickness allowed should be at least twice the size of the maximum aggregate particle of the RAP or aggregate. The maximum layer thickness may vary from 100 to 150 mm (4 to 6 in.). However, a 100 mm (4 in.) layer is recommended. The thicker the layer the more difficult it is to get density, and the cure period increases. The curing period should range from 7 to 14 days, depending on climatic conditions. The hotter and drier the weather, the shorter the curing period. Generally, the cure period should be about 2 days for each 25 mm (1 inch) of lift thickness. The water content of the recycled mixture should be below 1.5 percent prior to placing additional layers or a wearing surface.

Each layer of compacted mixture shall be at least [_____] mm inches but no more than [_____] mm inches in thickness. Each layer of recycled mixture shall be allowed to cure for [_____] days before placing a succeeding layer, unless a shorter curing period is approved in writing by the Contracting Officer.

3.3.4 Windrows

When windrows are used, they shall be of such size and shape to allow adequate mixing of materials without segregation, and to ensure that the

required thickness of pavement can be constructed.

3.4 COMPACTION OF MIXTURE

Compaction of the mixture shall be conducted to satisfy density, grade, and smoothness requirements. Bituminous mixtures shall be rolled until all roller marks are eliminated, and a field density of at least 86 percent of the theoretical maximum density has been obtained when tested in accordance with [ASTM D 2041](#).

3.4.1 Operation of Rollers and Tampers

The number, weight, and type of rollers shall be sufficient to obtain the required density. Initial rolling of the recycled mixture shall begin as the emulsion is starting to break. Where lift thicknesses exceed [75 mm 3 inches](#), breakdown rolling shall be accomplished with a large [22.5 to 27 Mg 25 to 30 ton](#) pneumatic roller. Either a pneumatic or a steel-wheel roller shall be used to breakdown roll thinner lifts. All rollers shall be equipped with watering devices to prevent material adhesion; however, excess water shall not be permitted. Vibratory rolling will be allowed to achieve required density. Finish rolling with a steel-wheel roller shall be used to remove any existing roller marks.

3.4.2 Correcting Deficient Areas

Mixture that becomes contaminated with foreign material, or is defective in any way, shall be removed to the full thickness of the course. The hole shall be cut with sides vertical and perpendicular to each other, with one pair parallel to the direction of traffic. Rolled areas shall not be skin patched to correct low areas and shall not be planed to correct high areas. Fresh paving mixture shall be placed in holes in sufficient quantity to produce a finished surface conforming to grade and smoothness requirements. Paving mixture shall be aerated, if necessary, and shall be compacted to the density specified herein. The Contractor shall provide competent workmen capable of performing all work incidental to the correction of deficiencies and defects.

3.5 JOINTS

Joints shall present the same texture, density, and smoothness as other sections of the course. Joints between old and new pavements or between successive days' work shall be made carefully to ensure continuous bond between old and new sections of the course.

3.5.1 Transverse Joints

The roller shall pass over the unprotected end of freshly laid mixture only when laying of the course has been discontinued. The edge of the previously laid course shall be cut back to expose even, vertical surface for the full thickness of the course. The fresh mixture shall be raked against the joints, thoroughly tamped, and then rolled.

3.5.2 Longitudinal Joints

The longitudinal joints shall be uniform, and without mixture segregation. When directed by the Contracting Officer, the longitudinal joint shall be cut back to expose an even, vertical surface for the full thickness of the course.

3.6 EDGES OF PAVEMENT

Edges of pavement shall be straight and true to required lines. After final rolling, excess material shall be cut off square and disposed of as directed.

3.7 TRAFFICKING

Trafficking on newly placed recycled mixtures will not be allowed prior to completion of compaction and the curing period.

3.8 ACCEPTABILITY OF WORK

3.8.1 Testing

Field tests shall be performed in sufficient numbers to ensure that the specifications are being met. Testing shall be the Contractor's responsibility and shall be performed by an approved commercial laboratory. The following tests shall be performed at the appropriate time, and will be the minimum acceptable for each type of operation.

3.8.1.1 Mixture Properties

NOTE: The mixture should normally be sampled and tested twice a day or for every 4 hours of production or placement.

A sample of the recycled mixture shall be obtained for every [_____] hours of placement of the mix. The asphalt cement shall be extracted from the mix according to ASTM D 2172. The asphalt content of the recycled material shall be within the tolerance given in paragraph JOB-MIX FORMULA. The gradation of the extracted aggregate shall be determined in accordance with ASTM C 117 and ASTM C 136. The extracted gradation shall meet the JMF and the corresponding tolerances.

3.8.1.2 Density Testing

NOTE: The frequency of testing for the maximum theoretical density (ASTM D 2041) should be tied to the frequency of the field nuclear test readings. Depending on the anticipated construction methods used, a nuclear density test should be performed about every 500 square meters (yards) of recycled mixture placed. Generally, one ASTM D 2041 test should be conducted for every 4 nuclear tests and four ASTM D 2041 tests should be performed for each full day of production. Consult CEMP-ET on test method to be used for cold-recycled mixture that is produced without additional bituminous material and fill in the brackets below.

Field density tests shall be conducted in accordance with ASTM D 6938, ASTM D 1556 or [_____]. When ASTM D 6938 is used, the testing shall be by the direct transmission method. The calibration of the nuclear test device shall be accomplished by testing in accordance with ASTM D 1556 as

described in paragraph "Calibration" of ASTM D 6938. Tests performed in accordance with ASTM D 6938 result in a wet unit weight of material. The moisture content of the recycled mixture shall be determined by ASTM D 2216, ASTM D 4643, ASTM D 4944, or ASTM D 4959. The calibration testing shall occur in an area representative of the entire project in regards to materials and compactive effort. A minimum of three of these tests shall be performed and at least three nuclear readings shall be taken near each of these areas. Each nuclear device shall be calibrated accordingly. Each day the nuclear devices used shall be recalibrated in the manner stated above or the selected area preserved and the devices calibrated in the same approximate locations each day. The field density shall be expressed as a percentage of the maximum theoretical density in accordance with ASTM D 2041. The Contractor shall furnish all tools, labor, and materials for obtaining samples and refilling sample locations. A minimum of one nuclear field density test shall be performed for every [_____] [metric tons tons] [square meters yards] of mixture placed.

3.8.1.3 Grade Conformance

NOTE: For cold-recycled pavements used only as a
base course in aircraft traffic areas, such as
airfield runways and taxiways, intervals between
grade-conformance and smoothness tests should not
exceed 8 meters (25 feet).

Measurements for deviation from grade shall be taken by running lines of levels at intervals of [_____] meters feet longitudinally and [_____] meters feet transversely to determine the elevation of the completed pavement. The finished and completed surface shall conform within 15 mm 0.05 foot to lines, grades, cross section, and dimensions shown on the drawings.

3.8.1.4 Surface Smoothness

Measurements for deviation from surface smoothness shall be taken with a 3.66 meter 12 foot straightedge. The finished surface of the pavement shall not deviate more than 10 mm 3/8 inch from the testing edge of the straightedge in the transverse or longitudinal direction. The straightedge shall be placed parallel to the centerline of each lane paved at intervals of [_____] meters feet and perpendicular to the centerline at intervals of [_____] meters feet. The locations and deviations from the straightedge of all measurements shall be recorded. The Contractor shall remove defective areas and replace with fresh paving mixture at no additional cost to the Government.

3.8.2 Material Samples

A sample of all materials used in the recycled mixture shall be obtained by the Contractor under the supervision of the Contracting Officer. The sample will be retained by the Government.

-- End of Section --